RWE

Welcome to Niederaussem Power Plant

Flexible coal power plant operation

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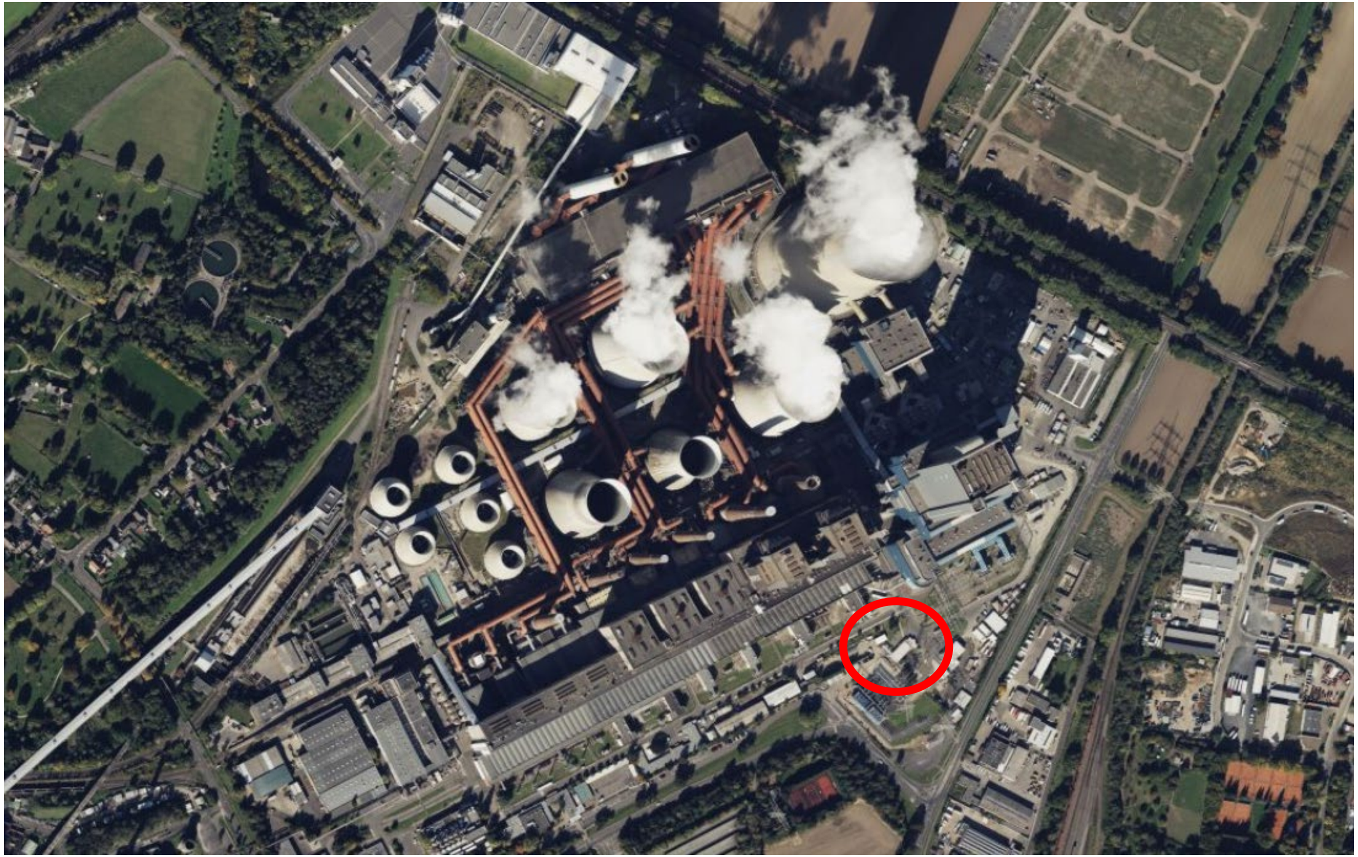
RWE Technology International GmbH

