Challenges and Learning from Flexibility Test Runs at Dadri, Maithon and Andal Power Plant

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Siemens Energy road map to reduce min load up to 40%

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Document Request, Technical Questionnaire

Information about design configuration, thermal/mechanical performance, degradation level, operation restrictions and experiences, maintenance monitoring

Evaluation of technical opportunity

Received data will be analyzed from Siemens-Energy.

Preparation and Alignment on flexibilization operation tests

Siemens Energy suggests a test procedure to increase of plant flexibilization (e.g. min load, ramp test).

Execution of test. Plant survey or detail assessment

Siemens Energy experts and the operators from the power plant execute the test according the agreed test procedure until first obstacle occurs. Execution of Plant survey or detail assessment

Evaluation of test results. Creation and implementation of opportunities and improvements

Siemens Energy investigates and implements the identified measures to improve the operation and maintenance status of plant, increase of efficiency and availability/reliability, decrease of lifetime consumption

Siemens Energy Engineering approach for the Boiler flexibilization test

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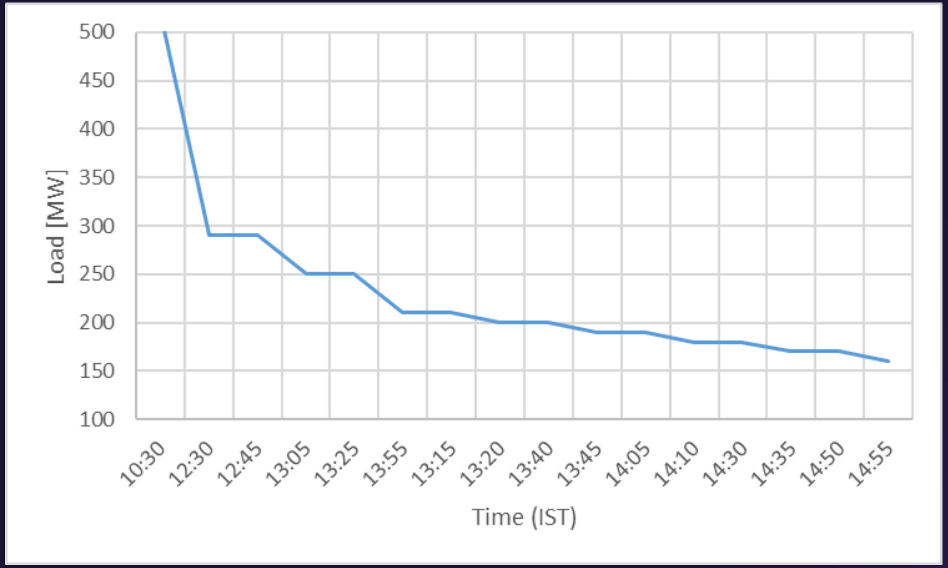
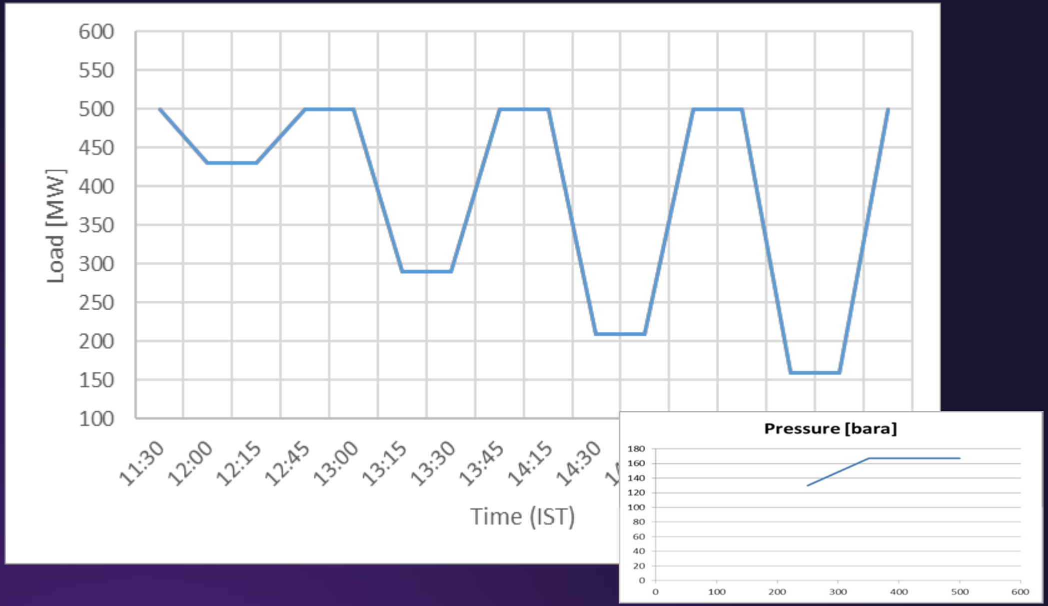


