Neurath F and G set new benchmarks

Location of Neurath

Also referred to as BoA 2 and 3, RWE's Neurath units F and G – 1100 MWe gross each with efficiency over 43% – use and build on the BoA package of advanced optimised lignite technologies first used at Niederaussem. Contributors to the high efficiency include: the largest lignite fired boilers in the world, with the most advanced steam conditions ever achieved for lignite; advanced steam turbine with titanium last stage blade, coupled to the highest rated two-pole generator yet built; nine-stage feedwater preheating; waste heat recovery from the flue gas; and optimisation of auxiliary power needs. A key rationale for the new units is the replacement of old, less efficient, units, leading to a significant reduction in CO_2 emissions, by some 6 million t/y compared with the emissions that would be produced by the older units in generating an equivalent amount of electricity.

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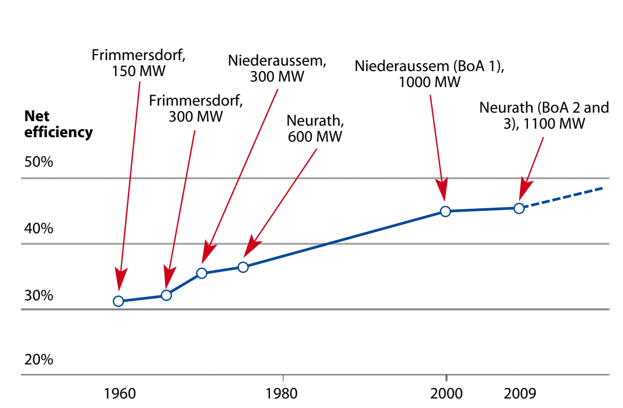
In June 2005, the Düsseldorf regional government gave its approval for the construction and operation at the Neurath site of two lignite-fired power plant units employing optimised plant technology (BoA). The Neurath facilities will be the second and third BoA units (BoA 2 and 3, after BoA 1, Niederaussem, which went on stream in 2003).

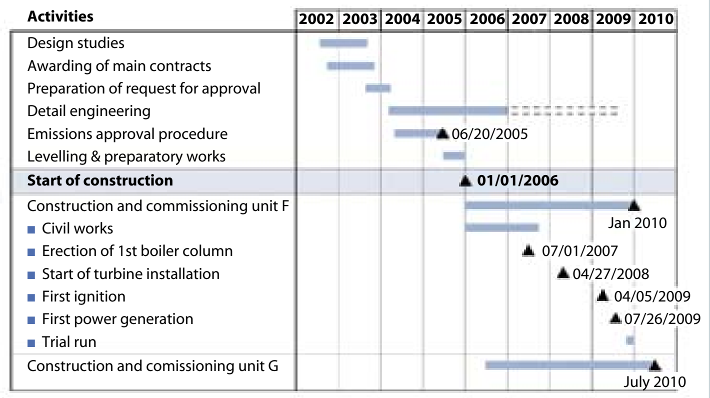
The two power plant units will have a gross capacity of 1100 MWe each (1050 MWe net) and a net efficiency of over 43%, similar to that of Niederaussem.

The most striking features of the Neurath site are the two 170 m high buildings for the steam generators (boilers), which will look much like the Niederaussem unit, and the two cooling towers.

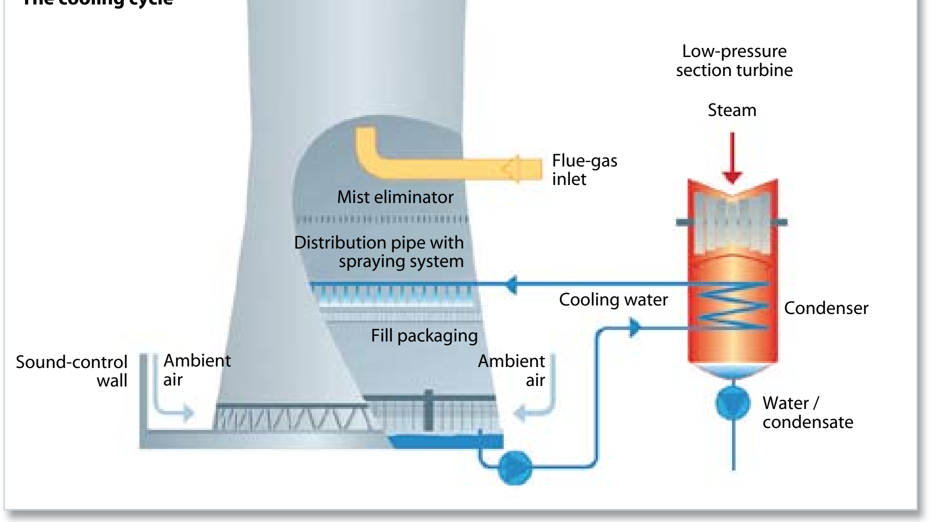
Efficiency improvements



Original schedule for Neurath F and G



The cooling cycle



As already touched optimised combustion in the furnace limits NO_x formation, as well as CO.

