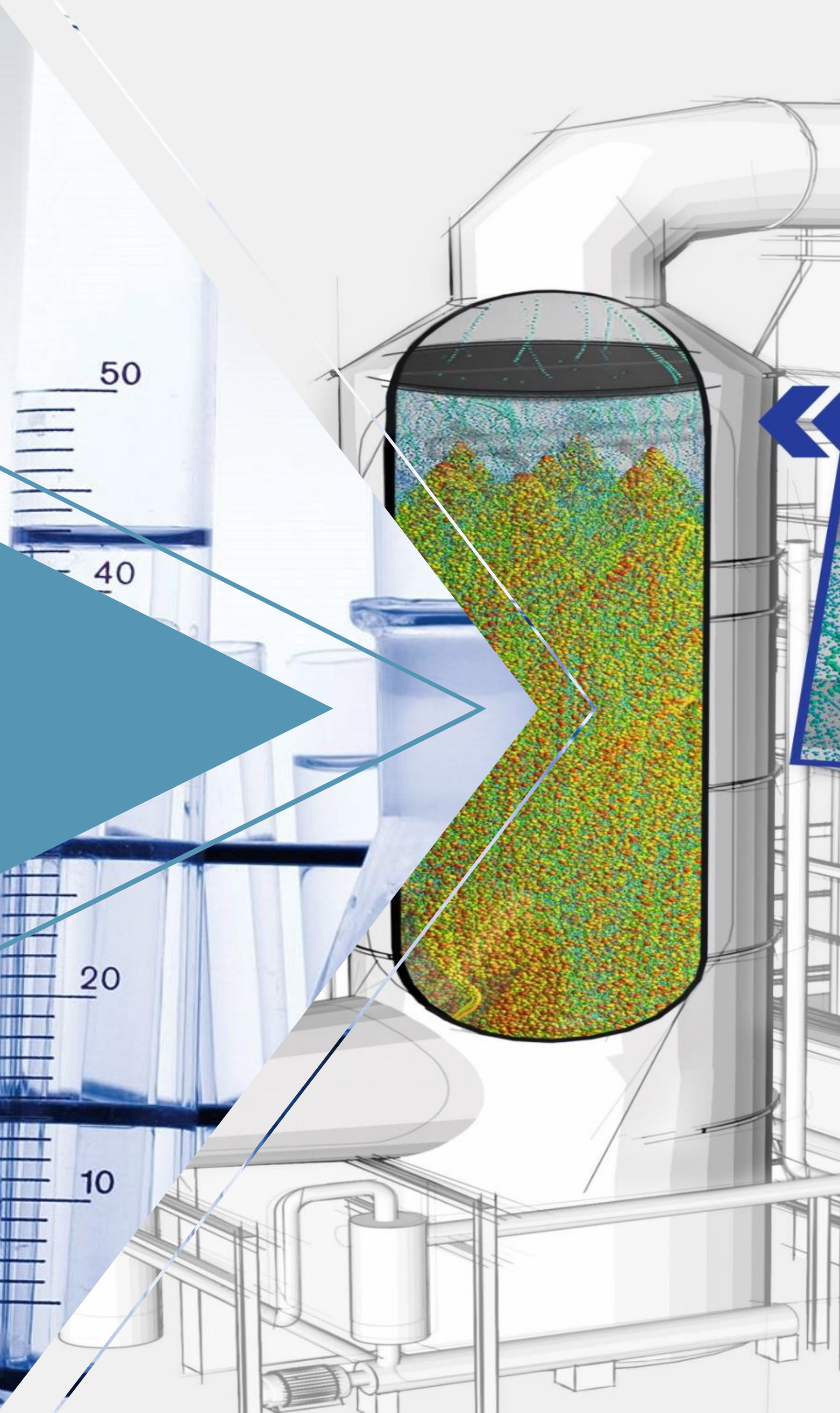
# VGBE

# WS FLUE GAS CLEANING 2023

# PRAGUE / CZECH REPUBLIC

LECHLER GMBH – GERMANY 2023



# Modernization and Process Optimization of Wet Flue Gas Desulphurization

# Absorbers by using new developed spray components

Substantial preconditions to reduce systems energy consumption, operating costs and maintenance in line with keeping new increasingly stringent regulatory limits is to provide **maximum availability** and **most optimized reactive surface** of the scrubber suspension. Another is to support **most uniform gas distribution** over the scrubber cross section.

The following paper describe how to achieve and how to increase separation results by setting up targetdeveloped spray components. The components further enable reductions of pressure drop in the system while using trays and suggest possibilities to equip critical scrubber sections with variants for an enhanced operational reliability and highly reduced maintenance and operation costs.

The **TwinAbsorbPro®** series comes in as well as valuable additional tool in combination with solutions for optimized dust separation.

LECHLER GMBH 2023

# EVERY SCRUBBER SYSTEM CAN BE IMPROVED

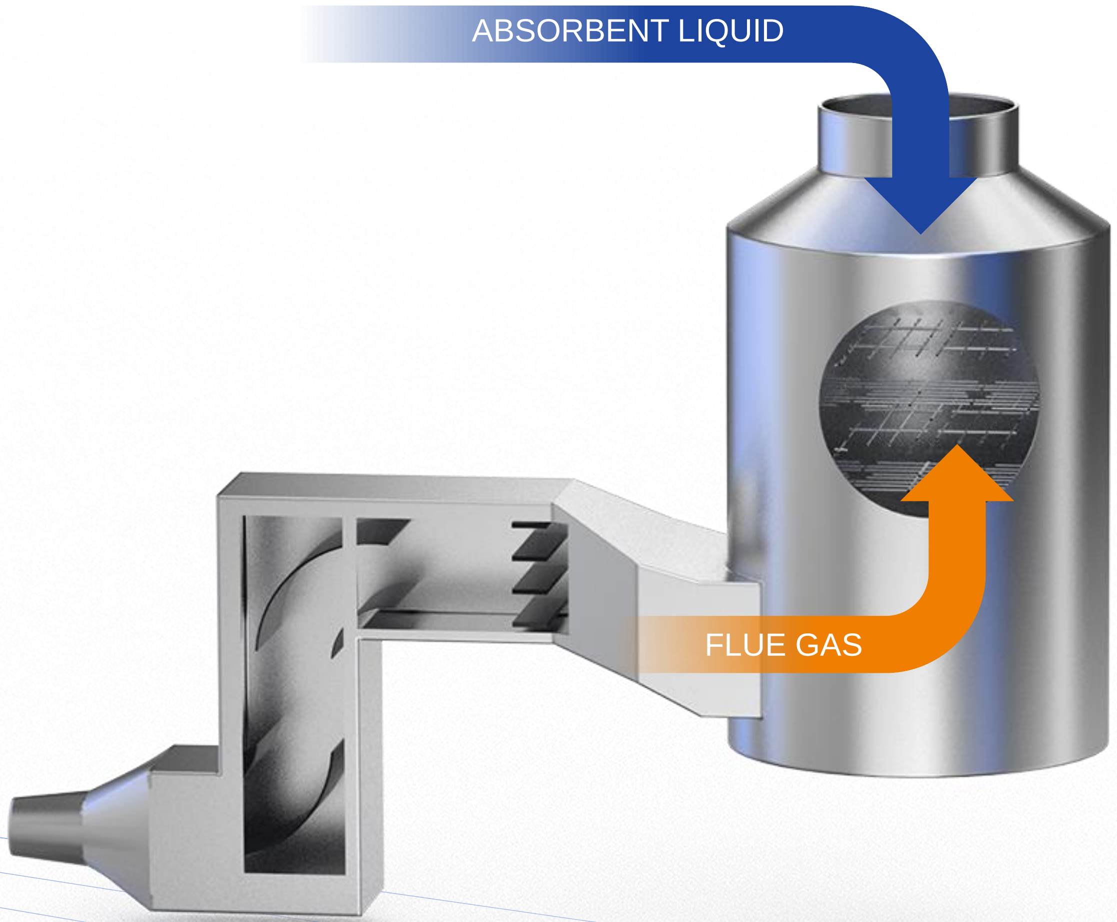
## IF: YOU CAN BALANCE THE GAS DISTRIBUTION

## IF: YOU CAN INCREASE THE REACTIVE SURFACE OF THE INJECTED LIQUID

**The injected spray** influence highly the process performance due to several features of sprays and nozzles.

Experience and knowledge about these features are an essential base to engineer customized spray solutions.

The presented spray solutions allow to follow stricter regulations coming with BREF limitations in line with the necessary need for operational cost reduction.