Test for Boiler part load reduction



Test for Boiler ramp-up/down

Case 1: Min load test in Dadri CFPP

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Capacity:	490 MW
Boiler / Steam Turbine:	BHEL / BHEL- Siemens design
Type:	Drum Boiler
Coal:	Domestic hard coal 3900 kcal/kg
Number of mills:	8
Actually min load:	50%
Achieved min load:	40%
Achieved ramp rate:	2-3%/min

June 2019: First min Load test to achieve 40% min load

- Load reduction from 490MW to min 195MW:
- 195 MW corresponding to 40% load was the lowest stable minimum load achieved

Recommended measures to automize 40% min load:

- Upgrade of Unit Control (drum level, steam temp., keeping of FG temperature -SCAPH etc.)
- Implementation of automatic sequences (mils, fans, BFP bypass)
- Optimization of fuel distribution, windbox pressure, tilt
- Fatigue Monitoring record (via FMS) to determine residual lifetime
- Thermal and combustion optimization based on Burner tuning
- Thermal/Mechanical optimization based on Boiler thermal modelling

Case 2: Min load test in Maithon CFPP

Capacity:	525 MW
Boiler / Steam Turbine:	BHEL / BHEL- Siemens design
Type:	Drum Boiler
Coal:	Domestic hard coal 4200 kcal/kg
Number of mills:	8
Actually min load:	55%
Achieved min load:	36%
Achieved ramp rate:	5 MW/min / 8 MW/min

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June 2019: First min Load test to achieve 36% min load

- Load reduction from 520MW to min 190MW:
- 190 MW corresponding to 36% load was the lowest stable minimum load achieved

Recommended measures to automize 36% min load:

- Upgrade of Unit Control (drum level, steam temp., keeping of FG temperature -SCAPH etc.)
- Implementation of automatic sequences (mils, fans, BFP bypass)
- Optimization of fuel distribution, windbox pressure, tilt
- Fatigue Monitoring record (via FMS) to determine residual lifetime
- Thermal and combustion optimization based on Burner tuning
- Thermal/Mechanical optimization based on Boiler thermal modelling

Case 3: Min load test in Andal Unit 2

Capacity:	500 MW
Boiler / Steam Turbine:	BHEL / BHEL- Siemens design
Type:	Drum Boiler
Coal:	Domestic hard coal 4000 kcal/kg
Number of mills:	8
Actually min load:	55%
Achieved min load:	30%
Achieved ramp rate:	12 MW/min / 16 MW/min

March 2022: First min Load test to achieve 30% min load

- Load reduction from 520MW to min 152MW:
- 152 MW corresponding to 30% load was the lowest stable minimum load achieved
- Target: 152-155 MW achieved and kept for >2.0 hours

Recommended measures to automize 30% min load:

- Upgrade of Unit Control (drum level, steam temp., keeping of FG temperature etc.)
- Implementation of automatic sequences (mils, fans, BFP)
- Optimization of feeders, fuel distribution, windbox pressure, tilt
- Fatigue Monitoring record (via FMS) to determine residual lifetime
- Thermal and combustion optimization based on Burner tuning
- Thermal/Mechanical optimization based on Boiler thermal modelling

Siemens Energy proposal for the next steps for technical release of min load upgrade below 40%

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<u>Next Steps:</u>

1. **Thermal Feasibility Study** (thermal boiler model is constructed by using computer software DEFOS, which permits a detailed representation of the thermodynamic and heat transfer processes) with design check of Boiler components.

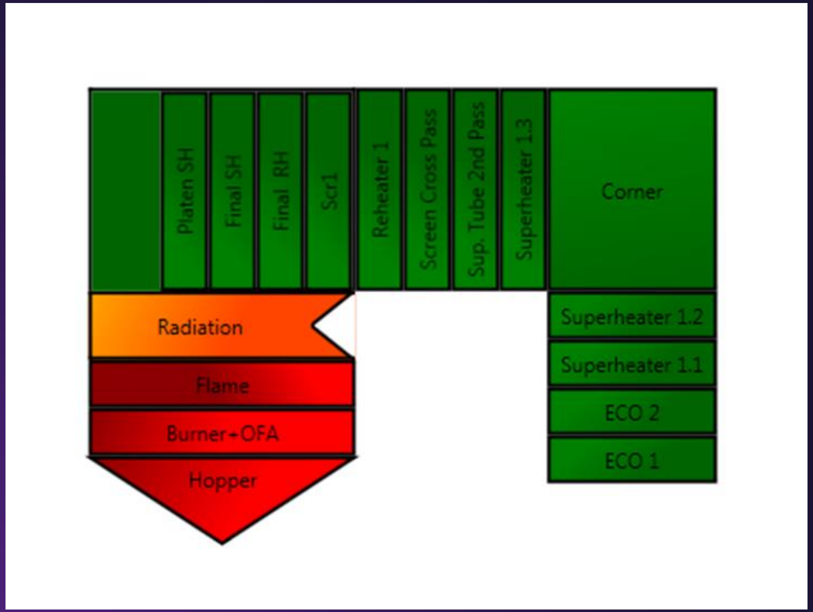
2. **Combustion and Burner feasibility study. Mechanical components feasibility study**

3. **Boiler/BOP Fatigue Assessment** (FEM calculation)

