Powering the business of our customers

Experience Matters

RWE’s experiences in flexible coal power plant operation

Flexible Operation of Thermal Power Plant: A Bridge to Decarbonized Energy System

Richard Sara – RWE Technology International GmbH

The RWE Group

RWE Group Structure

RWE AG

RWE Renewables Europe & Australia GmbH

RWE Renewables Europe & Australia, is one of the world's leading companies in the field of renewable energies and focuses on the development, construction and operation of wind power plants.

RWE Generation SE

With its power plants in Germany, the UK and the Netherlands, the approximately 3,000 employees of RWE Generation produce electricity primarily from gas, hydropower and biomass.

RWE Power AG

RWE Power AG with a workforce of 10,000 employees, is responsible within the Group for power production from lignite and nuclear energy.

RWE Supply & Trading GmbH

RWE Supply & Trading is the interface between RWE and the energy markets around the world.

RWE Offshore Wind GmbH

RWE Offshore Wind is a global energy company for sustainable electricity generation based on offshore wind power.

RWE Renewables Americas, LLC

RWE Clean Energy is responsible for the fast-growing renewable energy business in the USA. The focus is on the construction and operation of renewable energy plants.

RWE Technology International GmbH

RWE Technology International supports companies and organisations worldwide in their activities related to the energy transition. Across the entire value chain of a project, RWE Technology International delivers tailor-made and client-specific solutions for renewable energies, efficient mining, conventional generation and grid stabilisation.

Leading the way to a green energy world, we are driving forward the climate-neutral transformation of industry and society.

More than

50

bn euro gross will be invested in powerful and green generation capacity until 2030.

More than

50

Gigawatts of green net capacity by 2030.

Example of a solar power station:
Hickory Park solar power station is our largest solar storage project in the USA.

Example of a wind park:
Sofia off the coast of the UK: our largest offshore project worldwide, with a capacity of 1.4GW.

Content

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!

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
(Cancelled)

Design specifications of new power plants
Example: Power plant Westfalen

Operational characteristics (Hard Coal, 800 MW)

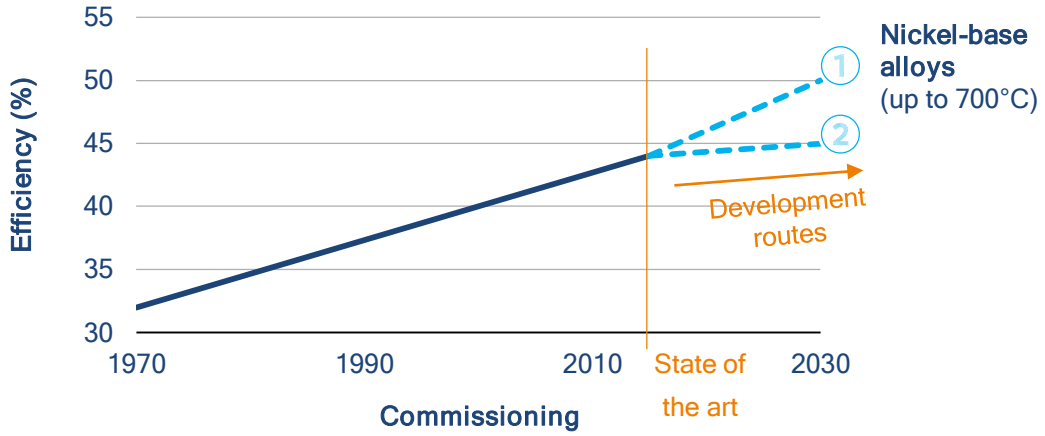
- Base and medium load
- Plant runs through in times of low demand
- Minimum load 25 – 30%, 7,500 operation hours per year

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



Nickel-base alloys
(up to 700°C)