The electrostatic precipitators separate out more than 99.8% of the dust carried by the flue gas.

While over 90% of the sulphur dioxide from the flue gas is removed by the FGD plant and turned into gypsum.

For flue gas desulphurisation, a wet limestone process is employed.

For process-related reasons, the main wastes produced by the power plant will be dry and wet ash as well as gypsum.

Some of the gypsum will be sold to the construction material industry. But, due to the inevitable variations in gypsum quality arising from the strongly fluctuating ash composition, and due to the likelihood of insufficient demand from the building sector, some of the gypsum will be used together with lignite ash for backfilling the mines from which the lignite will be extracted.

For the other process-related byproducts, it is planned to re-use them in the power plant.

The calciferous sludge from water treatment, for example, can be used to reduce pulverised limestone needs in the flue gas desulphurisation process.

Water management is another key environmental consideration. 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 (eg, the FGD), while excess amounts are directly discharged into the outfall ditch.

For service water, a purification plant will be available and the treated water will be released into the outfall ditch. Any surface water occurring will be initially collected in a rainwater settling basin and then released into the outfall ditch.

The minimising of noise has also been a key objective, requiring all mechanical equipment in the new units to be installed in enclosed rooms.

Within the units sound-proofing will be used as required to ensure that levels in the work areas are well below the permissible values. Low-noise machinery is being used where possible, but where it is not possible additional sound-proofing enclosures or structural partitions are being 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 falling into the bottom section, acoustic barriers are being erected outside them.

Assessments indicate that statutory noise emission levels in the vicinity of the power plant will be met comfortably.

Even though it is envisaged that all statutory environmental requirements for the power plant will be met by a good margin when F and G start up, nevertheless the new units have environmental implications for their immediate surroundings. Therefore experts at TUV Anlagentechnik GmbH have assessed the environmental compatibility of the F/G project. Backed by individual expert opinions, the impact on air, climate, soil, water, flora and fauna and, ultimately, humans, was assessed, as well as the potential impact on the landscape.

Comprehensive measurements made between December 2002 and June 2003 recorded the then existing levels of nitrogen dioxide and airborne particles (PM10) and included an evaluation of the heavy metals in the airborne particles and dustfall at Rommerskirchen-Nettesheim. In the period December 2003 to June 2004 measurements of prior contamination by dioxins/furans were carried out. Further prior contamination data were obtained from measuring stations operated by the environment office of the state of North Rhine-Westphalia.

Using the calculation procedures prescribed in Germany's 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 estimated . The results are shown in the table below.

It can be seen 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 levels are below the permissible air-quality values.

The data on existing, additional and total air contamination apply to the most unfavourable situation in each case in the region being assessed and the additional contamination due to the new units assumes they are emitting at the maximum admissible levels. Under normal operating conditions actual emissions would be much lower.

The future for lignite

Looking beyond Neurath F and G RWE Power is working on the next generation of lignite-fired power plants. These are expected to offer about a four percentage point increase in efficiency thanks to the use of dried rather than raw lignite, as used in today's plants, including Neurath F and G.

RWE Power is developing a drying technology called WTA – fluidised bed drying with internal waste heat utilization – for this purpose (see *Modern Power Systems*, December 2007, pp 17-21

A demonstration facility has been built next to the Niederaussem BoA unit and commissioning has just begun. The facility will trial the technology for the first time in conjunction with a large-scale power plant, with the aim of demonstrating that the WTA system in continuous operation is both technically and economically viable.

WTA is a proprietary development of RWE Power and since 1993 it has been undergoing trials and steady development at Frechen and Niederaussem.

WTA technology is also proposed as part of a major retrofit planned for the Hazelwood power plant in Australia (see *Modern Power Systems*, December 2007, pp 22-29).

It is expected that German electricity demand will grow only modestly in the coming decades. Over the past 10 years, consumption has 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 there is the projected phase-out of nuclear power – the share of which in power generation hitherto has been some 22%. This may be questionable in terms of climate policy and the impact on the energy sector, but it has been agreed between the federal government and the energy sector and potentially creates a huge generation gap that must be bridged. If the phase-out happens the nuclear contribution to annual electricity supply – presently around 140-170 billion kWh per year – will dwindle to nothing by 2030.

The German domestic renewable energy sources – hydro, wind, biomass, landfill gas, solar, geothermal and waste-to-energy – are at present making an 11% contribution towards 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 and by the middle of the century as much as one half of all energy is to come from renewables.

