# Fuel Flexibility and Fuel Change in Coal Power Plants

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# Agenda

- Introduction
- Fuel Change in Power Plants
- Fuel Handling & Storage
- Milling Challenges
- Combustion and Furnace
- Brief Case Studies

# Fuel Change in Power Plants

# Quality Requirements on Coals from the view of fuel purchaser and power plant operator

| Fuel Purchaser | Power Plant Operator |
|---|---|
| • Low-price purchase<br>• Undisturbed transport<br>• Universal and low-priced coal input<br>• Few restrictions relating to coal quality<br>• By-products marketing | • Handling and storage<br>• Milling and firing<br>• Ignition stability, flame stability<br>• Compliance with all limit values of emissions<br>• Avoiding mid-term & long-term damages |
| → "Price Thinking" | → "Costs-Thinking" |

# Fuel characteristics – complete analysis required

***Proximate analysis***
- H2O, ash and volatile matter (VM)

***Calorific value***
- Lower calorific value, higher calorific value

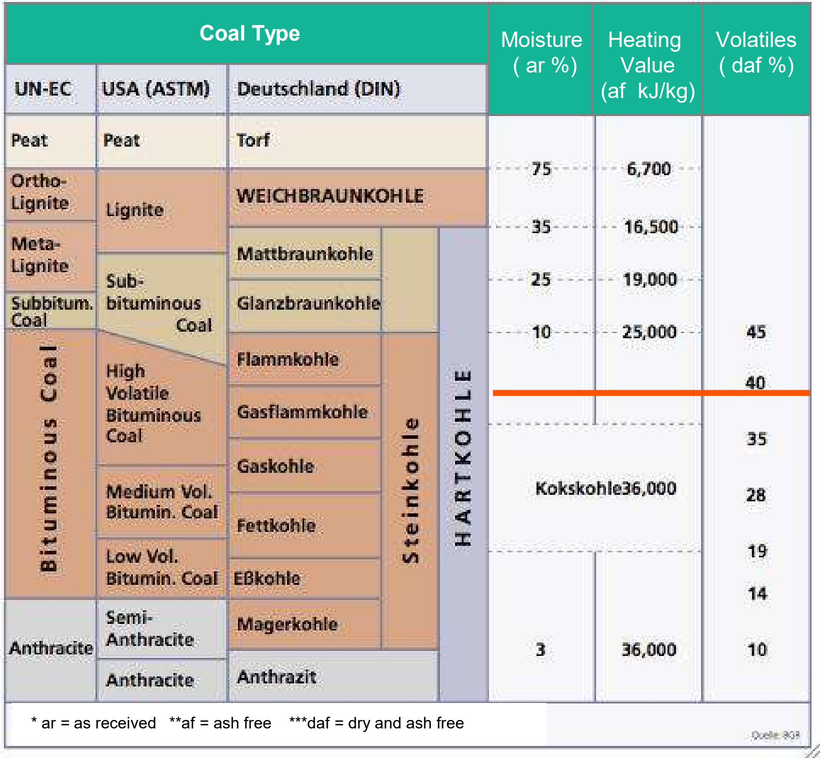
***Elementary analysis***
- C, H, N, O, S, Cl, F

***Ash analysis of macro-elements (XRF)***
- $SiO_2$, $Al_2O_3$, $TiO_2$, $Fe_2O_3$, CaO, MgO, $K_2O$, $Na_2O$, $P_2O_5$, $SO_3$

***Ash fusion trajectory in oxidizing and reducing atmosphere***
- Initial deformation temperature (IDT)
- Softening temperature (ST)
- Hemispherical temperature (HT)
- Fluid temperature (FT)

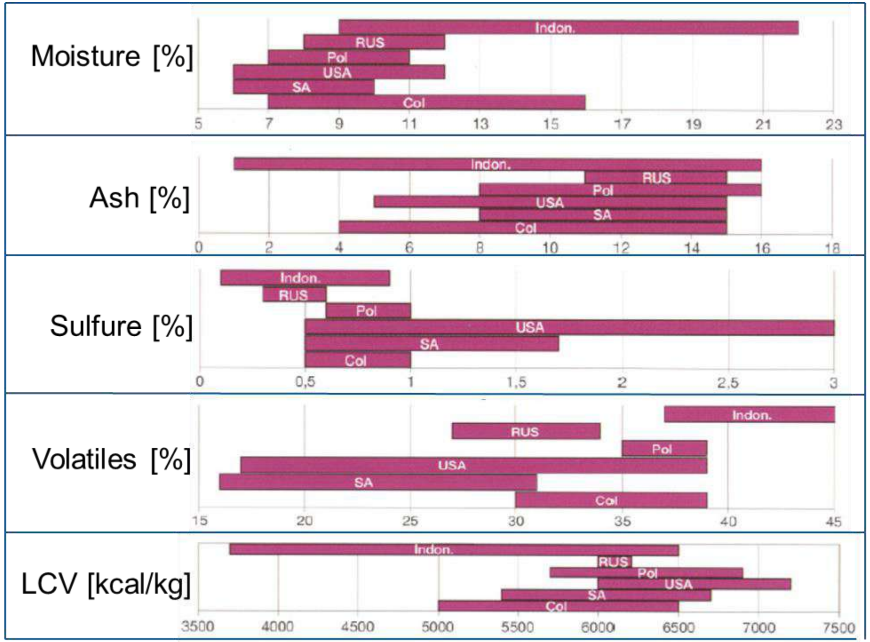
- ***Grindability (HGI, PMI)***

→ Complete analysis gives the whole picture of the combustion behaviour of a fuel