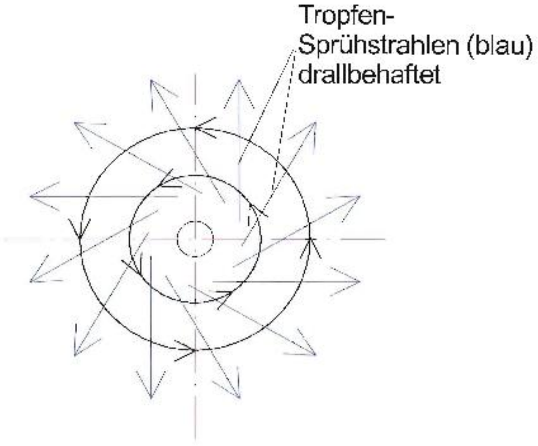


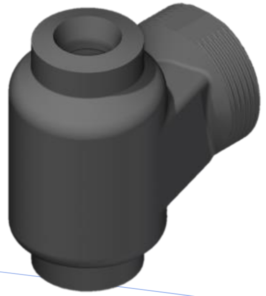
# SPRAY NOZZLES

Small component – high influence on:

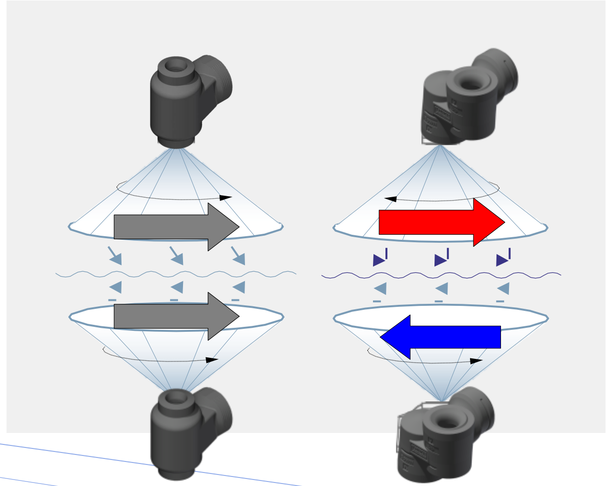
- Increase of relative velocity
- Support of even gas distribution
- Increase of turbulence due to counter rotating sprays

## Gas distribution

Standard



TwinAbsorb

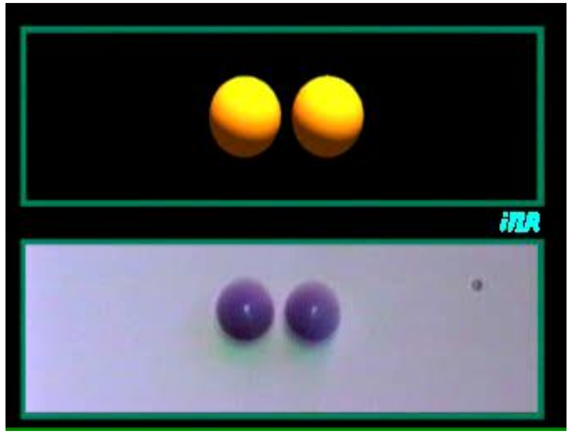
# SPRAY NOZZLES

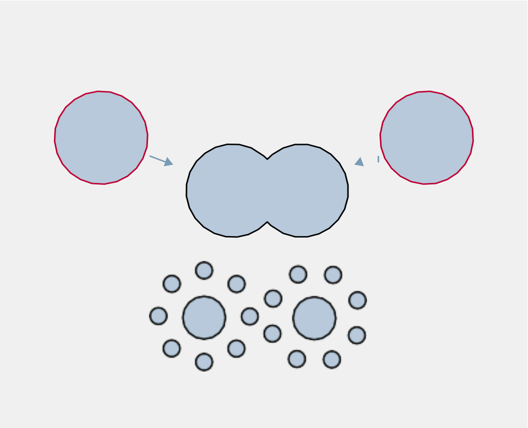
Small component – high influence on:

- Increase of specific reactive surface
- Reactivity of injected absorbent
- Multiplying collision areas by using equilateral spray cones



**Reactive surface**

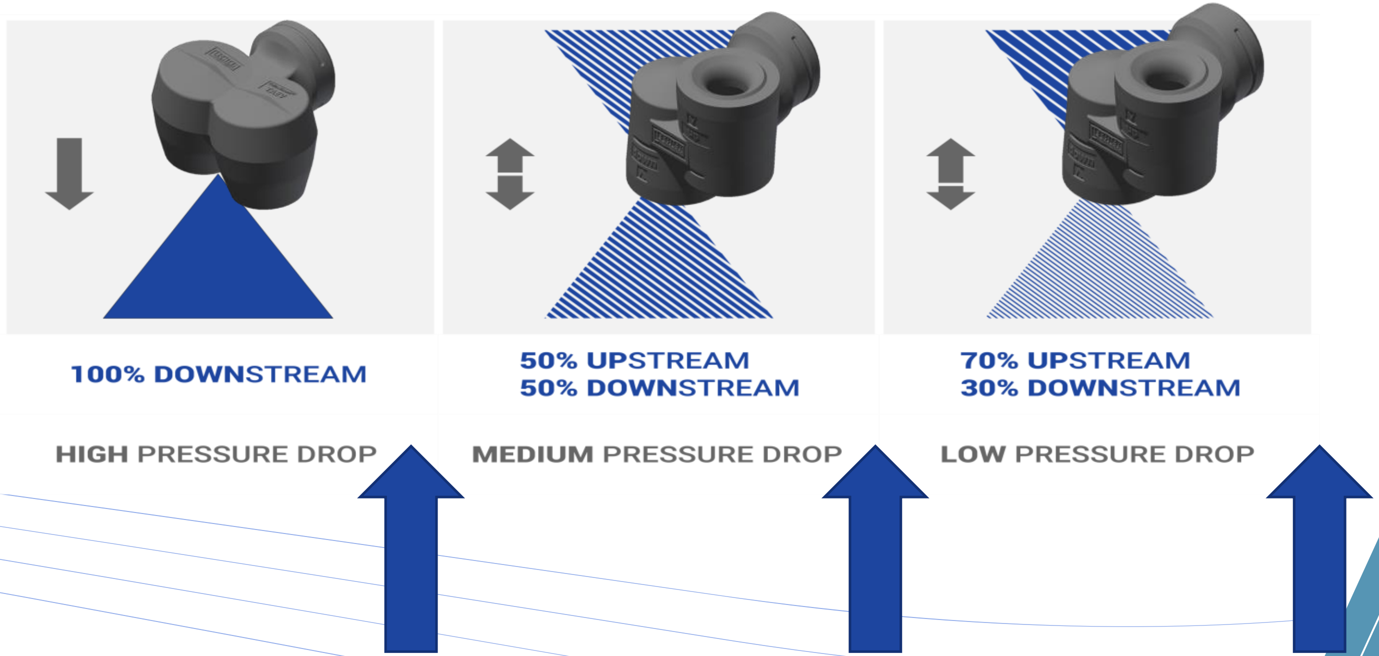




# SPRAY NOZZLES

Small component – but high influence on:

## Pressure drop




- Assist reduction of pressure drop when using a **tray**.

- Up to 0,2 – 1 mbar savings per spray bank are possible

- Up to 20-100 ++ KW (el.) savings in electricity demand for ID fan are possible

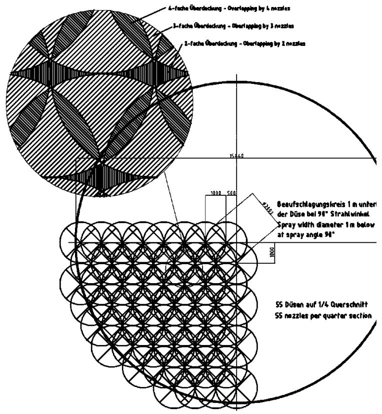
TRAY: Steinmüller Engineering-Gummersbach

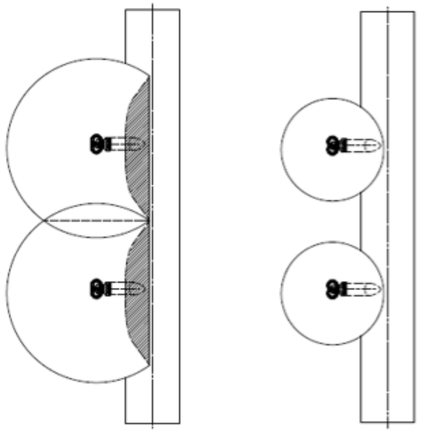
# SPRAY NOZZLES

Small component – high influence on:

*NEW TwinAbsorbPro©*
*patented*

## Coverage





# SPRAY NOZZLES

Small component – high influence on:

***NEW TwinAbsorbPro©***
*patented*

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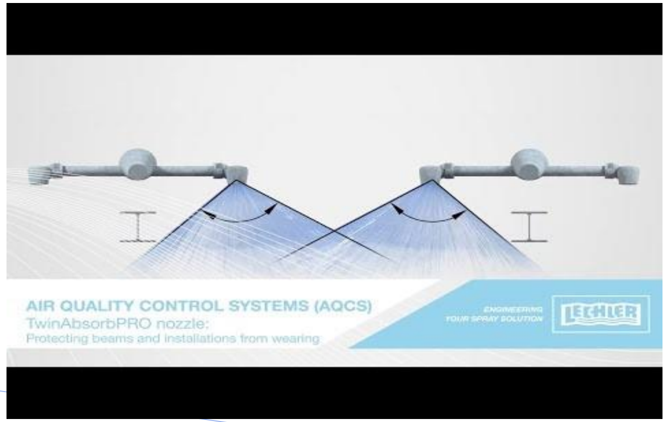
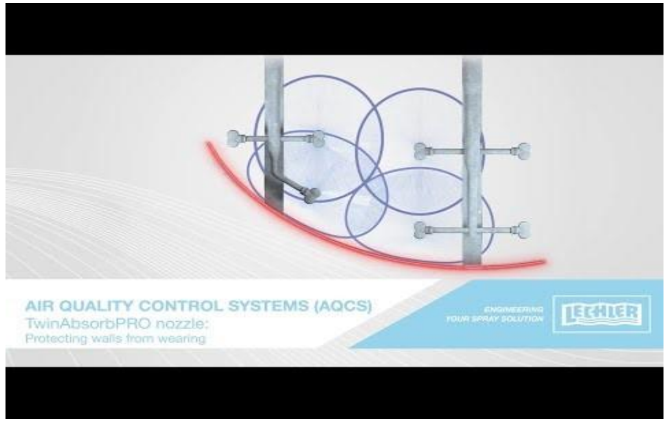
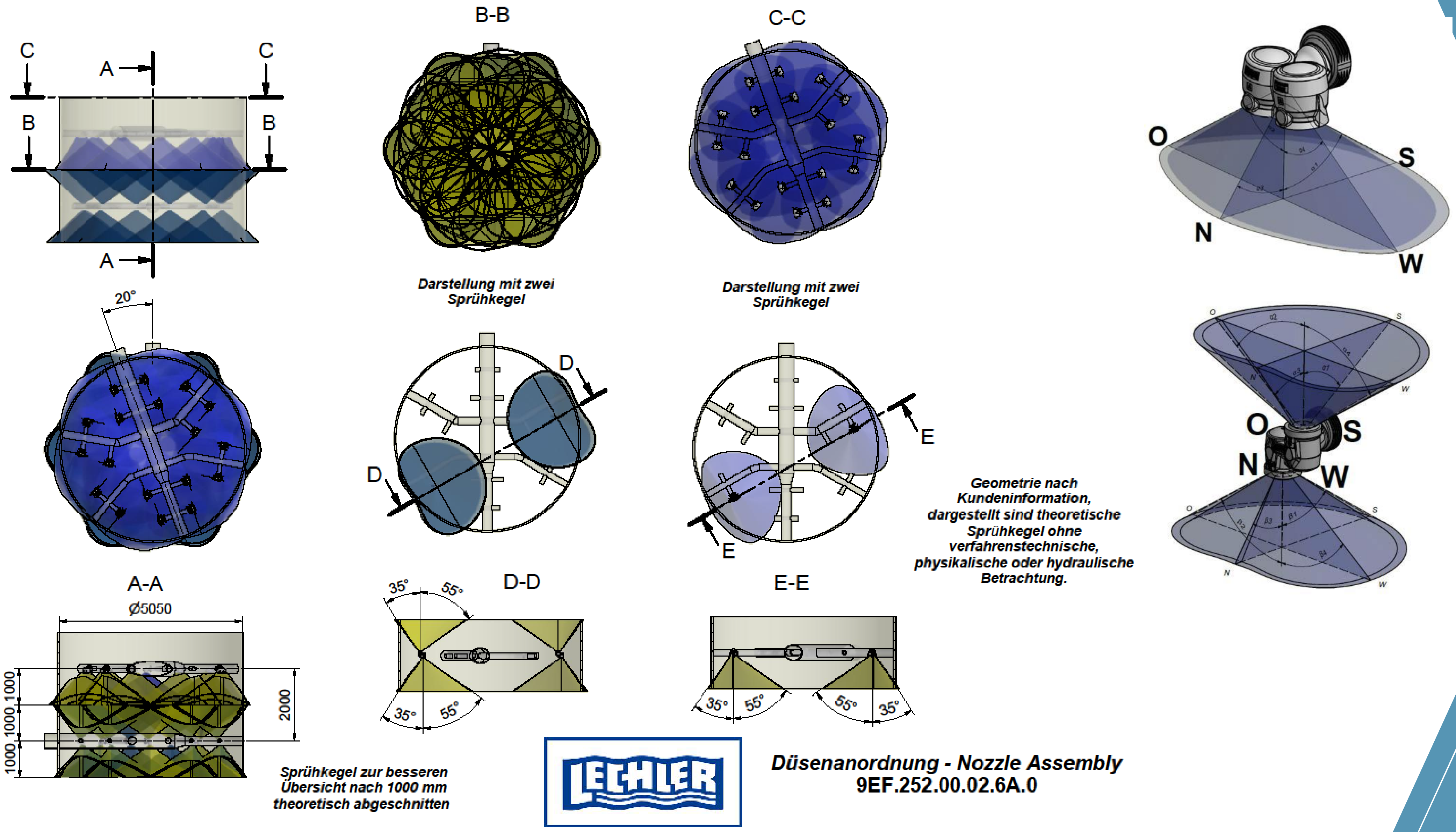
Efficiency &
Maintenance

