



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

December 16, 2016

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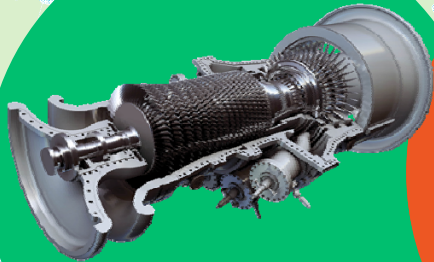
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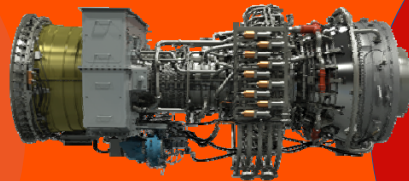


Power Service

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

~1.5 of installed capacity
enough to power
B homes

~28,000

power generation assets
globally ... the world's
largest installed base



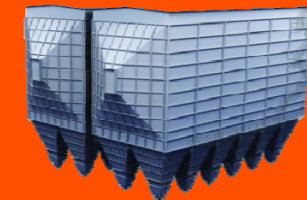
~2,000
boilers



 ~2,600
utility steam
turbines



 ~3,400
industrial steam
turbines



 ~3,000
air quality
control systems

FLEET360*

Total Plant Solutions

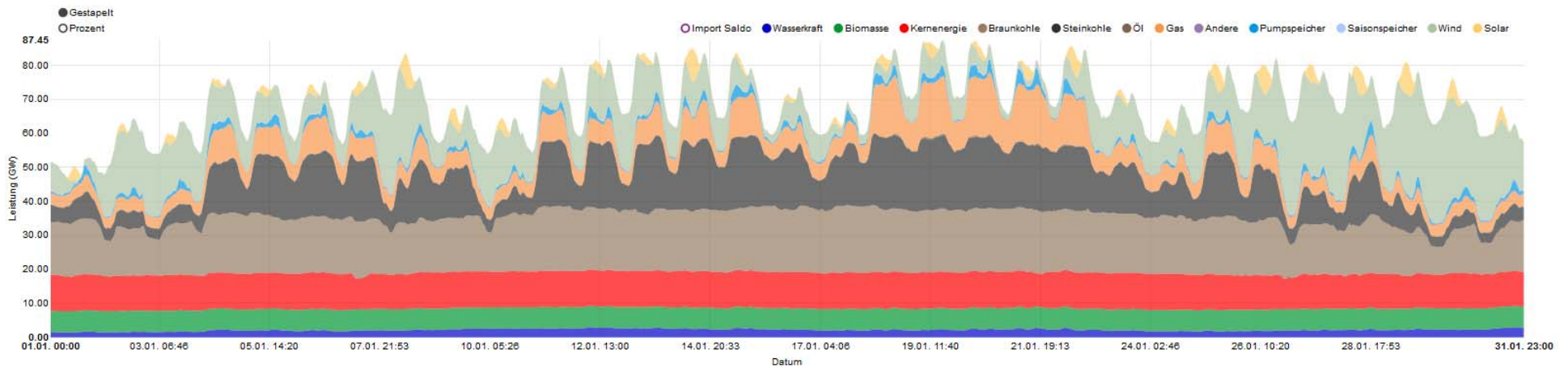


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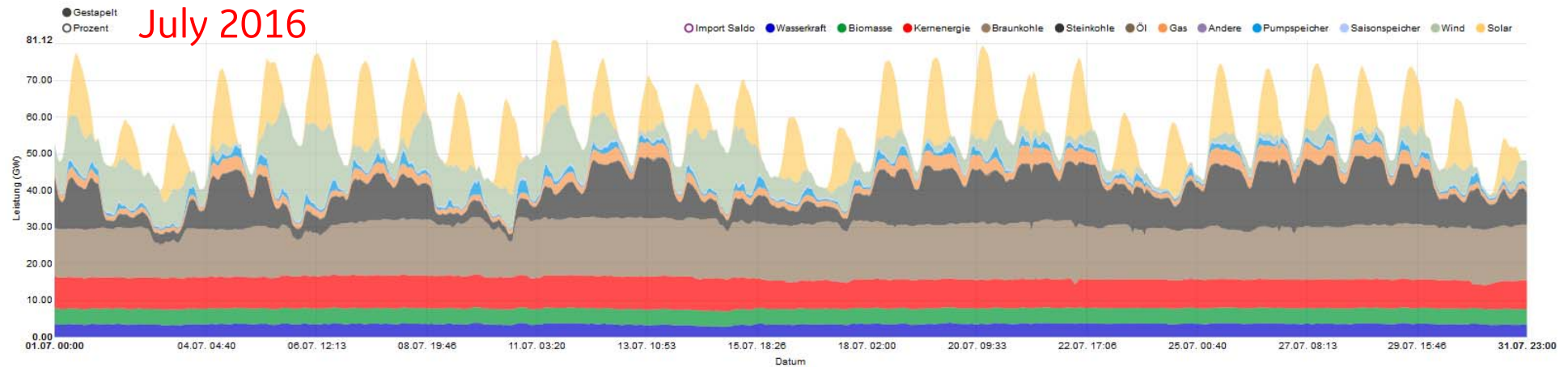
Impact of renewable power on operation profiles

