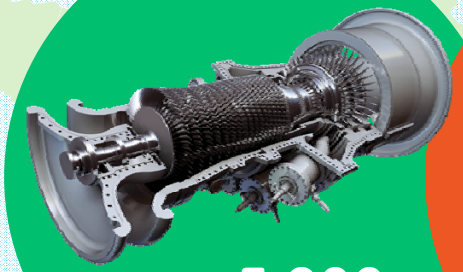
Flexible, reliable and efficient power plant technology – GE's Europe Experience

December 16, 2016

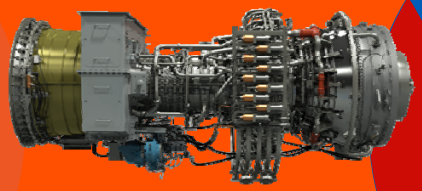
Bill Miller, Henrik Nielsen and Chinmoy Mohanty

Power Service

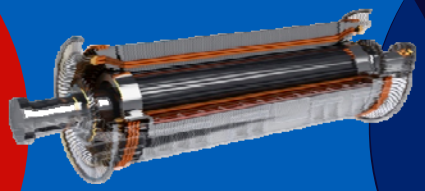
Power Services delivers a more balanced portfolio across total plant capabilities.



~5,900
gas turbines



~1,600
aeroderivative gas turbines



~9,900
generators

~900
heat recovery steam generators

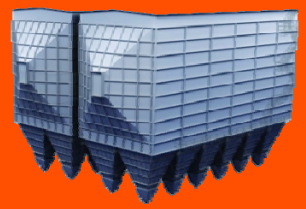
~1,600 GW ~1.5of installed capacity ... enough to power B homes

~28,000 power generation assets globally ... the world's largest installed base

~2,000
boilers

~2,600
utility steam turbines

~3,400
industrial steam turbines

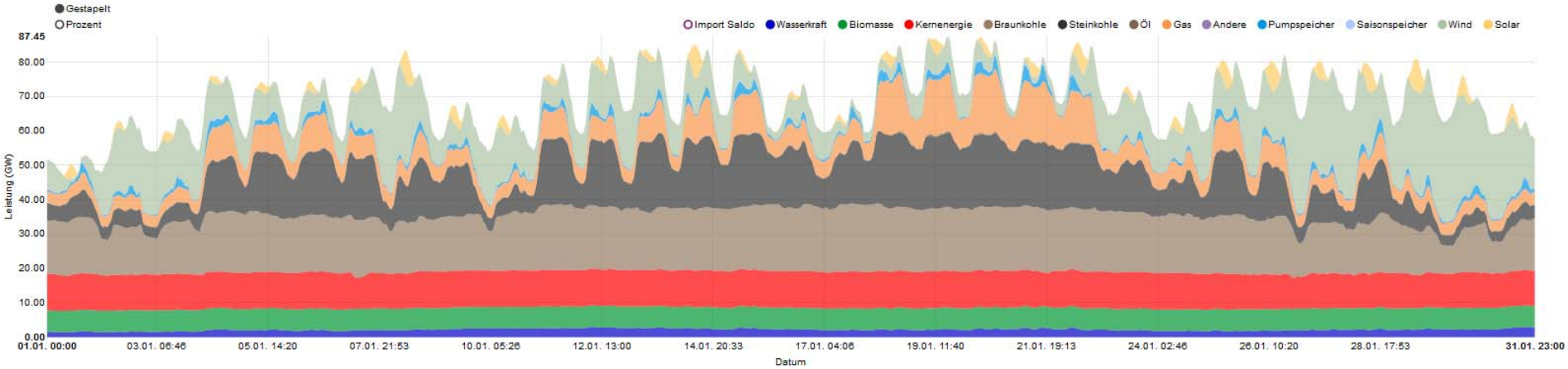


~3,000
air quality control systems

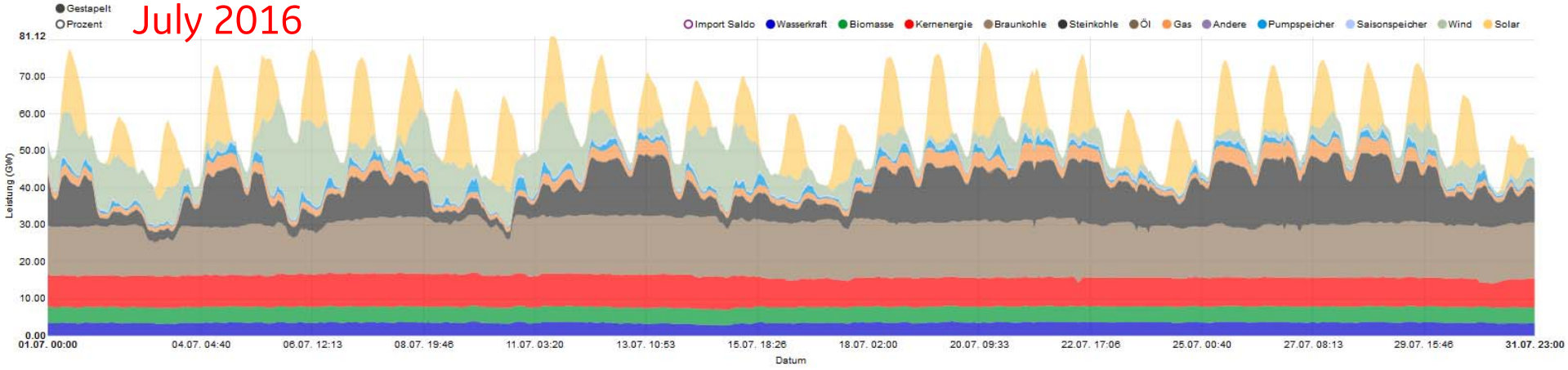
Impact of renewable power on operation profiles

