Modernization and Optimization of Flue Gas Cleaning Plants

Solutions for Air Pollution Control Upgrades following BAT revision in 2017

Speakers:
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Dr. Axel Thielmann (Department Manager Proposals Flue Gas Cleaning)




Employment Record Dr. Stefan Binkowski

2013 - present	Steinmüller Engineering GmbH, Gummersbach, Germany Engineering and Supplies for Power Plants Department Manager Flue Gas Cleaning Process
2009 - 2013	Steinmüller Engineering GmbH, Gummersbach, Germany Engineering and Supplies for Power Plants Head of Flue Gas Desulphurization Department
2005 - 2009	Steinmüller Engineering GmbH, Gummersbach, Germany Engineering and Supplies for Power Plants Process Engineer Flue Gas Cleaning
2001 - 2005	Universität Dortmund, Germany Lehrstuhl Umwelttechnik, Fachbereich Chemietechnik, Dr.-Ing. (PhD)

Employment Record Dr. Axel Thielmann

2015 - present	Steinmüller Engineering GmbH, Gummersbach, Germany Engineering and Supplies for Power Plants Department Manager Proposals Flue Gas Cleaning
2013 - 2014	Steinmüller Engineering GmbH, Gummersbach, Germany Engineering and Supplies for Power Plants Project Manager Sales & Marketing and Business Development
2009 - 2012	Siemens AG, Erlangen, Germany Services and Supplies for Power Plants Project Manager HRSG Inspection Program
2006 - 2008	Siemens AG, Berlin, Germany Services and Supplies for Power Plants Project Manager Modernizations of Gas Turbines
2001 - 2005	Max-Planck-Institute for Chemistry, Mainz, Germany Biogeochemistry Department Project Manager Airborne Sampling Campaigns
1997 - 2000	ETH Zürich, Switzerland Institute for Atmospheric and Climate Science PhD Thesis about Ozone Formation in Urban Environments

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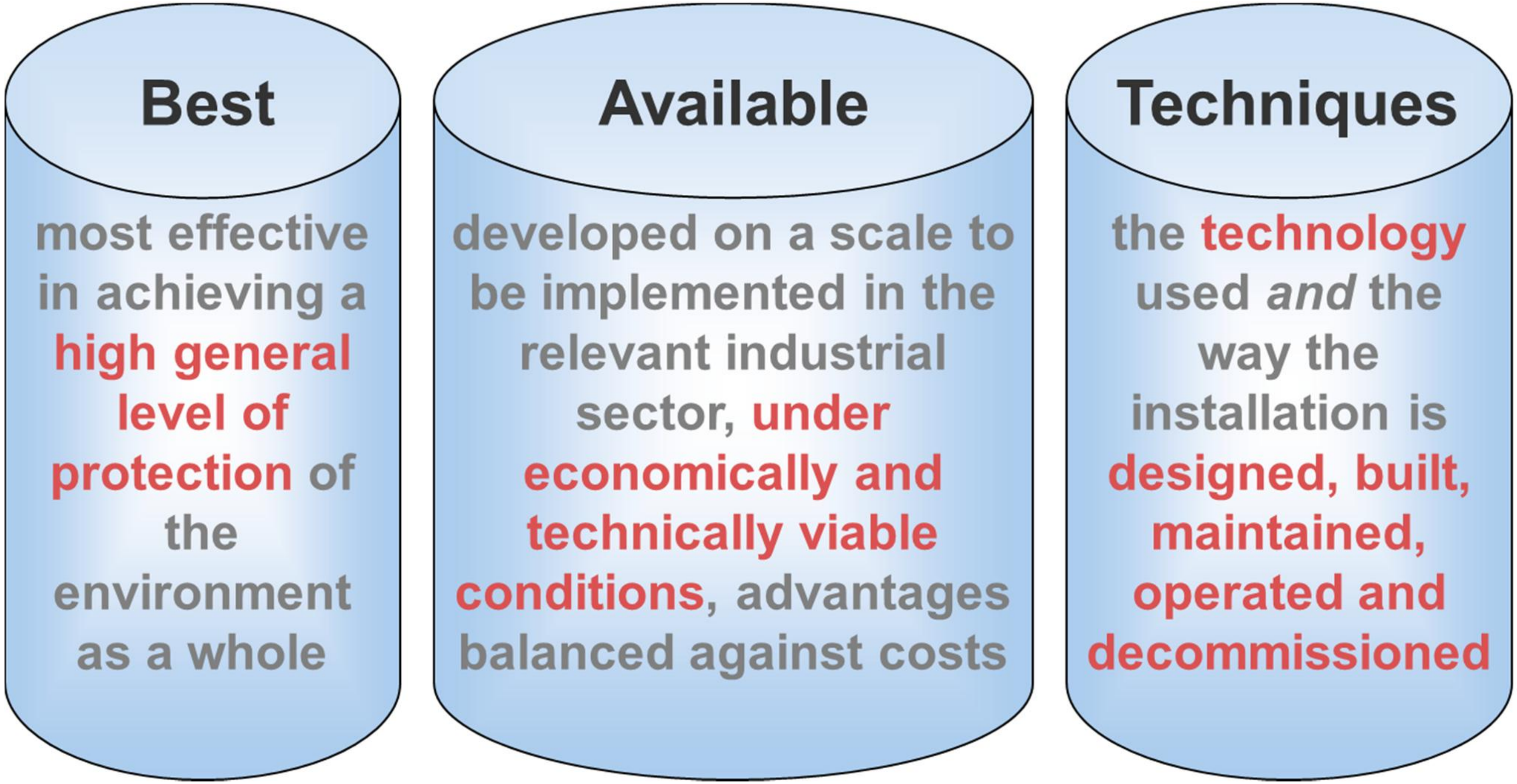
Industrial Emissions Directive – Rationale



BAT: Best Available Techniques
BREF: BAT REFerence Document

Industrial Emissions Directive – BAT and BREF

BREF 2017: Emission Limit Values (ELVs) under discussion for existing Large Combustion Plants (LCPs) ≥ 300 MWth

	Current IED	BAT Yearly[1]	BAT Daily[1]	BREF 2017[2]	China 2020[3]
NOx [mg/Nm³]	200	65-175	85-220	150	50
PM [mg/Nm³]	20	2-10	2-10	10	5
SO_2 [mg/Nm³]	200	10-180	25-220	130	35
HF, HCl [mg/Nm³]	---	1-5	---		
Hg [µg/Nm³]	---	1-3 (hard coal) 1-7 (lignite)	---		