4. **Optimization of Existing Controls**

5. **Condition Monitoring incl. Boiler Fatigue Monitoring System** (Condition monitoring systems should monitor highly loaded boiler and piping components against creep and fatigue, corrosion/erosion processes, fouling/slagging, thermal performance degradation)

Boiler thermal model of flue gas segment:



Example of recommended upgrades

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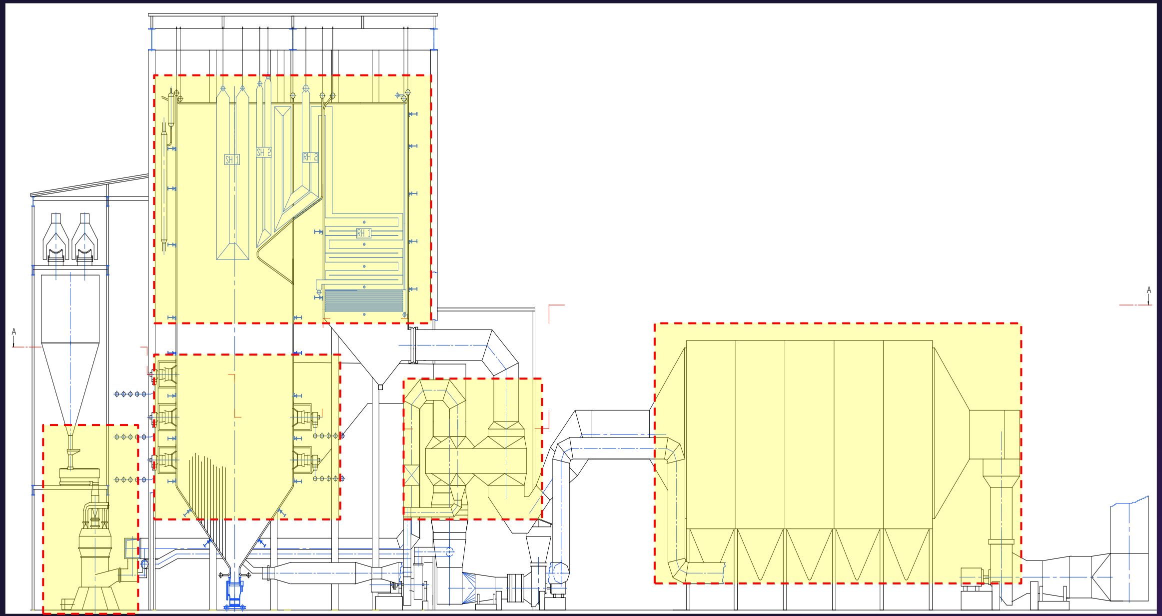
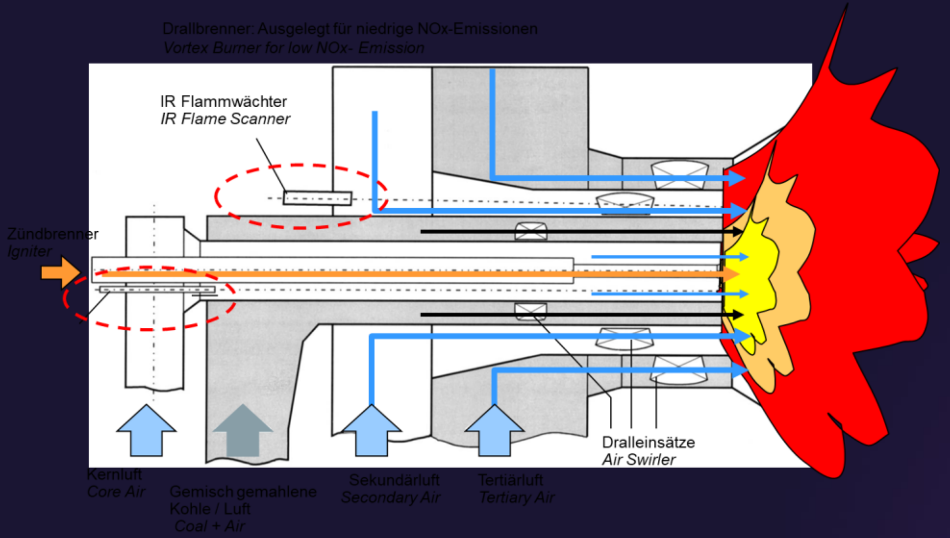
Measures	Effect
Design optimization of heating surfaces in heat flux critical zone Rifled tubes	Reduction of thermal stress / better tubing cooling • Increase of allowable heat flux • Adjustment of boiling crisis point to moderate heat flux zone (outside burner belt)
Retrofit / Re-design of attemperators	Improvement- / Increase of spray water mass flow Better water mixing (evaporation distance)
Improvements of control for: TDBFP, burner tilts, OFA, furnace and air parts, fans, mils	Establishment of smooth and uniform combustion behavior. Improve of controllability for W/S part of boiler and BOP in part load Improvement of part load stability and efficiency
Optimization of feeders, fuel distribution, windbox pressure (installation/retrofit of flaps), tilt	
Combustion optimization (burner belt, OFA, SA)	
Decrease of fouling. Slagging potential monitoring	Improvement of thermodynamic, decrease of thermal stress. Retrofit of soot blowers (automatic approach)
Increase of RH outlet temperature for Part Load	Implementation of RH slide pressure curve, Activation of upper burner level, Activation of positive tilting of burner