Demand on Flexibilty – Energy Production Germany

January 2016



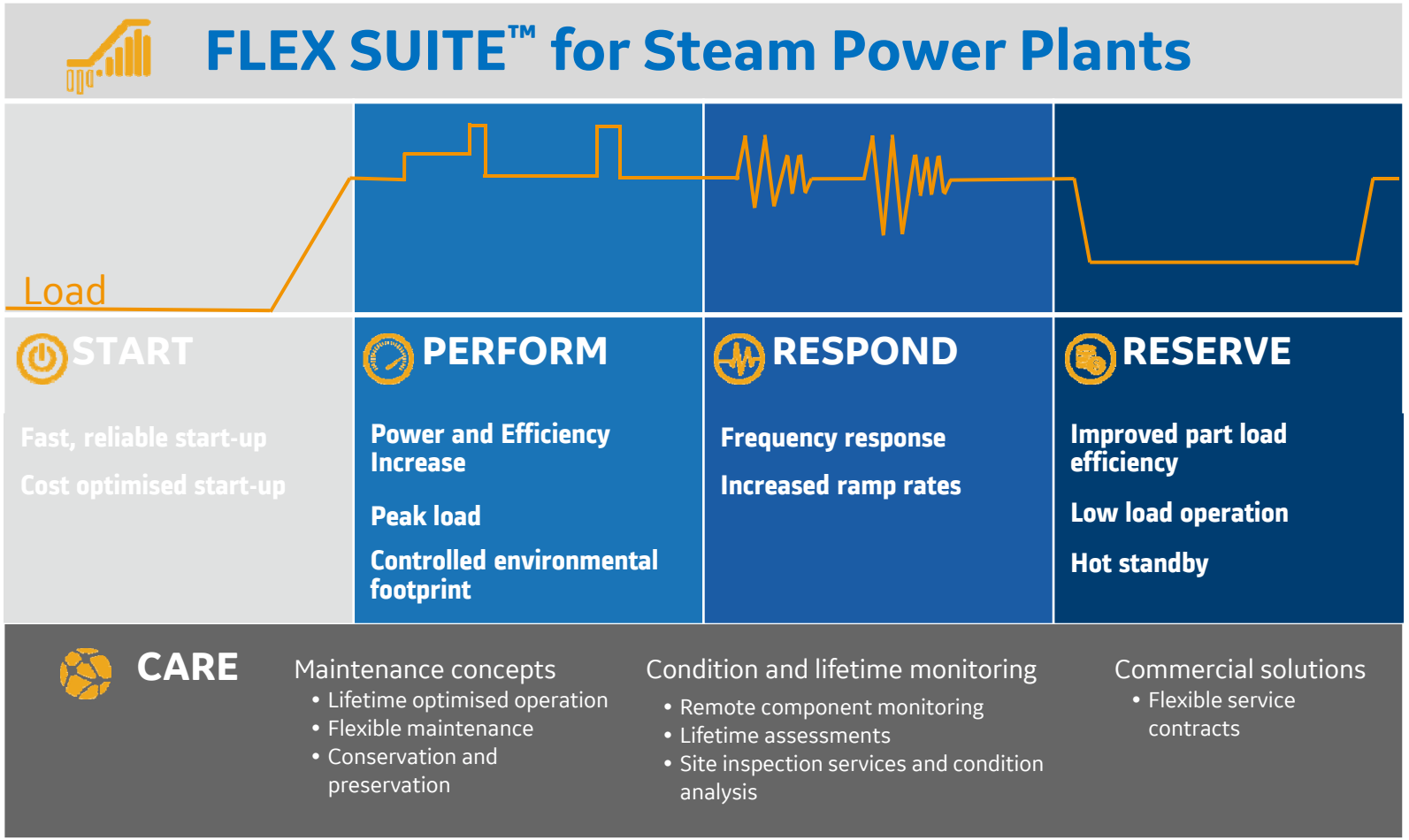
July 2016



Demand of flexible operation will increase ~ 20 % of volatile power production

FLEX SUITE™ Steam

Offering for Steam Plants



FLEET360* STEAM PLANT SERVICES SOLUTIONS – FLEXIBILITY

DIGITAL SOLUTIONS

- **Steam Plant Asset Performance Management**
- **Low Load Optimization**
- **Part Load Optimization**
- **Enhanced Fast Ramp/Startup/Response**
- **BoilerOpt and Digital Boiler +**
- **Digital Twin**

STEAM TURBINE

- **Blade Vibration Monitoring**
- **Valves and Actuator Monitoring**
- **Enhanced ST Rotor Stress Control**