Niederaussem Power Plant

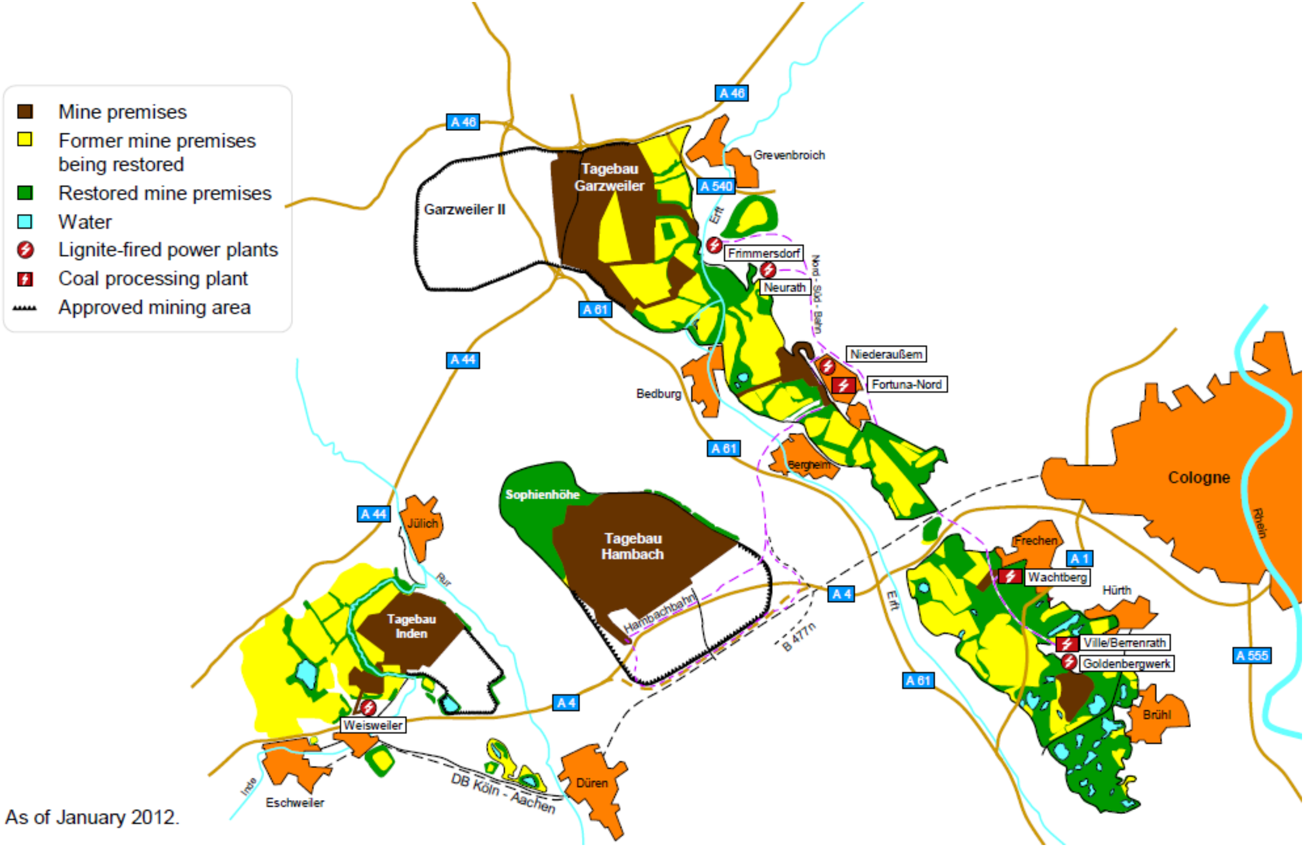


RWE made a lot of effort to increase flexibility and efficiency of its plants in the last decades
Example Lignite

	150 MW Block	300 MW Block	600 MW Block	1,000 MW BoA-Block
COD	1963	1965 – 1971	1974	2003
η	31%	32 – 34%	35 – 36%	>43%
Coal	1.2 kg/kWh	1.1 kg/kWh	1.1 kg/kWh	0.9 kg/kWh

Next Project:
2× 550 MW
Pre-dried lignite
CFBC Units
(Canceled)

RWE's Rhenish lignite mining region and Lignite Power Plants



As of January 2012.

Fuel characteristics – complete analysis

Proximate analysis
- H_2O, ash and volatile matter (VM)

Calorific value
- Lower calorific value, higher calorific value

Elementary analysis
- C, H, N, O, S, Cl, F

Ash analysis of macro-elements (XRF)
- SiO_2, Al_2O_3, TiO_2, Fe_2O_3, CaO, MgO, K_2O, Na_2O, P_2O_5, SO_3

Ash fusion trajectory in oxidizing and reducing atmosphere
- Initial deformation temperature (IDT)
- Softening temperature (ST)
- Hemispherical temperature (HT)
- Fluid temperature (FT)

Grindability (HGI, PMI)