1

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

2

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

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

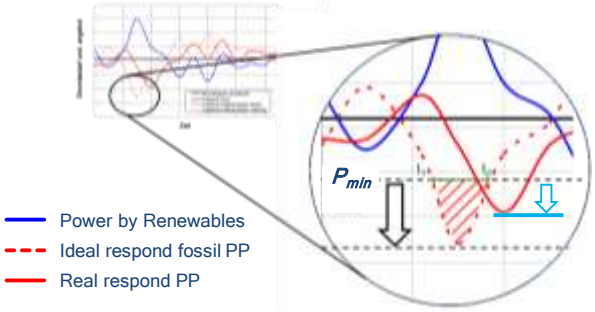
Short minimum downtime

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



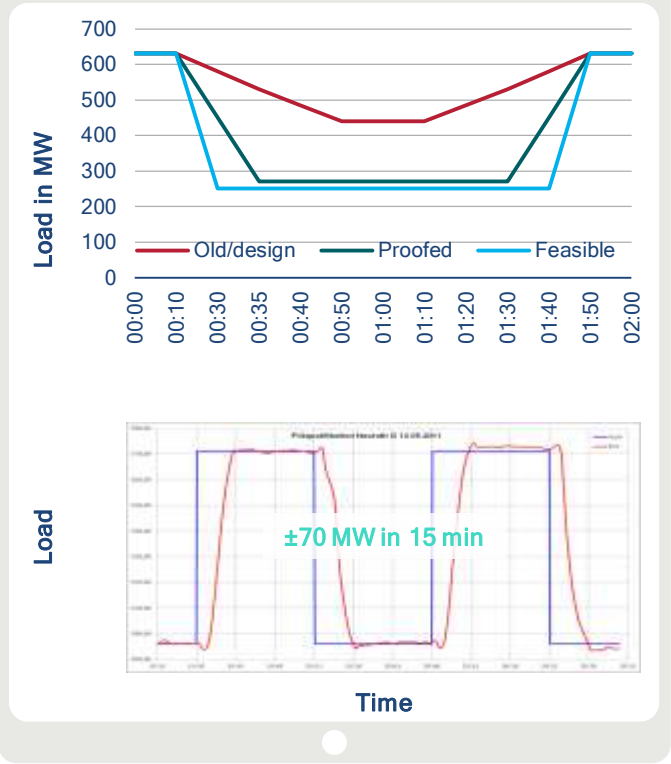
In todays market

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

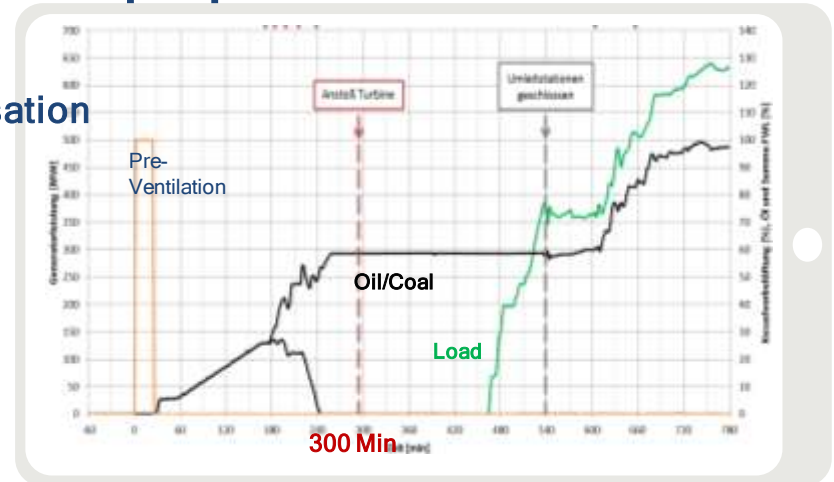
Ceal-fired power plants (e.g. 600 MW unit D, Neurath)