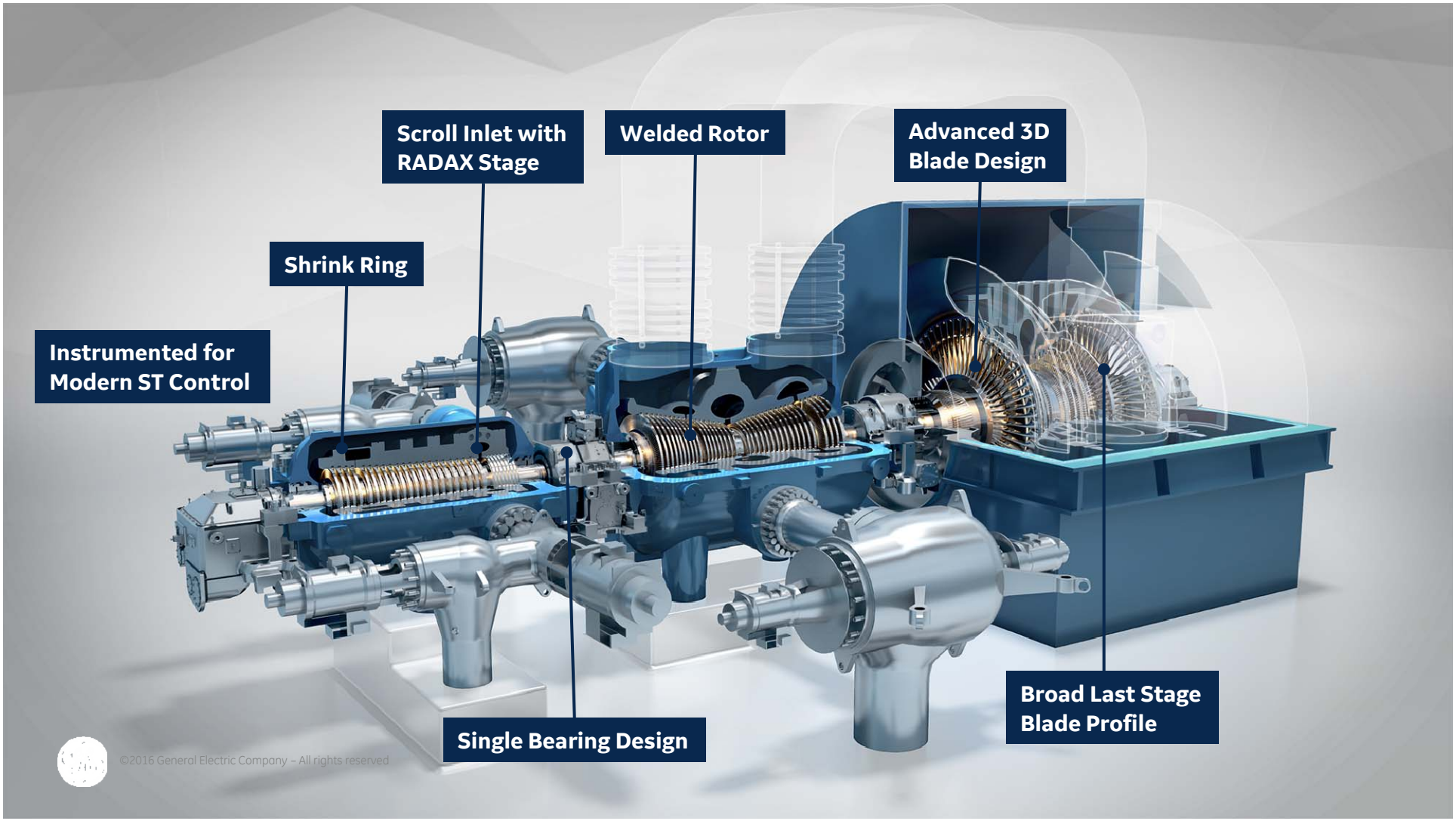
BOILER

- **Flame Scanners**
- **Plasma Burner**
- **Burner Upgrade**
- **Smart Mill**
- **Stability Monitor**
- **Low Load Boiler Package**
- **Auto Tune**
- **Air Preheater Upgrade**

*Trademark of General Electric Company.

Min. Load	Start-up	Load Gradient	Heat Rate	Availability	No_x Emission
40 → 10%	3 → 1.5 h (hot) 10 → 4 h (cold)	2 → 6%/min	-2%	+2%	-20%