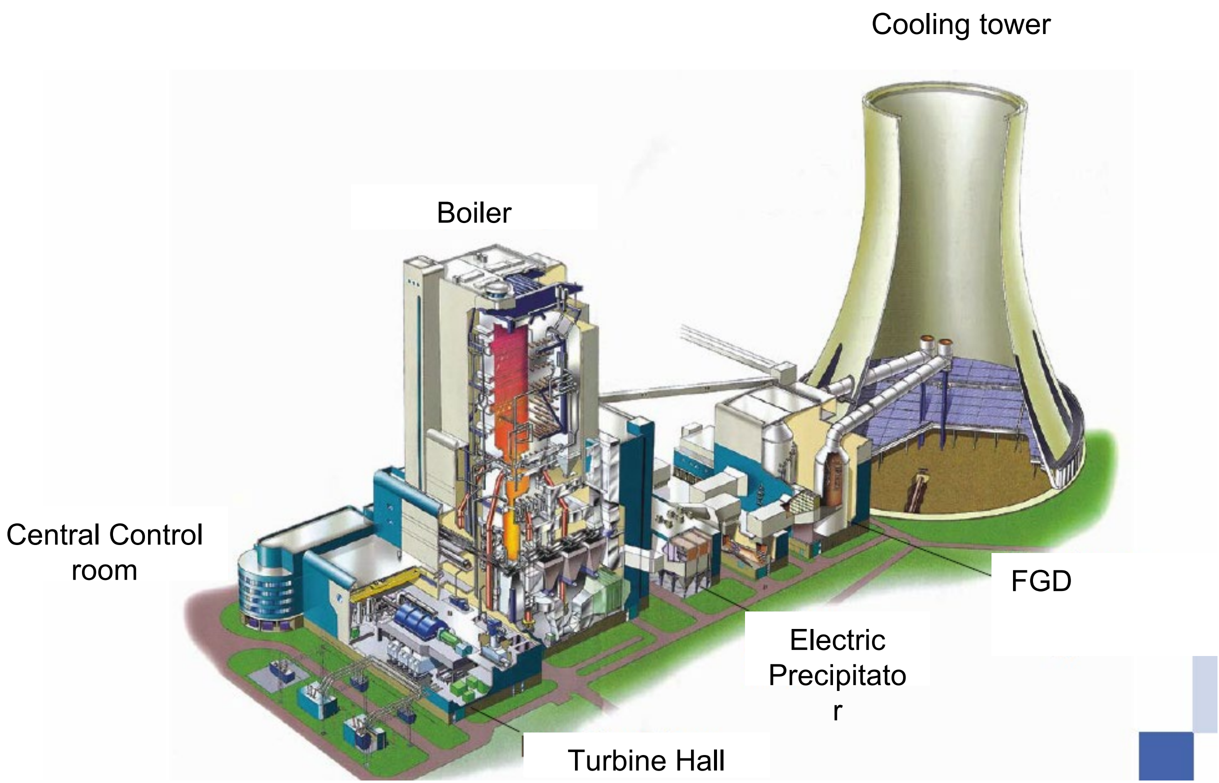
Kohlenarten				Wassergehalt (%)	Energiegehalt af* (kJ/kg)	flüchtige Anteile waf** (%)
UN-EC	USA (ASTM)	Deutschland (DIN)				
Peat	Peat	Torf				
				75	6,700	
Ortho-Lignite	Lignite	WEICHBRAUNKOHLE				
				35	16,500	
Meta-Lignite	Sub-bituminous Coal	Mattbraunkohle	HARTKOHLE			
				25	19,000	
Subbitum. Coal	Sub-bituminous Coal	Glanzbraunkohle	HARTKOHLE			
				10	25,000	45
Bituminous Coal	High Volatile Bituminous Coal	Flammkohle	Steinkohle / HARTKOHLE			
						40
Bituminous Coal	High Volatile Bituminous Coal	Gasflammkohle	Steinkohle / HARTKOHLE			
						35
Bituminous Coal	High Volatile Bituminous Coal	Gaskohle	Steinkohle / HARTKOHLE	Kokskohle36,000		
						28
Bituminous Coal	Medium Vol. Bitumin. Coal	Fettkohle	Steinkohle / HARTKOHLE			
						19
Bituminous Coal	Low Vol. Bitumin. Coal	Eßkohle	Steinkohle / HARTKOHLE			
						14
Anthracite	Semi-Anthracite	Magerkohle	Steinkohle / HARTKOHLE			
				3	36,000	10
Anthracite	Anthracite	Anthrazit	HARTKOHLE			

af * = aschefrei waf ** = wasser- und aschefreie Substanz

Quelle: BGR

→ **Complete analysis gives the whole picture of the combustion behaviour of a Fuel**

BoA1 Unit K 1000 MW Class



BoA1 Unit K 1000 MW Class

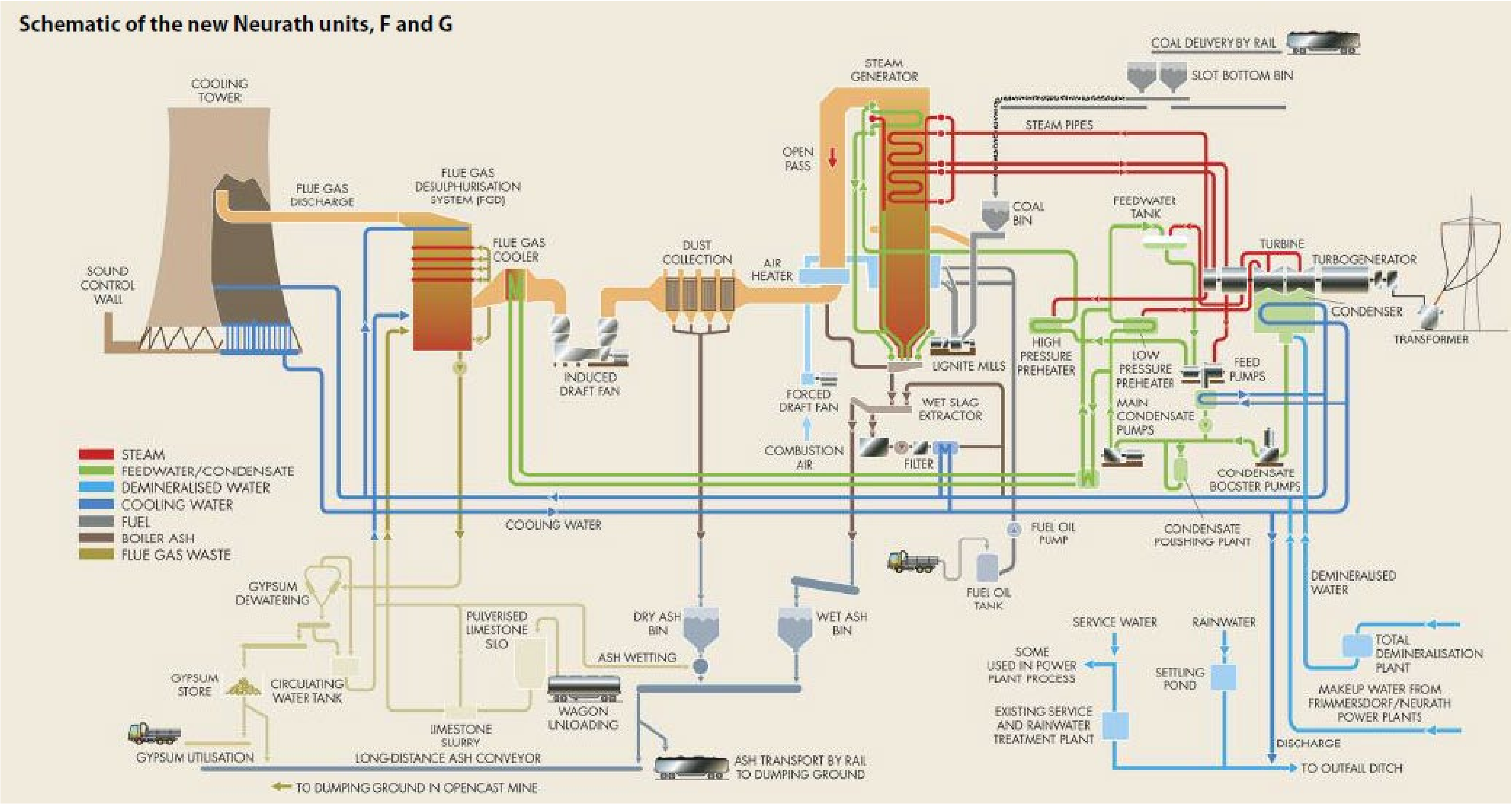
Technical data:

• net power output	965 MW
• net efficiency	45,2 %
• live steam	580 ° C/275 bar
• intermediate steam	600 ° C/59 bar
• condensor pressure	29 / 35 mbar
• flue gas temperature at FGD inlet	100 ° C

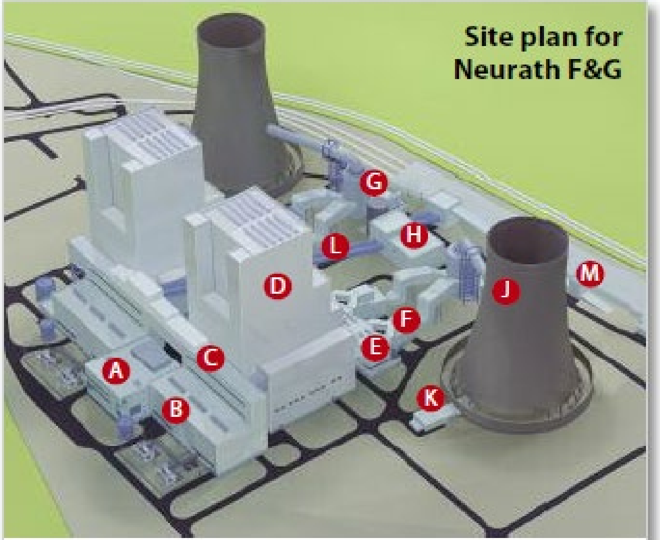
Project implementation:

Start of planning:	01.07.1996
Request for approval:	21.03.1997
approval:	12.11.1997
Start of site preparation:	12.12.1997
Start of construction:	03.08.1998
First grid connection:	28.08. 2002

Process Flow Sheet of Lignite PFC

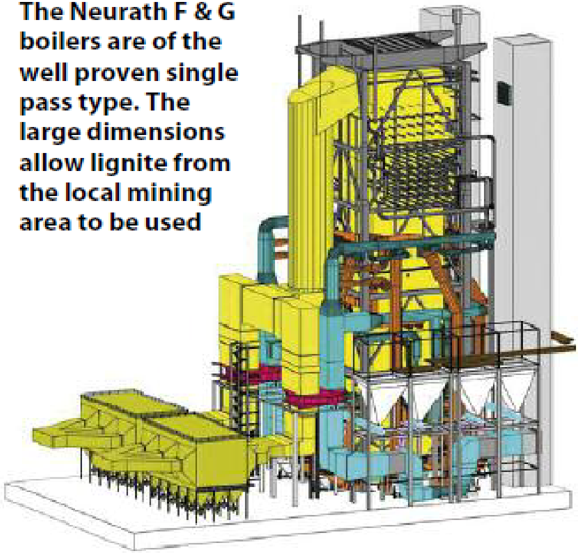


Unit F&G (BoA 2&3) - Most Compact & Efficient Arrangement



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

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)

What does flexibility mean?