# PROJECT SAMPLE WASTE INCINERATOR PLANT



# PROJECT SAMPLE WASTE INCINERATOR PLANT

**MVV Mannheim**

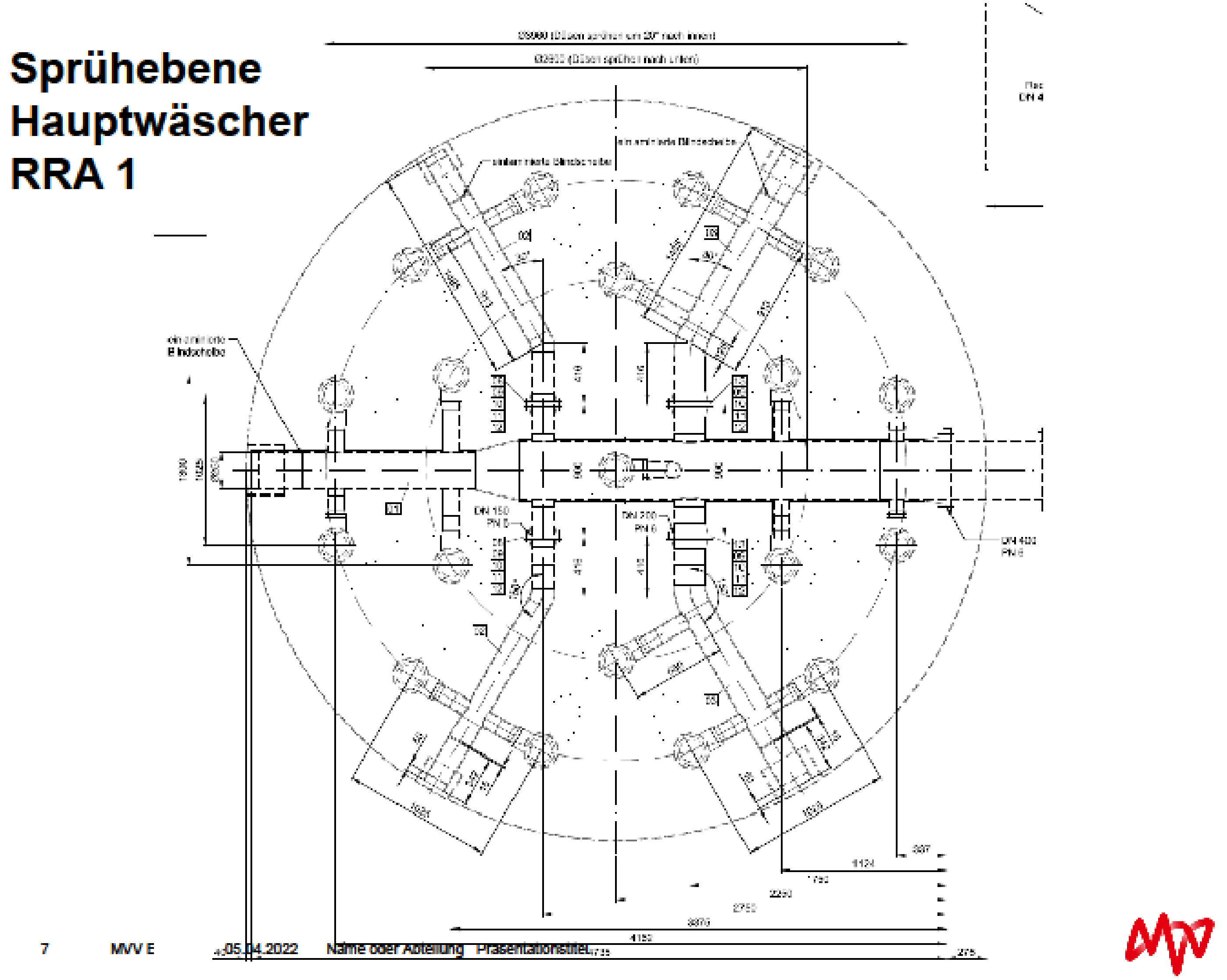
Branch: WIP

Application: $SO_2$ Removal

Product: TwinAbsorbPRO®

# PROJECT SAMPLE WASTE INCINERATOR PLANT

***Before***



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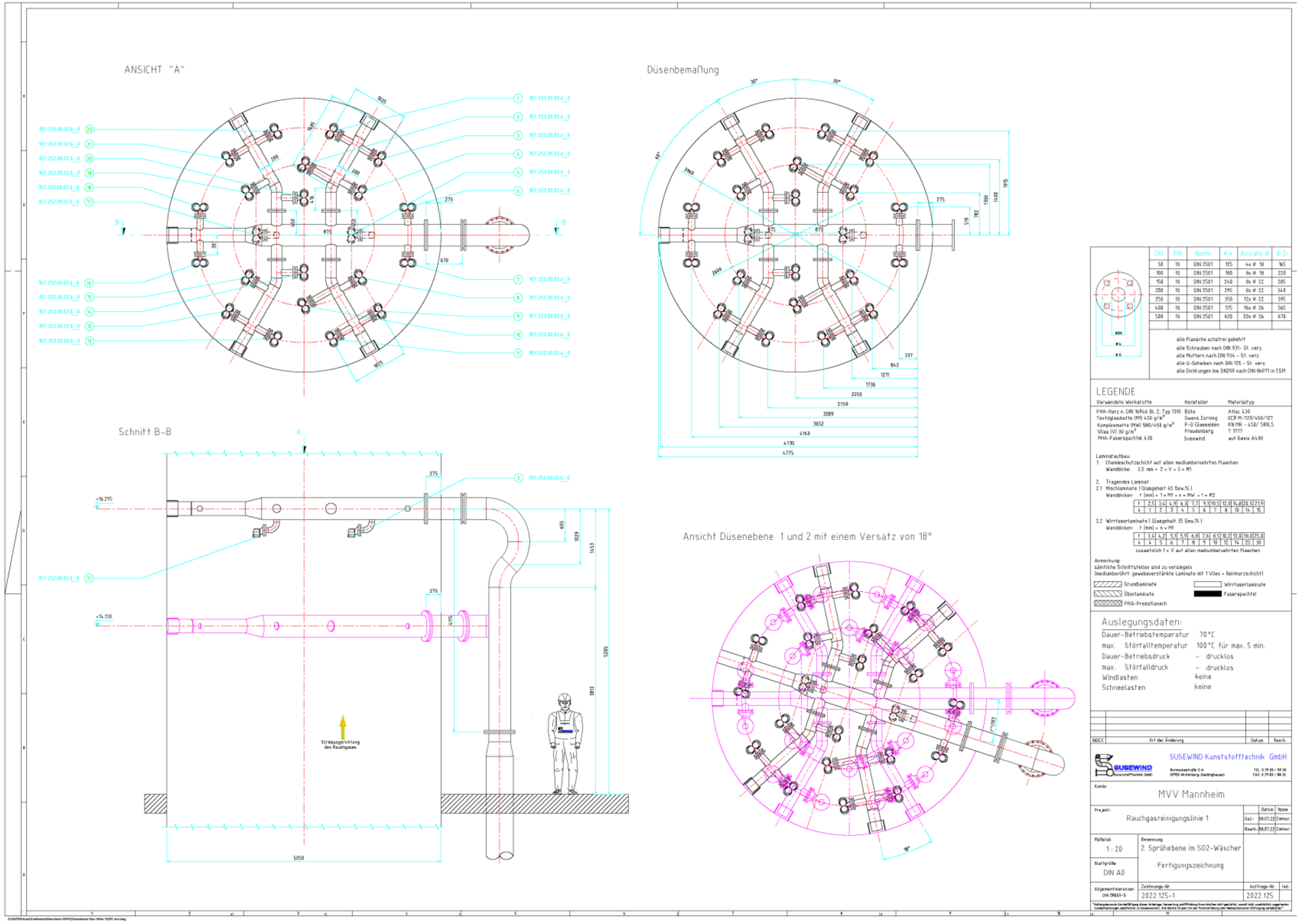
# PROJECT SAMPLE WASTE INCINERATOR PLANT

**_After_**



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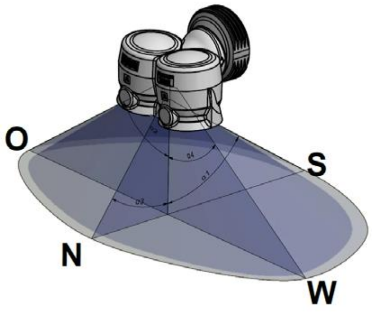
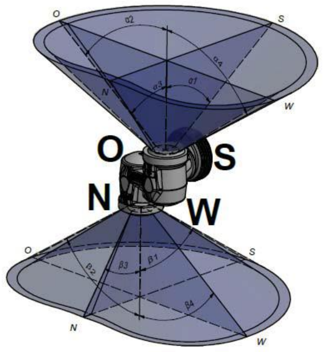
# Modernization and Process Optimization of Wet Flue Gas Desulphurization Absorbers by using new developed spray components

## RETROFIT MVV MANNHEIM





CO-AUDITOR

MVV Mannheim

Dr.-Ing.Thomas Behrendt

# Upgrading the $SO_2$-scrubber


Dr.-Ing. Thomas Behrendt

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We inspire
with energy

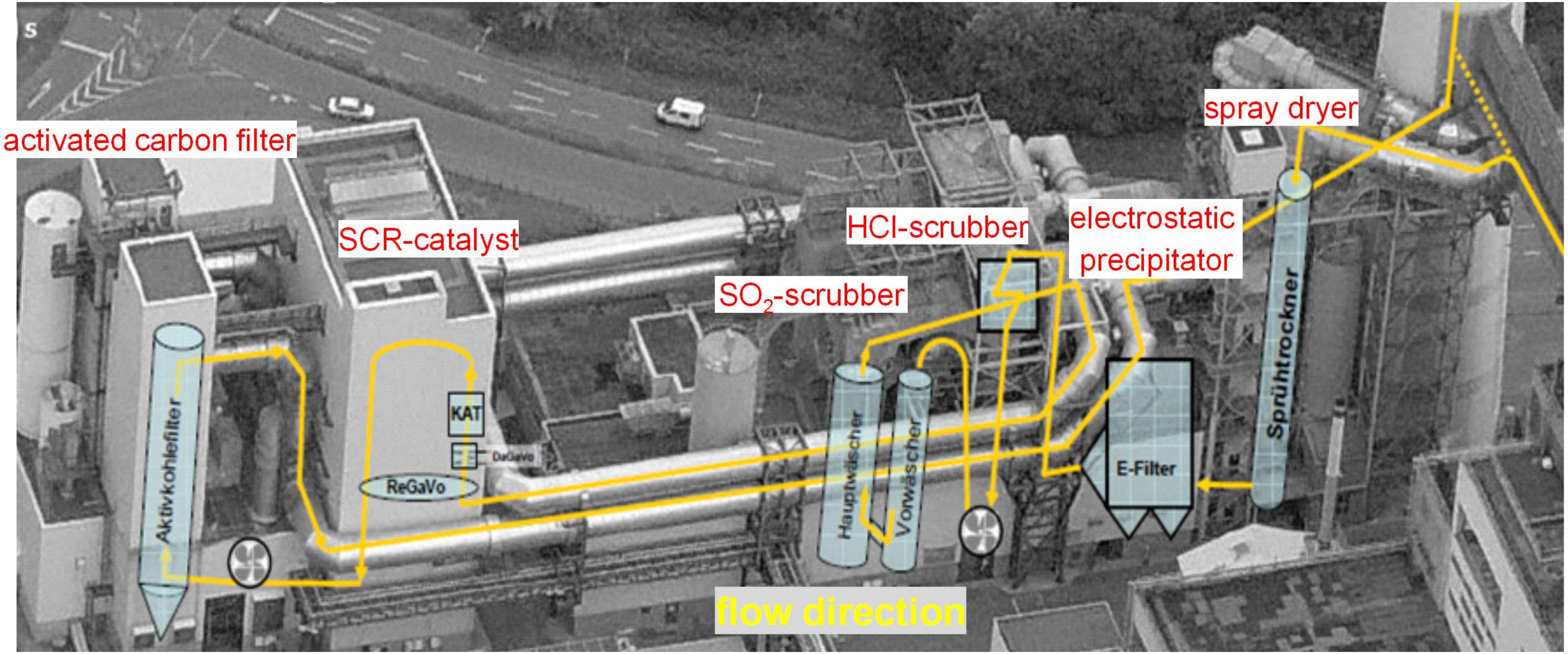
# MHKW Mannheim, energy from waste

- **Waste throughput 700.000 t/a**
- **Treatment of sewage sludge 135.000 t/a**
- **Waste incineration since 1965**