GE Flexible Steam Turbine Features

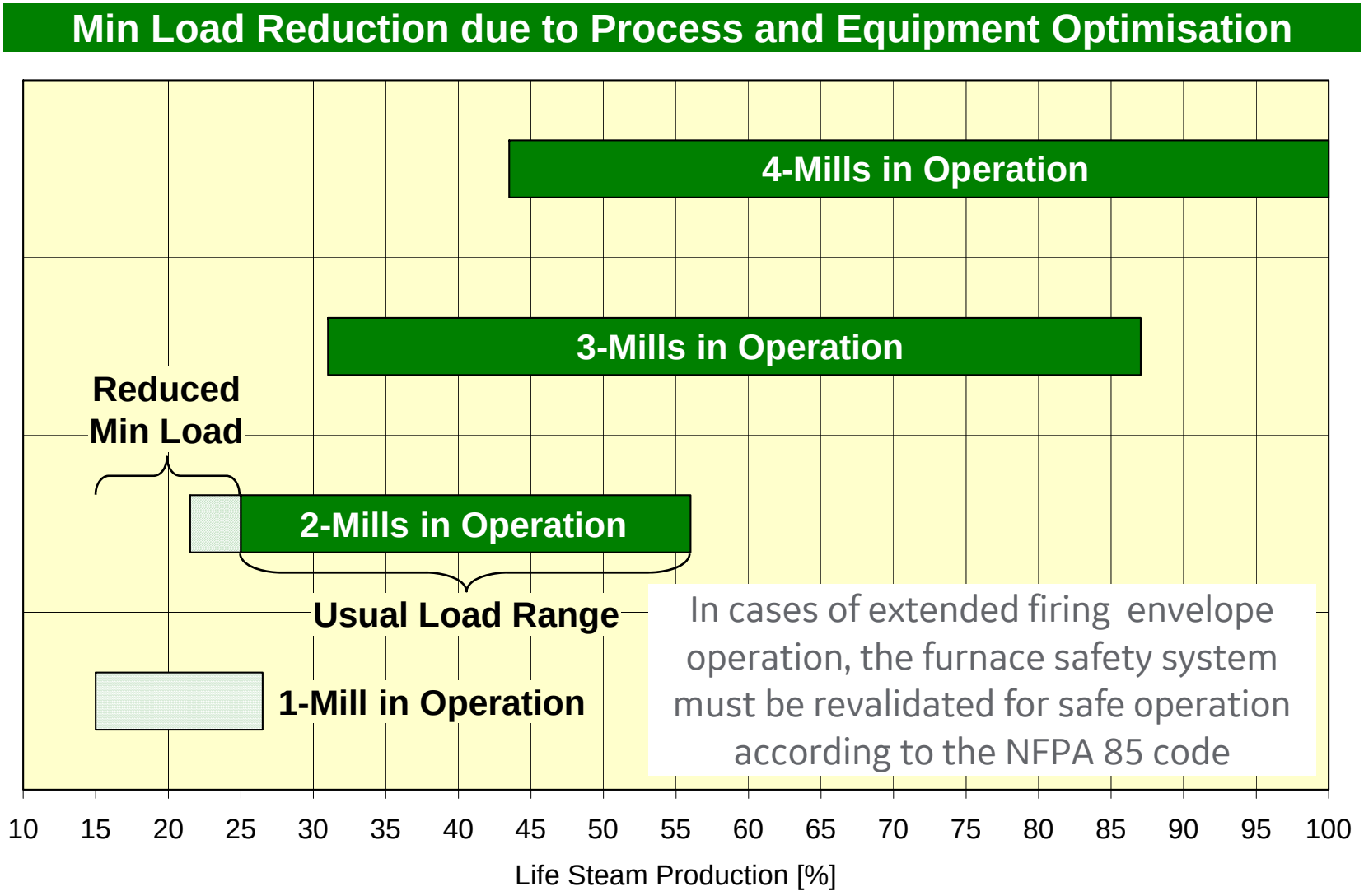


Boiler Flexibility Topics

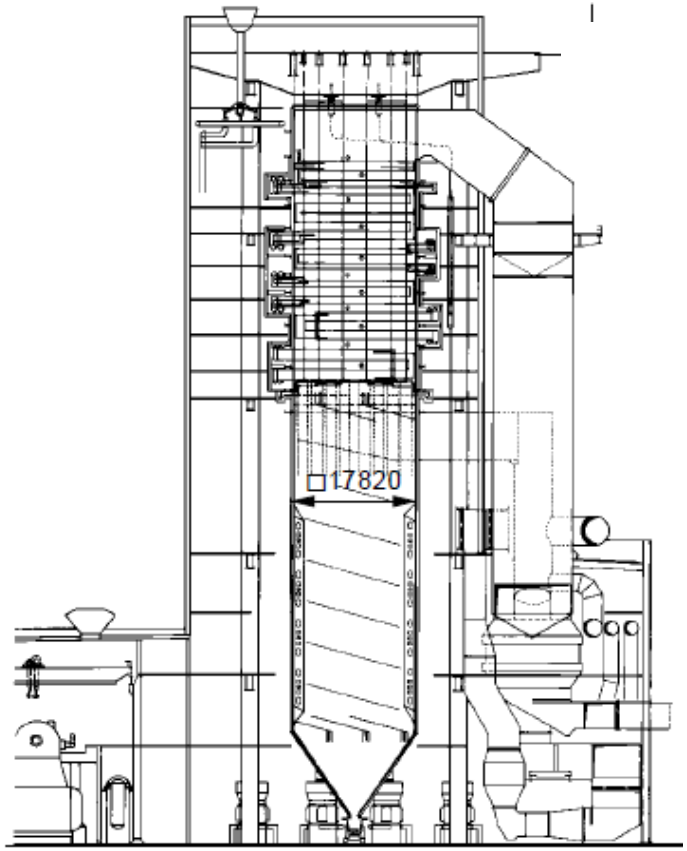
Practical Examples

- Optimisation / Minor works / Low Load
- Minor Intervention / Efficiency / Upgrade Envelope
- Fuel Change Topic
- Fast Ramp / Upgrade
- Major Retrofit

Optimisation – Conventional Power Plants
Load Range Extension for Bituminous Coal



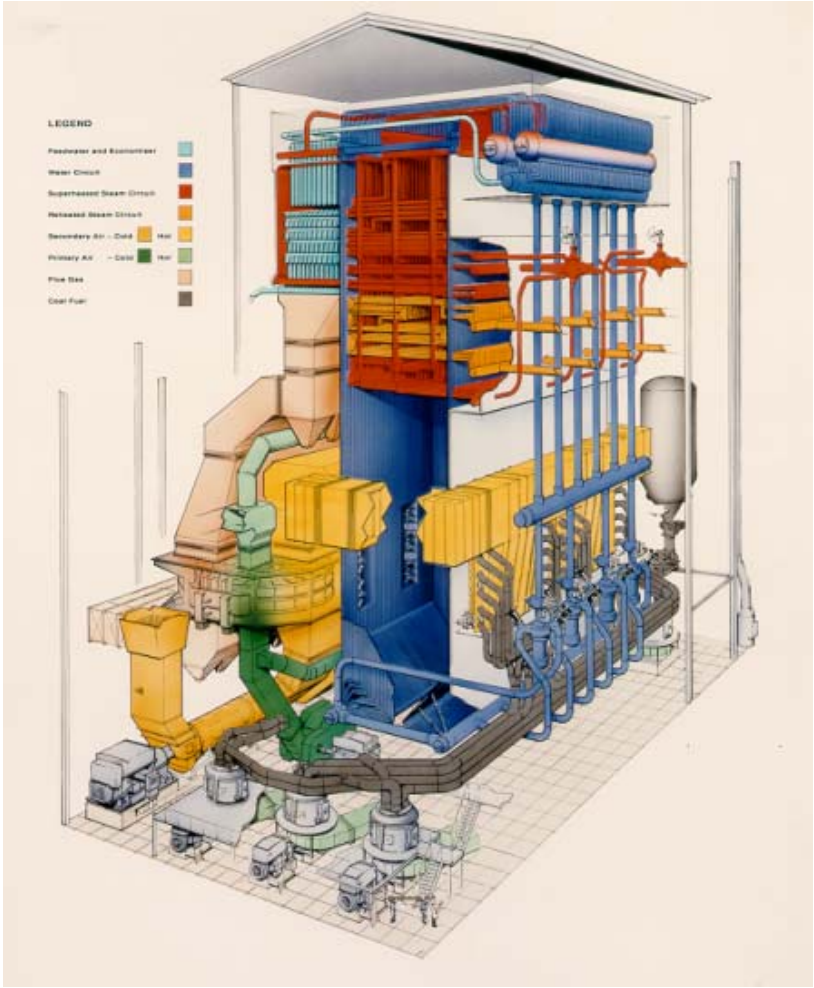
Small Project
800 MW Bituminous coal unit