Demand on Flexibility – Energy Production Germany

January 2016



July 2016

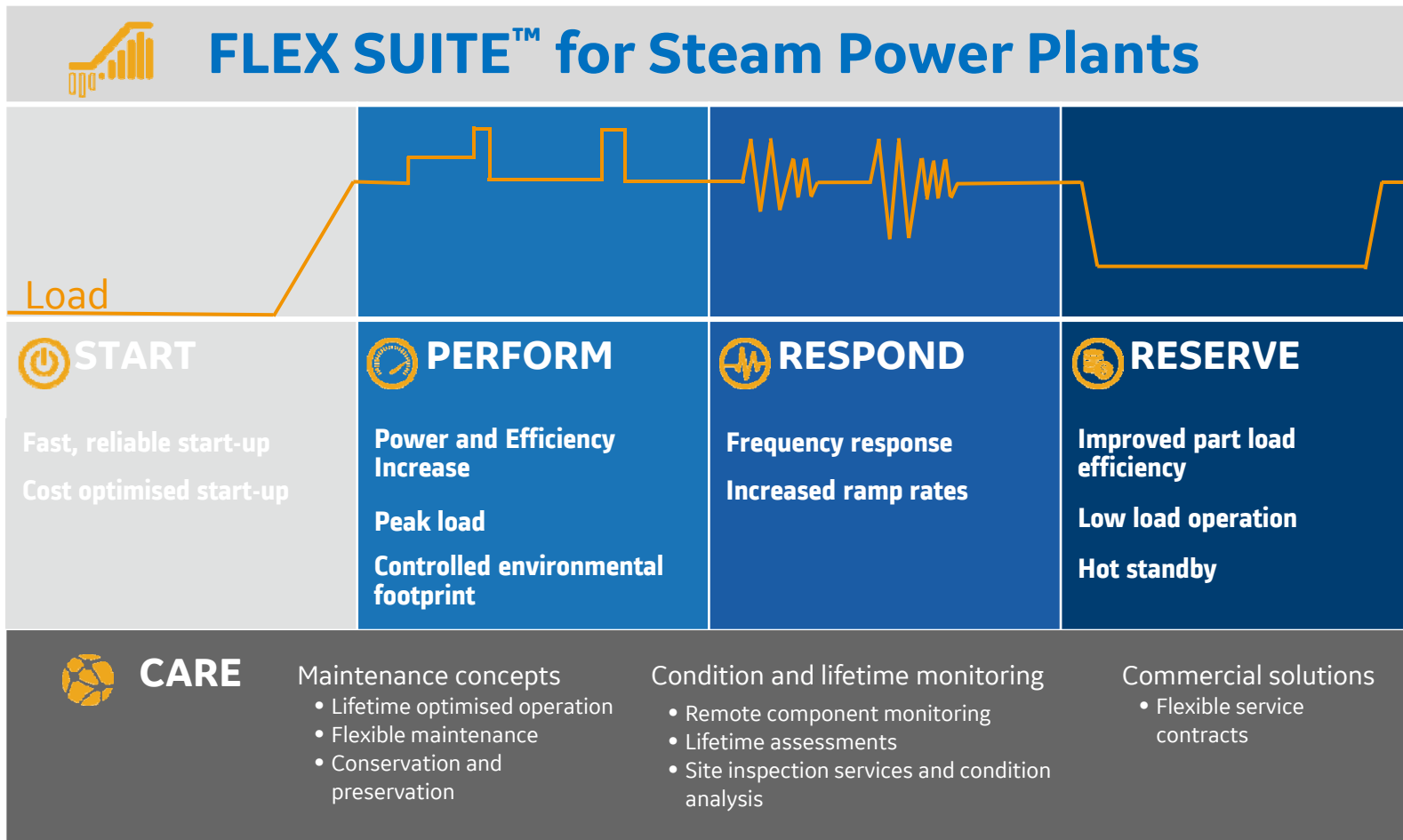


Demand of flexible operation will increase ~ 20 % of volatile power production



FLEX SUITE™ Steam

Offering for Steam Plants



FLEET360* STEAM PLANT SERVICES SOLUTIONS – FLEXIBILITY



DIGITAL SOLUTIONS

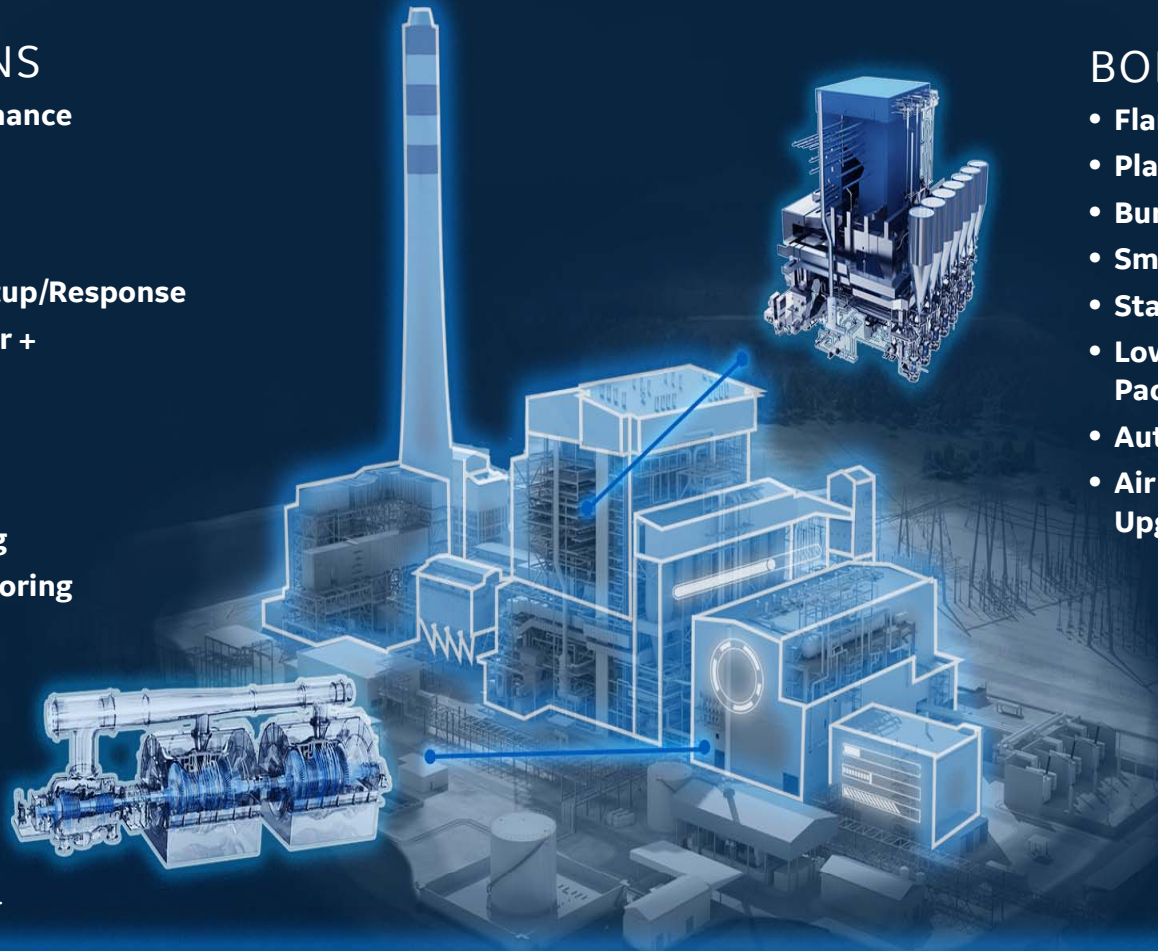
- Steam Plant Asset Performance Management
- Low Load Optimization
- Part Load Optimization
- Enhanced Fast Ramp/Startup/Response
- BoilerOpt and Digital Boiler +
- Digital Twin