Natural gas, too, is likely to enjoy an increasing share of the power generation market. It already accounts for around 12% of the total.

The outlook for hard coal is mixed: a decline in the use of domestically mined fuel and an increase in the use of imported coal.

But meeting power needs from natural gas, imported hard coal, and increased electricity imports creates fewer domestic jobs and less value added than electricity from indigenous energy sources such as lignite. It is estimated that economically mineable lignite deposits in Germany are sufficient to last for generations to come. Also, the lignite can be extracted under competitive conditions and the industry can get by without subsidy.

Currently lignite fired power plants account for about a quarter of Germany's electricity production, with Rhenish lignite providing about 13% of the total electricity.

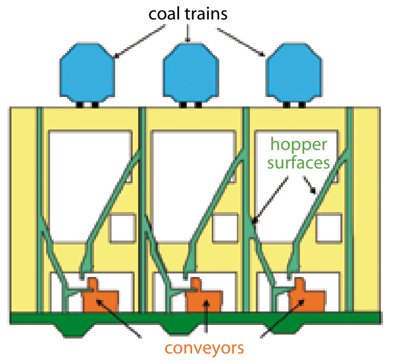
Analyses, eg by the Prognos research institute, have suggested that lignite may even gain in importance as an electricity source in the long term future. But this need not be at the expense of the environment or the climate thanks to more efficient power plants, as exemplified by Neurath F and G. MPS

Summary of key data for Neurath F and G

Location	Grevenbroich, Neurath (near Cologne, Germany)
Owner/operator	RWE Power AG
Fuel	Lignite (domestic)
Cooling system	Cooling tower with natural draught
Installed capacity (MWe)	1100 gross, 1050 net
Net efficiency (%)	Greater than 43
Flue-gas waste heat utilisation (degrees)	350/160/125
Steam generator	
Type	Once-through, tower
Steam flow (t/h)	2870 (2960 max)
Steam pressure (bar)	272 (280.4 max)
Steam temperature (°C)	600
Furnace capacity (MWt)	2392 (2800 max)
Raw lignite input (guarantee lignite)(t/h)	820 (1326 max)
Steam turbine	
Type	STF100
Number of modules (casings)	4
Steam pressure (bar)	259
Steam temperature – inlet/reheat (°C)	595/604
Speed (rpm)	3000
Generator	
Type	GIGATOP
Rating (MVA)	1333
Power factor	0.825
Frequency (Hz)	50
Terminal voltage (kV)	27
Excitation system	Static excitation system
Cooling system	Hydrogen plus water

Condensing plant	
Circulating water temperature (°C)	18.2
Condenser pressure (mbar)	48
Tube material	Stainless steel
Feedwater heating plant	
Number of feedwater preheating stages	9
Number of feedwater heaters	8
Number of feedwater deaerating tanks	1
Feedwater inlet temperature (°C)	292
Main pumps	
Condensate extraction pumps (%)	3 x 50
Feedwater pump	1 x 100 % main turbo driven feedwater pump plus 2 x 40% start-up motor driven feedwater pumps
Circulating water pumps (%)	2 x 50
Polishing plant	Yes
Main transformers	
Rated output (MVA)	2 x 1100 (per unit)
Primary/secondary (kV)	420/27
Unit transformers	
Rated output (MVA)	2 x 100/60/60 (per unit)
Primary/secondary(kV)	27/10.5/10.5
Standby transformer	
Rated output (MVA)	90/45/45
Primary/secondary (kV)	110/10.5/10.5

Cross section through underground coal bunker



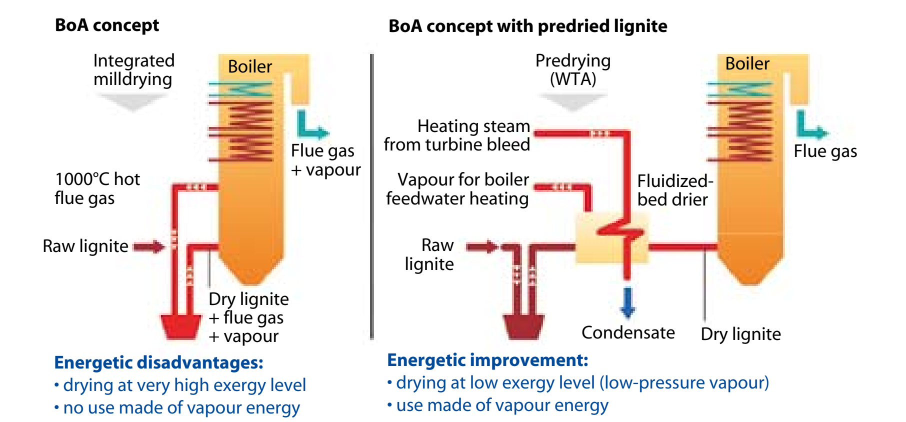
Technical data

Bunker volume	50 000 t
Storage capacity	30 h (design)
Overall dimensions	310m x 33m x 23 m
Excavation	605 000 m³
Concrete volume	60 000 m³