- 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

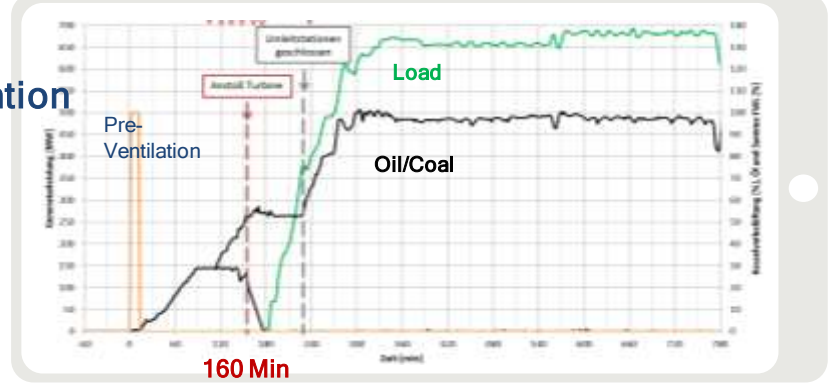


Start up optimisation at a 600 MW unit

Before optimisation



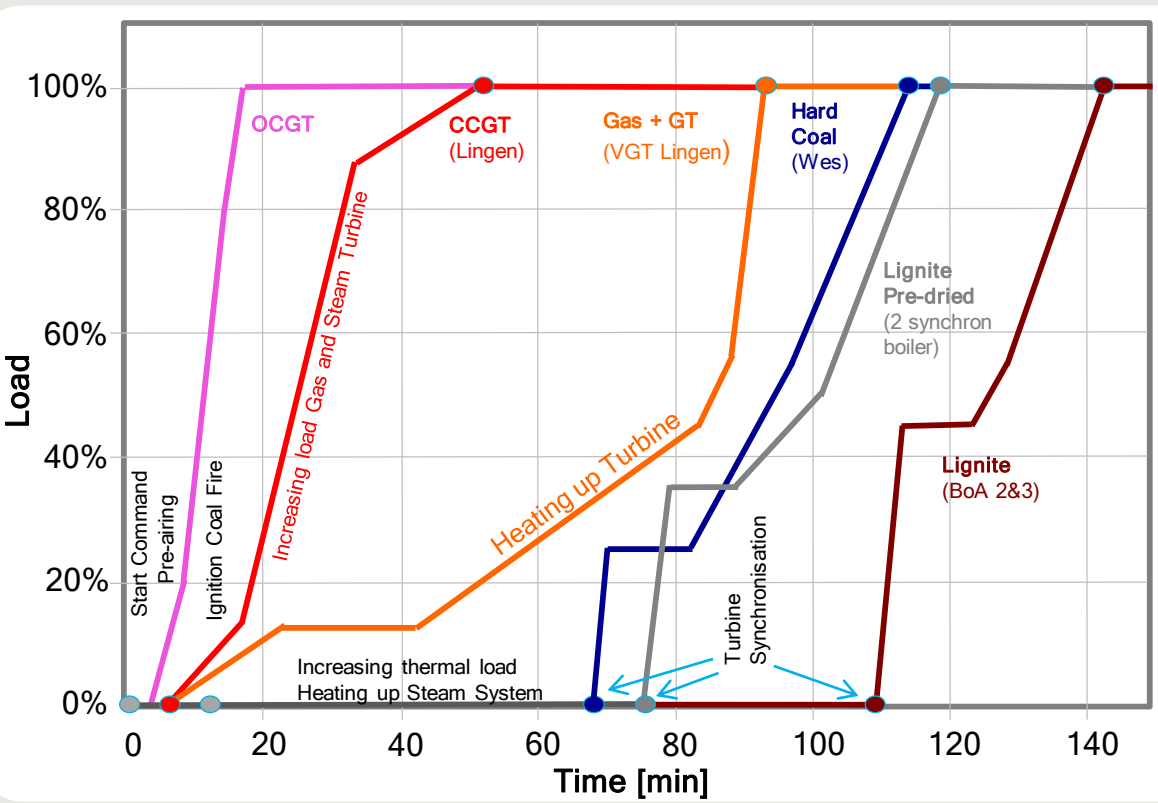
After optimisation



- 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.

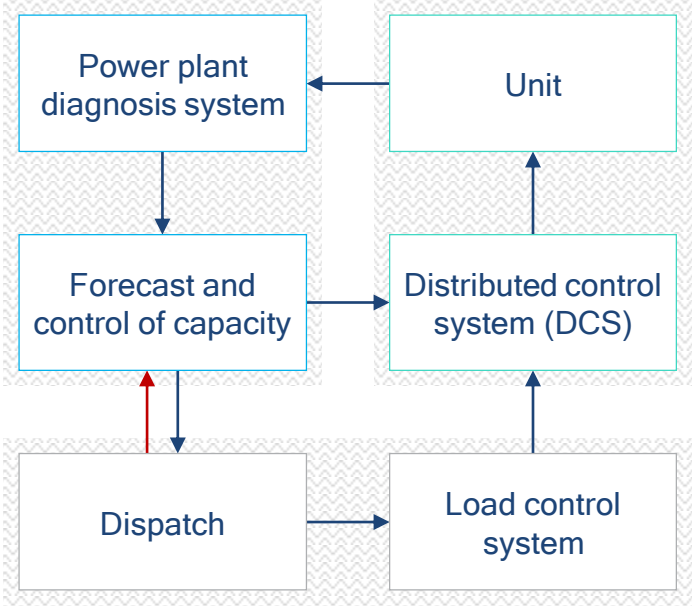
Cold Start - General Comparison of Load Change Rates