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
40 → 10%

Start-up
3 → 1.5 h (hot)
10 → 4 h (cold)

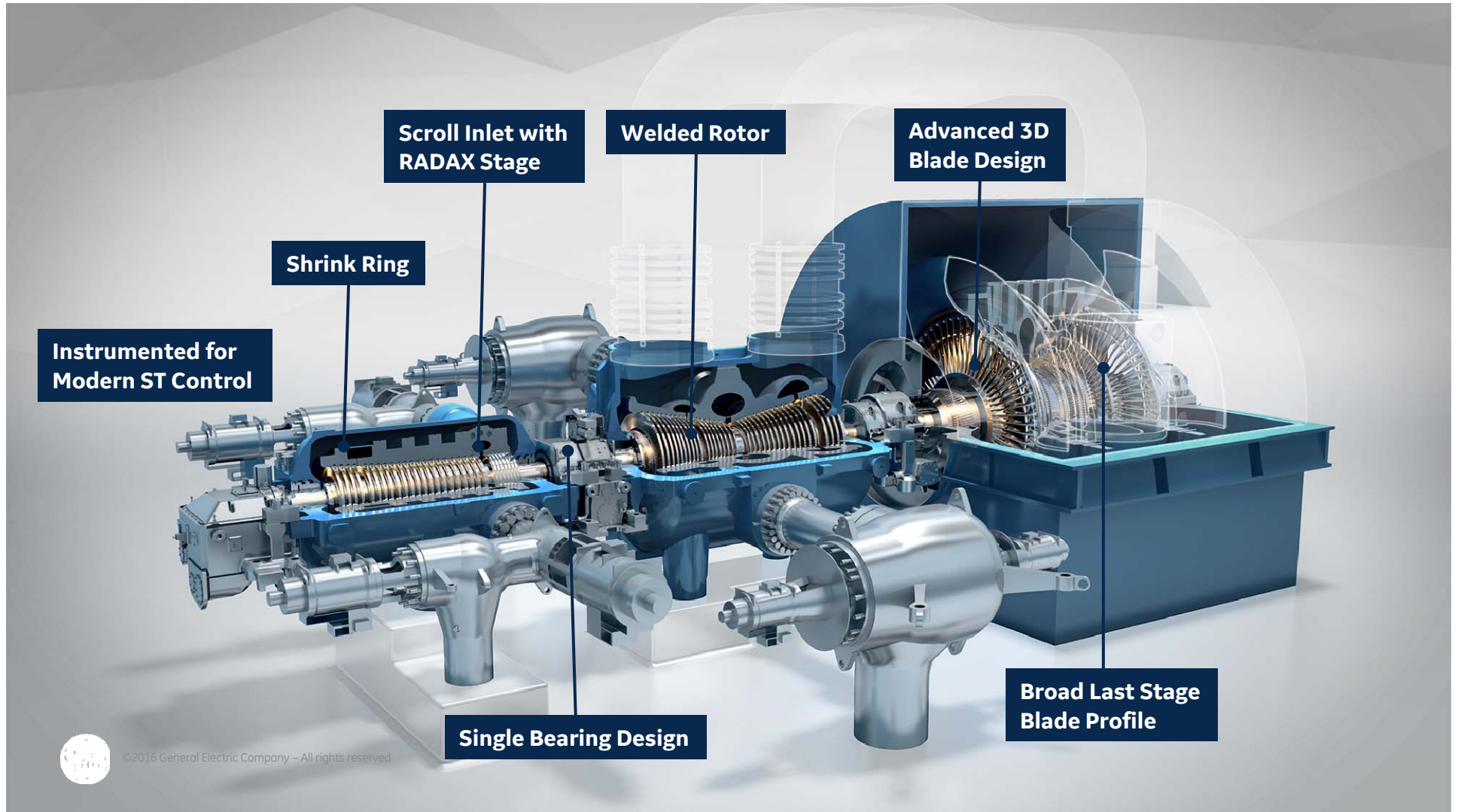
Load
Gradient
2 → 6%/min

Heat Rate
-2%

Availability
+2%

No_x Emission
-20%

GE Flexible Steam Turbine Features