# Wide Range of imported Coals

- High quality fluctuations by imported coals
- Analysis of coal quality by independent laboratories
- Analysis of price-oriented characteristics
- Clauses in the supply contract for price regulation by quality fluctuations



# Possible effects of changing the Coal Range

| Parameter | Major Effects |
|---|---|
| Calorific value | Coal logistics, Block performance, Heat absorption, Flue gas exit temp. (FEGT) |
| Water content | Coal logistics, Block performance, Fluid Dynamics at Burner, Flame stability, Exhaust gas temp., ESP Performance |
| Ash content | Coal logistics, block performance, Flame stability, Ash removal System |
| Ash composition | Fouling and Slagging, Eutectics, Erosions, Corrosions |
| Ash Softening Temperature | Fouling and Slagging at FEGT |
| Volatile components | Self ignition, Flame ignition, Milling process, Dust explosion, Mill explosion |
| S / Cl content | ESP Performance, High temp. corrosion, FGD, Gypsum quality |
| Grindability | Milling process, fines at Burners, Burnout |

# Impact of Fuel Properties to Power Plant Operation
(Matrix)

| | design and operation | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| characteristic values | coal transport | coal storage area | coaling | mills | burner | firing | ash-removal | air preheater | electric filter | desulphurisation | ash transport and storage | pollution | Σ |
| moisture | x | x | x | x | x | x | | x | x | x | | | 9 |
| ash | | | | | | | x | x | x | | x | x | 5 |
| ash composition | | | | x | | X | x | x | x | | x | x | 6 |
| volatiles | x | x | x | x | x | x | | | x | | | | 7 |
| sulphur | | | | x | | x | | x | x | x | | x | 6 |
| fixed carbon | | | | | x | x | | | | | | x | 3 |
| chlorine | | | | | | x | | | | | | | 1 |
| HGI | | | | x | x | x | | | | | | | 3 |
| size distribution | x | x | x | x | | X | | | | | | | 4 |
| NCV | x | x | x | x | x | | | | | | | | 5 |
| ash melting behaviour | | | | | | x | | | | | | | 1 |
| macerals | | | | x | x | x | | | x | | | | 4 |

Ø 4,5 ≈ 5

important coal quality parameters (moisture, ash, ash composition, volatiles, sulphur, NCV)

exception regulation (HGI)

# Fuel Handling & Storage

# Fuel Handling and Storage

## Transport

> Coals which tend to get hot during shipment should be avoided.

> The heating-up process will continue in the Stock pile or Silo

## Storage

### Coal Silo

> Blending of different coals is limited (last in, first out)

> Protected against sun and rain, no dust pollution

### Coal Yard

> Most common praxis for older plants and plants far from residential areas

> During unloading, the coarse parts roll down, which can cause undefined blending

## Handling

> For all storage solutions a FMS **(Fuel Management System)** is required in order to blend the coals if required

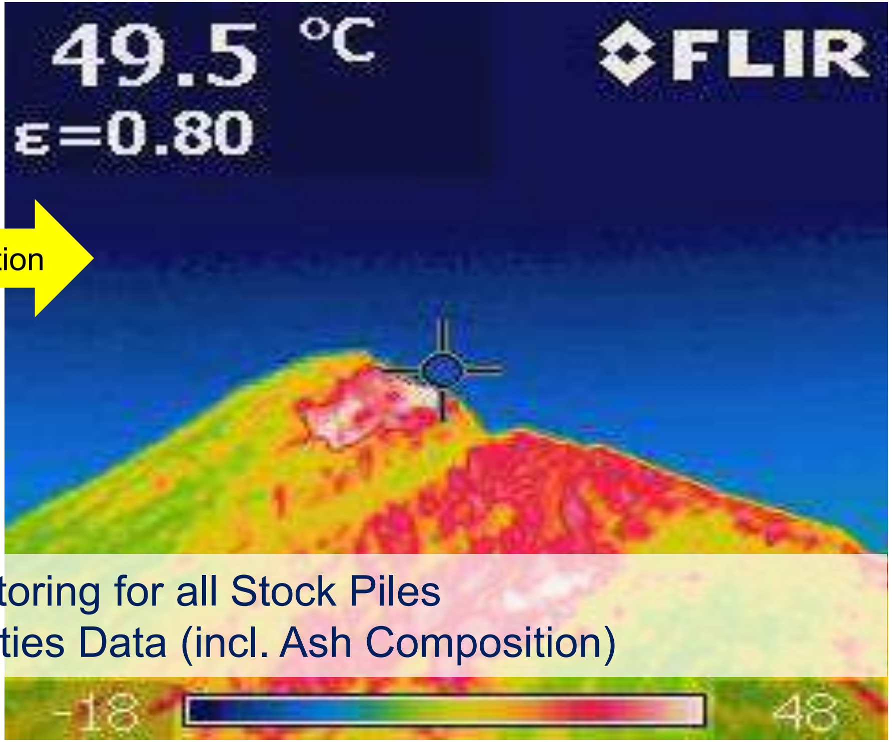
> Some SBC tend to **self ignition**. Therefore Temperature monitoring is required