- 800 MW hard coal unit
- GE Tower boiler, once through
- Tangential firing
- GE steam turbine
- Unit with district heating (240 MW) and process steam extraction
- Design Low load operation: 30%

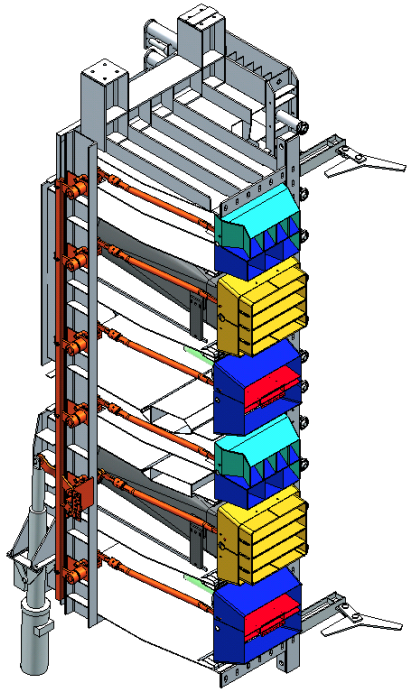
Load Range & Efficiency Improvement
Minor Intervention

- 2 x 500 MWe, Tilting Tangential Burners. GE OEM.
- Coal Preparation by 6 x Vertical Spindle GE pulverizers
- Fired on high ash Bituminous coal
- Problem, high unburnt loss, minimum load ~50%
- Minor modification to burners to target low load and UBC reduction.