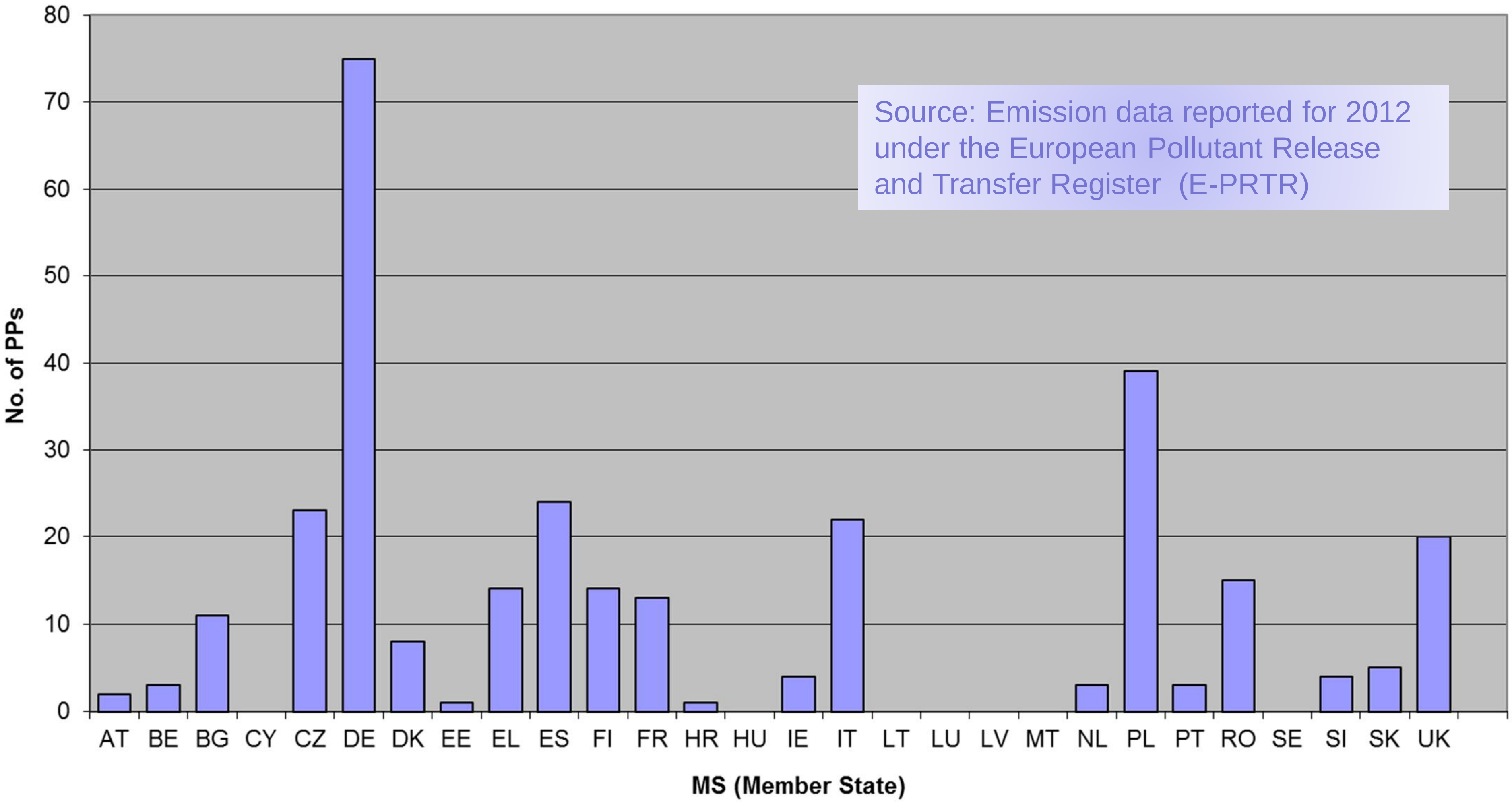
1: Rolf Becks, Umweltbundesamt (German "Environmental Protection Agency"), during the 11th "VGB-Fachkonferenz REA-, SCR- und Entstaubungsanlagen in Großkraftwerken" 25./26. November 2015

2: expected new ELVs in the European Union

3: ELVs required in the 13th Five Year Plan 2015-2020

Industrial Emissions Directive – Affected Power Plants

Potentially all Power Plants in the EU (≥ 300 MWth, > 90% solid fuels) will require Air Pollution Control Equipment Upgrades due to the BREF 2017



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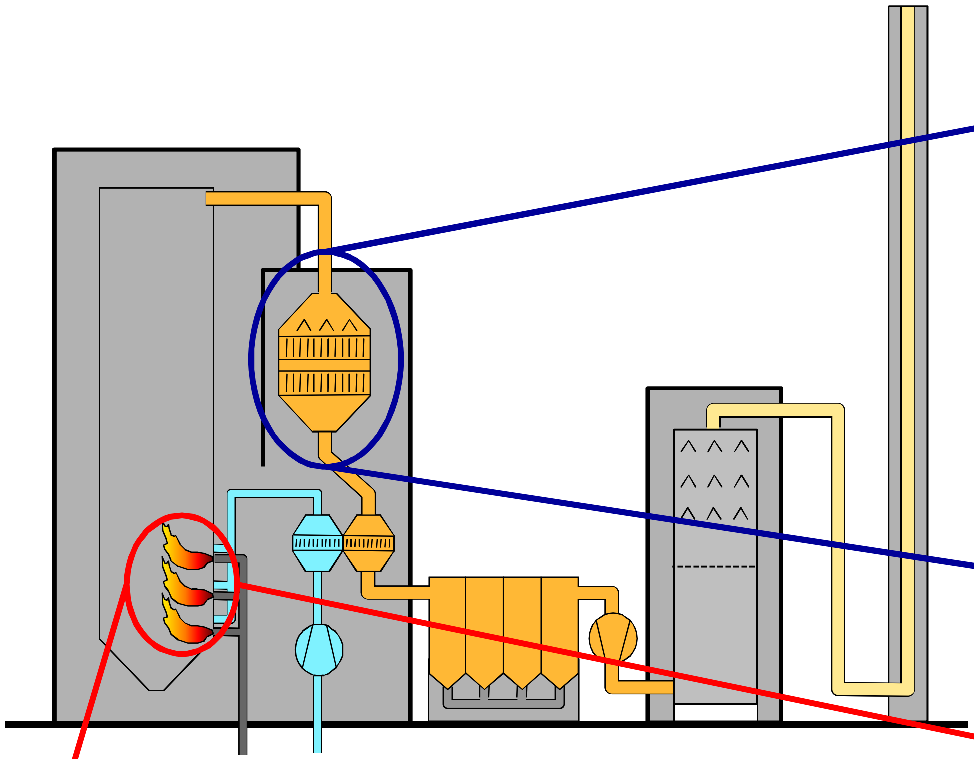
DeNOx – Steinmüller Product Range



Secondary Measures:

- SCR retrofits and upgrades
- SNCR systems
- Adaption of heating surfaces following SCR retrofits

Primary Measures:

- Replacement or modifications of burners to Low-NOx-Burners
- Installation of Over-Fire-Air ports
- Optimization of air supply / air ratio
- Adaption of coal mills

DeNOx – Shell Wesseling

Reference project key data

- Location Wesseling (near to Cologne) / Germany
- Refinery with fuel oil fired Boiler (unit 6)
- Boiler capacity 200 $MW_{therm.}$
- Flue gas volume flow 192.000 Nm^3_{wet}/h
- Flue gas temperature 325 °C
  (downstream of air preheater)
- NOx Emission after boiler 570 mg/Nm^3
- Firing of HFO / Cracker residue (HHVR) / off-gas