> Area with a potential of **Dust explosion** must be cleaned frequently

# Stock Pile

## Smouldering Stock Pile after Fire Fighting

## Temperature Monitoring



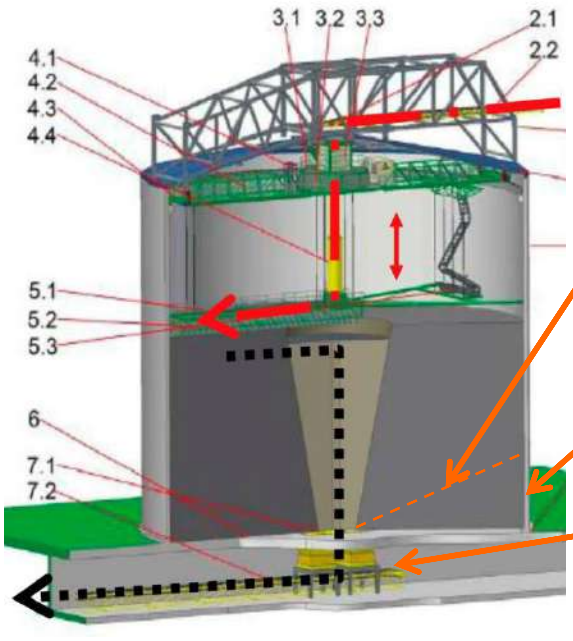

Prevention

→ RWE has installed Online Temperature Monitoring for all Stock Piles

→ FMS controls detail storage and Coal Properties Data (incl. Ash Composition)

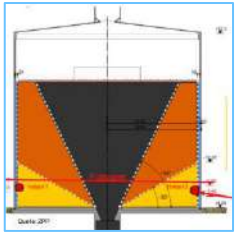
# Coal Silo - Problem Zones

## The following components encountered problems during operation:




### Slope angle < 36 °

Hotspots are created in the edge area up to approx. 2 m away from the silo wall, the area with the lowest compaction of the stored material
→ This creates sufficient cavities for volatiles and air for self ignition and smouldering fire



### Maintenance door (leaking frame)

Between the outer edges of the steel frame of the mounting door and the concrete was located around a clear air gap
→ Cause of smouldering fire

### Leaky flat slide

During a longer standstill a smouldering fire occurred by entering Oxygen in the discharge area
→ Cause of smouldering fire

*Source: Trianel*

# Lesson Learned

## Prevention

- Complete analysis of the process (operation and standstill)
- Rejecting high risk coals in an early stage
- Concepts for fire extinguishing
- Detection of potential areas of dust explosion
- Sensitizing the crew to the dangers and risks

## Solution

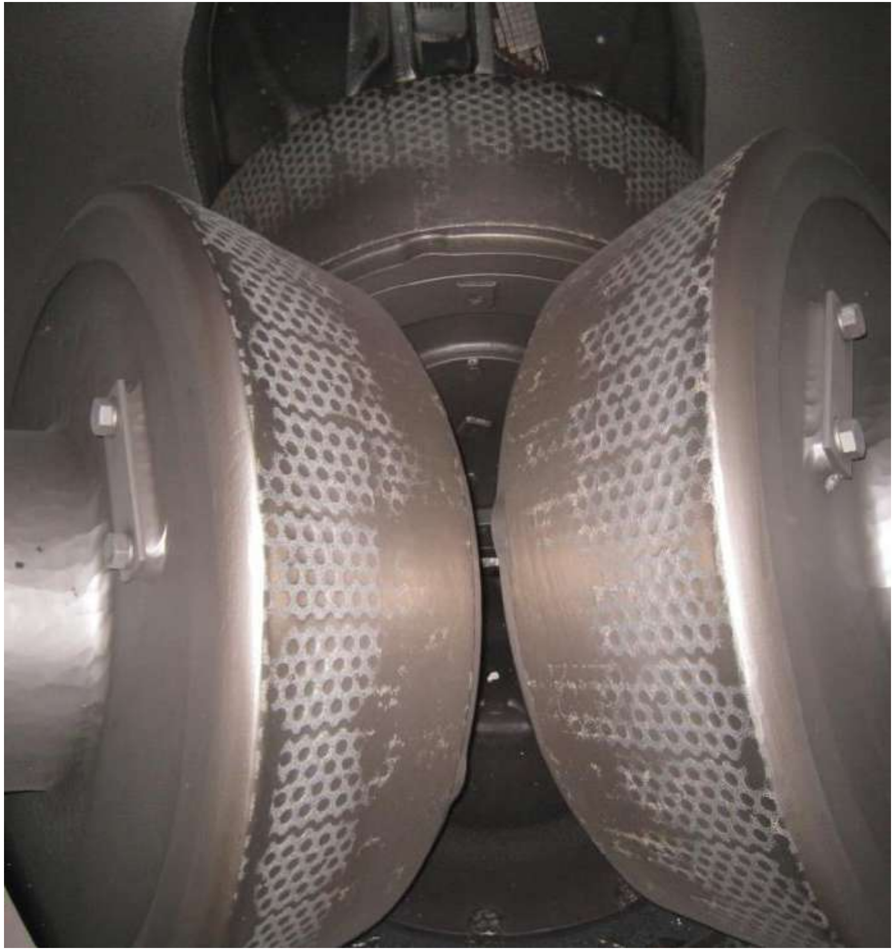
- Installing suitable early warning systems (software & hardware)
- Continuous monitoring of the determined problem zones
- Installing FMS and fire fighting systems
- inertisation with N2, separation of hazardous area
- Regular cleaning of areas with fine dust deposits
- Instructions and training the operation and maintenance staff