Boiler Flexibility Topics

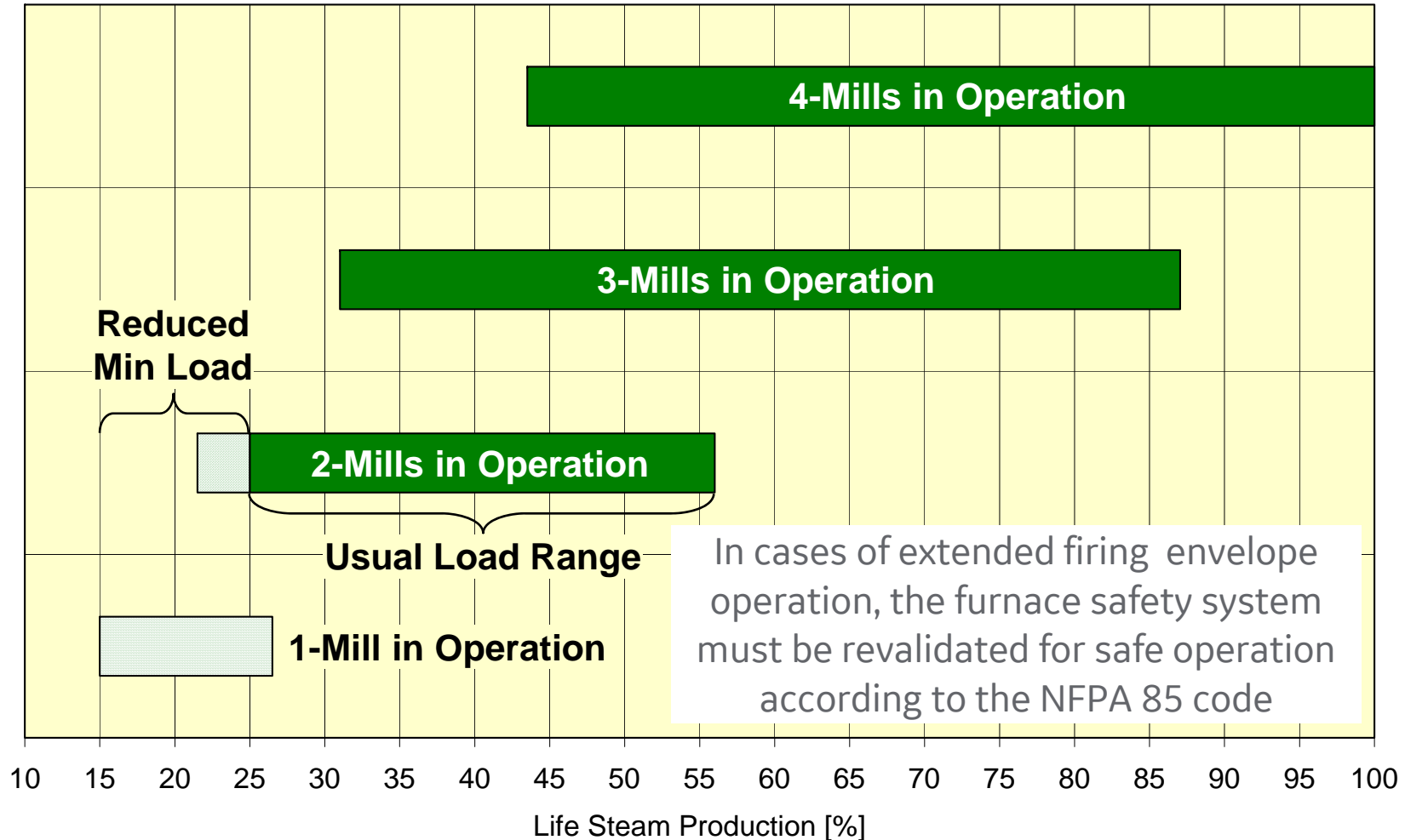
Practical Examples

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



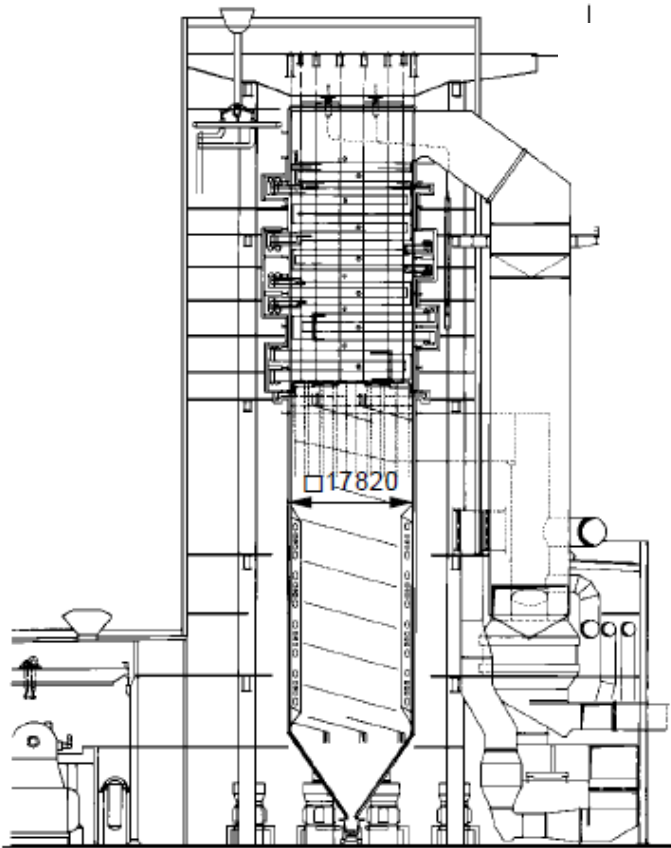
Optimisation – Conventional Power Plants Load Range Extension for Bituminous Coal