Aerial view of coal bunker, Feb 2008

The excavation for the underground bunker (Sept 2006), up to 43 m deep in parts

The future: WTA lignite predrying



Expected effect of Neurath F and G on air quality

	What percentage of the allowed air-quality value will be reached after units F and G enter operation?			By what percentage does air pollution increase after units F and G enter operation?			
	Admissible air-quality value under TA Luft	Total air pollution after units F and G are commissioned (sum of prior and added contamination)		Prior contamination		Max. additional contamination from operating units F and G	
	µmg per m³ air	µg per m³ air	Percentage of admissible air-quality value	µg per m³air	Percentage of admissible air-quality value	µg per m³ air	Percentage of admissible air-quality value
Sulphur dioxide	50.0	7.6	15.2%	7.0	14.0%	0.6	1.2%
Nitrogen dioxide (NO_x)	40.0	32.7	81.8%	32.5	81.3%	0.2	0.5%
Airborne particles	40.0	30.1	75.3%	30.0	75.0%	0.1	0.3%
	g per m² and day	g per m² and day		g per m² and day		g per m² and day	
Dustfall	0.35	0.114	32.6 % g	0.114	32.6%	0.00002	0.006%

Immediately after the regional government approval RWE Power started site preparation for the BoA 2 and 3 units at Neurath and in September 2005 took the final decision to proceed with the €2.2 billion project. The decision was taken by RWE on the assumption that emissions rights prevailing in 2005-2008 for new and replacement plants would continue to apply after 2008 under NAP (National Allocation Plan) 2.

A crucial objective of the new units is a reduction of CO_2 emissions for RWE's lignite power plant fleet as a whole, via increased efficiency and the shutting down of old, less efficient, units.

With an efficiency of more than 43% the BoA units certainly meet this goal.

The replacement of the old 150 MW units by BoA 2 and 3 will lead to a reduction in CO_2 emissions of about 6 million t/y relative to the emissions that would be produced by the old units in generating an equivalent amount of electricity.

The site area occupied by the two new units at Neurath is just under 37 ha and less than 40% of this will be occupied by buildings. As an ecological offset for the erection of the two new power plant units, including rail links and overhead lines, RWE is reforesting some 21 ha of farmland in the areas of Neurath, Sinsteden and Vanikum. In addition special farming methods will be introduced to a further 10 ha of land to encourage wildlife habitation.

Commercial operation of the new Neurath units is envisaged for 2010. However work on the unit F steam generator was suspended in October 2007 due to a serious accident. Work on unit G has continued, while preparations are underway to restart work on the unit F steam generator shortly. While the original schedule (see p 23) envisaged that unit F would start up before G, the order is now likely to be reversed.

Energy capital


The existing Neurath plant

The Grevenbroich region, where the Neurath plant is located, has traditionally played an important role in energy supply: it was close to here that the first lignite deposit in the northern mining area was discovered. That was back in 1858, and for decades, the lignite was mined in opencast operations and upgraded in two neighbouring briquette factories. Despite this mining tradition, the Neurath power plant site is relatively young compared with the other Rhenish power plant locations: the first unit only went on stream in 1972 and by 1976, a total of three 300 MW units and two 600 MW units had been commissioned.

Like all other large lignite-based power plants, the Neurath power station, which uses lignite from the Garzweiler and Hambach opencast mines, operates in baseload mode.

RWE now mines some 100 million tons of lignite every year in the Rhenish lignite-mining area, most of which is used to generate electricity. Lignite needs no subsidies and represents an economic asset for the entire region.

Plant description

The high efficiency of the BoA 2 and 3 units at Neurath can be ascribed to: the steam conditions (600/605°C); the steam turbine technology; the nine-stage feedwater preheating system; the maximisation of waste heat recovery from the flue gas; and minimisation of auxiliary power needs (eg through use of turbine driven feedwater pumps).

The two new units are located to the east of the existing Neurath units and will make use of existing facilites where possible, some of which must in part be retrofitted or extended.

For lignite supplies, a new coalyard in the form of an underground slot-bottom bin is being built. The raw lignite will be delivered to the new bin using RWE's own north–south railway connecting the power plant site to the Garzweiler and Hambach opencast mines.

From there, the lignite will be transported by a new conveyor belt system to the day bins in the boiler houses.

The lignite mills pulverise the lignite and, to lower its high moisture content (48 to 60%), dry it using hot flue gases taken from the furnace. Next, together with heated air from the flue-gas air heater, the pulverised lignite is blown into the combustion chamber of the steam generator.