Market-oriented control/ Forecasting of available performance

Closed loop process
that combines RWE's expertise as operator and trader

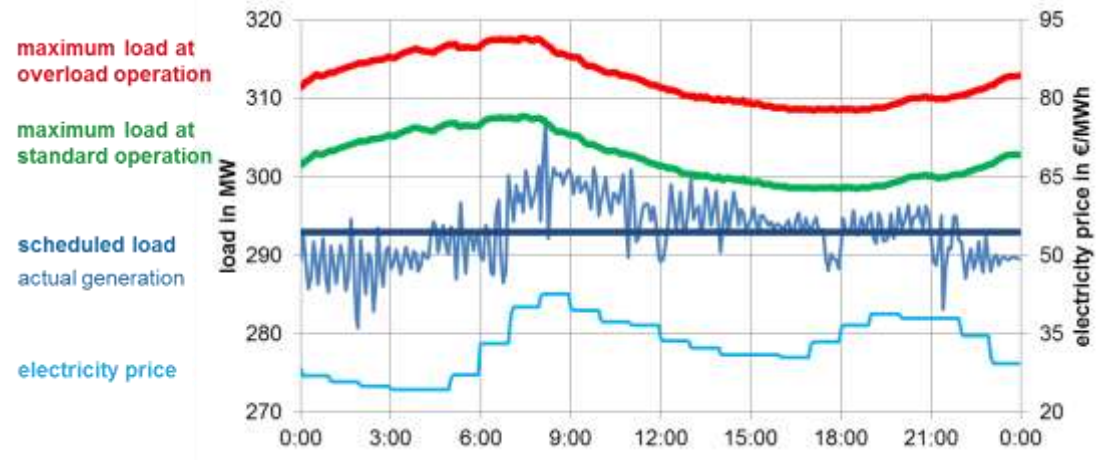
- **Technically established forecast increases transparency and forecast accuracy (day ahead and intraday)**
- Market-oriented control of the load capacity
- More accurate following of schedule by units
- Substantial simplification of daily business (communication dispatch and power plant)



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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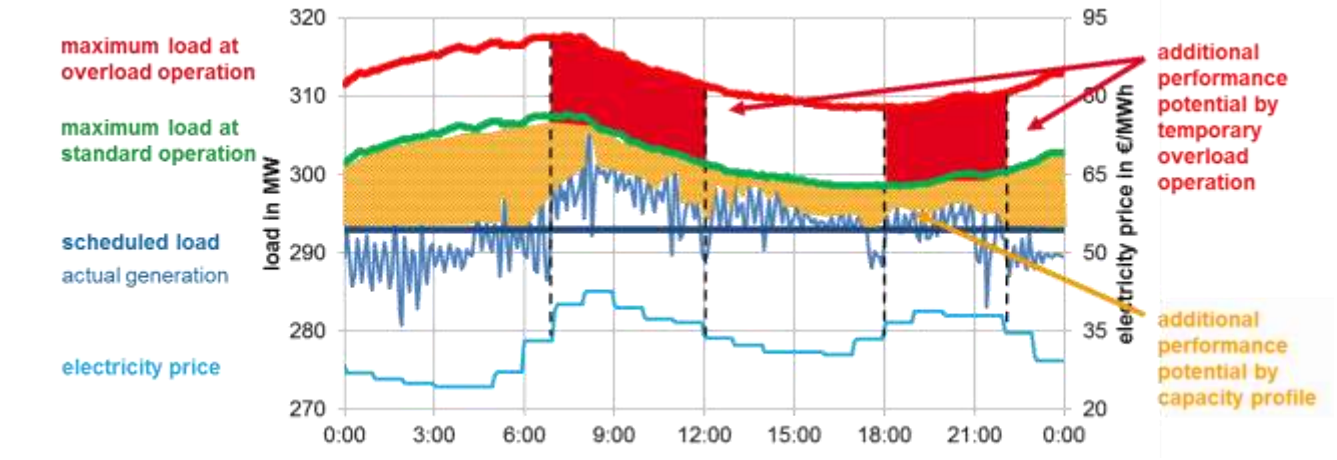