## Benefits

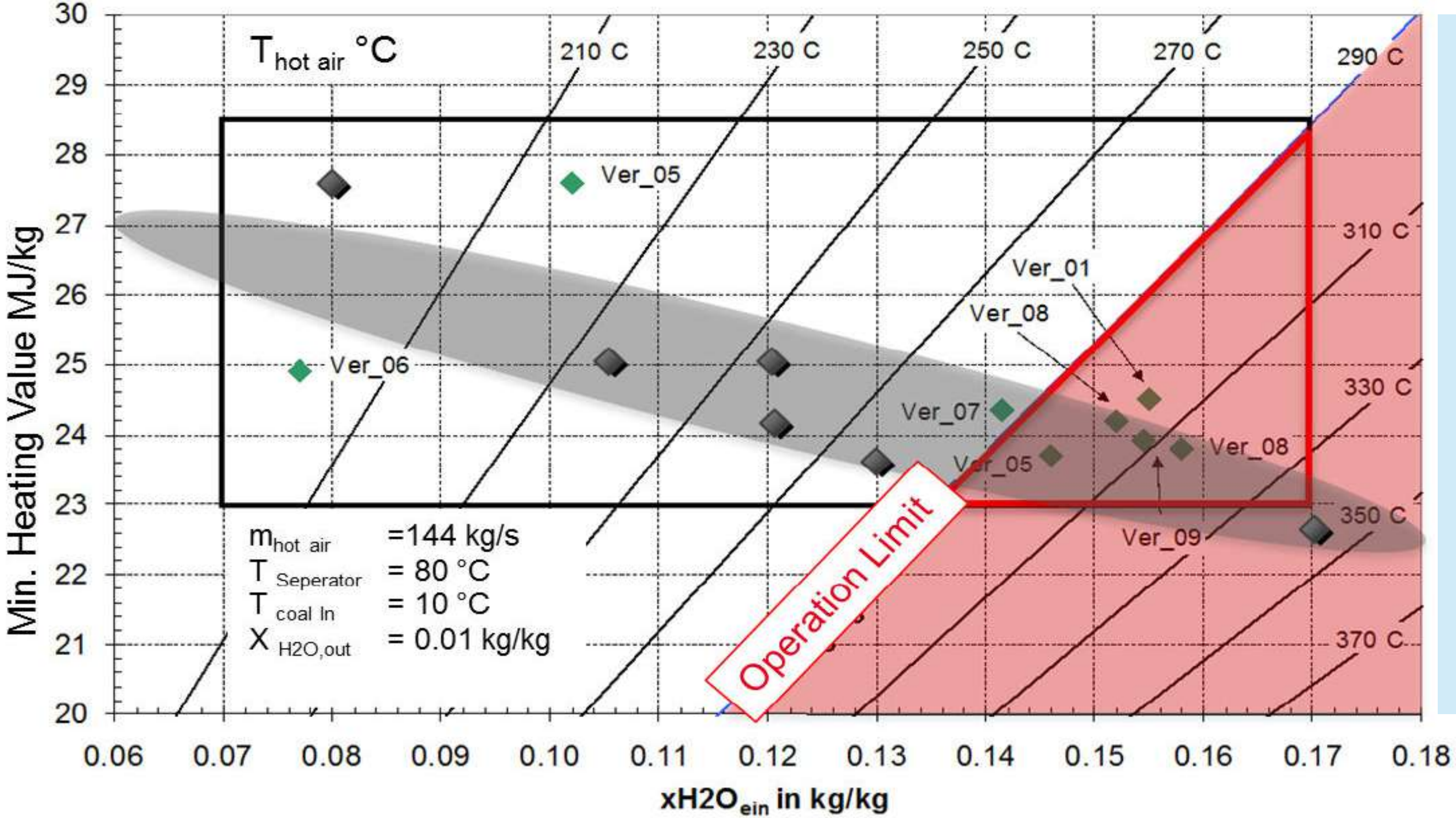
- Reducing the unforeseen outages and costs