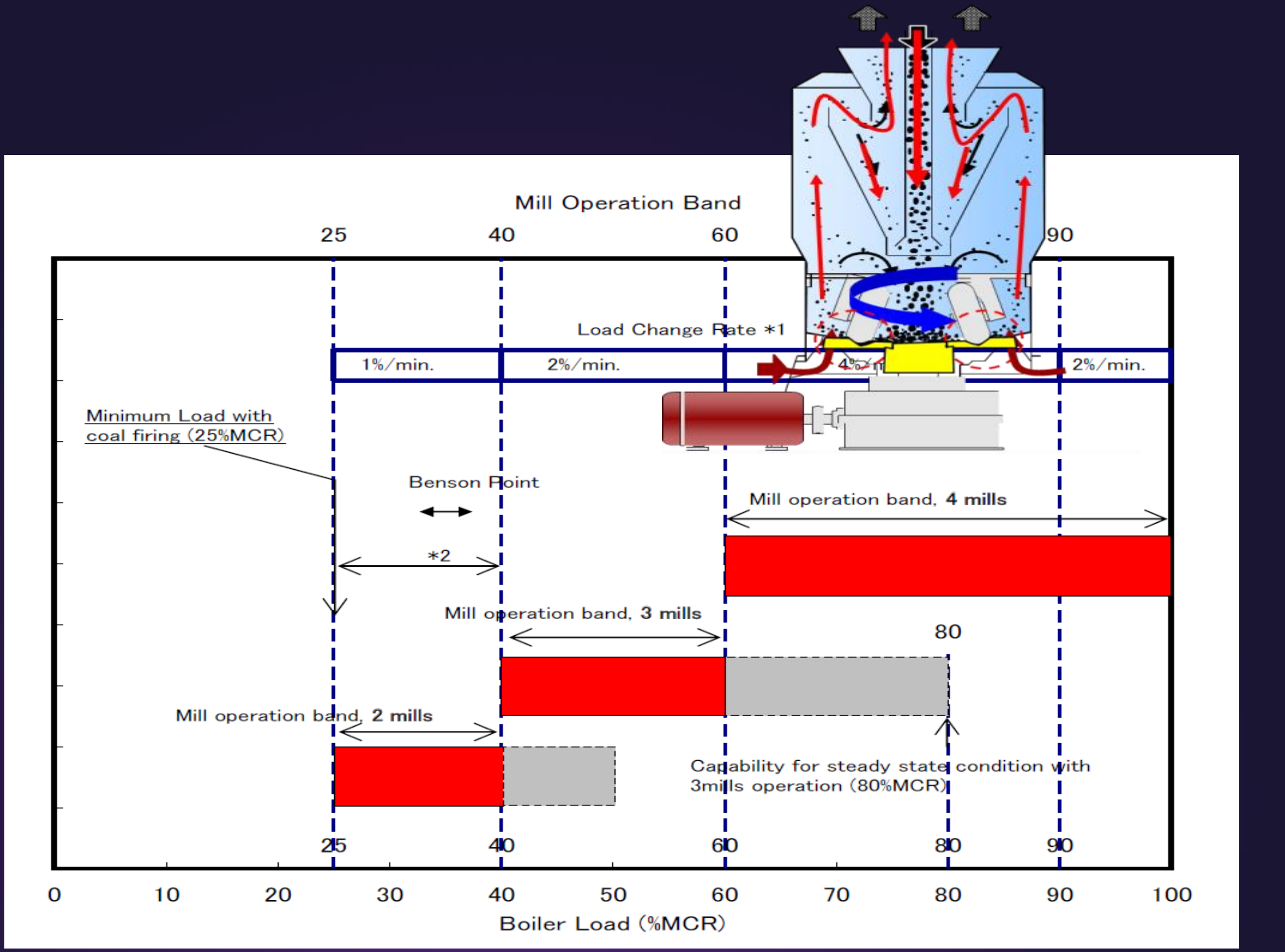
Part Load Challenges to reduce min load below 40%:



1. **Fuel Composition** (knowledge of the fuel composition and of the fuel properties incl. ash is very important for the steam generator design)
2. **Fuel supply system** (Mill operation diagram, Mill operation concept, Pressure drop of support lines, Air bypass flap, Control system, Mill classifier behavior, Mechanical restrictions of mill etc.)
3. **Combustion** (Fuel composition stability, Temperature/O_2/Concentration turbulences, Symmetry of flame, Aerodynamics, Combustion efficiency, Emissivity, Windbox pressure controllability, Support fuel)
4. **Evaporator Stability** (Activated Burner Level) / ECO Stability for possible ECO outlet steaming
5. **Boiler Thermal Design** (HP/RH Material Temperature (Platen, LSH, Control system, Flue gas damper, Activated Burner Level, Attemperator)
6. **APH** (Flue gas outlet aerodynamic, Water/Sulphur dew point), Flue gas pollution (ESP, fabric filter efficiency)
7. **Boiler degradation level** (actual state)