The once through steam generators each have a capacity of 2392 MWt (2800 MWt max) and are the largest lignite fired boilers in the world, with the highest steam mass flows, supercritical steam pressures and steam temperatures ever reached for lignite – the size (notably the height) coupled with the steam parameters creating particular challenges.

Combustion is subject to constant monitoring and adjustment of the lignite and air feed, so that it is optimised and NO_x production minimised. The legally prescribed emission limit values for NO_x – 200 mg/m³ of flue gas – can be comfortably met by these combustion measures alone, without additional post combustion systems, eg selective catalytic reduction.

The lignite combustion temperature is about 1200°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, which consist of tubes, and to the tube banks suspended in the flue-gas flow. Heated feedwater flows through these tube systems and is evaporated and superheated.

After 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 to preheat the combustion air. After flowing through these heat exchangers, the flue gas – cooled from about 350°C to 160°C – is conducted in two parallel lines to flue gas cleaning systems. The latter consist of dust extraction, by electrostatic precipitation, followed by flue gas desulphurisation (FGD).

A further portion of the remaining flue-gas heat is removed from the flue gas before it is fed into the desulphurisation 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 flue gas desulphurisation system, which employs polypropylene and concrete for the scrubber wall materials.

The main steam produced by the steam generator has a pressure of 272 bar and a temperature of 600°C and is initially expanded to 58.7 bar in the turbine's high-pressure section, where the temperature falls to 356°C. This steam is conducted back to the steam generator and superheated again (reheated) to 605°C. In the intermediate- and low-pressure sections the steam expands to the pressure of 48 mbar prevailing in the condenser, where it is precipitated as water.

The cooling water is re-cooled in the cooling tower by falling as rain in continuous contact with cooling air. The cooling air required for this in the energy-efficient natural-draught tower necessitates the tower height of around 170 m.

The cooling water that evaporates during re-cooling and the cooling water that must be discharged to avoid excess concentrations of salt has to 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. As an alternative, the new units can also be supplied with treated water from Niederaussem.

The steam turbines, each rated at 1100 MWe, are of the Alstom STF100 type. They employ fully flow optimised blading.

At Neurath a compact four casing configuration is employed: HP, IP and two LP (whereas at Niederaussem there is a three-casing LP) .

The two-casing four-flow low pressure turbine stage is made possible through the use of titanium 1.408 m last stage blades – the longest last stage blades currently offered on the world market, providing an exhaust cross section of 13.2 m². The compactness of the steam turbine contributes to reduced construction costs.

The electrical generators are of the Gigatop type (with hydrogen cooled rotor and water cooled stator) and, at 1333 MVA, these will be among the highest rated two-pole machines in the world.

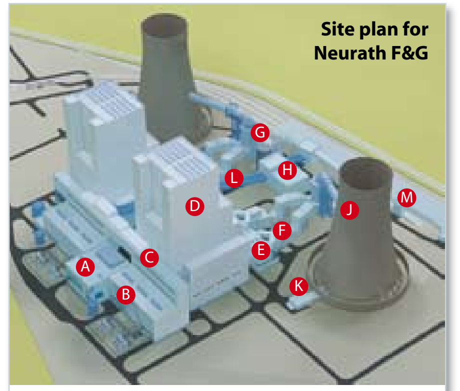
The generator terminal voltage is 27 kV. The voltage is stepped up to 380 kV for grid connection.

Environmental impacts

As well as reduced CO_2 emissions, the new units will also achieve low specific SO_2, NO_x and dust emission levels.

They will certainly be comfortably below the statutory limits, as specified in the German ordinance on large combustion plants: SO_2 – 200 mg/m³ and a minimum sulphur removal rate of 85%; NO_x – 200 mg/m³; CO – 200 mg/m³; and particulates – 20 mg/m³.

Site plan for Neurath F&G



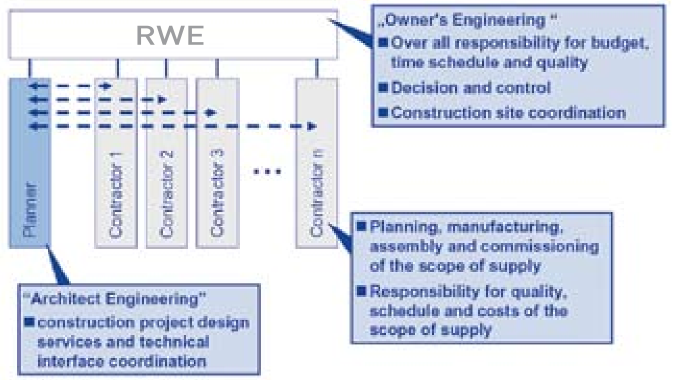
A	Main switchgear and control building	G	FGD building
B	Turbine hall	H	Switchgear building for FGD
C	Intermediate building	J	Cooling tower
D	Boiler house	K	Cooling water pump house
E	Electrostatic precipitator	L	Coal conveyor bridge
F	Induced draft fan building	M	Coal bunker