→ Guideline to prevent smouldering and dust explosions for Coal Handling

# Milling Challenges



# When the Mill Design limit is exceeded




Moisture in Coal

no clear correlation, but tendency W ↑ then LCV↓

Operator must be aware about the incoming coal

→ Changing the operation parameter required

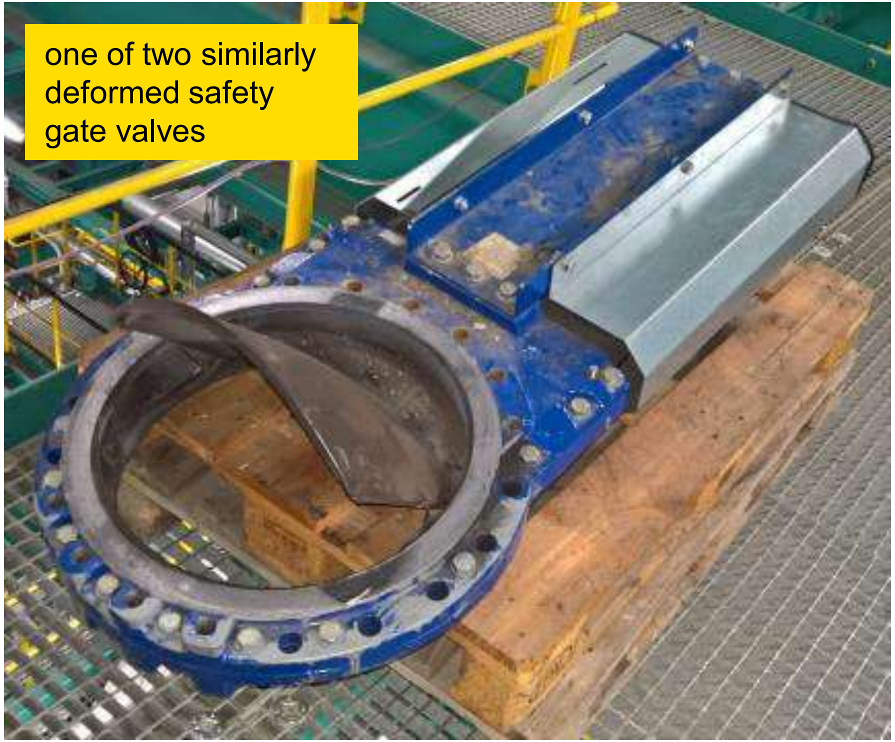
→ (e.g. reduction of the Separator temperature)

# Mill Damage during Operation

→ During operation with lower rank coal mill explosion happened

Elevator door pressed in

In close range mill 4 high heat radiation



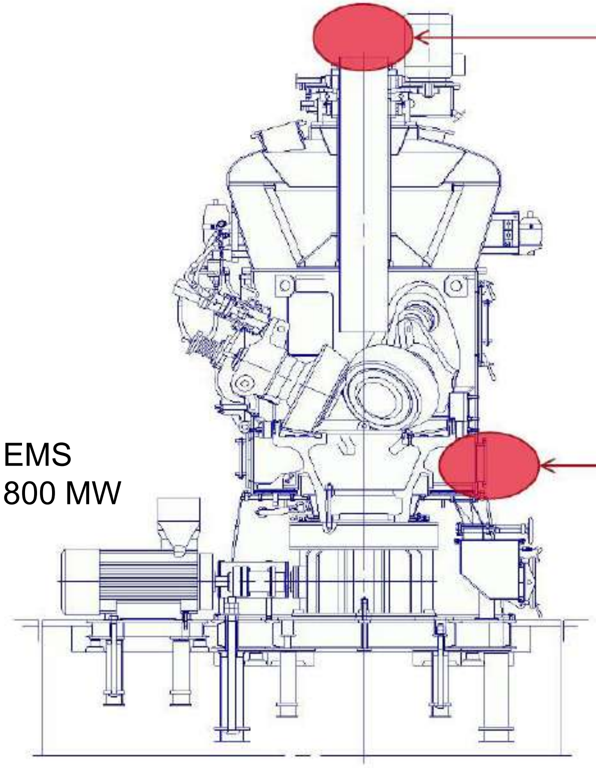
one of two similarly deformed safety gate valves