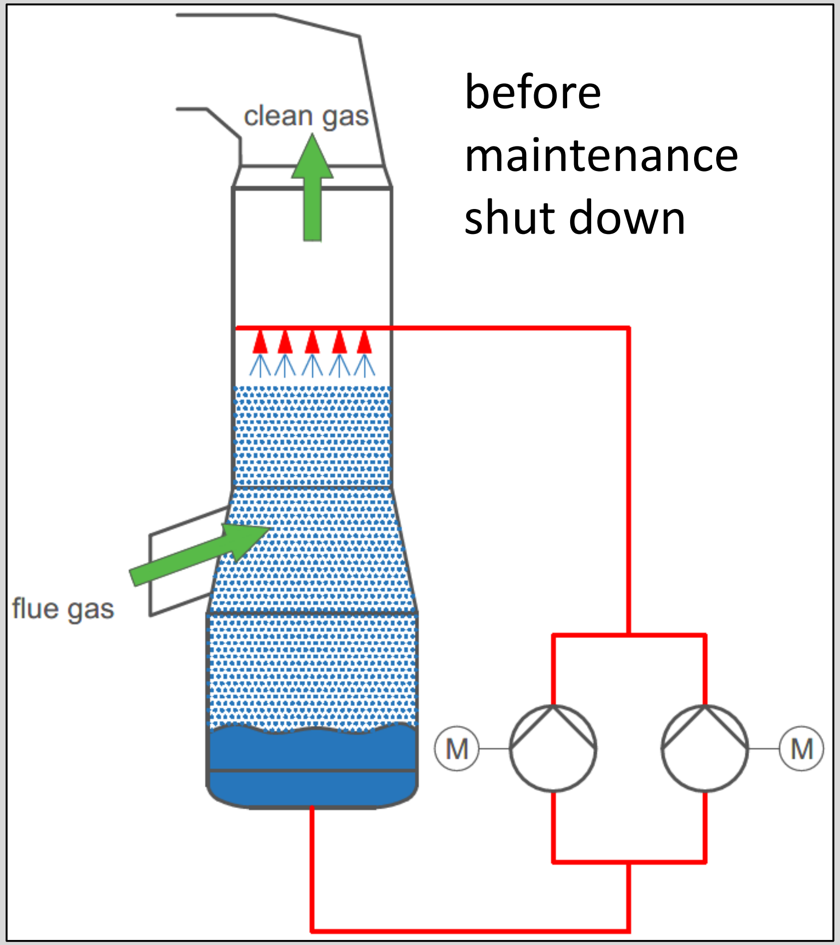
- **Adaptation of the flue gas cleaning plant 1 to the new requirements through the commissioning of the new sewage sludge treatment plant**
- **Flue gas volume flow: +20 %**
- **Raw gas concentration $SO_2$: +30 %**

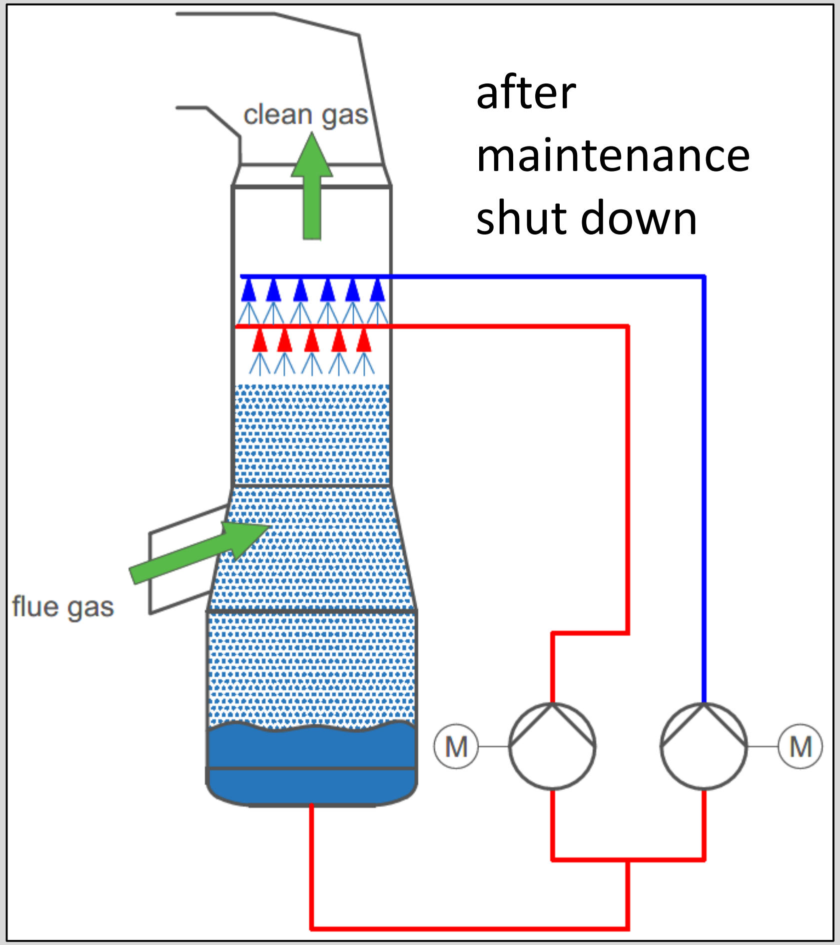
➔ **Upgrading the $SO_2$-scrubber**

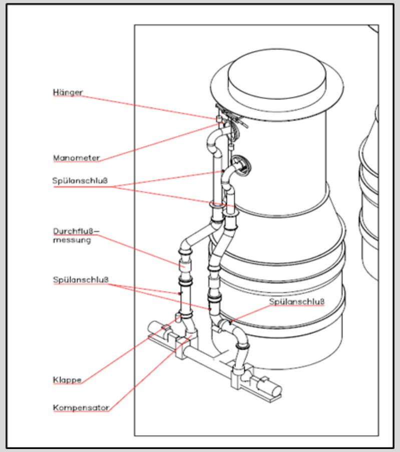
# Overview of the wet flue gas cleaning plant



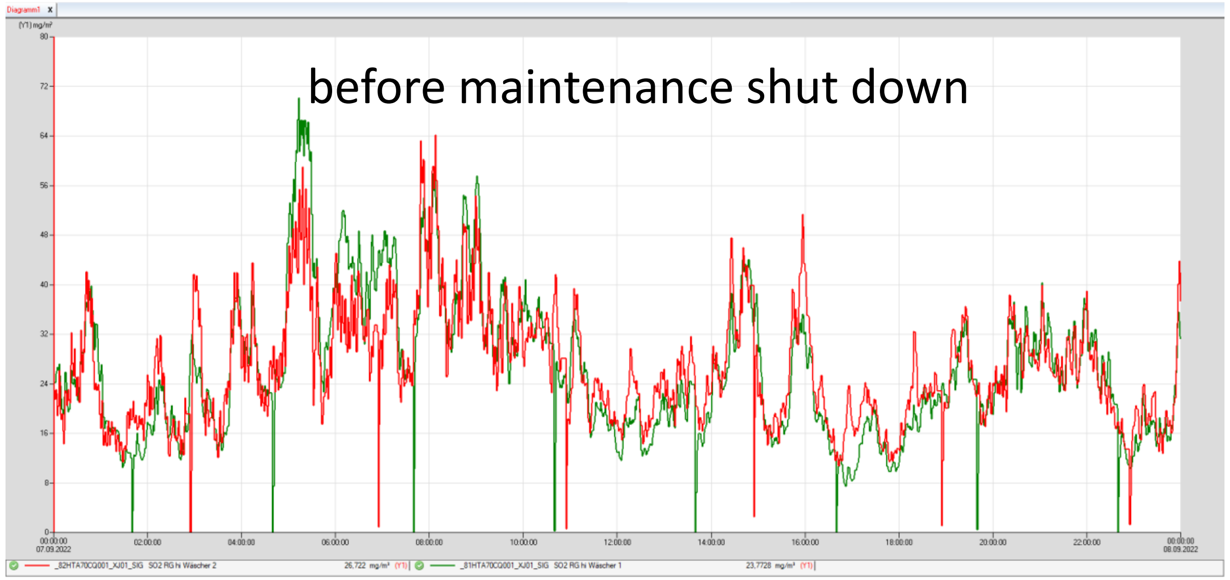
# Upgrading the $SO_2$-scrubber of the flue gas cleaning plant 1