Site as of 5 March 2008. The picture shows the four stair towers, two per unit and, in the centre of the picture, boiler structural steel for unit F (right), where the October accident occurred, and for unit G (left)

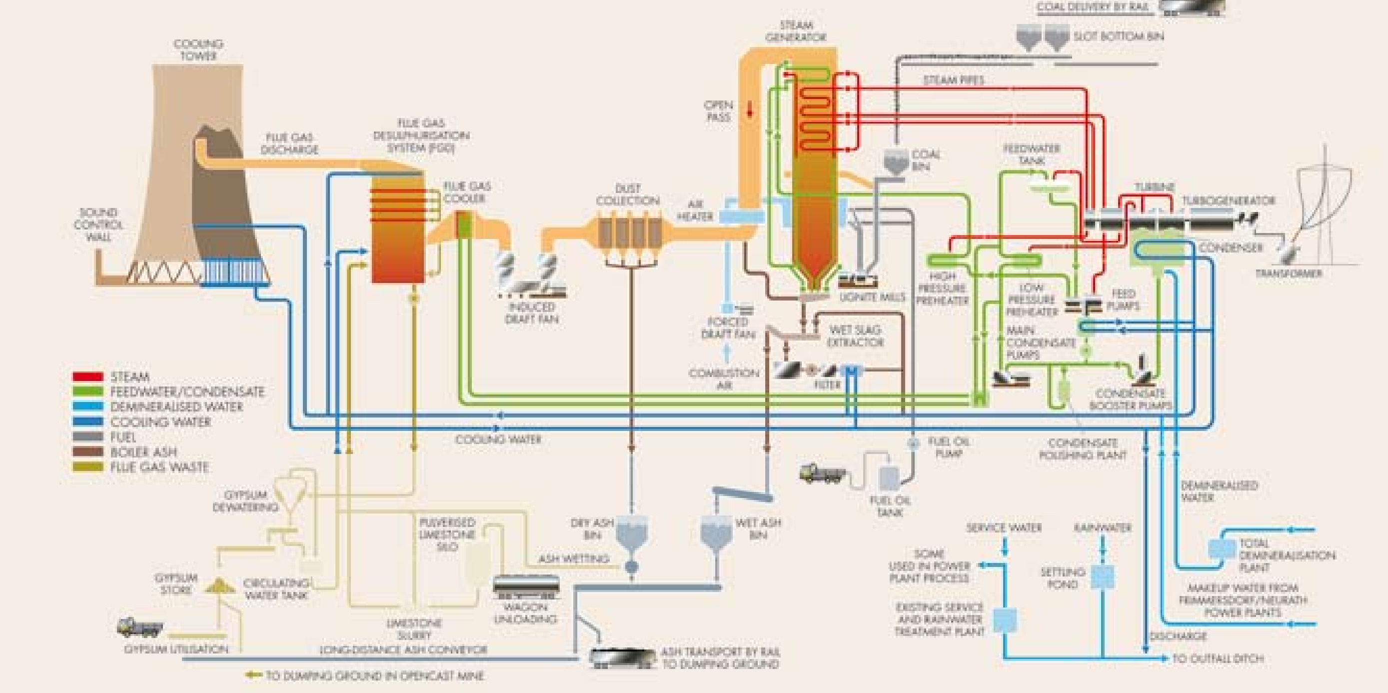
Key contractors and the multi contract approach

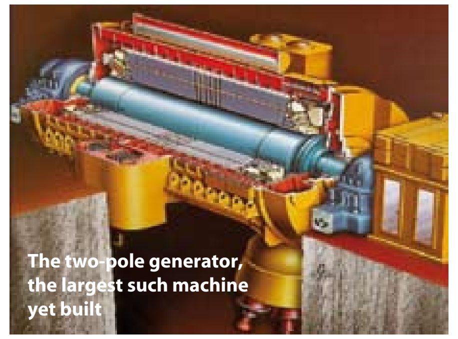
Key contractors:

Architect engineer	Alstom Power Systems
Steam boiler	Hitachi Power Europe, Alstom Power Systems
Steam turbine, generator	Alstom Power Systems
Civil Works	Strabag
Cooling tower	GEA, Alpine Bau
Desulphurization system	AE&E
Control system	Siemens
Electrostatic precipitator	FISIA Babcock Environment
High pressure piping	BHR Hochdruck-Rohrleitungsbau, KAM Kraftanlagen München
IP-LP Pressure piping	Babcock Borsig Service, MCE/VAM, Kiel
Coal supply	ThyssenKrupp Fördertechnik
Main transformers	Siemens