High flexibility can be described as follows:

Dynamic flexibility

- High operational gradient (load change speeds)
- Short start-up time and short minimum downtime
- Lowest possible minimum load and options to temporarily maximise the load

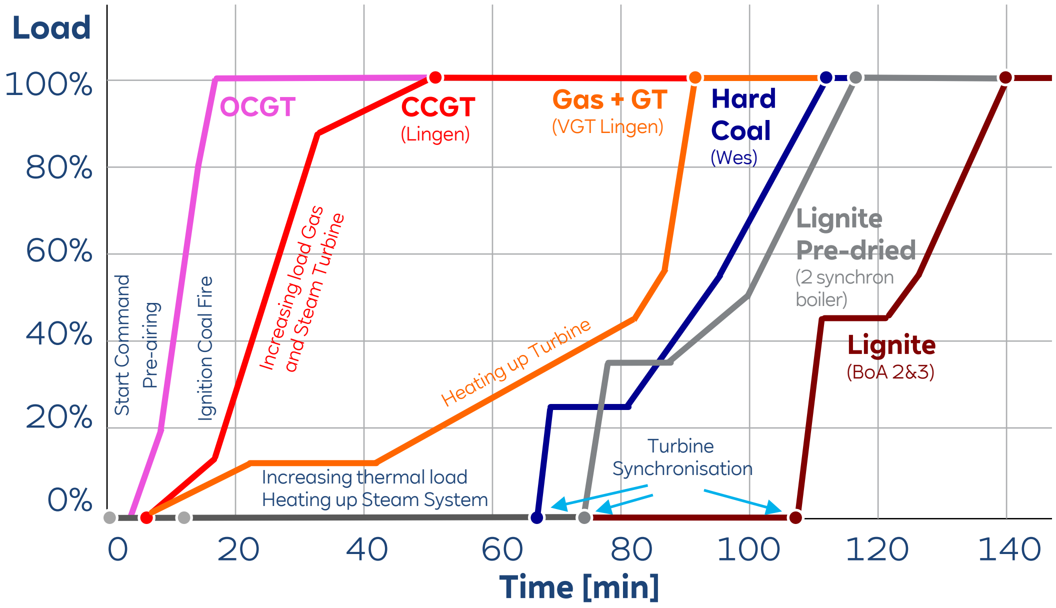
Operational flexibility

- High number of start ups and load cycles at reduced lifetime consumption
- High efficiency at lowest possible minimum load
- Uniform, high efficiency curve across the load
- Fuel flexibility

RWE's philosophy regarding flexibilisation

Create value by combining technical solutions, process improvements, culture change and market focus!

Cold Start – Comparison Load Change Rate



Design specifications of new power plants

Example: Power plant Westfalen

Operational characteristics (Hard Coal, 800 MW)

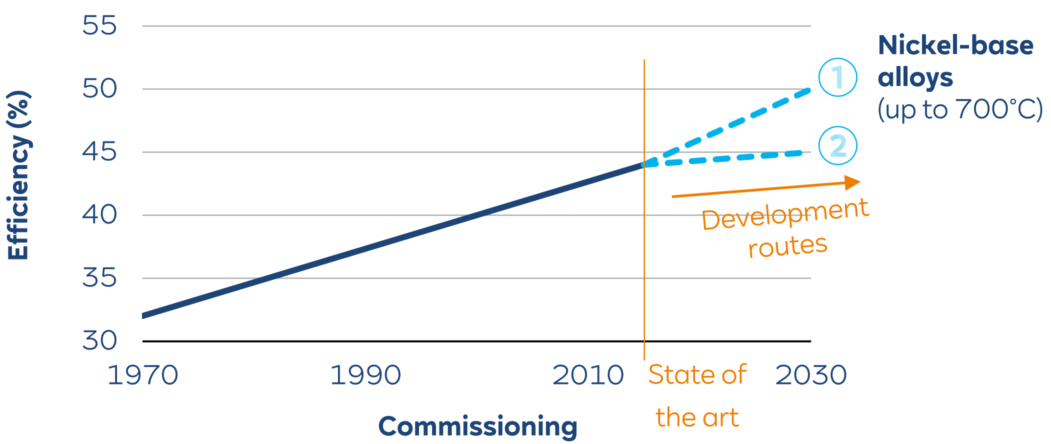
- Base and medium load
- Plant runs through in times of low demand
- Minimum load 25 – 30%, 7,500 operation hours per year

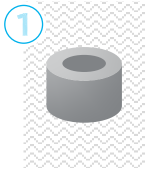
Operation Mode	Yearly	40 years
Cold Starts	6	240
Warm Starts	42	1,680
Hot Starts	84	3,360
Load Cycles	1,200	48,000

Flexibility requirements are assessed and taken into account during the design stage of the plant.

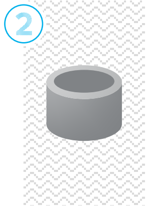
New advanced materials allow increase in flexibility or efficiency

Efficiency development of lignite-fired plants





High efficiency
Increase in steam parameters for new build plants (700°C power plant)



High flexibility
Constant steam parameters in existing and new plants (600°C live steam temperature)

Use of nickel-base alloys depends on operating conditions of future power plants.

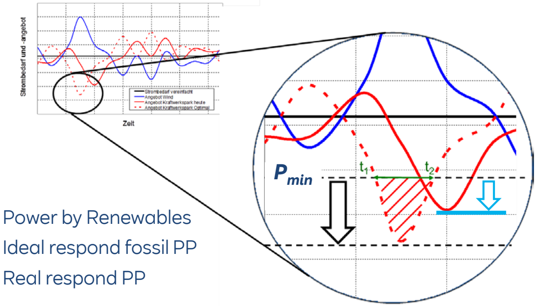
Short minimum downtime

Lifetime consumption consideration

- After command “fire off” measures must be carried out to bring the unit fast back into the “Ready” operating state. Hereby, the condition of the unit must be considered.
- Time leader in coal firing is the pre-ventilation due to security.
- Gentle cooling of the steam generator before air purging, which increases the lifetime but is time-consuming. This measure avoids the temperature stresses.