DeNOx – Shell Wesseling

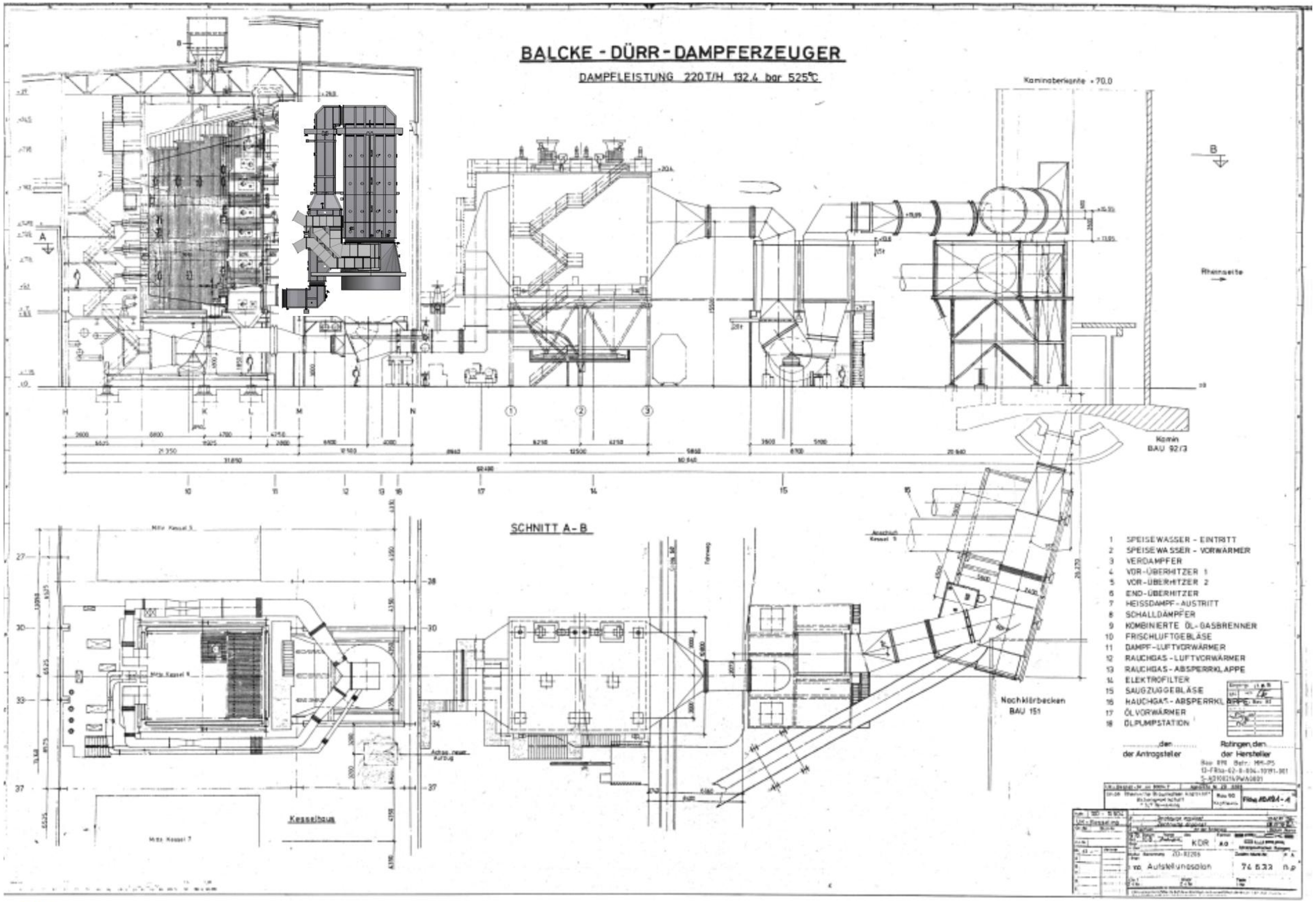
Shell Wesseling requirements:

- NOx less than 140 mg/Nm³ @ 3 % O_2,dry
- NH_3 slip less than 1 mg/Nm³ @ 3 % O_2,dry

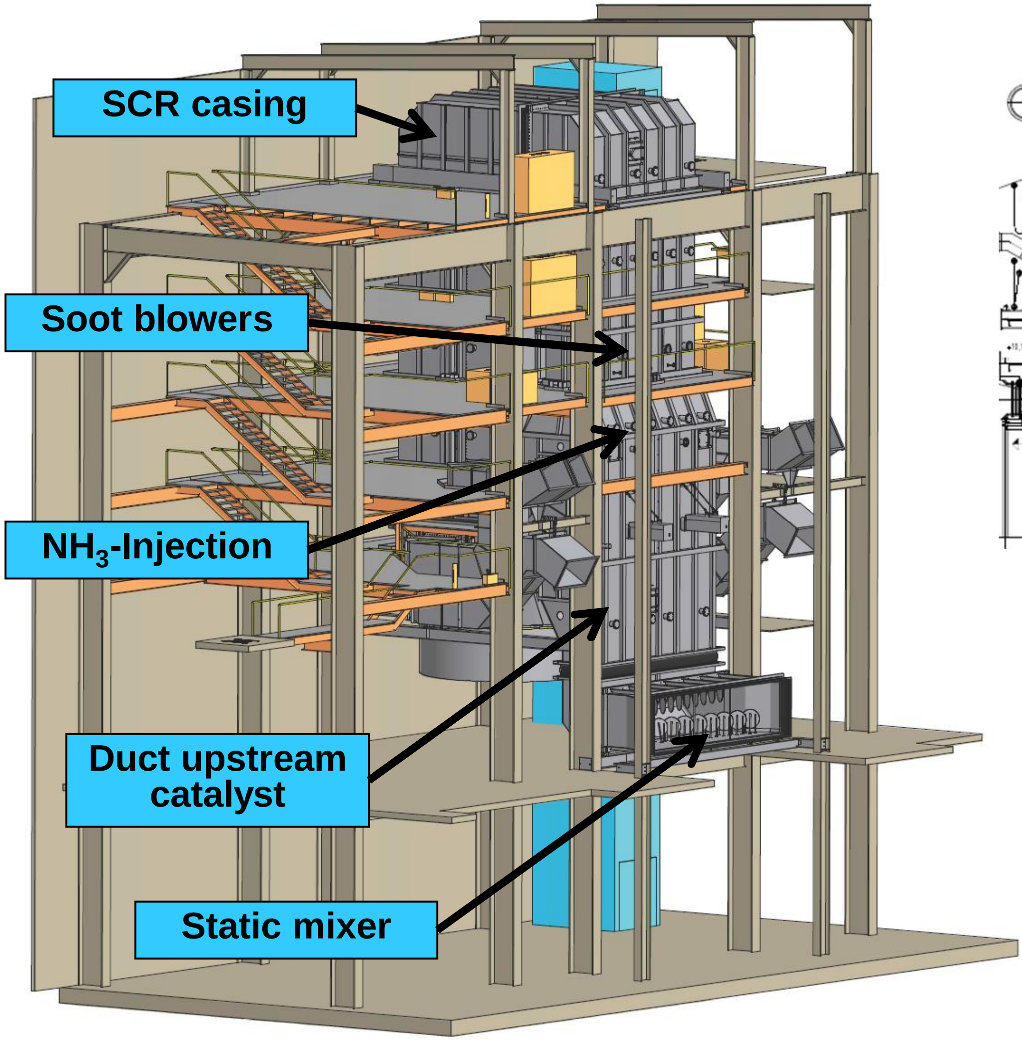
Steinmüller scope:

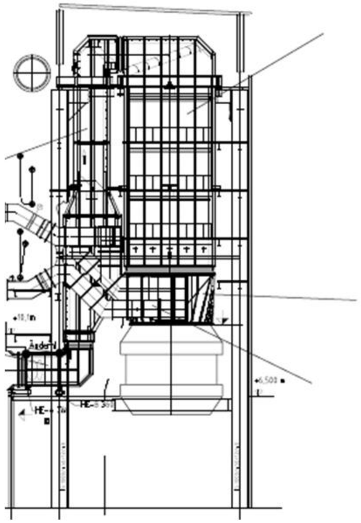
- Engineering and Supply of new low NOx burners
- Engineering and Supply of SCR DeNOx
  (consortium with Balcke Dürr for erection)
- Engineering of boiler heating surface modifications
  (as sub-supplier to Balcke Dürr)

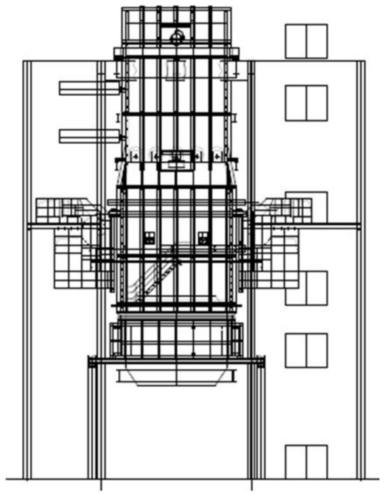
DeNOx – Shell Wesseling - Implementation



DeNOx – Shell Wesseling - Steinmüller Scope







DeNOx – Shell Wesseling - Modification of Pressure Part of Boiler 6

Technical Data:

Steam data	200 t/h
Max. operation pressure	132,4 bar
Test pressure (1.2 x 132.4 bar)	159 bar
Superheated steam temperature	525 °C
Year of construction	1978

Heating surfaces:

ECO I:	564 m²
ECO II:	542 m²
Natural circulation system:	1243 m²
Superheater sling tube	173 m²
Pre-Superheater 1	1187 m²
Pre-Superheater 2	522 m²
Final Superheater	249 m²
Total:	4480 m²

DeNOx – Shell Wesseling - Customer Benefits

- Integrated design (modification of heating surface and temperature window for SCR) for all load cases
- LowNOx burner design + SCR allows:
  - Cost benefit analysis of primary and secondary measures
    → Lower investment and operational costs
  - Reduction of interfaces
    → Easier contracting and handling of guarantees
- Construction and erection in existing plant with limited space
- Burners for special applications (HFO, HHVR, off-gas)

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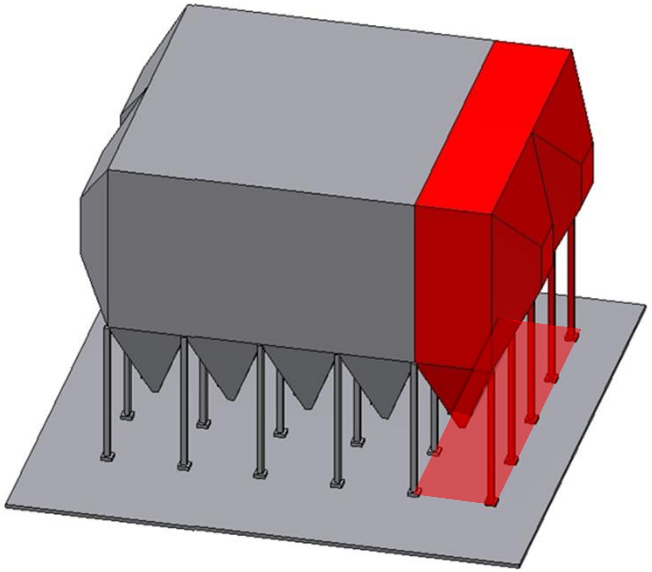
ESPs – Upgrade Possibilities

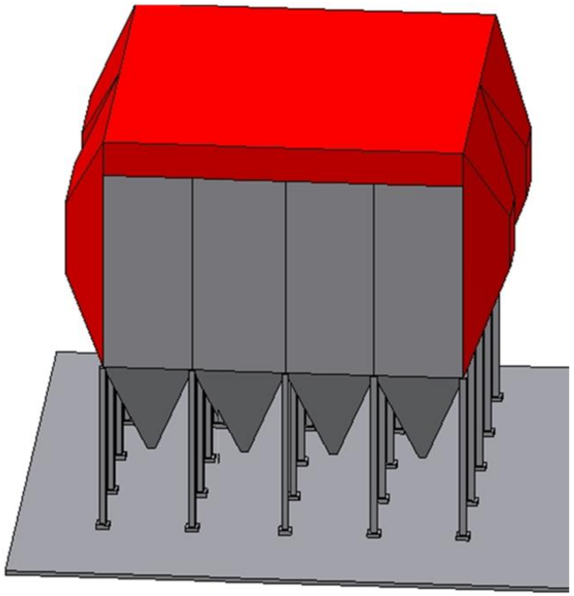
Measures I

- Additional ESP field OR higher ESP casing
- Adapted ESP lane width

  → Reduced flue gas velocity and hence higher dust removal efficiency

- Deployment of modern 3-phase high voltage aggregates
- Adapted high voltage control



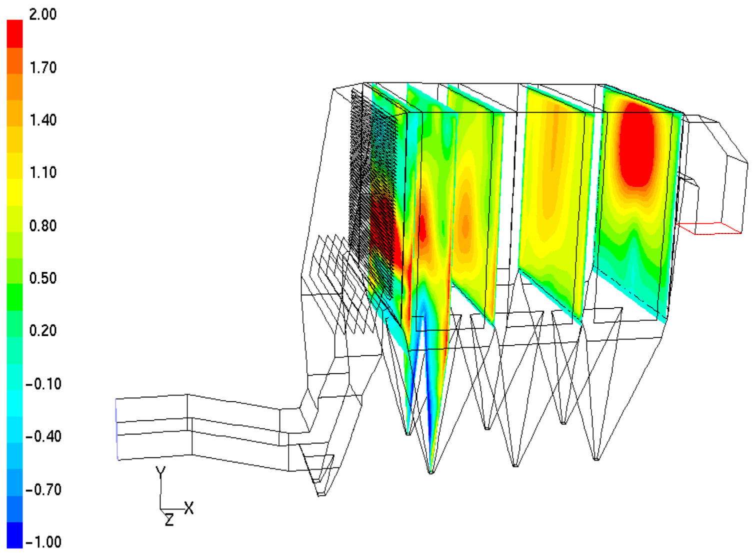


ESPs – Upgrade Possibilities

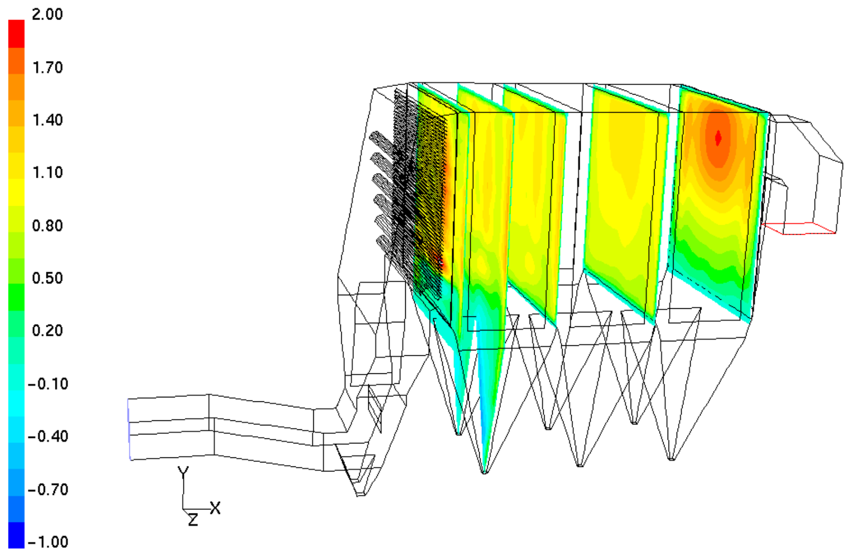
Measures II

- Primary removal of coarse particles in the inlet hood
- Homogenization of flue gas velocity distribution