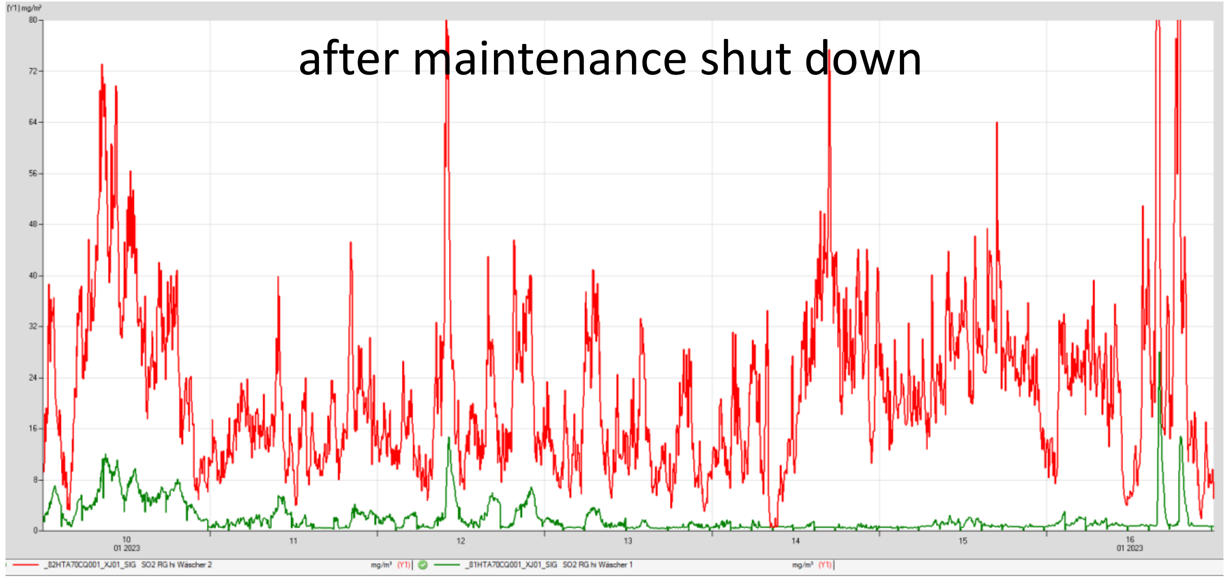
# $SO_2$-concentration after the $SO_2$-scrubber




flue gas cleaning plant 1 green
flue gas cleaning plant 2 red

identical design of the
flue gas cleaning plants 1 and 2

same composition and volume flow of the flue gas (flue gas collecting duct in front of the flue gas cleaning plants 1 and 2)



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**A company in the
Rhine-Neckar metropolitan region**

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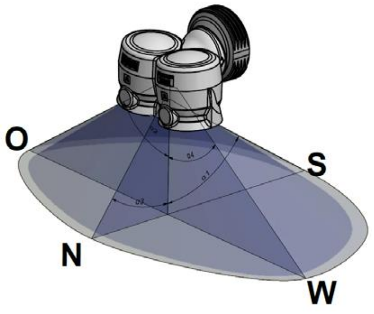
# Modernization and Process Optimization of Wet Flue Gas Desulphurization

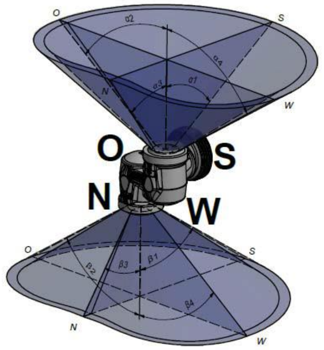
## Absorbers by using new developed spray components

# RETROFIT TPP BELCHATOW

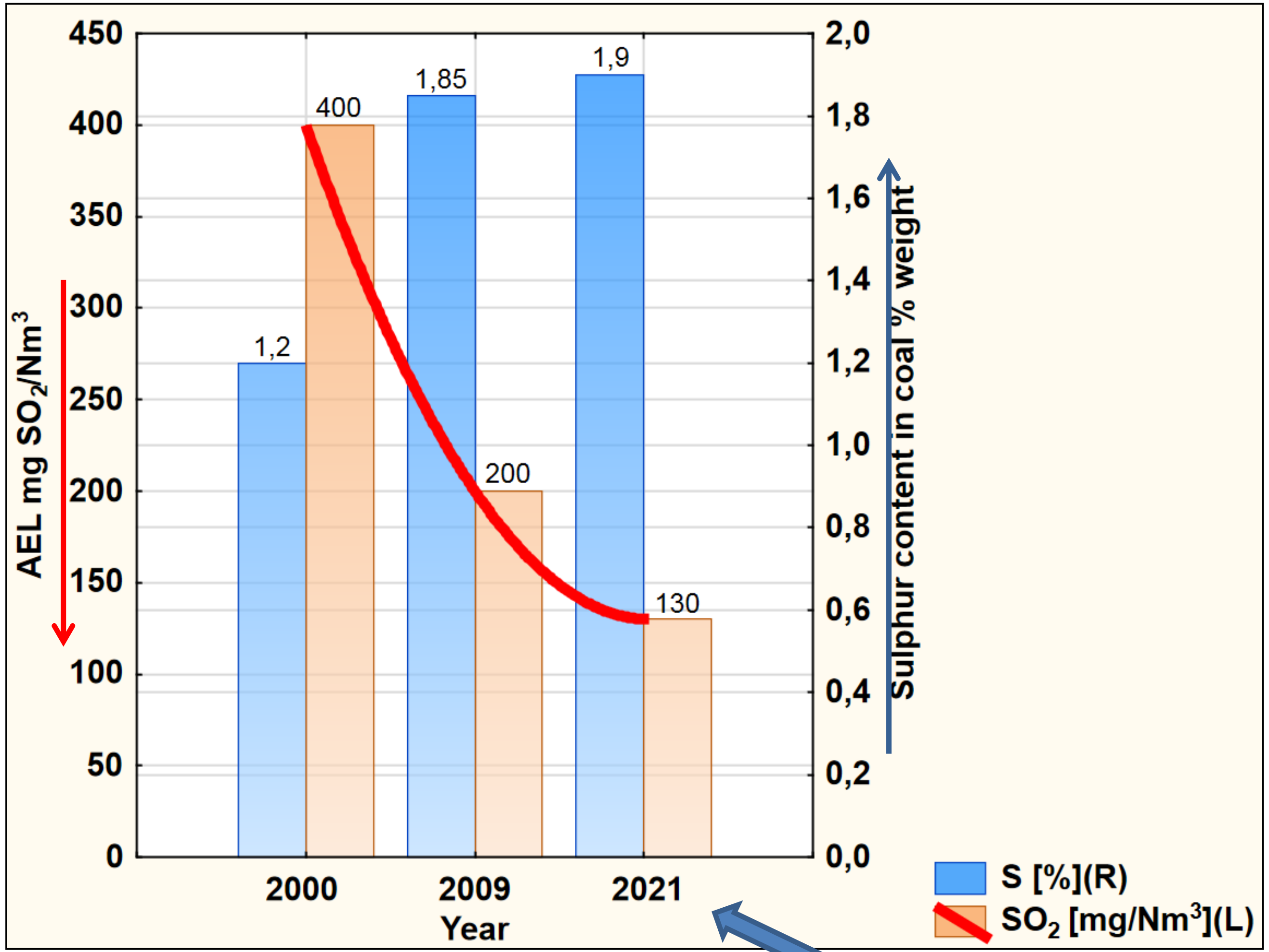



CO-AUDITOR

RAFAKO S.A.
Dip.-Ing. Jerzy Mazurek



## Genesis of the project: Increase in sulphur content in fuel due to reduction of $SO_2$ emission limit (AEL)




Belchatow Power Plant is the largest lignite-fired power unit both in Poland and in Europe.

Total electrical power of boiler units operated in Belchatow PS is 4732 $MW_e$.