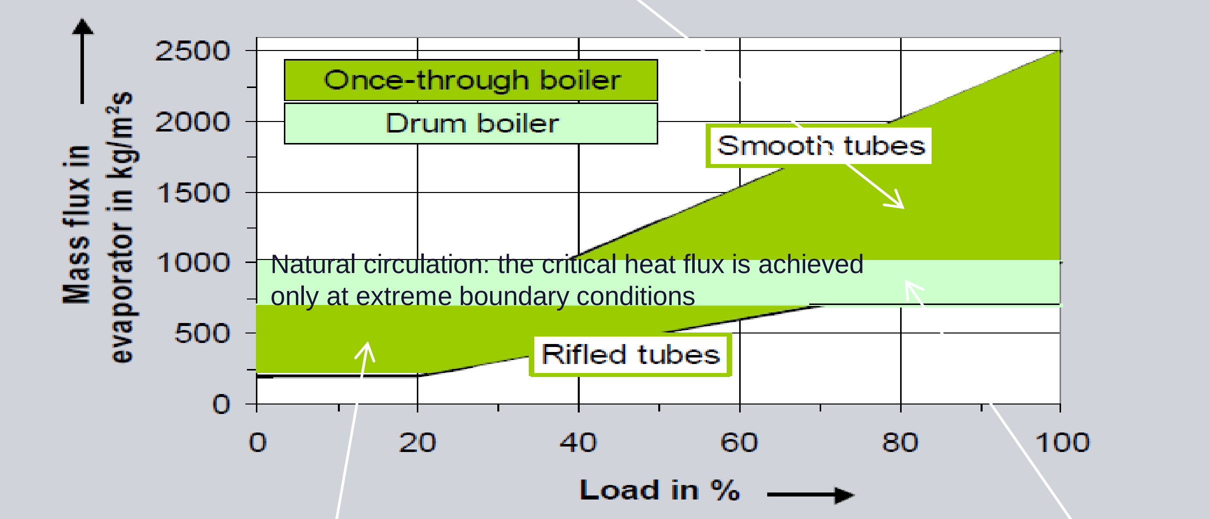
Example of Part Load Challenges (mill operation diagram: 4 mills, 500 MW)

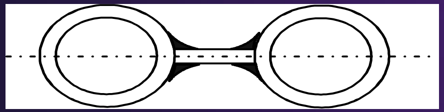


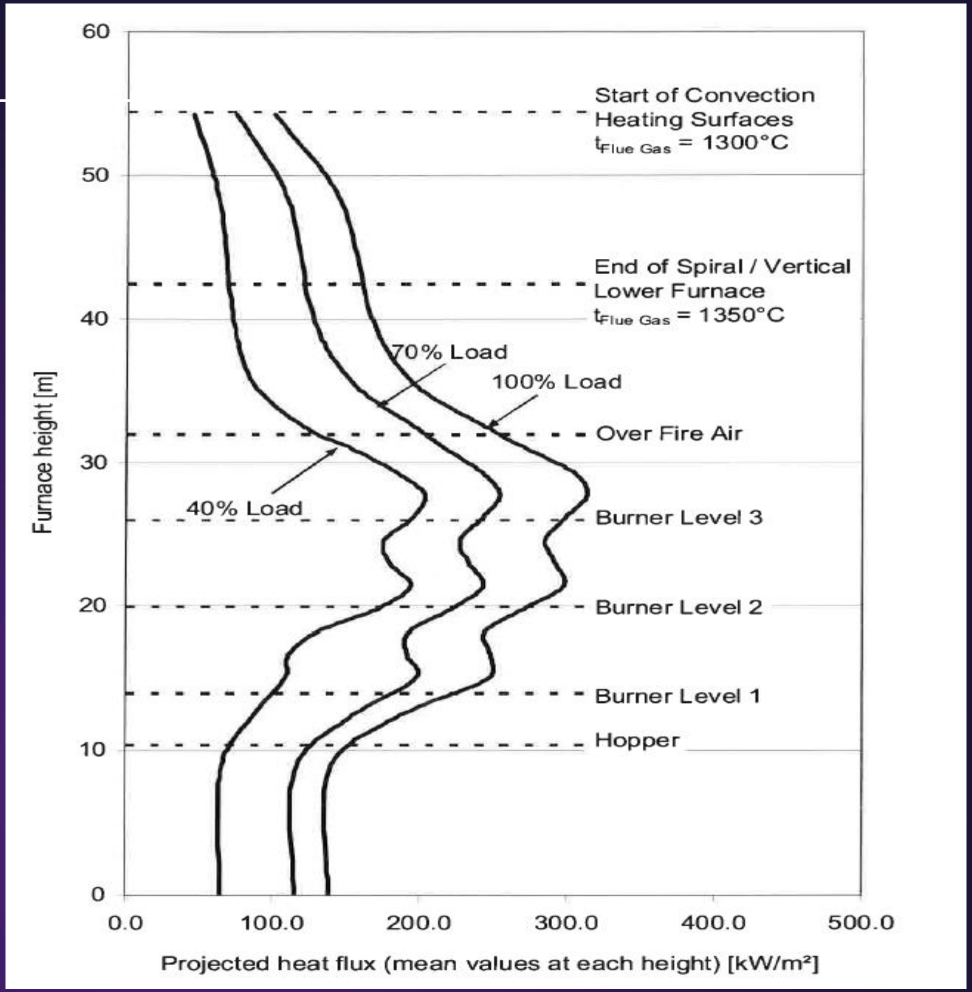


Example of Part Load Challenges (heat flux, flow density)