Before



After



ESPs – Example: CET Govora

- Power plant CET Govora, 7 Units of 380 MWth
  - Flue gas volume flow: 1.024.000 m³/h
  - Dust load (raw gas): 70.000 mg/Nm³ @ 6% O_2
  - Clean gas before retrofit: > 200 mg/Nm³ @ 6% O_2
  - Clean gas after retrofit: < 50 mg/Nm³ @ 6% O_2
  - Pressure loss improvement: - 30 Pa (0,3 mbar)

- Revamp of 2 existing ESP casings
  - Including Engineering and Supply of steel components
  - Reduce dust emission < 50 mg/Nm³
- New ESP-design (roof) whilst maintaining original footprint and creating a reduction in pressure loss
- Reduction of dust emission from 280 mg/Nm³ to below 30 mg/Nm³

ESPs – Example: CET Govora - Implementation

ESPs – Customer Benefits

- Reduction of dust emissions < 10 mg/Nm³
- Upgrade possible whilst maintaining original footprint and weight (SE low weight ESP-roof)
- Reduction in pressure loss (adapted ESP lane width & ESP hoods)
- Power savings (modern high voltage aggregates & control)
- Robust design

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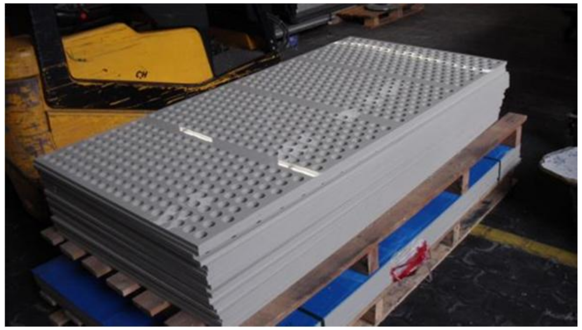
FGD – Upgrade Possibilities

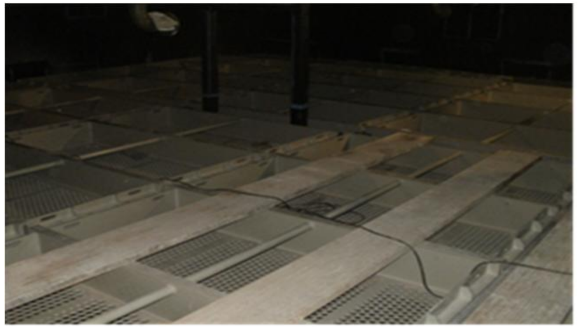
- Optimizing gas flow distribution and gas-liquid contact
  - Nozzle type and nozzle arrangement
  - Wall rings
  - Tray
  - CFD analysis
- Optimizing FGD operation
  - Limestone quality, injection point
  - Oxidation air system
  - Liquid level
  - Number of operated pumps
  - pH value
- Combination of above mentioned measures

FGD – Tray Basket Elements

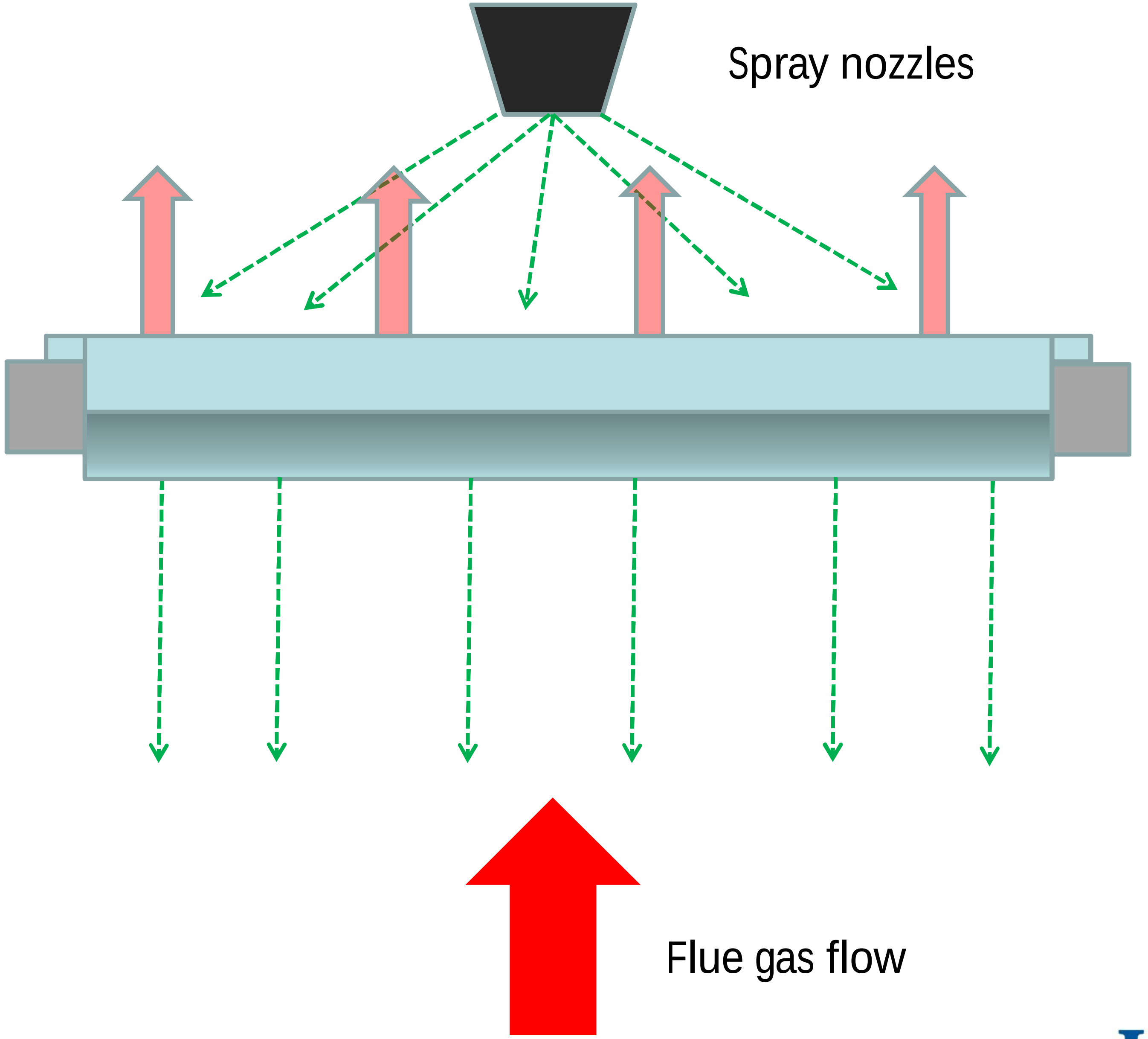
Steinmüller Engineering "tray basket elements"