Min Load Reduction due to Process and Equipment Optimisation



Small Project

800 MW Bituminous coal unit

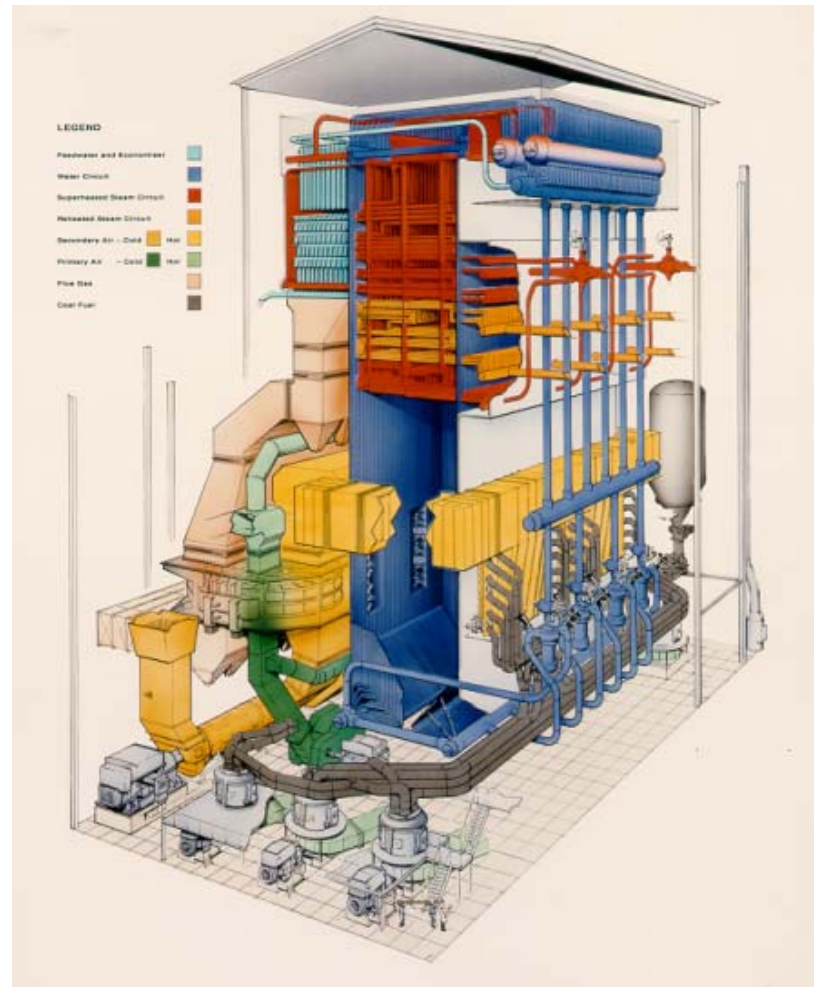


- 800 MW hard coal unit
- GE Tower boiler, once through
- Tangential firing
- GE steam turbine
- Unit with district heating (240 MW) and process steam extraction
- Design Low load operation: 30%



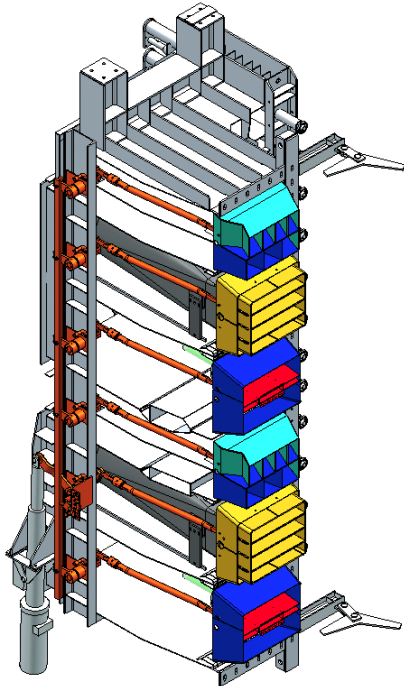
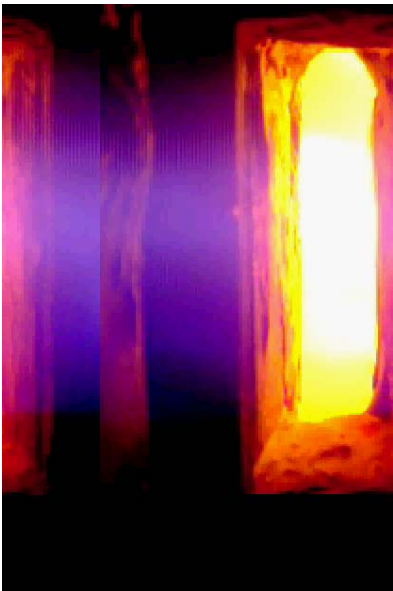
Load Range & Efficiency Improvement Minor Intervention

- 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.

