Experiences with the improvement of minimum load in coal fired power stations

Manfred Schesack
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We are specialists in all matters relating to the generation and marketing of electricity and heat – open to any technology.

› 7 hard coal fired power plants and 1 refinery power plant in Germany

› 3 hard coal fired power plants in Colombia, Turkey and the Philippines

› 2 waste to energy facilities in Germany

› More than 200 distributed generating facilities on the basis of renewable sources and for energy supply to industry and heat supply

› Installed gross capacity of about 5,300 MW in Germany and 1,950 MW abroad

› 6,104 employees in Germany and abroad

› Total sales of EUR 3.9 billion and EBITDA of EUR 281 million in 2016

› Investment volume of about EUR 223 million in 2016
Our mission

Our contribution
We make our contribution to the successful transition to sustainable energy supply. With our strong and highly efficient power plant portfolio and our installed capacity of around 5,300 MW in Germany.

Energy mix
In our energy mix in Germany and abroad, we rely on fossil and renewable sources of energy and develop sustainable generation and supply concepts.

Innovative solutions
We understand the ongoing changes in the electricity and heat markets and develop innovative solutions to complement our range of products and services.
Worldwide in demand

Termopaipa IV Coal Power Plant
Colombia (165 MW_{el})

Crucea North Wind Farm
Romania (108 MW_{el})

Mindanao Coal Power Plant
Philippines (232 MW_{el})

Arenales Concentrated Solar Power Plant
Spain (50 MW_{el})

Vishakhapatnam Coal Power Plant
India (1,040 MW_{el}) 5% shareholding and O&M

Iskenderun Power Plant
Turkey (1,320 MW_{el})

STEAG headquarters
Own power plants / investment projects
Engineering / projects
STEAG headquarters
Representative offices / subsidiaries
Operation and maintenance contracts
Disposal and marketing of power plant by-products

2017-12-01
Improvement of flexibility in coal fired power stations
We focus on our strengths: planning, developing, building and operating power plants, and marketing the energy and by-products they produce.

- Hard coal fired power plants
- Power plants based on renewable sources of energy
- Refinery power plants
- Industrial power plants
- Natural gas fired power plants

- Electricity
- District heating
- Coal
- Gas
- Emissions certificates

- Project development
- Project implementation

- Hard coal
- Natural gas
- Mine gas
- Renewable resources
- Scrap wood

- Engineering services
- Energy contracting
- Recycling and marketing of power plant by-products
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STEAG’s fleet

Improvement of flexibility in coal fired power stations
Example: 150 MW unit (2-mills operation)
Example: 150 MW unit (1-mill operation)

CO emission was main limitation
Example: 750 MW unit (1-mill operation)

Variation of firing rate

No process modifications required
Improvement of flexibility in coal fired power stations
Limitations – Overview

Flue gas temperature

Economizer

Reheaters

Superheaters

Evaporator

Benson vessel

Catalyst

Further FG Cleaning

Emissions

Steam temperatures

HP

MP + NP

Extraction pressures (in particular CHP)

Turbine ventilation and erosion

Unit control

Frequency control

Boiler protection system (ESS)

Flame stability

Once-through operation / circulation mode

HP-Preheaters

Feed water pump

Feed water tank

LP-Preheaters

Condenser
Limitations – Overview

Flue gas temperature

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Unit control

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Steam temperatures

HP

MP + NP

G

Condenser

Extraction pressures (in particular CHP)

Mills

Flame stability

Once-through operation / circulation mode

HP-Preheaters

Feed water pump

Feed water tank

LP-Preheaters

Honeymaker
Limitations – Flame stability and flame detection

Good prerequisites but inappropriate (zonal) flame detection
Limitations – Flame stability and flame detection

1-mill operation improves flame stability / detection

Limitations – Steam temperatures

Frequent problem: Inappropriate spray water control
Limitations – Steam temperatures

Intentional reduction of temperature set-points

- Main steam temperatures cannot be kept
- $T_{MS}$ depends on mill activated (upper levels preferred)
- Inadmissible thermal stress to be avoided

![Graph showing temperature set points](attachment:image.png)
Efficient way: Recirculation pump
Further common limitations

- Emissions
- Flue gas system (DeNOx, DeSOx, ESP)
- Dew points
- Controls optimized for nominal load
- Safety system does not allow 1-mill operation
- Inadmissible throttling of turbine valves (IP)
- Turbine
- Stockyard
- Frequency control
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• Internationally frequency control is a basic requirement for coal-fired power plants (up to 5%)
• To be provided over the entire load range (also at minimum load)
• Frequency control solely by means of throttling of turbine control valves
• Turbine control valves already severely throttled at current minimum load

Measures: Sliding pressure operation / inherent storage capabilities
Inherent storages

\[ \Delta P : \text{transient load change potential} \]
\[ T_{\text{delay}} : \text{delay time} \]
\[ T_{\text{capacity}} : \text{storage capacity (time)} \]

- HP Preheaters: \( \Delta P = 5\% \)
  \( T_{\text{delay}} < 10\text{s} \)
  \( T_{\text{capacity}} = 5\text{ min} \)

- Feedwater tank: \( \Delta P = 5\% \)
  \( T_{\text{delay}} < 30\text{s} \)
  \( T_{\text{capacity}} = 5\text{ min} \)

- LP Preheaters: \( \Delta P = 2.5\% \)
  \( T_{\text{delay}} > 30\text{s} \)
  \( T_{\text{capacity}} = 5\text{ min} \)

- Condenser
- Condensate pump

Depends on mill type

- \( G \): Condensate tank
- \( MP + LP \): Feedwater pump
- \( HP \): Reheater
- \( MP \): Super-heaters
- \( LP \): Economizer
- \( MP \): Evaporator

\( s \): high capacity delay
\( s \): \( \leq \)
\( T \): potential change
\( \Delta T \): load transient

2017-12-01
Improvement of flexibility in coal fired power stations
Musterprotokoll zum Nachweis der Erbringung von positiver Primärregelleistung

Frequenz

Erbringung = 15 Min.
Pause = 15 Min.
Erbringung = 15 Min.

Leistung

Aktivierung ≤30 Sekunden
Deaktivierung ≤30 Sekunden
Aktivierung ≤30 Sekunden
Deaktivierung ≤30 Sekunden

0 5 10 15 20 25 30 35 40 45 50 55 60
0 5 10 15 20 25 30 35 40 45 50 55 60

-100 %
-50 %
0 %
50 %
100 %

Frequenz Leistung
Example: 780 MW unit
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Roadmap to a proper 1-mill operation

- Analysis of status quo and definition of suitable measures
- Discussion with OEMs (boiler, turbine) to evaluate potential limitations
- Identification of relevant interlocks in the DCS (in particular safety system)
- Discussion with related authorities
- Test runs to confirm and identify limitations
- Implementation of measures to overcome limitations
Thank you very much for your attention!

For further information please visit us at www.steag.com