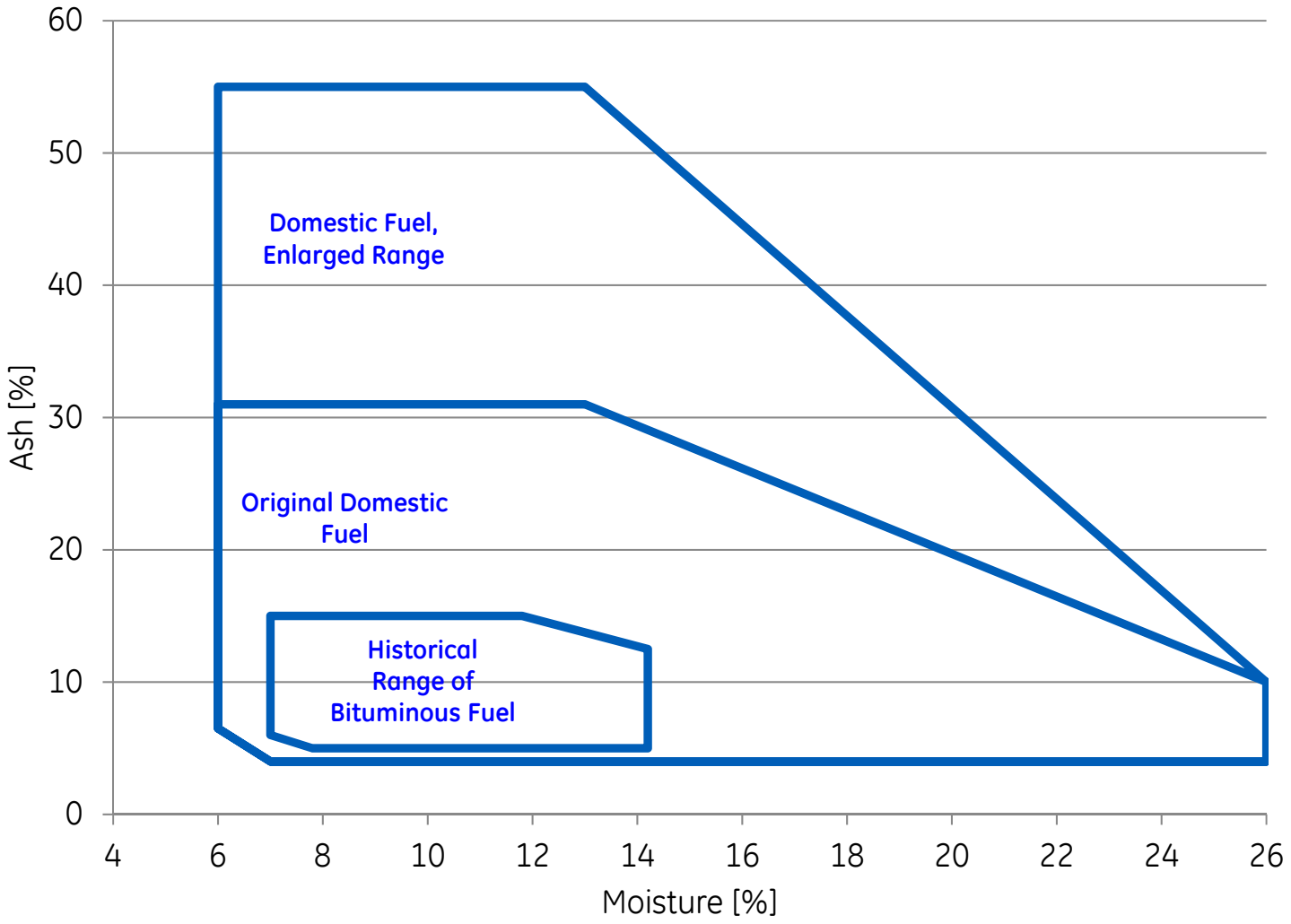


Load Range & Efficiency Improvement
Minor Intervention

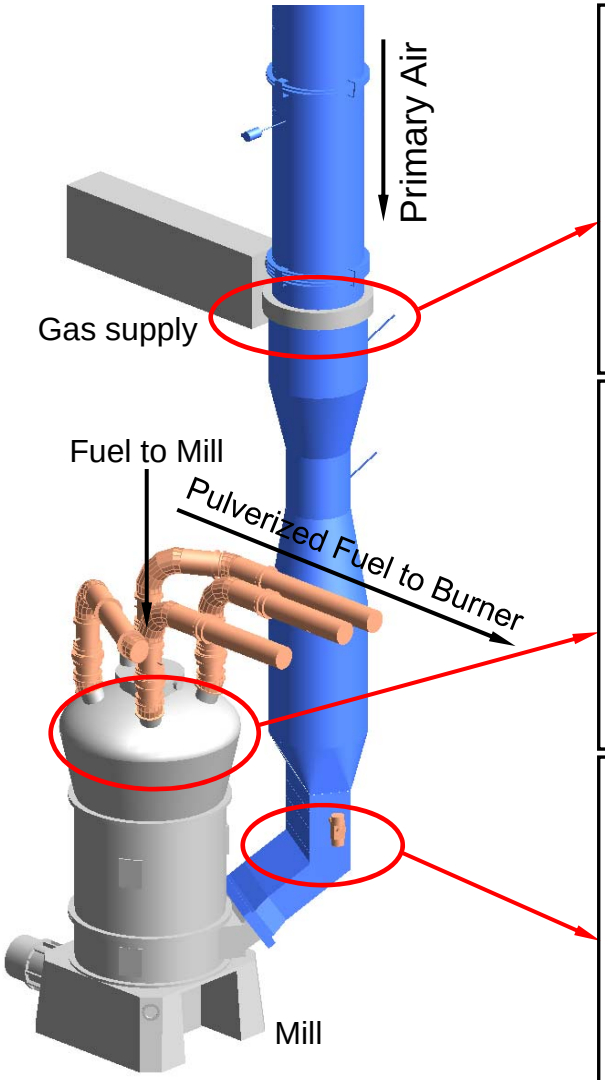
	UBC Performance (lower = better)	Lowest Load with coal only
Actual pre-conversion	8.6%	50%
Predicted post conversion	6.8%	25%
Actual post conversion	3.8%	25%