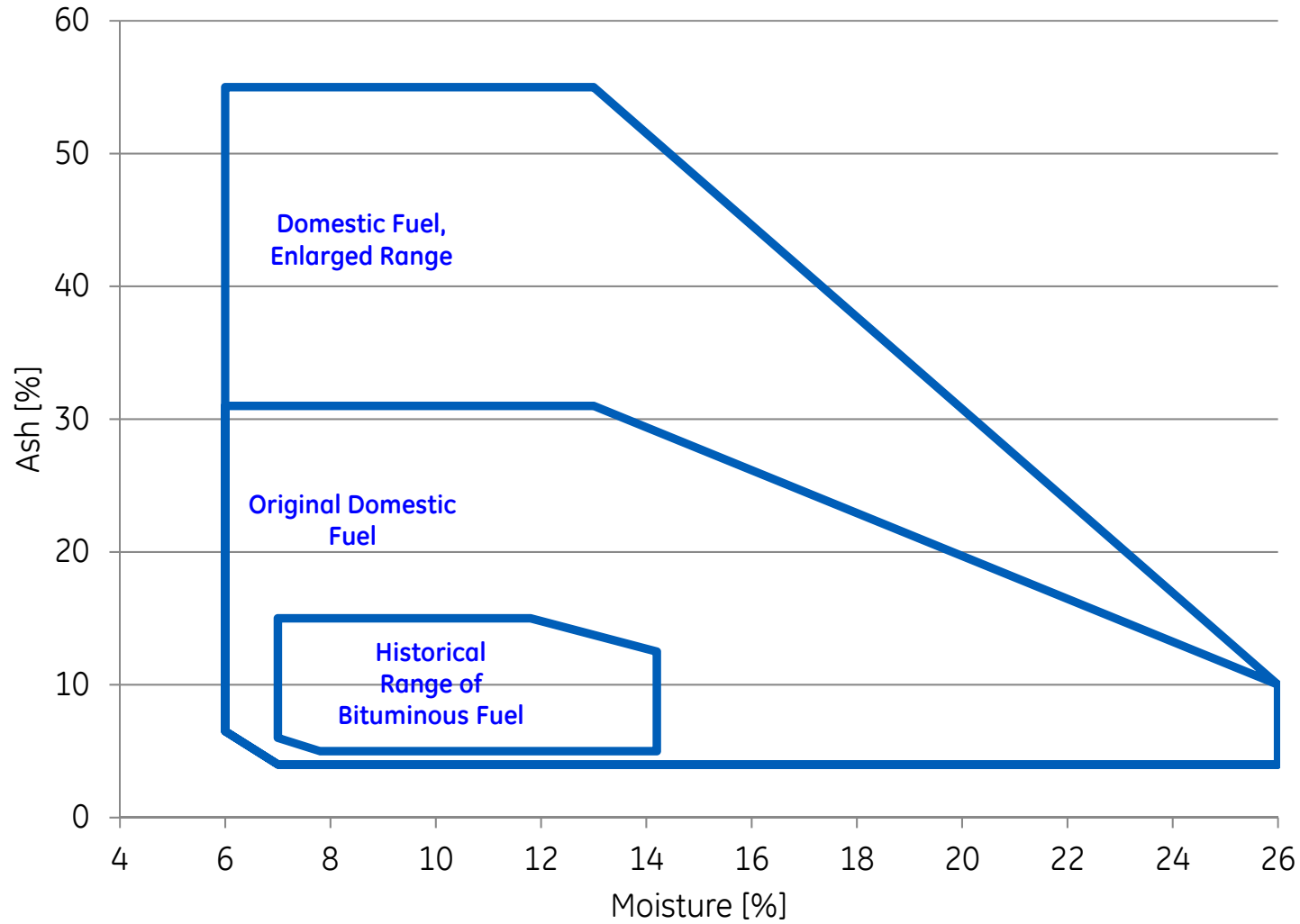


Load Range & Efficiency Improvement Minor Intervention

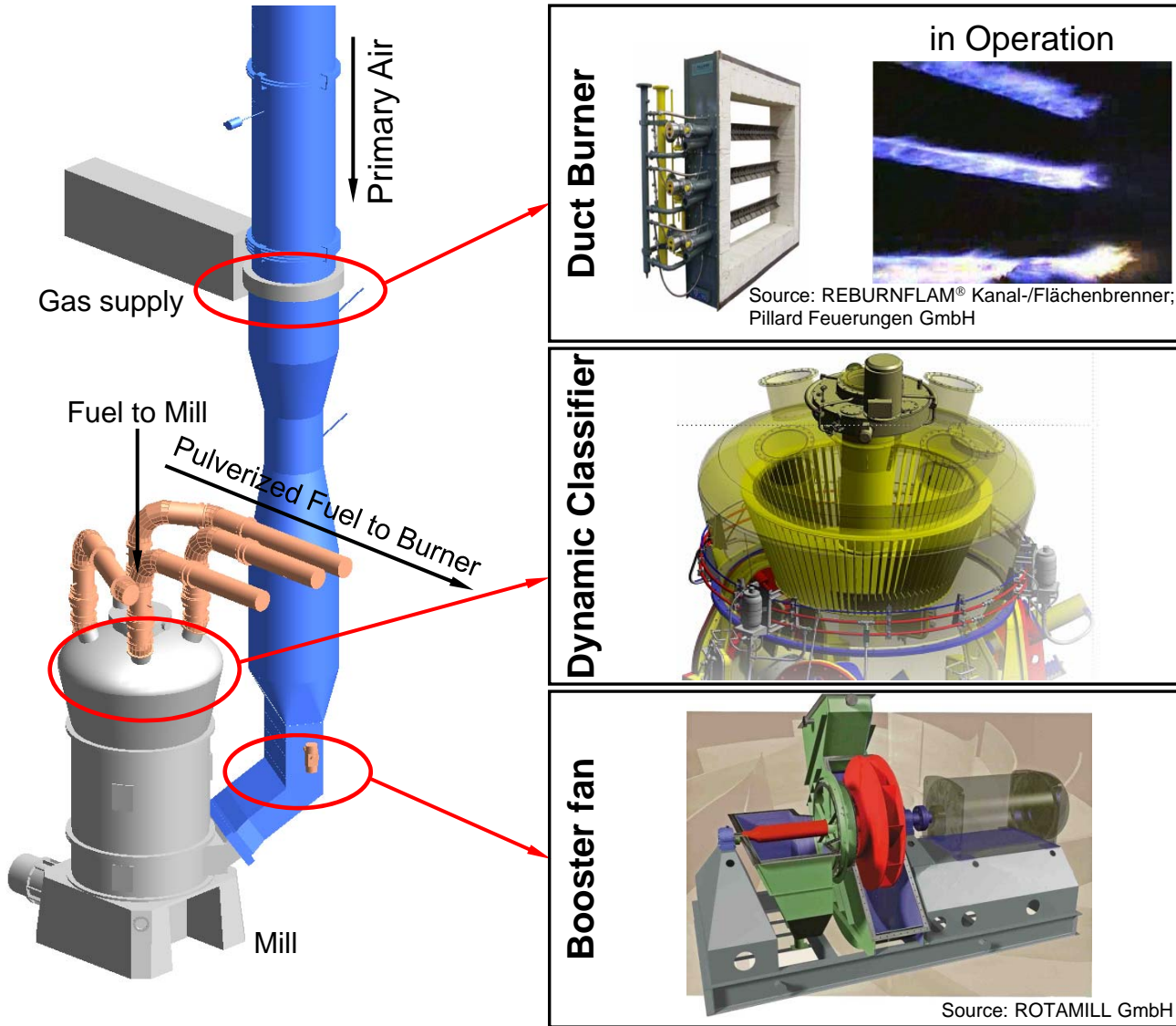
	UBC Performance (lower = better)	Lowest Load with coal only
Actual pre-conversion	8.6%	50%
Predicted post conversion	6.8%	25%
Actual post conversion	3.8%	25%