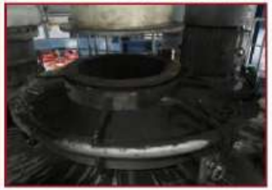
BK
608 MW

# Damage on mill by explosion at Standstill

→ After unforeseen outage 3 mill explosions happened in a time period of 45 min

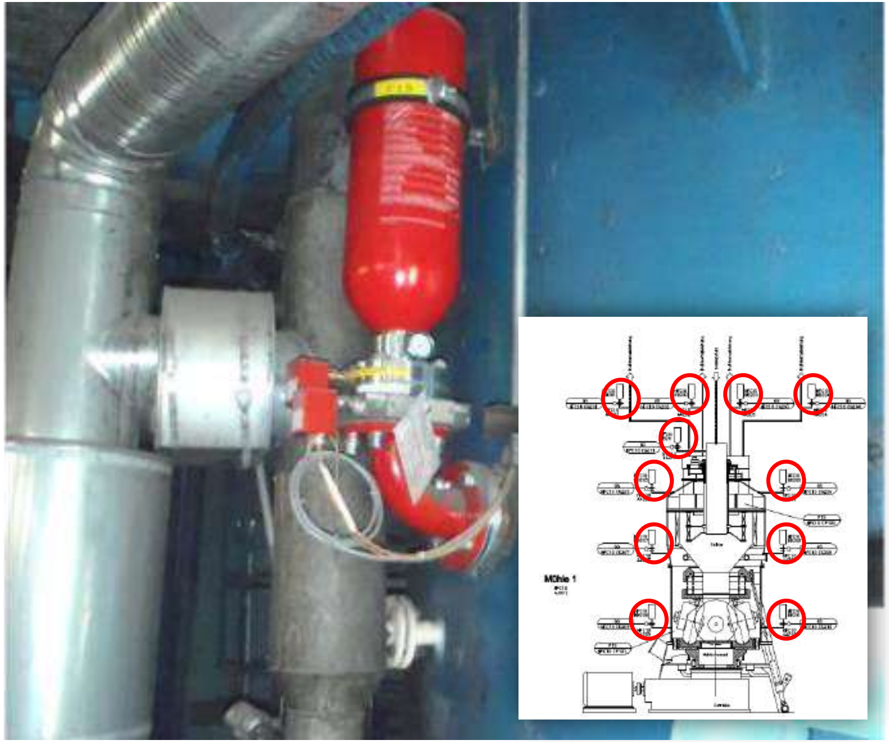
EMS
800 MW



# Explosion Suppression System at the Mills

→ Suppression Systems have been installed utilizing High Volatile Coals and Biomass



# Mill damage by foreign objects

→ Impurities in imported coal caused minor and major damaged in the mill (mostly Russian coal)

WES
800 MW

# Measures to avoid Mill Explosion

## Prevention

- Analysis of the process and re-calculation of the mills regarding incoming coals
- Rejecting high risk coals in an early stage
- Preparing a catalogue of the properties for the imported coals
- Sensitizing the crew to the dangers and risks

## Solution

- Continuous monitoring of the determined problem zones in the mill
- Avoiding coals with a volatile content over a certain value (e.g. 39%)
- Adapting the operation parameters to the particular coal (e.g. reduction classifier temp.)
- Sufficient steam injection after shut down of the mills
- Installing of fire fighting systems
- Detailed operation and maintenance Instructions
- Training the staff

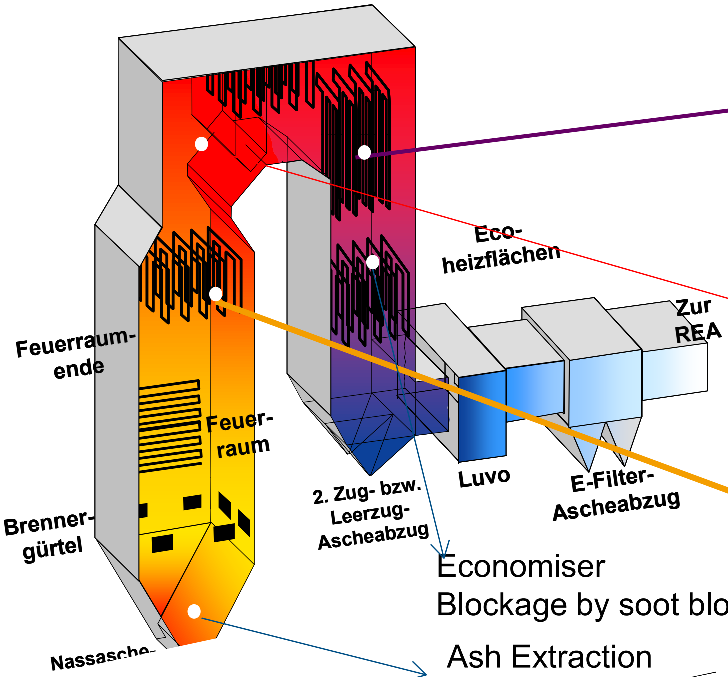
→ VGB Guideline has been created to prevent explosions in the coal mills

## Benefits

- Reduction of unforeseen outages and risk of human injuries.