- Material: poly propylene with reinforcement
- Standardized modular basket design
- Easily combined to cover the whole cross section
- Project specific variation of hole size and arrangement
- Convenient working platform when covered with planking
- Different absorber shapes can be covered



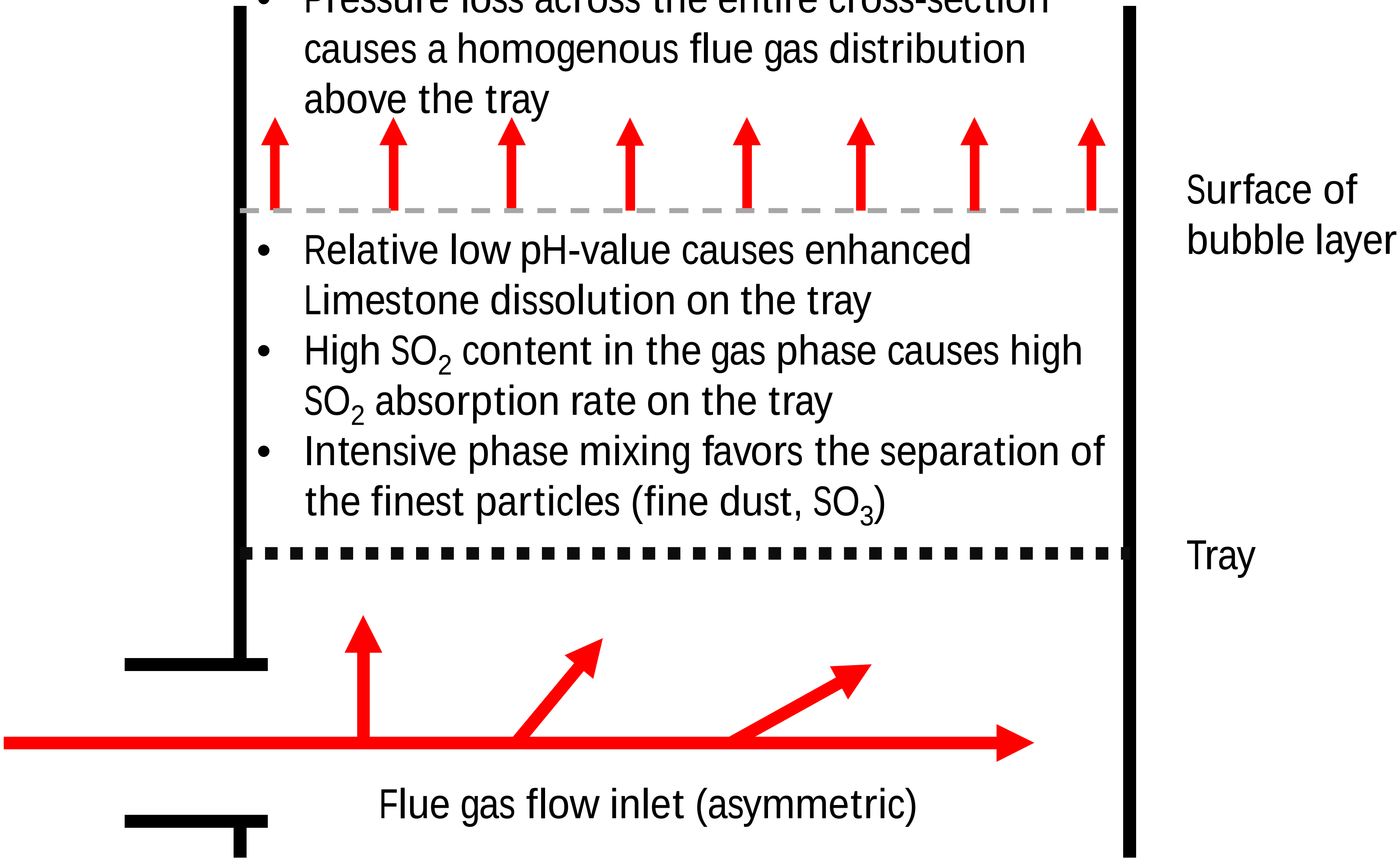


FGD – General Functional Principle of the Tray



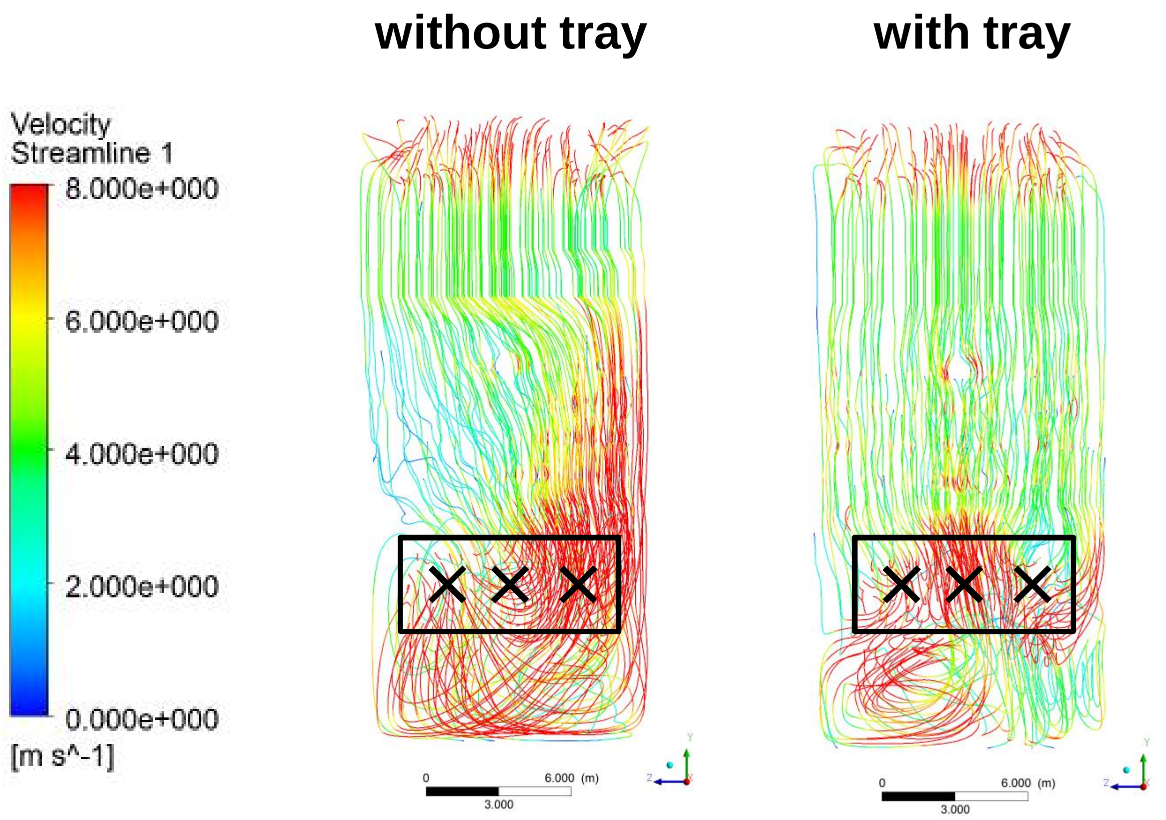
FGD – General Functional Principle of the Tray