Heat flux profile for:
- Base Load
- 70 % Load
- 40 % Load







Example of Part Load Challenges (SH/RH material temperature, HRH steam temperature)

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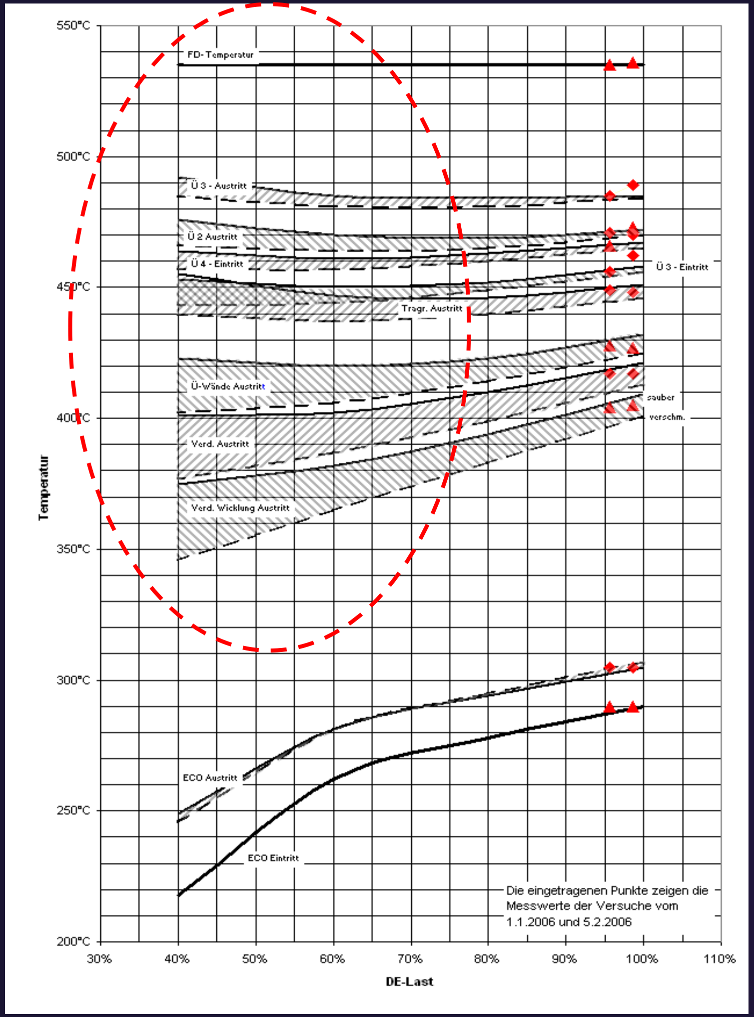
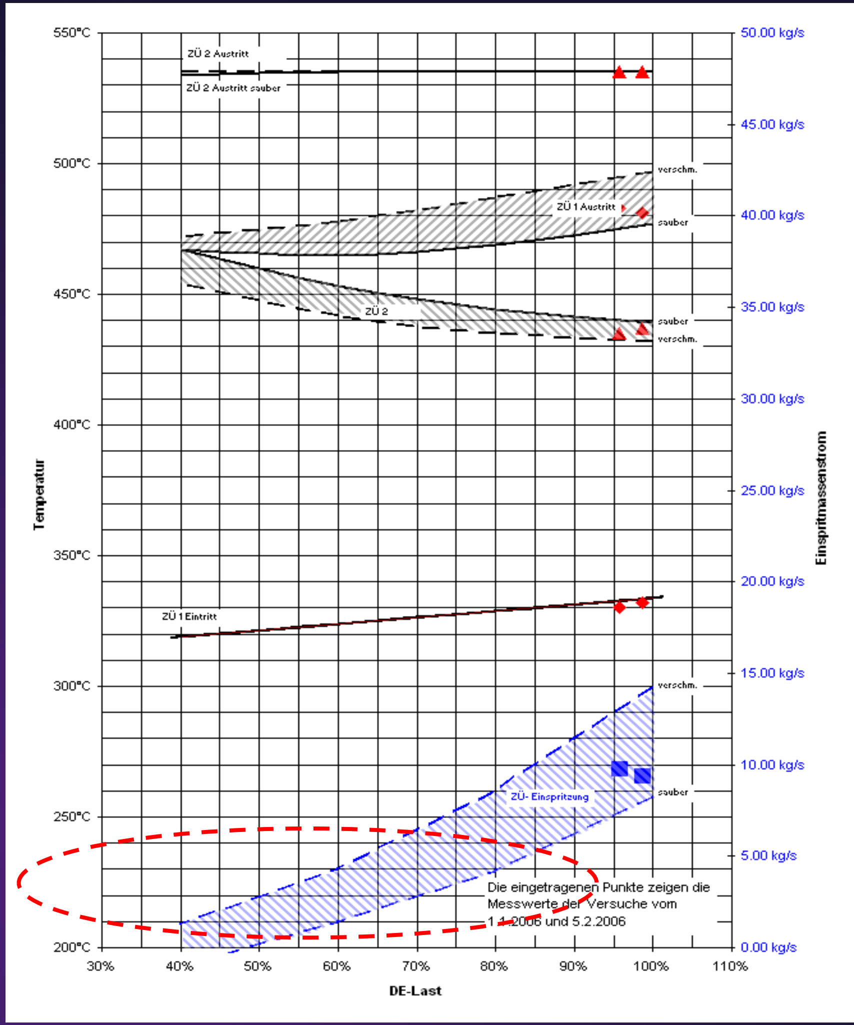