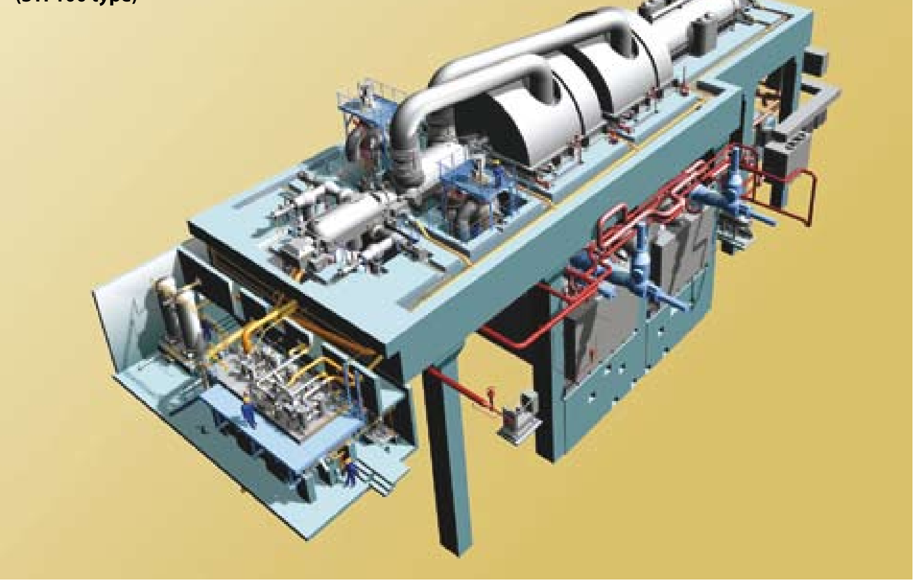
Schematic of the new Neurath units, F and G



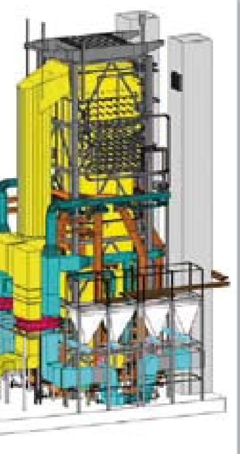

The two-pole generator, the largest such machine yet built


Neurath innovation: polypropylene and concrete are used for the flue gas scrubber internal walls

The four casing steam turbine (STF100 type)



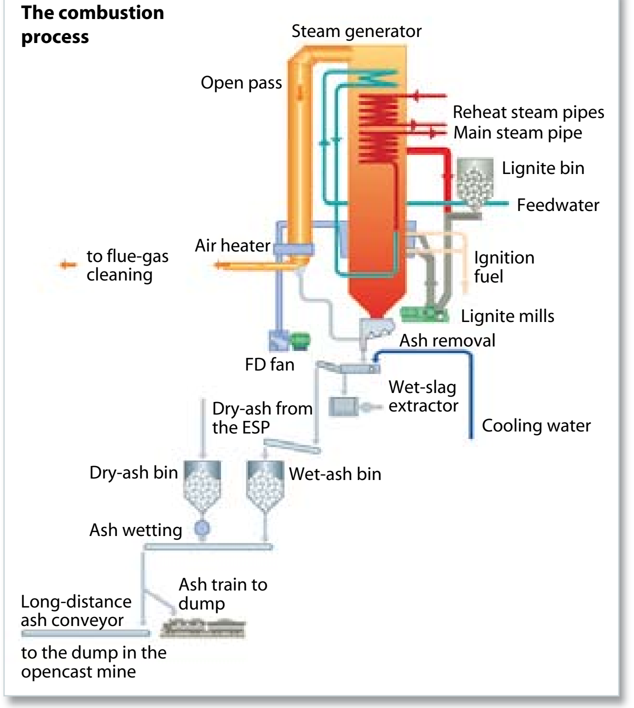
The Neurath F & G boilers are of the well proven single pass type. The large dimensions allow lignite from the local mining area to be used