2021: Start of Implementation Best Available Techniques Reference Document for the Large Combustion Plants (BAT Conclusion)

**TARGET:**

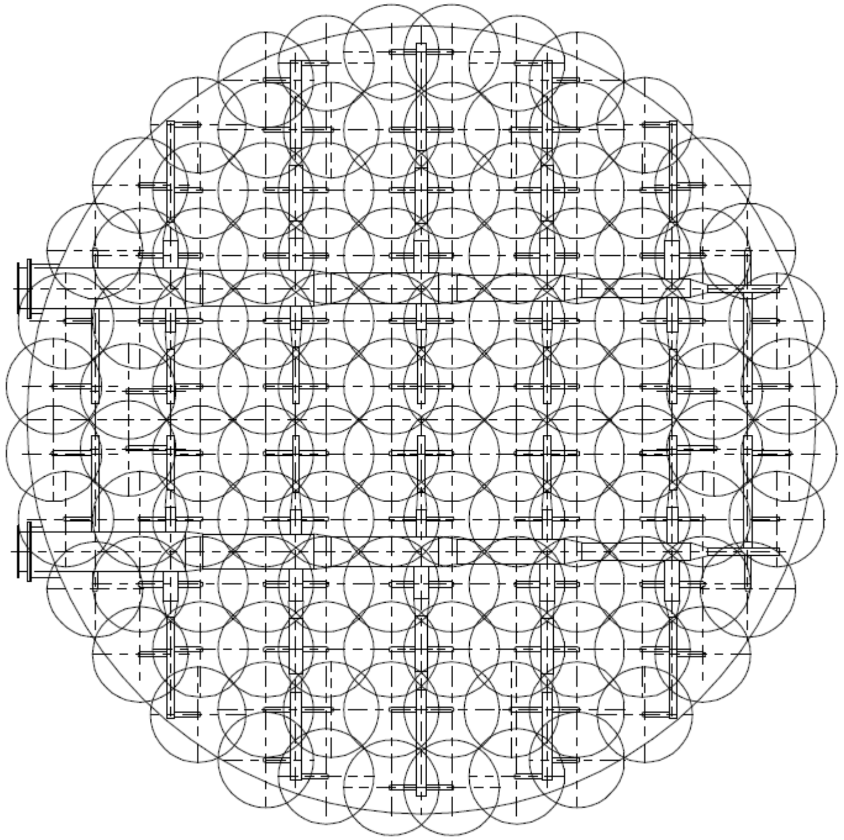
| | AEL [mg/Nm$^3$] | | Eff. $SO_2$ removal | |
|---|---|---|---|---|
| Before | 200 | | 98,0% | |
| After | 130 | -35% | 98,7% | +0,7% |

## Technology used for increase efficiency $SO_2$ removal

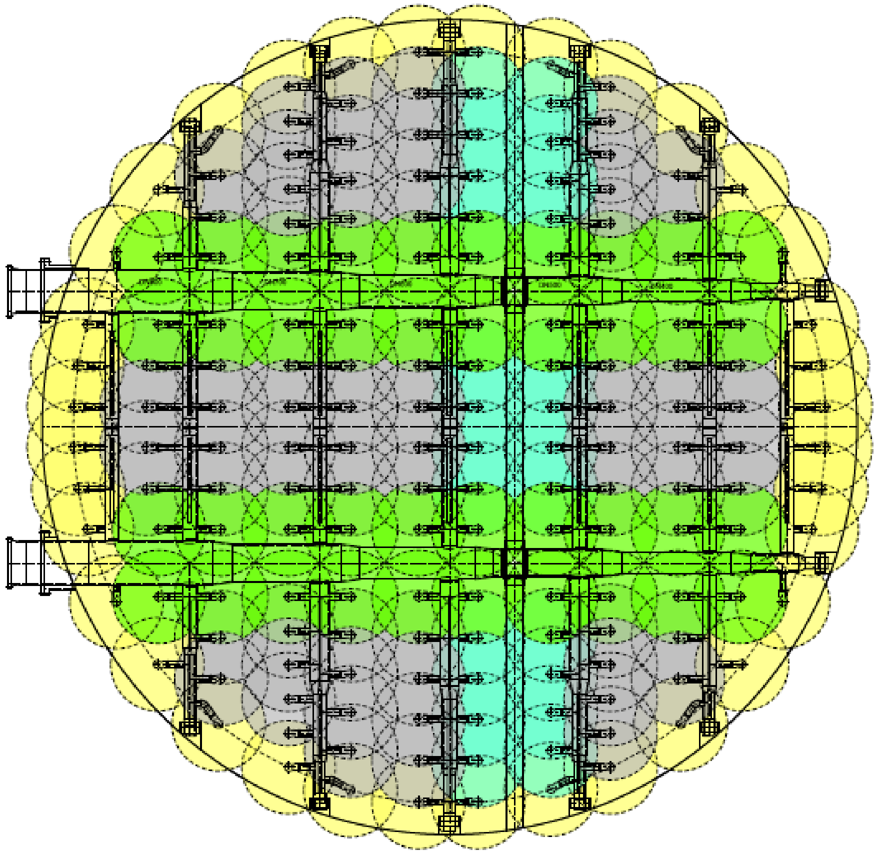
| Unit No<br>Unit Power<br>Absorber diameter | Year of start FGD operation (basic project) | Technology for increase eff. $SO_2$ removal | | Date of commissioning after modernization |
|---|---|---|---|---|
| | | New concept and new nozzles for spray level | Additional used technology | |
| 7 / 390 MW / 15,7 m | 2003 | TwinAbsorb-EH, -H | **FGD_2.0 (RAFAKO)**<br>**Research project** | 12.2017 |
| 9 / 390 MW / 15,7 m | 2003 | TwinAbsorb-EV, -H, -EH | **FGD_2.0 (RAFAKO)** | 09.2020 |
| 10 / 390 MW / 18,7 m | 1994 | TwinAbsorb-EV, -H, -EH | **FGD_2.0 (RAFAKO)** | 09.2020 |
| 5 / 380 MW / 15,7 m | 2000 | TwinAbsorb-EV, -H, -EH | **FGD_2.0 (RAFAKO)** | 12.2020 |
| 6 / 394 MW / 15,7 m | 2000 | TwinAbsorb -EV, -H, -EH | **FGD_2.0 (RAFAKO)** | 12.2020 |
| 12 / 390 MW /18,7 m | 1996 | TwinAbsorb-EH, -H<br>**TwinAbsorbPRO** | **FGD_2.0 (RAFAKO)** | 10.2021 |
| 11 / 390 MW / 18,7 m | 1996 | TwinAbsorb-EH, -H<br>**TwinAbsorbPRO** | **FGD_2.0 (RAFAKO)** | 10.2021 |
| 3 / 380 MW/ 17,0 m | 2007 | TwinAbsorb-EV, -H, -EH | **FGD_2.0 (RAFAKO)** | 11.2021 |
| 8 / 390 MW / 18,7 m | 1995 | TwinAbsorb-EV, -H, -EH | **FGD_2.0 (RAFAKO)** | 11.2021 |
| 4 / 380 MW / 17,0 m | 2007 | TwinAbsorb-EV, -H, -EH | **FGD_2.0 (RAFAKO)** | 12.2021 |
| 14 / 858 M / 2x16,0m | 2011 | TwinAbsorb-EH, -H<br>**TwinAbsorbPRO** | - | Planned<br>12.2023 |

## Spray levels modernization concept
## Example for unit 7
## Generally: Individual design for each absorber

Before … After



**Quantity of nozzles per one level: 120 pc**
**Types of nozzle: 2**
**Nozzle capacity: 1583 l/min**
**Connection type: lamination DN125**



**Quantity of nozzles per one level: 172 pc**
**Types of nozzle: 5**
**Nozzle capacity: 1105 l/min**
**Connection type: Victaulic, DN100**

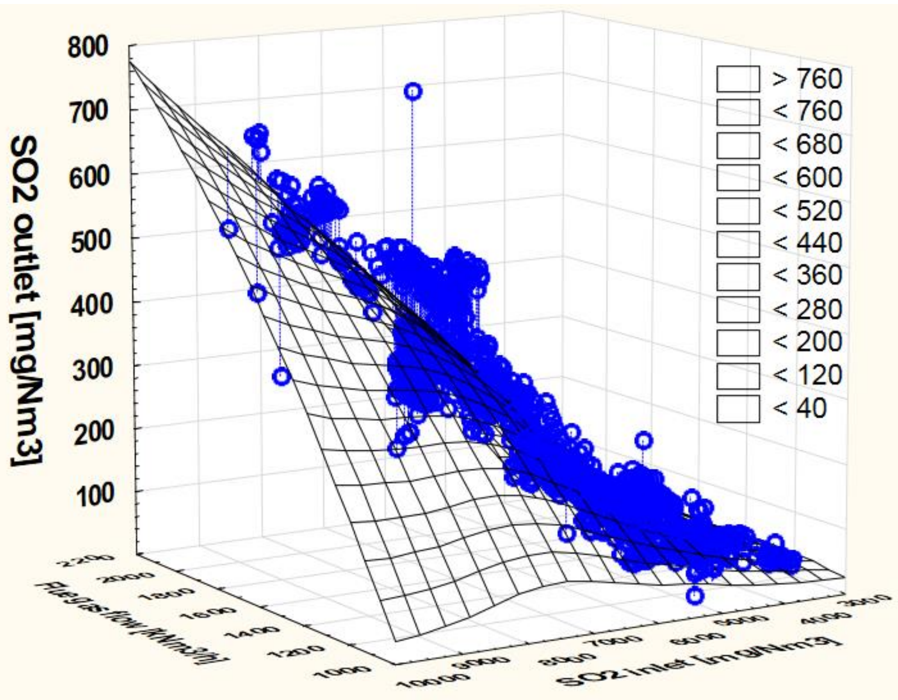
# Spray levels modernization concept and FGD_2.0 process technology
## Photos for unit 7 after modernization