- Pressure loss across the entire cross-section causes a homogenous flue gas distribution above the tray
- Relative low pH-value causes enhanced Limestone dissolution on the tray
- High SO_2 content in the gas phase causes high SO_2 absorption rate on the tray
- Intensive phase mixing favors the separation of the finest particles (fine dust, SO_3)



FGD – Flue Gas Velocity Distribution

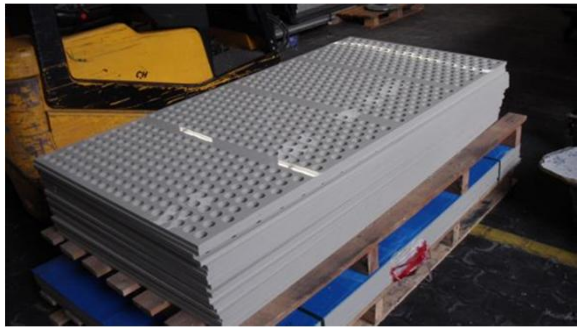
- Nearly homogeneous flue gas flow in the absorption zone by implementation of a tray
- More effective SO_2 separation by the spray layers

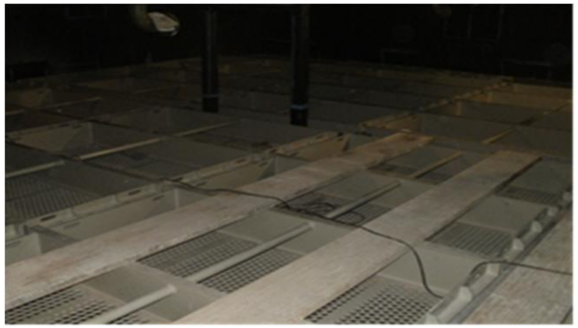


FGD – Tray Basket Elements

Steinmüller Engineering "tray basket elements"

- Establish a bubbling layer → liquid contact layer
- Enlarged contact surface
- Increase removal efficiency of SO_2, SO_3, Dust
- Influence on the removal efficiency comparable to one spray level
- More equal gas distribution
- Increase limestone utilization
- Reduce residual limestone in gypsum
- Increase oxidation of sulfite
- Reduce mercury re-emission



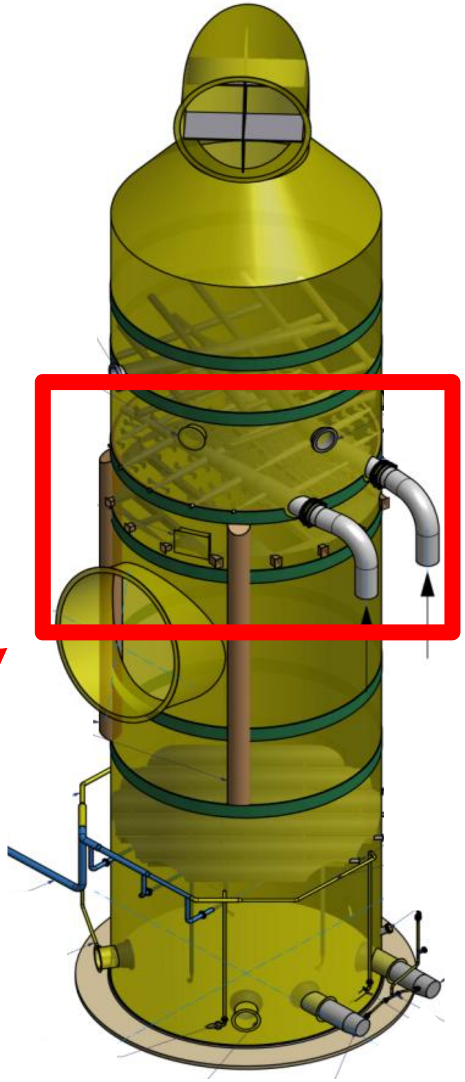


FGD – Tray Revamp: References

Location	Fuel	Volume flow [Nm^3/h]	Original removal rate	Removal rate after Revamp
Völklingen (HKV)	Hard Coal	800.000	88 %	94 %
Völklingen (MKV)	Hard Coal	600.000	87 %	94 %
Deuben	Lignite	625.000	95 %	98 %
Novaky	Lignite	1.250.000	96 %	98 %
Herten	Waste	60.000	90 %	96 %

FGD – Tray Revamp: Example Deuben

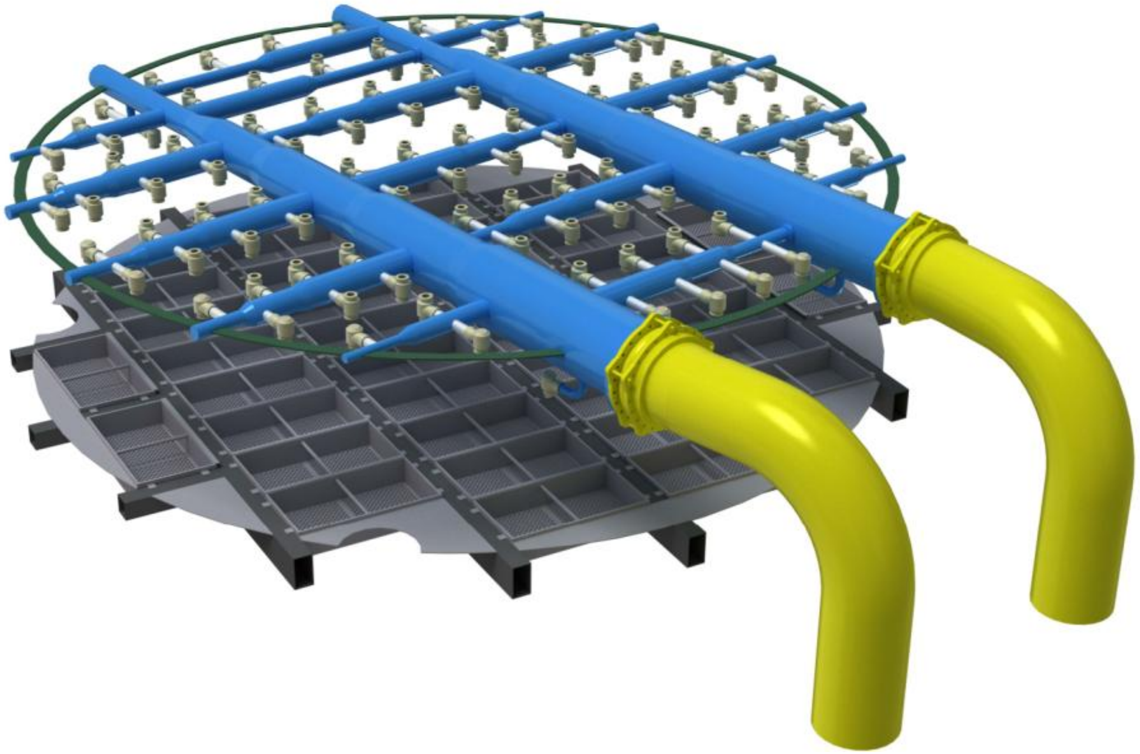
- SO_2 content in raw gas:
  7.600 mg/Nm^2 → 8.200 mg/Nm^3 (6% O_2)
- SO_2 content in raw gas:
  380 mg/Nm^3 → < 230 mg/Nm^3
- Max. flue gas flow:
  625.000 Nm^3/h (wet)
- No additives (e.g. adipic acid)