Lifetime consumption is considered in the design and in the operation of our plants.

Renewables vs. Conventional PP



Power by Renewables
Ideal respond fossil PP
Real respond PP

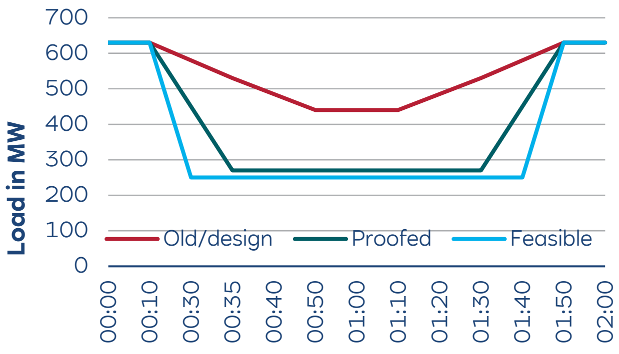
In todays market

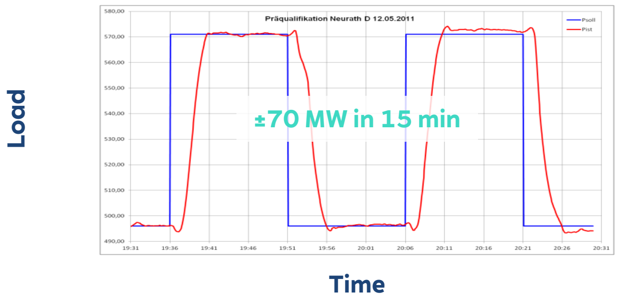
Minimum downtime	With **low** Life Time reduction	With **high** Life Time reduction
Hard coal/ lignite	<240 min	Min. 30 min

I&C optimisation makes modern power plants even faster

Ceal-fired power plants (e.g. 600 MW unit D, Neurath)

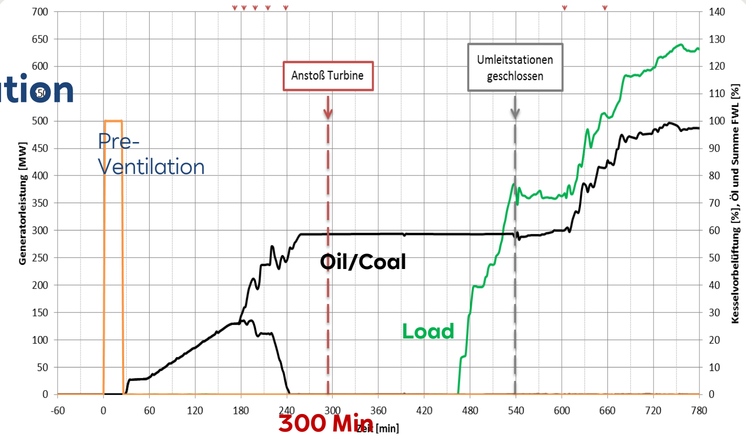
- Reduction in **minimum load** of 20%-points
- Increase in **load change rate** 5 MW/min → 15 MW/min
- **Secondary reserve** capability ±70 MW in 15 min
- Enhanced load band for **primary reserve** (min load +max PFR shift/max load –max PFR shift)



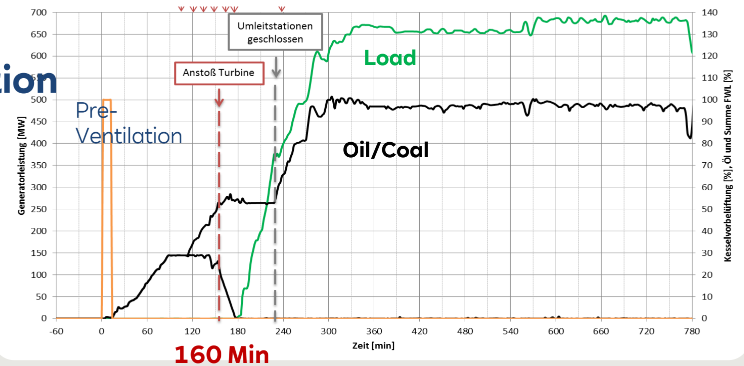


Start up optimisation at a 600 MW unit

Before optimisation



After optimisation



- Question limitations and boundary values
- Parallelise processes
- Minimise waiting times
- Assess of components were the maintenance is crucial and ensure good condition of these components
- Faster start-ups …
  - … without increased lifetime consumption
  - … without reduced plant safety