Decrease of boiler loads leads to decrease of HRH steam temperature:

Fix pressure: 2,0-2,5 K/% load
Sliding pressure: 1 K/%load

High impact of fouling and slagging tendency

Base load:
Increase of fouling tendency will lead the increase of RH attemperation



Siemens Energy References

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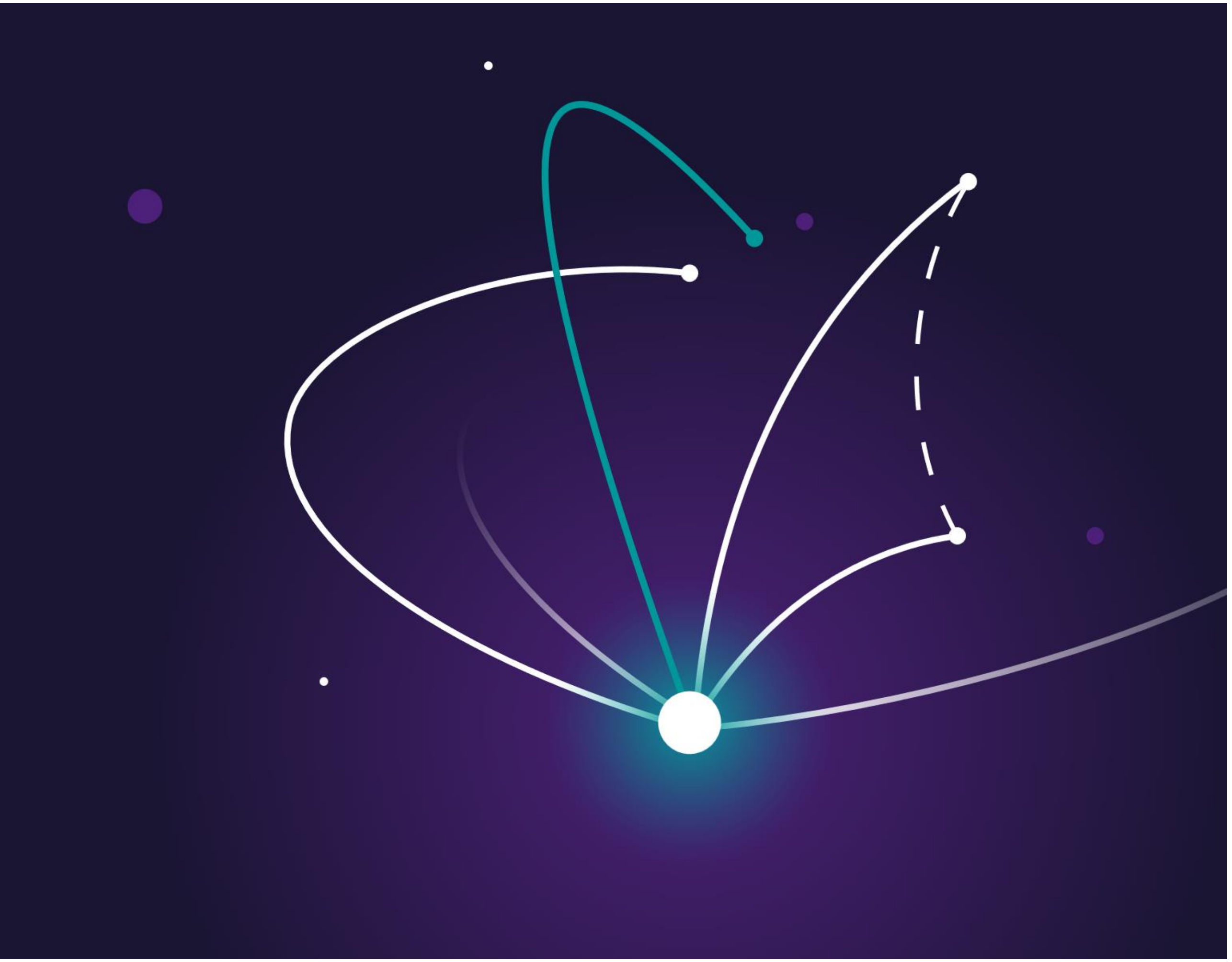
Voerde CFPP	Atlas CFPP	Neurath CFPP	Dadri CFPP
			
• Germany • 700 MW • Benson Boiler • Hard Coal • Opposed wall firing	• Turkey • 2 x 600 MW • Supercritical • Hard Coal • T-fired boiler	• Germany • 2 x 630 MW • Benson Boiler • Lignite • T-fired boiler	• Dadri • 500 MW • Drum Boiler • Hard Coal • T-fired boiler
20% min load achieved	min load reduced by 30%	40% min load achieved	40% min load achieved

Thanks for your attention!