Change of Fuel – Fuel Flexibility



Fuel and load Flexibility - Bituminous Coal

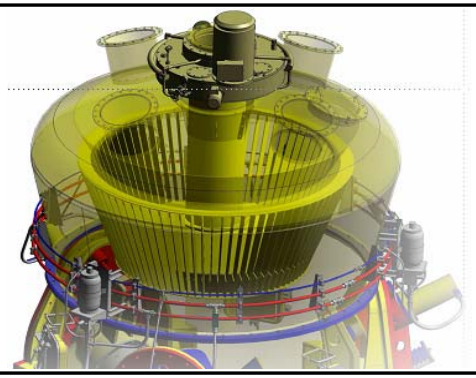


Duct Burner

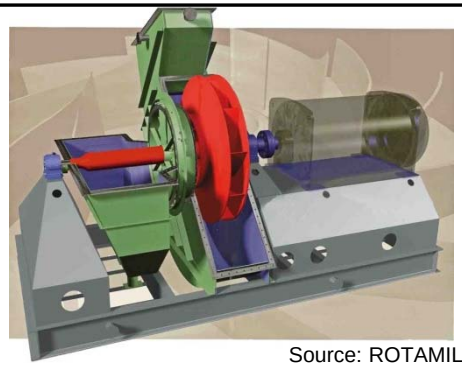
in Operation

Source: REBURNFLAM® Kanal-/Flächenbrenner; Pillard Feuerungen GmbH

Dynamic Classifier



Booster fan



Source: ROTAMILL GmbH

Faster Start-Up
Low Load Operation

Fuel Range Extension

Fast
Load Changes

Fuel Range Extension

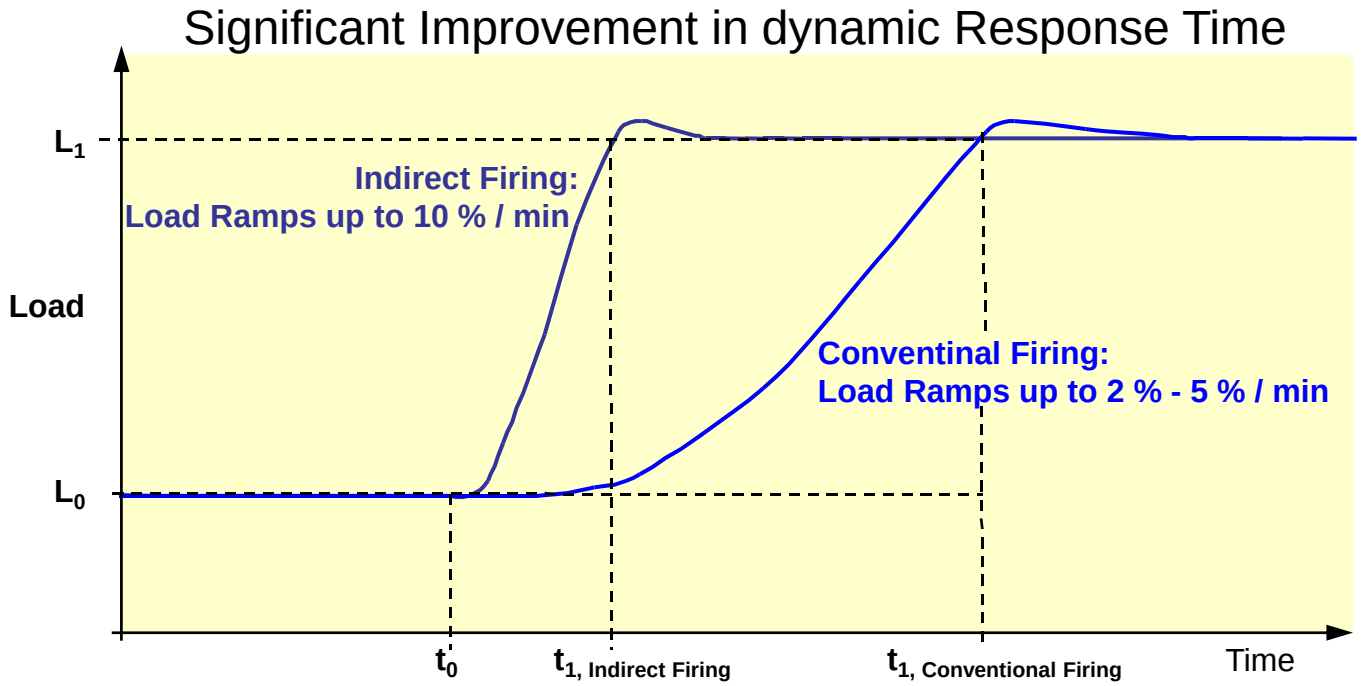
Fuel Range Extension

Indirect Firing System
Reduction of dynamic Response Delay

Fast Load Changes

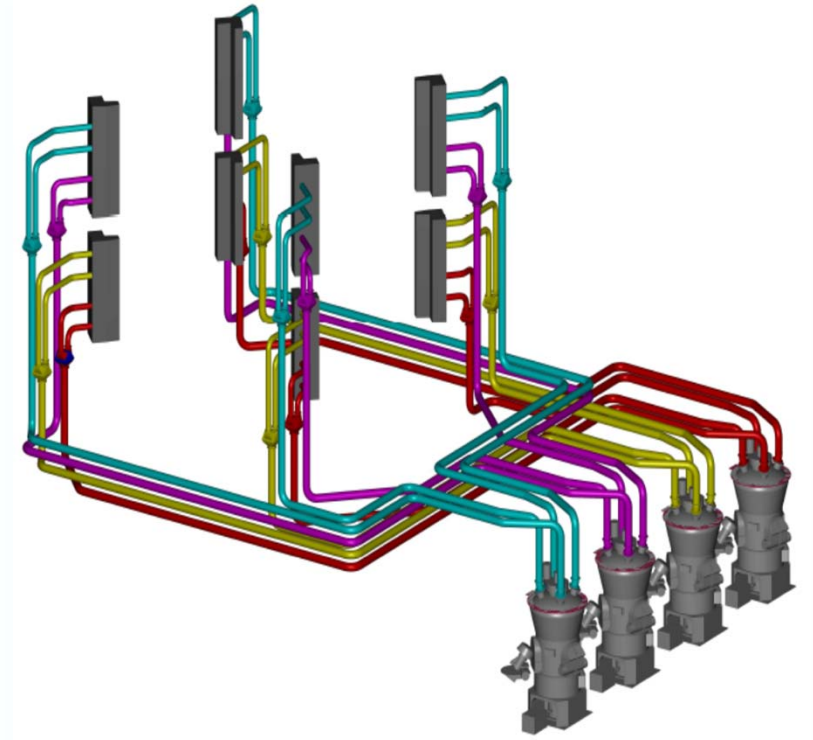
Reduction of dynamic Response Delay (Secondary Control)

- Grinding Process causes Delays due to Storage Capacity of Mill
- Indirect Firing separation of Grinding and Storage
- Significant Reduction of System Response Time