Change of Fuel – Fuel Flexibility



Fuel and load Flexibility - Bituminous Coal



Duct Burner

in Operation

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

**Faster Start-Up
Low Load Operation**

**Fuel Range
Extension**

Dynamic Classifier

**Fast
Load Changes**

**Fuel Range
Extension**

Booster fan

Source: ROTAMILL GmbH

**Fuel Range
Extension**



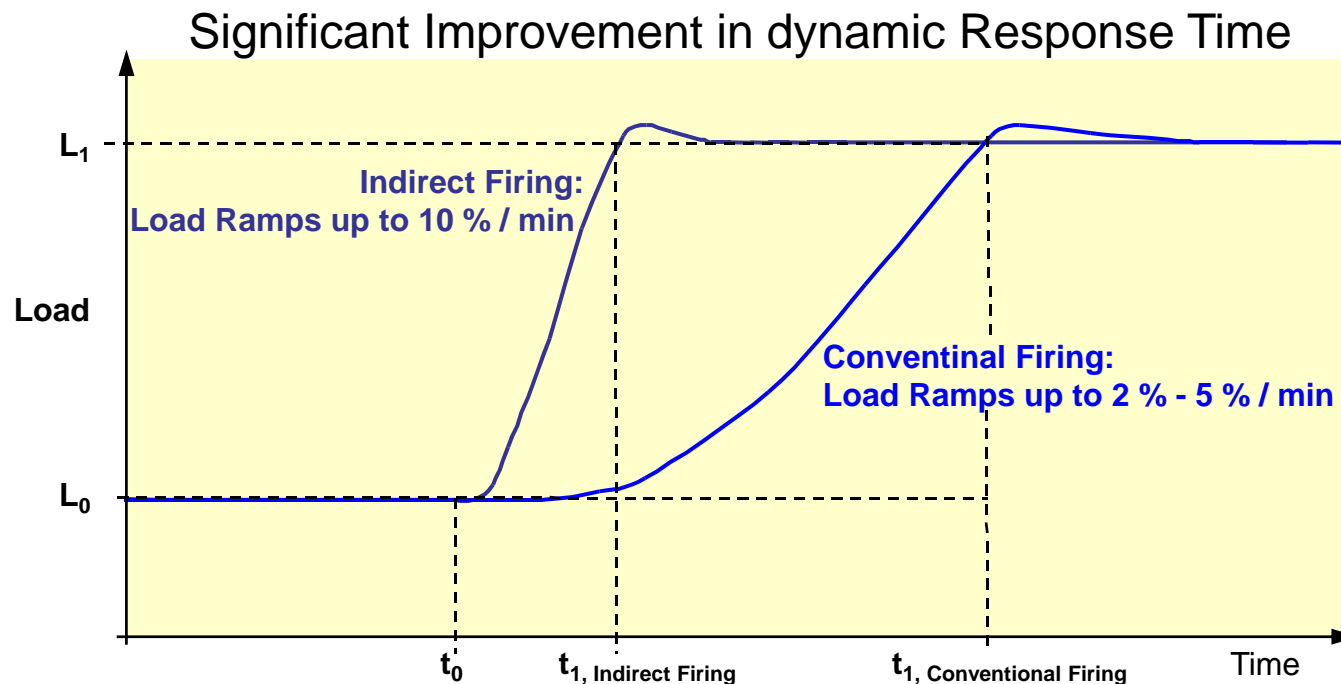
Indirect Firing System

Reduction of dynamic Response Delay

Fast Load Changes

Reduction of dynamic Response Delay (Secondary Control)

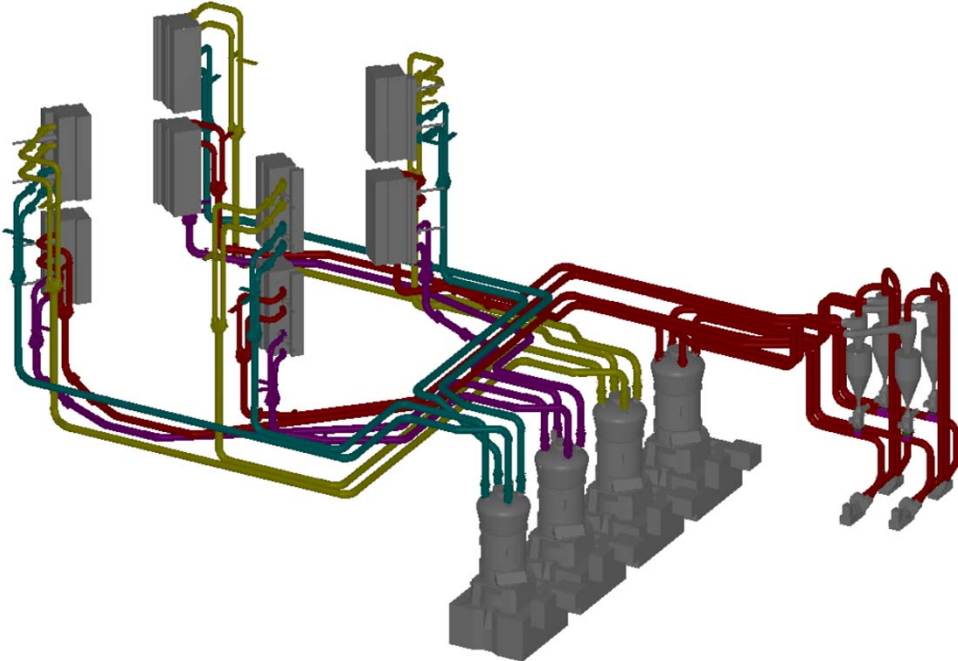
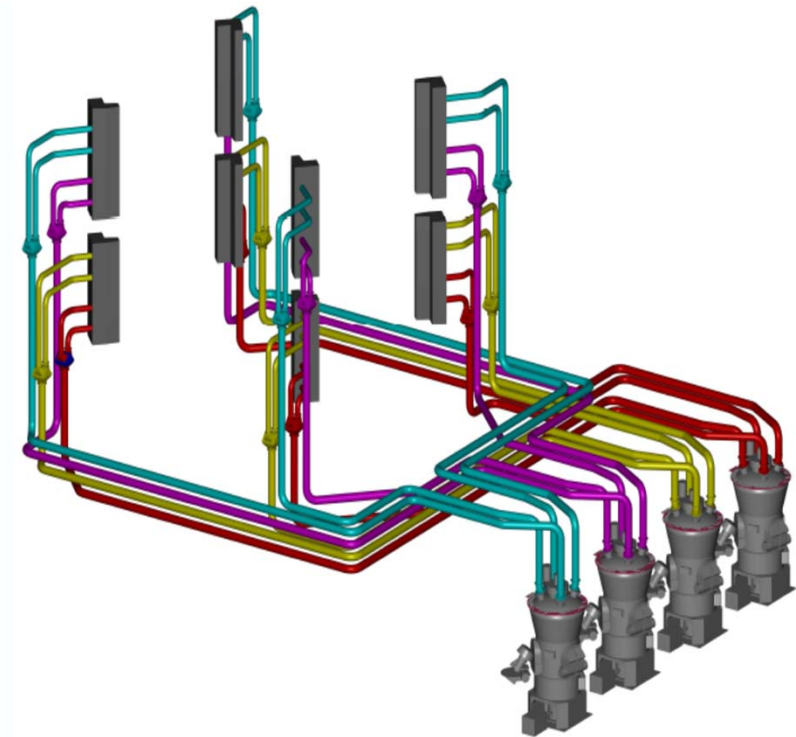
- Grinding Process causes Delays due to Storage Capacity of Mill
- Indirect Firing separation of Grinding and Storage
- Significant Reduction of System Response Time