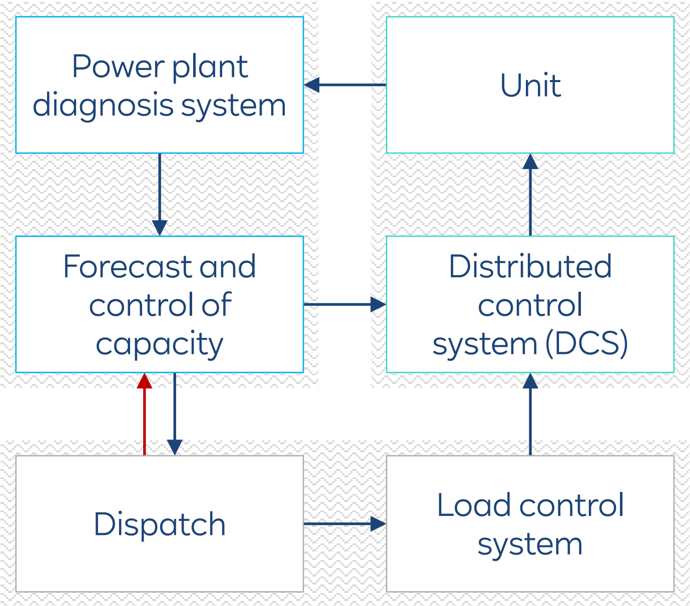
Key to success:
Combination of expertise in process technology and I&C optimisation.

Market-oriented control/ Forecasting of available performance

Closed loop process

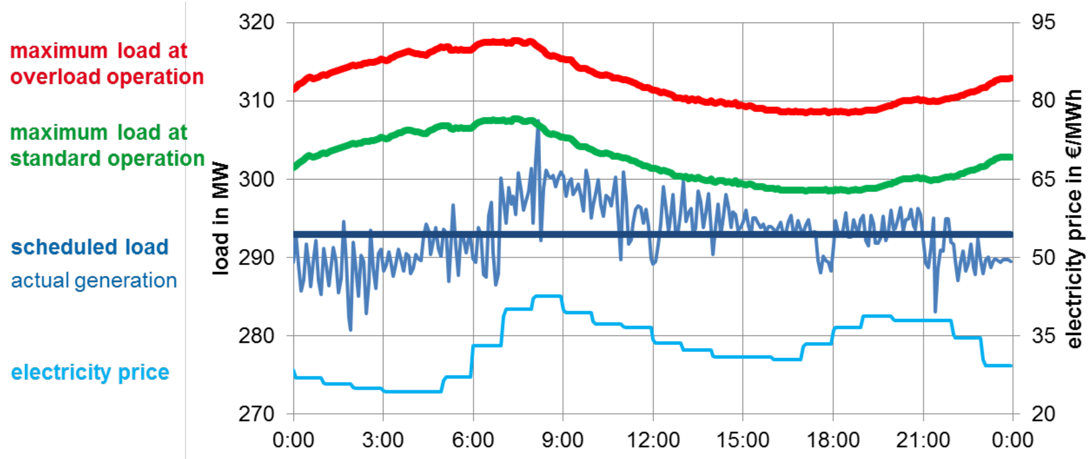
that combines RWE's expertise as operator and trader

- **Technically established forecast increases transparency and forecast accuracy (day ahead and intraday)**
- Market-oriented control of the load capacity
- More accurate following of schedule by units
- Substantial simplification of daily business (communication dispatch and power plant)



Application: Maximal load optimisation
Control and forecasting of available performance

Prognosis tool based on data from a process quality optimisation system



- Fully automated market-oriented provision of power (incl. options such as preheater operation, etc.)
- Consideration of the current condition of the unit and external influences

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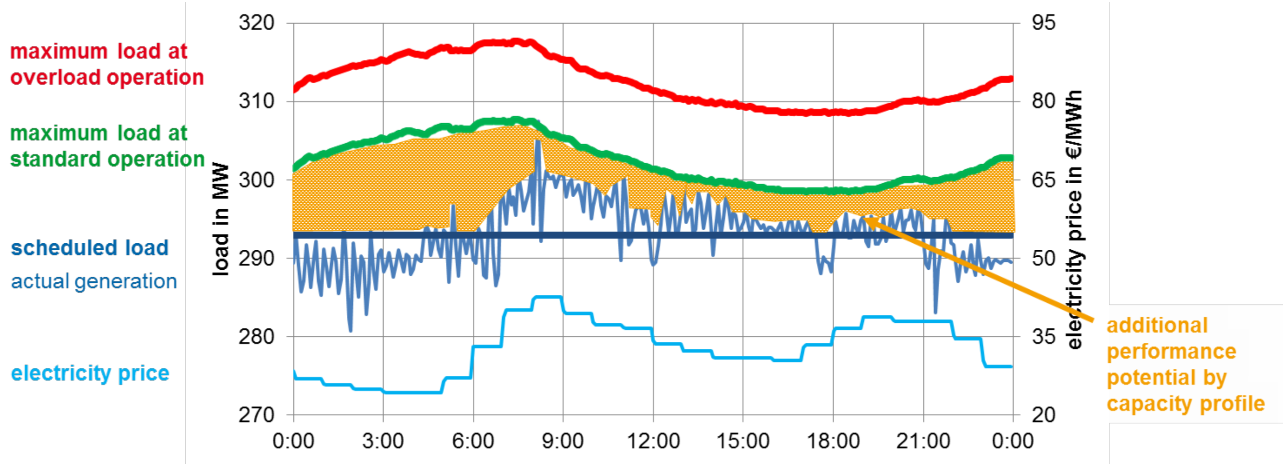