# Combustion and Furnace

# Fouling and Slagging is a major Issue



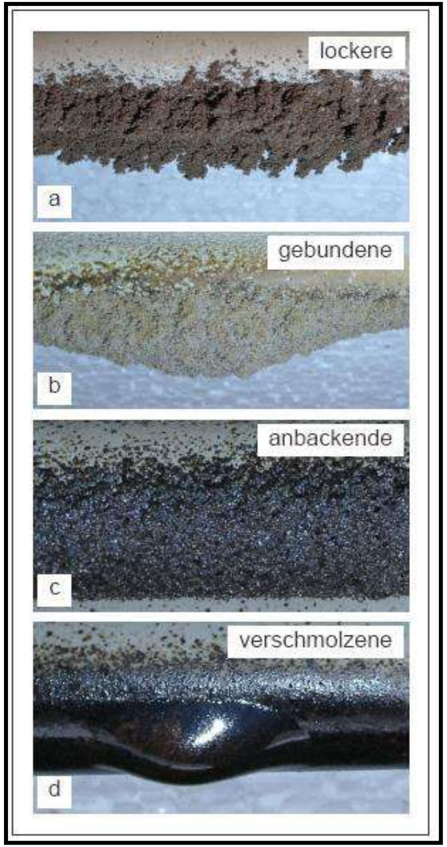

Fouling Zone

Sintering Zone

Slagging Zone

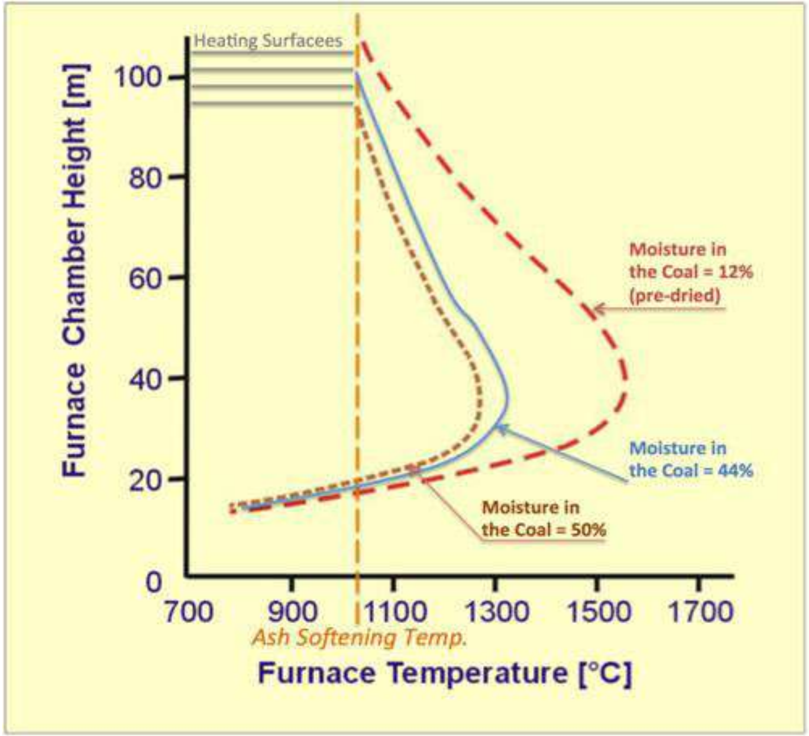
Economiser
Blockage by soot blowing

Ash Extraction
blockage




→ Determining Flowing transitions in the formation of deposits

# Furnace Temperature Distribution and FEGT
## (Example Moisture)




### Sintering at the first Heating Surface


→ The FEGT must be kept bellow the Ash Softening Temperature

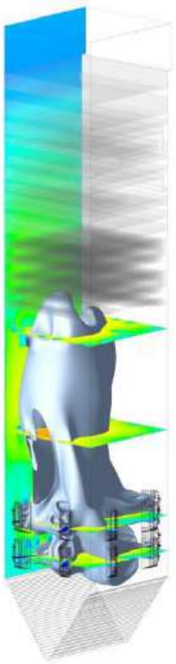
# ISO-Thermal surface of 1100 °C in the Furnace