Optimisation of Conventional Firing Option for Dynamic Response Improvement

Mill → Burner

Mill → PF Separator / Silo → Burner



Direct Firing System (Conventional)

(Partly) Indirect Firing System



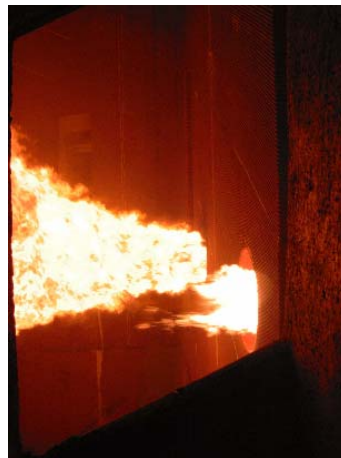
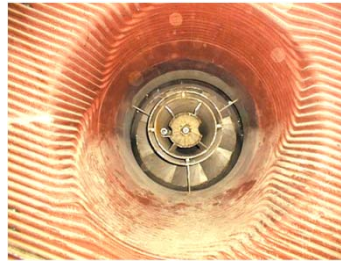
Optimisation of Conventional Firing Start up with – Dried Coal – eliminates support energy

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

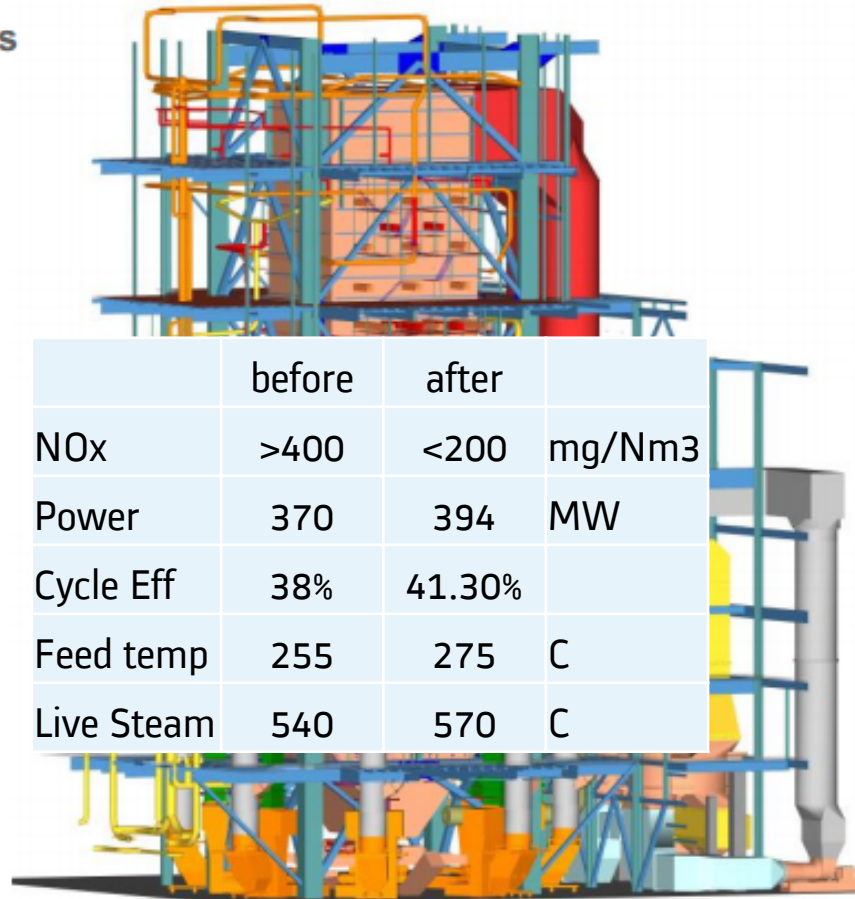
Performance Improvem.
Cleanability
Erosion Protection

Ducts & expan. joints

Material Upgrades
Repairs

Air heater

High Efficiency Heating Elements
Air Leakage reduction
Cleanability



Waterwalls

Cleanability
New Burner openings

Overfire air (OFA)

Two stage OFA

Burners

Low NOx burners

Bottom ash handling




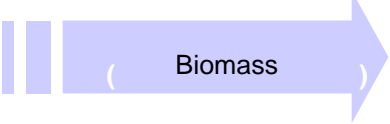
Modified After
Burning Grate

Coal pulverizers

Improved classifiers
Advanced wear parts



Summary

	State of the Art	Further Development (Newly built and existing Plants)
 Time for Start-up	2 - 6 Hours Depending on Startup Conditions	1 - 4 Hours Depending on Startup Conditions
 Minimum Load Bituminous Coal	Newly built Plants: 25 % Existing Plants: 40 %	Conventional Firing 15 - 20 % Indirect Firing 10 %- 15 %
 Load Ramps	ca. 2 – 5 % / min	Up to 10 % / min
 Biomass	10 % CoCombustion	100 % Combustion