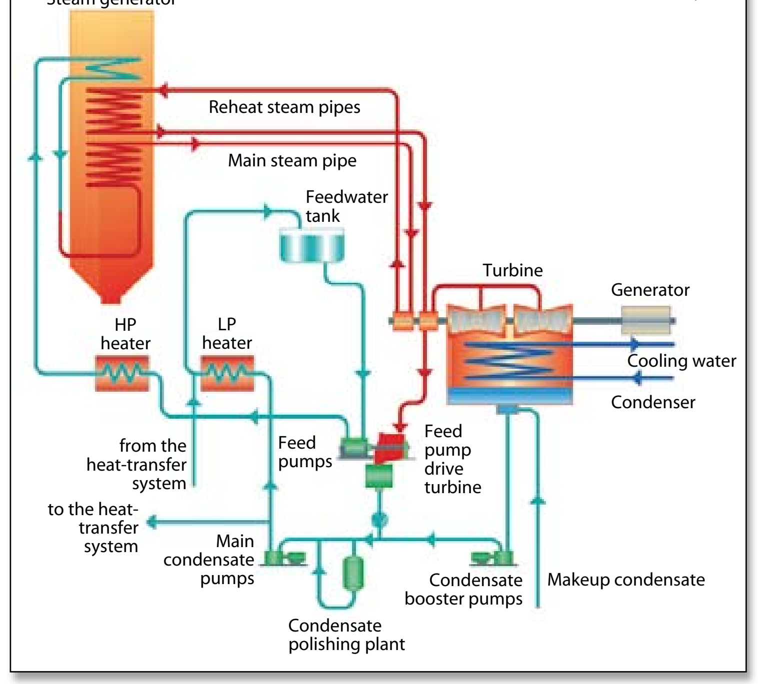
Technical data

Firing thermal capacity	2392 MW (max. 2800)
Lignite feed	820 t/h (max. 1300)
Main steam	272 bar / 600°C
Hot reheat steam	55 bar / 605°C
Total dimensions	170 m x 100 m x 100 m
Dimensions of boiler	14 2m x 26 m x 26 m
Heating surfaces	146 000 m² (~15 ha)

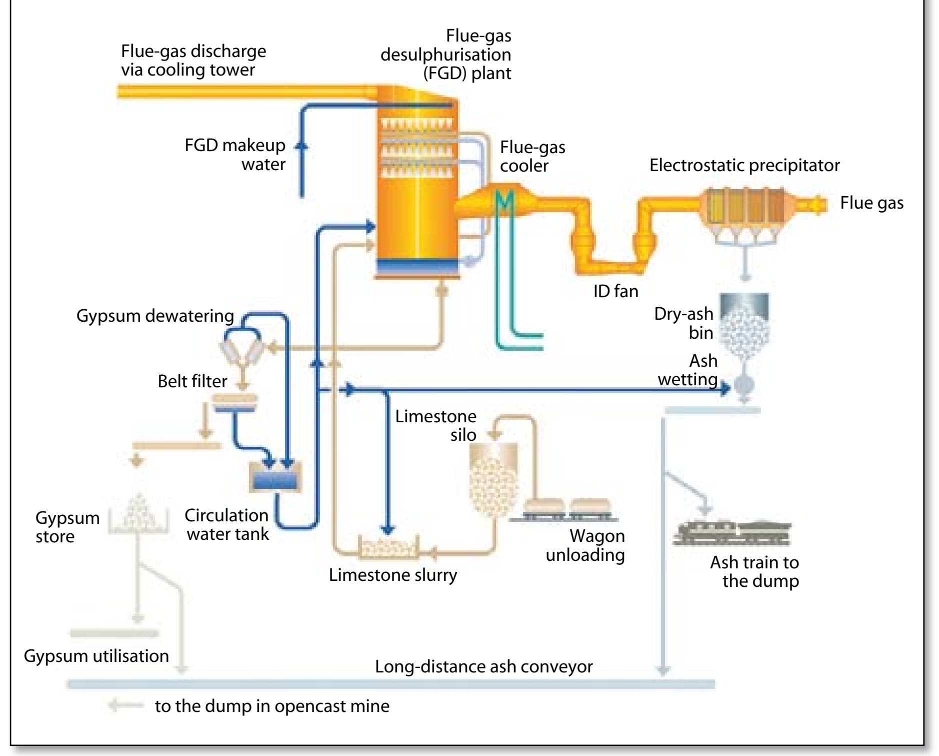
The combustion process

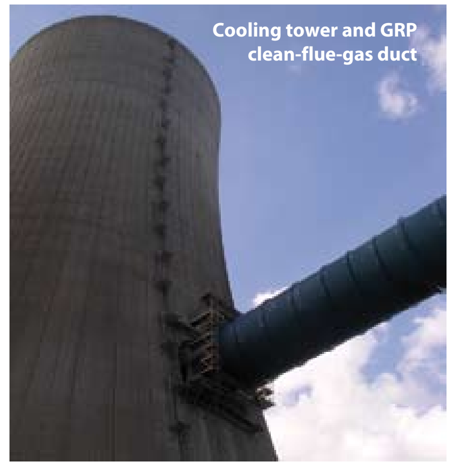


The water–steam cycle



Flue gas cleaning schematic




Cooling tower and GRP clean-flue-gas duct


Inside the unit F cooling tower (March 2008)