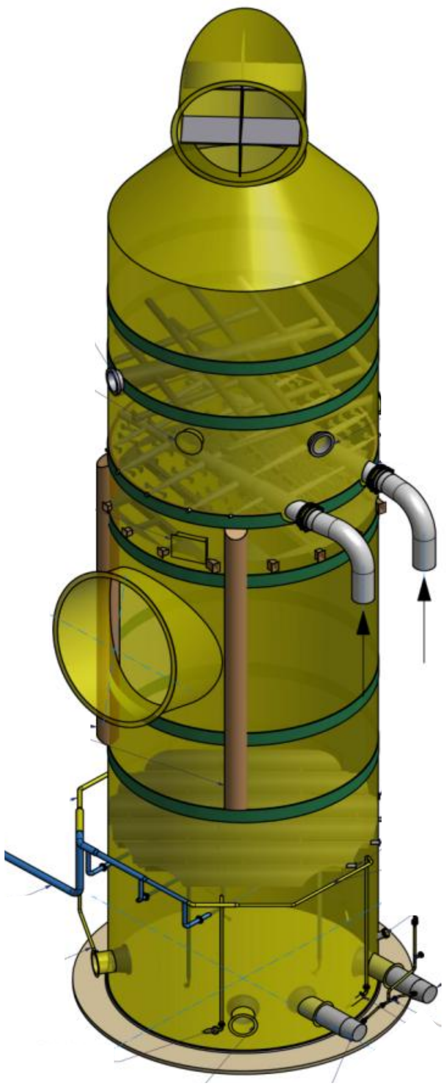


Combine first and second spray level
to create space for tray installation

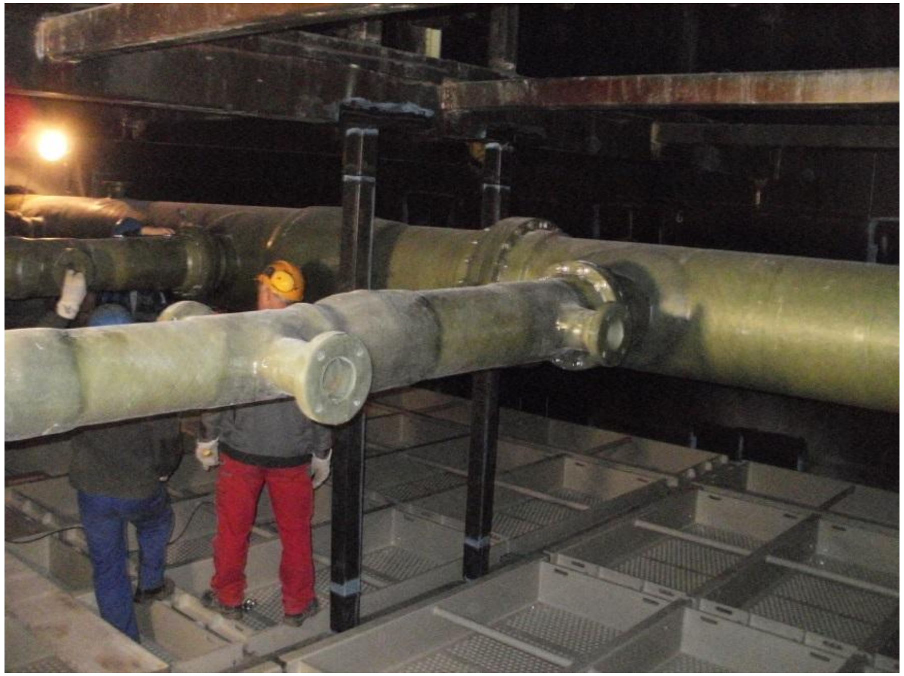
FGD – Tray Revamp: Example Deuben

- Install Tray modules at support of former 1st level
- Installation time: 231 hours





FGD – Tray Revamp: Installation



FGD – Tray Revamp: Advantages and Disadvantages

Influences	With Tray
SO_2 / SO_3 separation rate	Increase of the separation rate
Pressure loss	Increase of the pressure loss 0 - 6 mbar
Power consumption at constant separation rate (i.e. 5 spray levels without a tray vs. 4 spray levels with tray)	Recirculation pumps: less power consumption Booster fan: more power consumption
Limestone utilization factor	Slight increase by about 1 %, i.e. slight decrease of limestone consumption
Flue gas velocity distribution	Homogeneous flue gas distribution after the tray
Dust separation	Reducing of the residual dust content
Oxidation of Sulfite and Mercury	Increase oxidation of sulfite (less deposits), increase oxidation of mercury (less re-emission)

FGD – Tray Revamp: Pressure Loss

- New coal quality; SO_2 increase: 10.000 mg/Nm³ → 14.500 mg/Nm³ (6% O_2)
- New emission limit value: < 400 mg/Nm³ → < 200 mg/Nm³
- Constant pressure loss: → Δp = constant
- Maximum flue gas flow: → 1.400.000 Nm³/h (wet)
- No additives (e.g. adipic acid)

- Installation of tray level increases pressure loss
- Full compensation of pressure loss by:
  - Reduction of the spray levels
    (also save power for 1 recycle pump)
  - Use of other nozzle types
  - Modification of mist eliminator

Guarantee: No additional pressure loss for overall system !

FGD – Tray Revamp: Customer Benefits

Steinmüller Engineering offers customized FGD upgrades for:

- Lower emission limit values for SO_2, SO_3, Dust (IED 75/2010 & BREF)
- Changing fuel range (e.g. higher S-content of coals)
- Cost savings I (e.g. pump power)
- Cost savings II (lower maintenance expenditures, shorter outage times)
- Complete system from one source
  - Less interfaces
  - SE has the process know-how and the contacts to sub-supplier → best interaction

FGD – Tray Revamp: Savings on OPEX Example

- Cost savings by less power consumption (savings recirculation pumps minus booster fan upgrade):
  - 300.000 – 500.000 €/a
- Cost savings by less limestone consumption:
  - 50.000 – 90.000 €/a
- Cost savings by scaffolding in the lower part of the absorbers:
  - ca. 50.000 €/revision

- Total operational cost savings for two absorbers (2x 1,7 Mio. m^3/h)
  → approx. 500.000 €/a

Content

Summary

Our Solutions for Air Pollution Control Upgrades

- Meeting of emission limit requirements in answer to IED & BREF
- Balancing (CAPEX & OPEX) between primary and secondary APC upgrades
- Integrated plant solutions
- Reducing interfaces
- Best combination of qualified equipment sub-suppliers
- Cost savings
- Additional SCR experience through IHI (e.g. mercury oxidation)

We will find the best solution for your plant together !

Thank you for your attention