## (Retrofit of a 600 $MW_e$ unit based of CFD Calculations)

**FEGT > Ash Softening Point = 1100°C**

**FEGT << Ash Softening Point = 1100°C**

**Before retrofit**



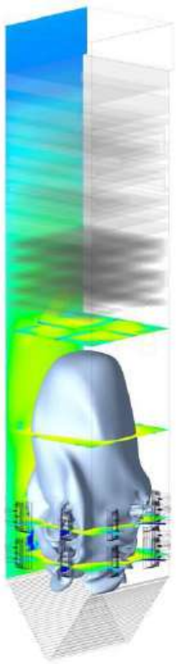
**Heating Surface**
**OFA Level 2**

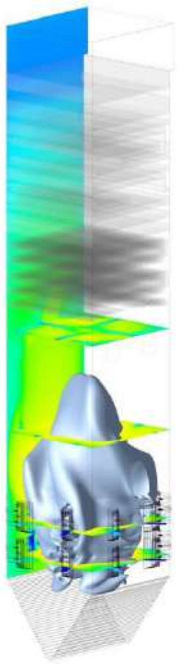
**OFA Level 1**

**Burner Level 1**

**Burner Level 2**

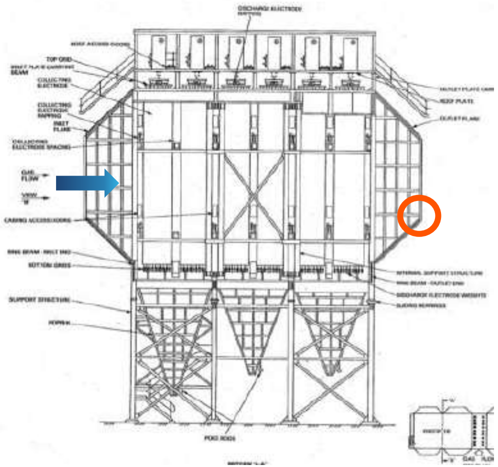
**After Burner retrofit**

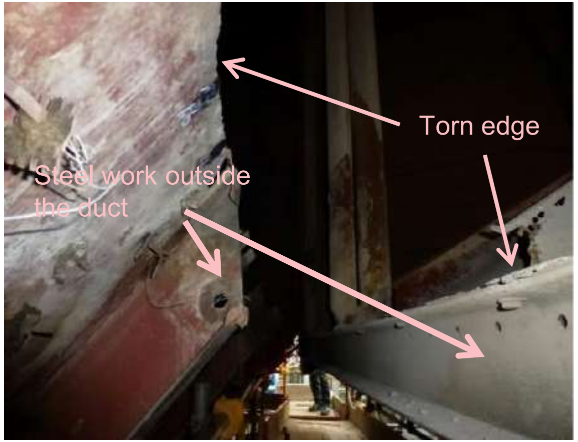


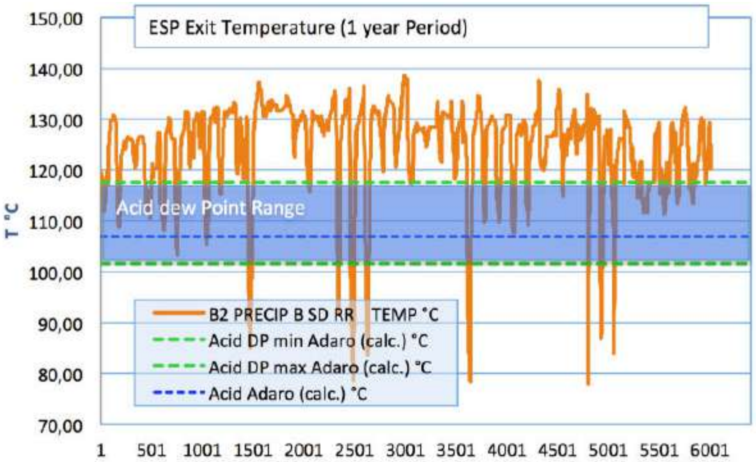


# Brief Case Studies

# ESP Corrosion
## (700 $MW_e$ Hard Coal Plant, South China)

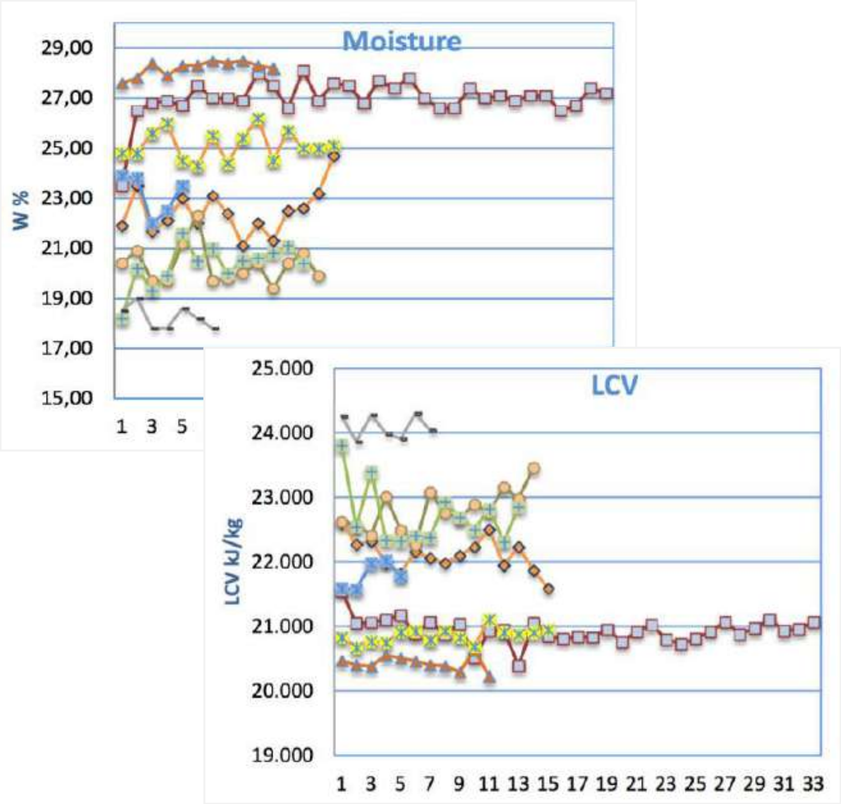





→ **Due to combustion of particular imported coals the flue gas temp. is critically close to the acid dew point and in some periods bellow it**

# Improved Operation of thermal fleet




## Snapshot

| Client | Location |
|---|---|
| Chinese Power Utility | South China |

### Challenge

RWE-TI carried out several consultancy services, aiming solve combustion and O&M problems

### Solution

Complete analysis of the fuels, combustion process, operation data and installations. Optimization the of O&M process

### Benefits

The proposed optimization measures allowed to avoid unforeseen outages when utilizing a wider range of coals

# Improved combustion of a thermal fleet

## Snapshot

| Client | Location |
| --- | --- |
| Malakoff Corporation Berhad | Malaysia |

### Challenge

For one of the leading IWPP companies in South-East Asia, RWE-TI carried out several consultancy services, aiming to boost efficiency of their existing coal-fired power plants.

### Solution

This included complete analysis of the combustion system, processes and adjacent installations. We focused on the design and operational performance data.

### Benefits

The proposed optimization measures allowed for longer outage intervals and utilizing a wider range of coals.

# Thank you very much for your attention

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