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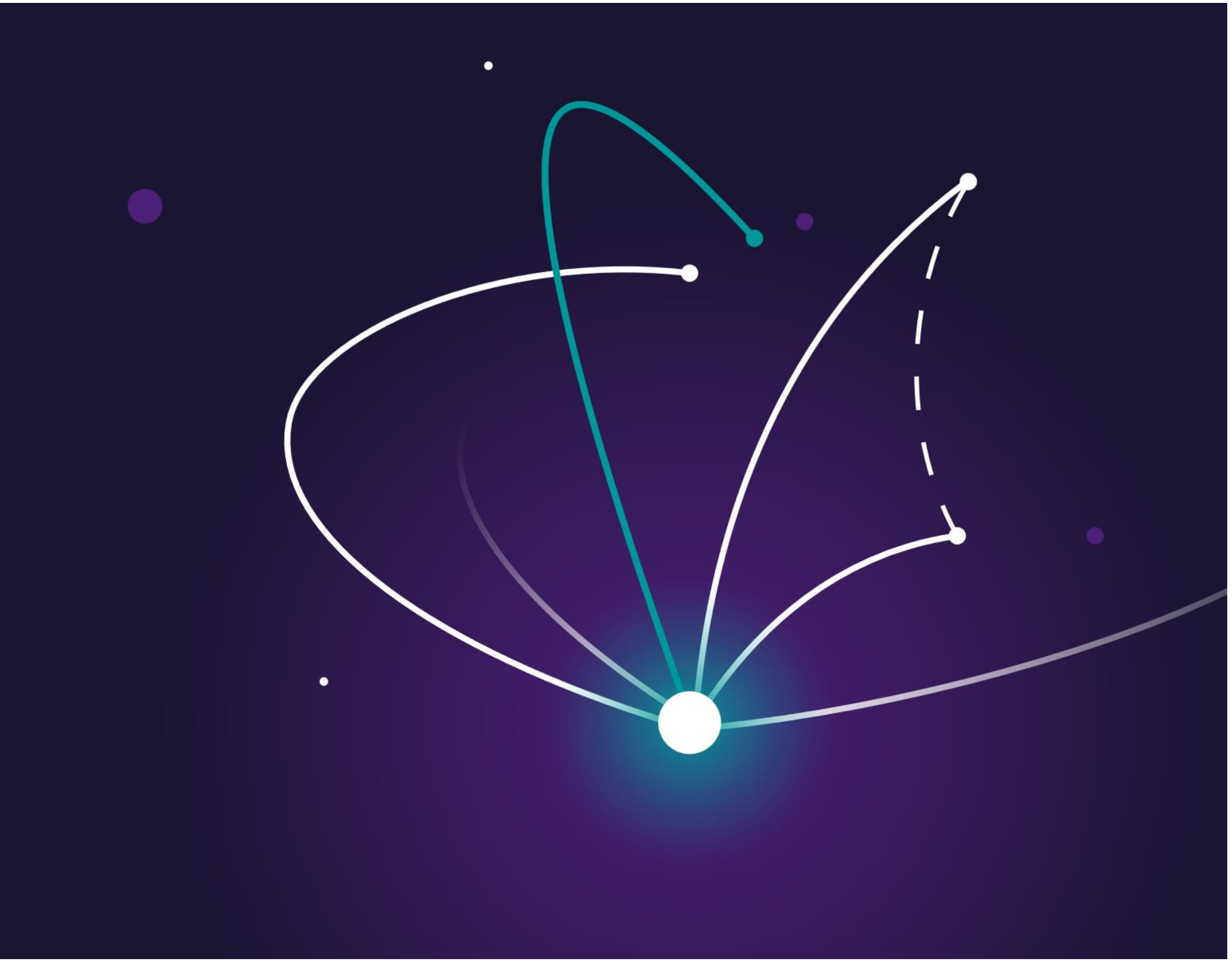
Back-up



Siemens Energy Experience in the Field of Flexibilization Journey of Coal Fired Power Plants in India

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Operation in Full load

- Min / Base / Peak Load Power Plants
- High Efficiency and availability

Flexible Operation

- Min Load Reduction up to 40%
- Automatic start & stop of mills & fans
- Condition Monitoring

Increase Flexibility

- Min Load Reduction below 37%
- Thermo-Mechanical Assessment

Conversion of CFPP

- Synchronous Condenser (reactive Power) / C2G

Strategical CFPP

- Standby Power Plant to secure energy supply