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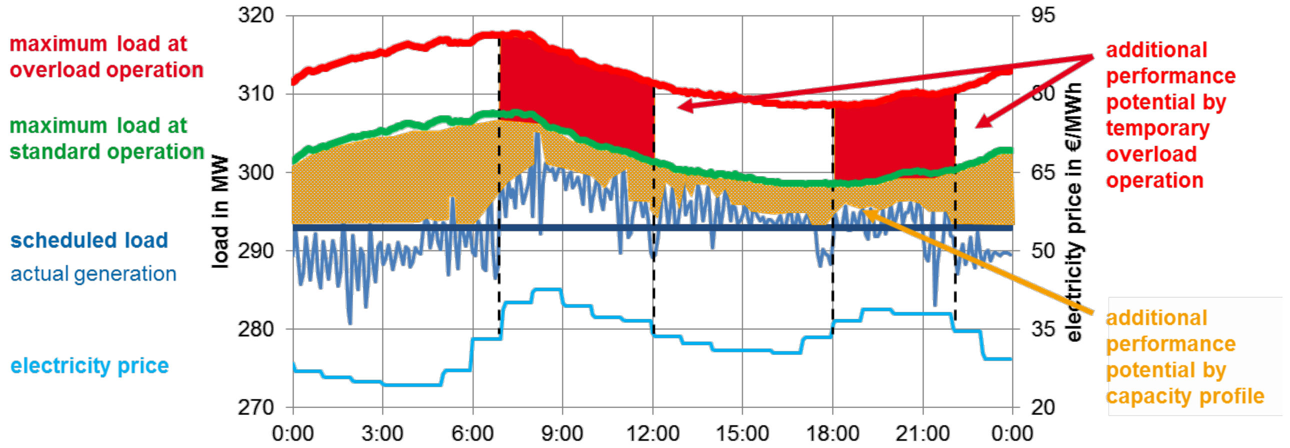

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Predicting dynamic minimal load

Example: Combined heat and power plant (CHP)

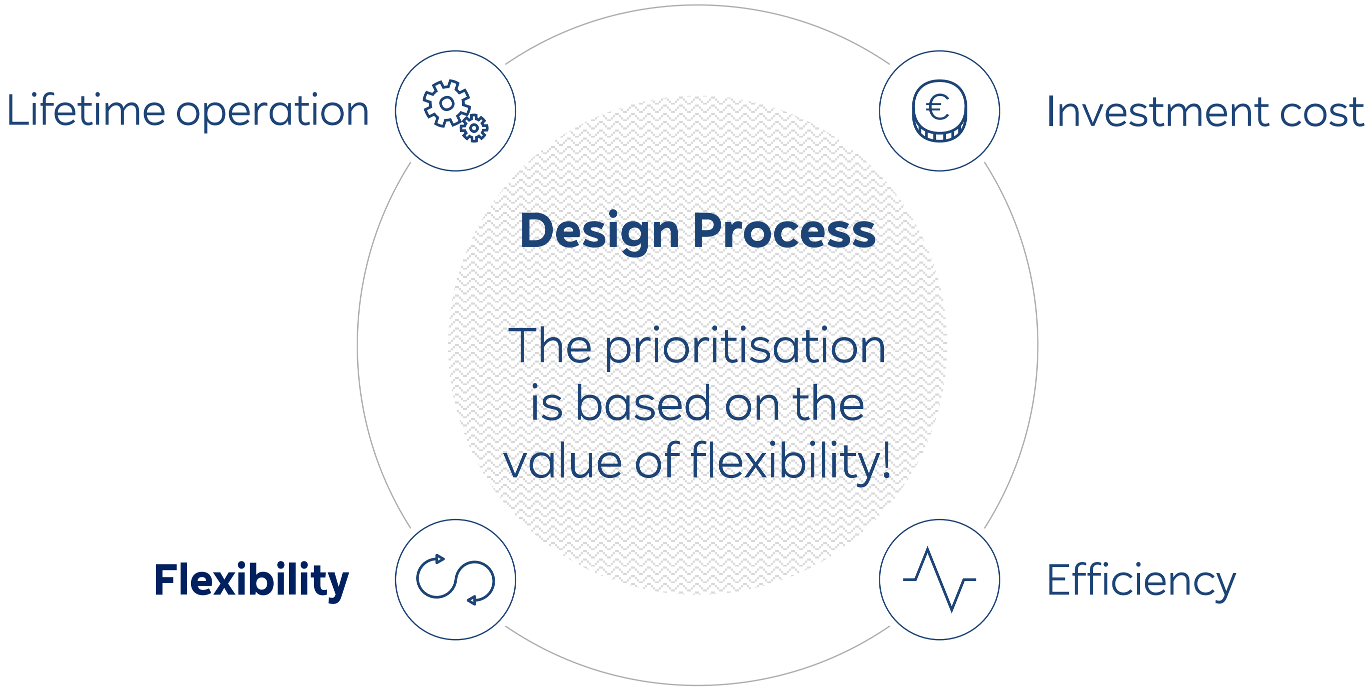
Big Data based prognosis tool

1. Forecast of heat demand of different consumers
2. Minimal load prognosis based on heat demand forecast
3. Processed information to be utilised by the dispatcher

Benefits

- **Minimise losses** due to must run conditions
- **Avoid plant shutdown** and start of backup heat supply unit by minimising **minimal load**

Future design and optimisation priorities



Thank you very much for your attention