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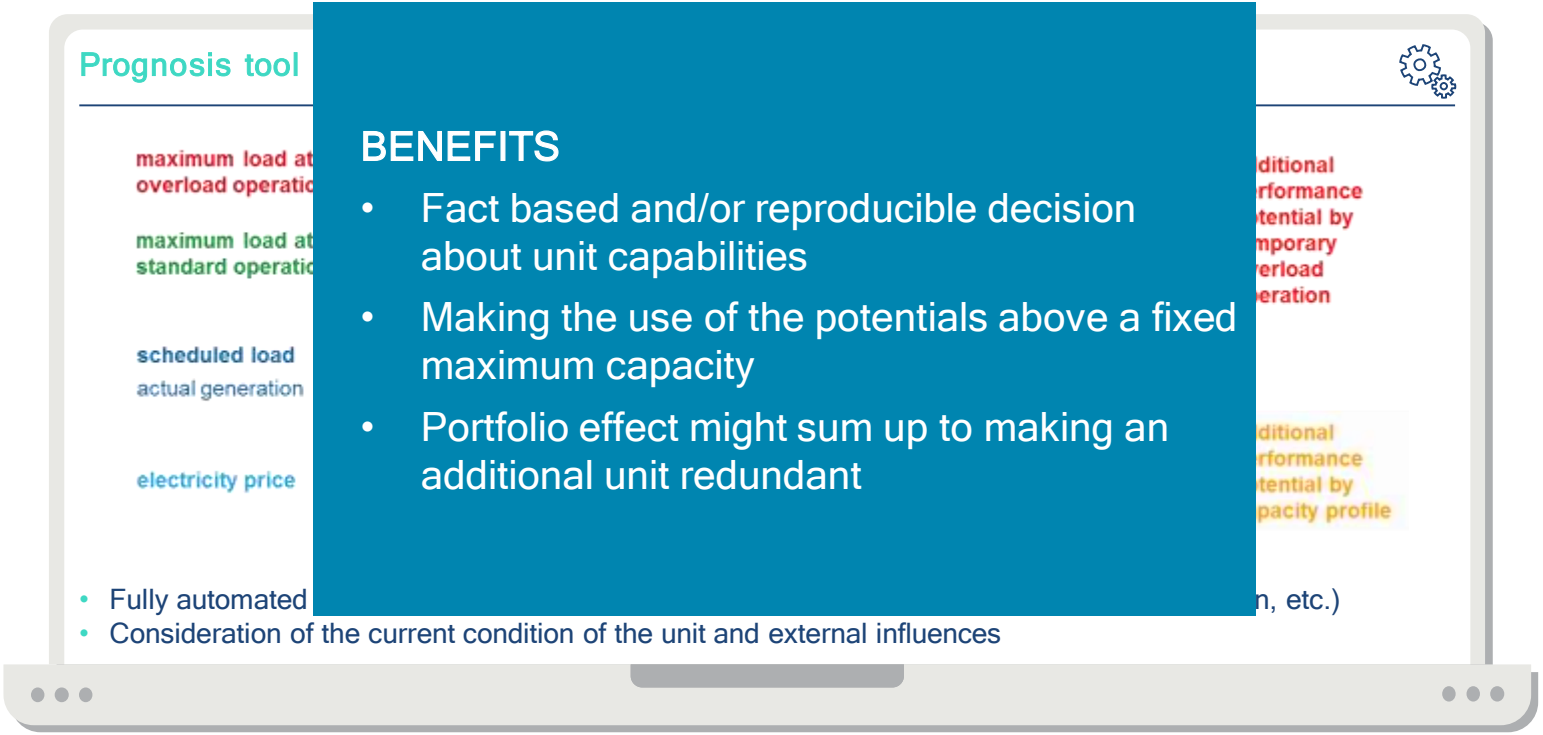
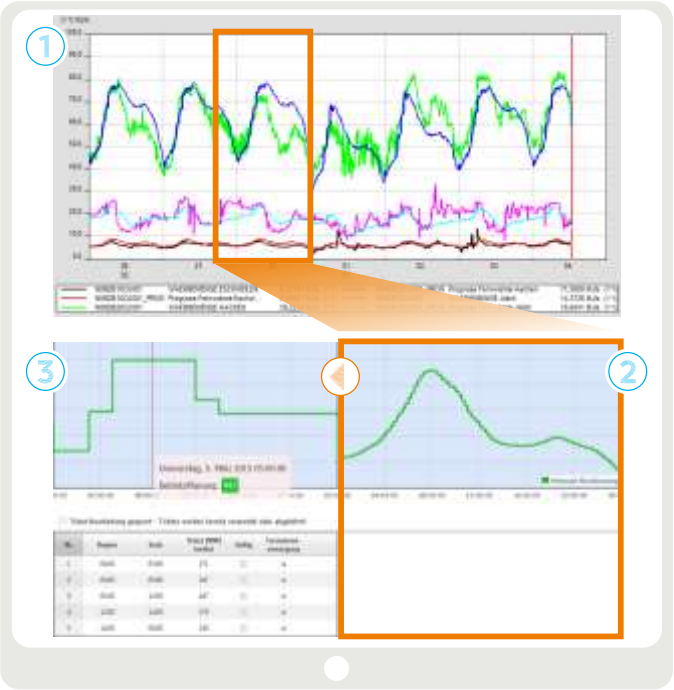


Predicting dynamic minimal load

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