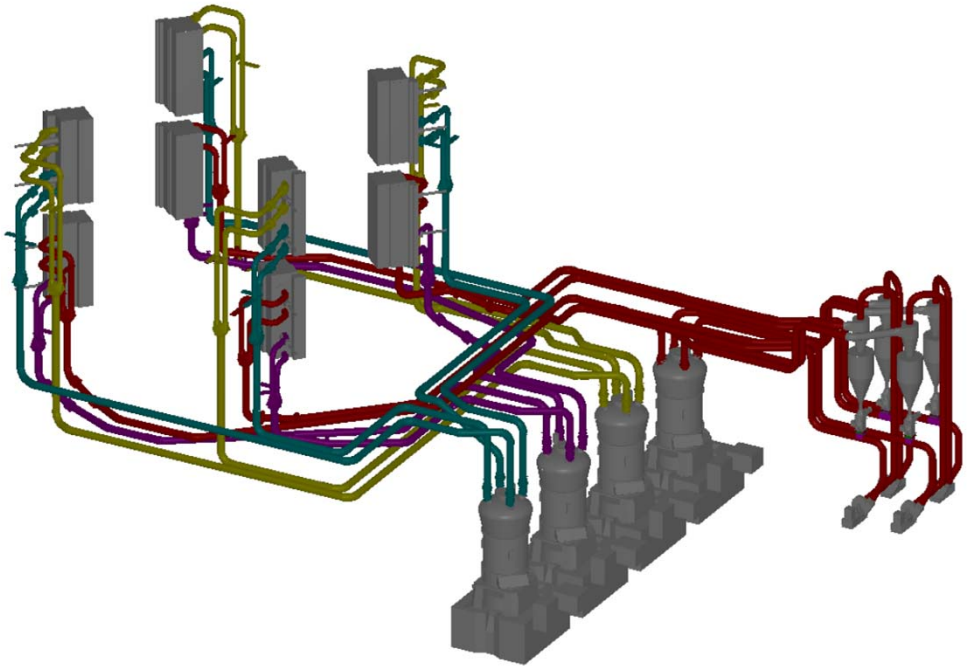
Optimisation of Conventional Firing
Option for Dynamic Response Improvement

Mill → Burner



Direct Firing System (Conventional)

Mill → PF Separator / Silo → Burner



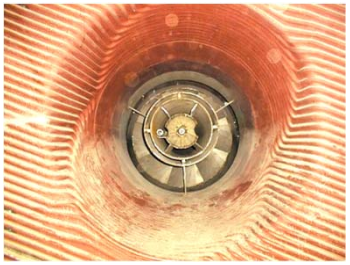
(Partly) Indirect Firing System

Optimisation of Conventional Firing
Start up with – Dried Coal – eliminates support energy

Niederaußem K: 8 x 90 MW_{th}

- Start-up/Support Firing
- Operation since 2003

Dried Lignite Burner



Dried Lignite Storage Silo

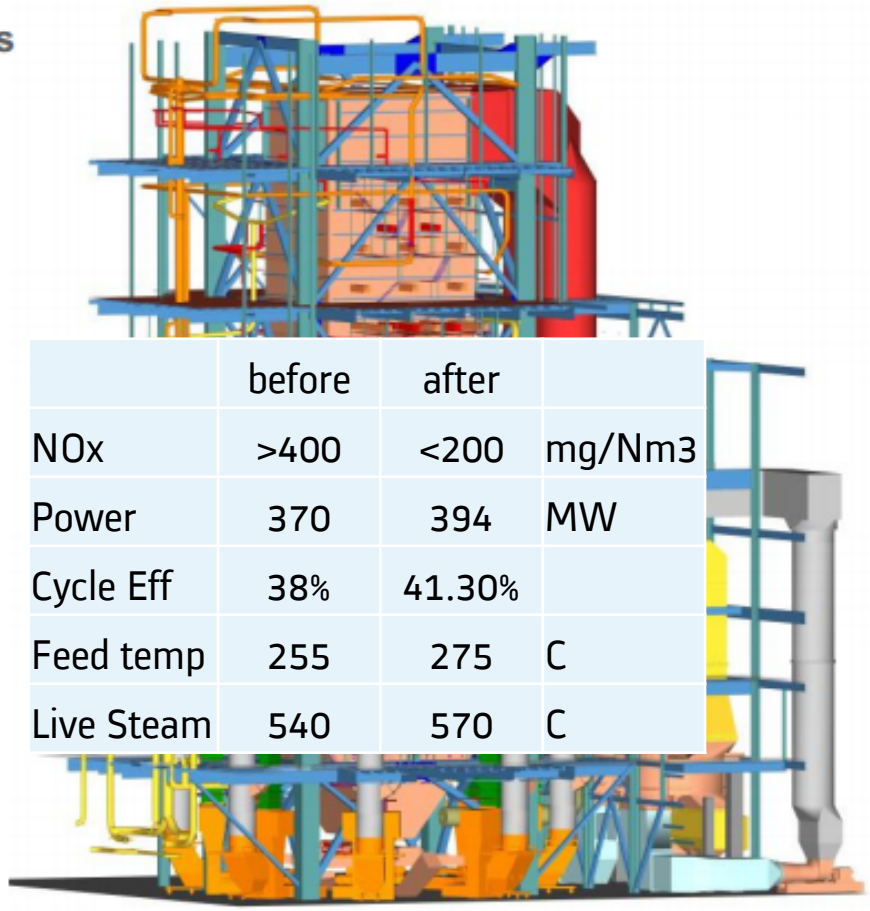
Large Retrofit Project

Superheaters & Reheaters
Performance Adjustments
Material Upgrades
Cleanability

Economizer
Performance Improvem.
Cleanability
Erosion Protection

Ducts & expan. joints
Material Upgrades
Repairs

Air heater
High Efficiency Heating Elements
Air Leakage reduction
Cleanability



	before	after	
NOx	>400	<200	mg/Nm3
Power	370	394	MW
Cycle Eff	38%	41.30%	
Feed temp	255	275	C
Live Steam	540	570	C

Waterwalls
Cleanability
New Burner openings

Overfire air (OFA)
Two stage OFA

Burners
Low NOx burners

Bottom ash handling
Modified After Burning Grate

Coal pulverizers
Improved classifiers
Advanced wear parts

Summary