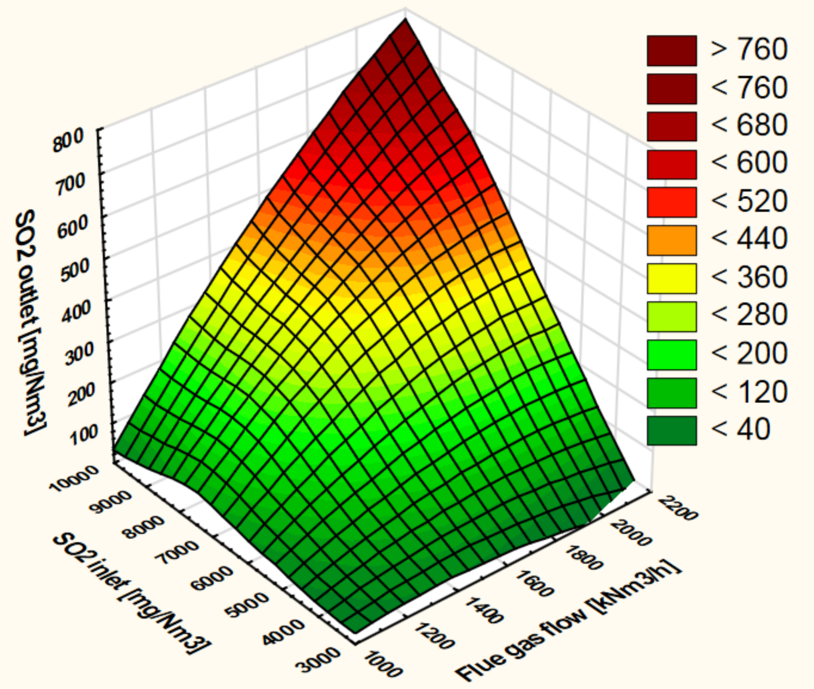


**Visualization of the effects of absorber modernization on the example of unit 7.**
**Synergistic effect of using new nozzles and FGD_2.0 process technology.**
**Developed on the basis of data from field equipment (continuous measurements of gas parameters)**

**3D diagram of $SO_2$ concentration in the clean gas at the chimney relative to the raw flue gas volume flow and $SO_2$ concentration at the FGD inlet for 3 spray banks in operation.**

~2000 measuring points → … → Curve fitting




**Developed on the basis of the analysis of data from 1 full month of work before and after modernization (sampling period: 60s).**

**Visualization of the effects of absorber modernization on the example of unit 7.**
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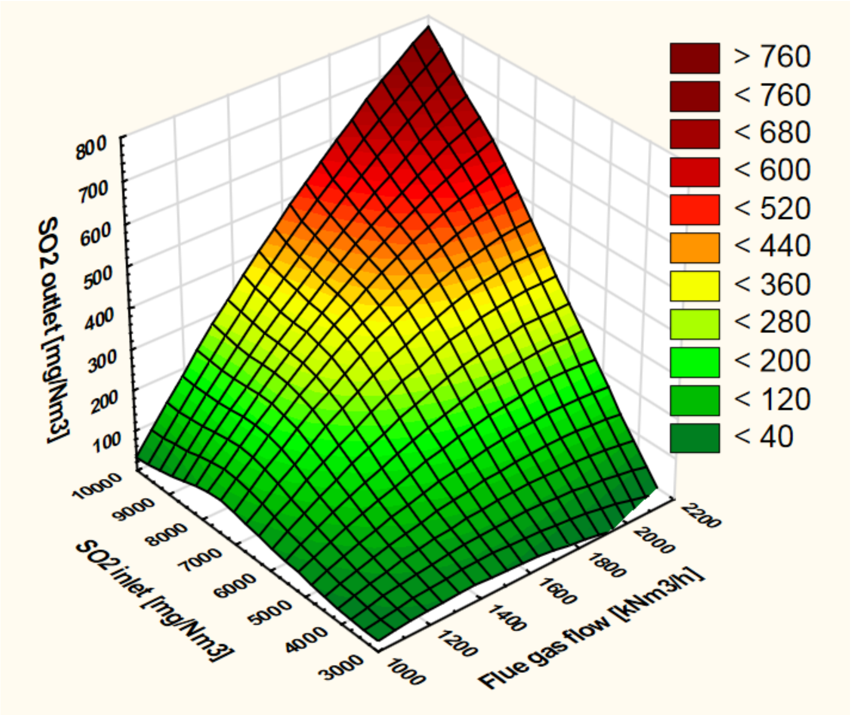
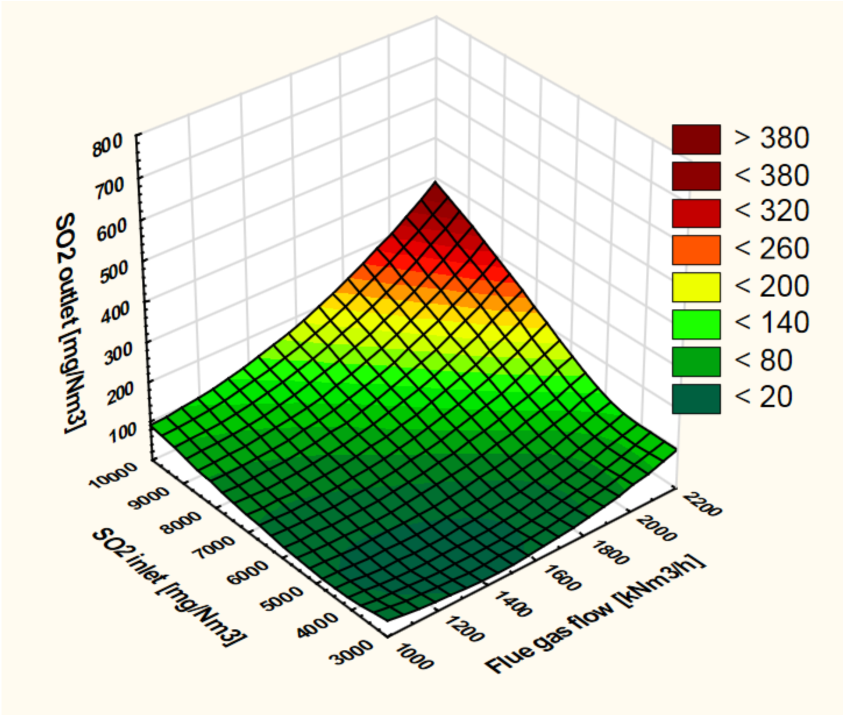
**3D diagram of $SO_2$ concentration in the clean gas at the chimney relative to the raw flue gas volume flow and $SO_2$ concentration at the FGD inlet for 3 spray banks in operation.**

Before … After




Developed on the basis of the analysis of data from 1 full month of work before and after modernization (sampling period: 60s).

**Comparison of the results of work from the monthly period before and after modernization allows us to conclude that the outlet concentration of $SO_2$, and thus $SO_2$ emissions, has been reduced by over 50%.**

## Results of warranty measurements made by an independent measuring company

| Unit | Date of warranty measurements | $SO_2$ inlet [mg/Nm³] | $SO_2$ outlet [mg/Nm³] | $SO_2$ removal efficiency [%] |
|---|---|---|---|---|
| 7 | 21.04 - 23.04.2020 | 9396 | 68 | 99,3 |
| 9 | 17.05 - 21.05.2021 | 7188 | 50 | 99,3 |
| 10 | 17.05 - 21.05.2021 | 7485 | 79 | 98,9 |
| 6 | 27.09 - 01.10.2021 | 8017 | 49 | 99,4 |
| 12 | 05.12 - 09.12.2021 | 9928 | 82 | 99,2 |
| 11 | 05.12 - 09.12.2021 | 9028 | 81 | 99,1 |
| 3 | 08.06 - 09.06.2022 | 9152 | 11 *) | 99,9 |
| 4 | 08.06 - 09.06.2022 | 9458 | 120 | 98,7 |
| 5 | 10.08 - 11.08.2022 | 8328 | 84 | 99,0 |
| 8 | 05.10 - 06.10.2022 | 9324 | 107 | 98,9 |
| | **on average** | **8730** | **73** | **99,2** |

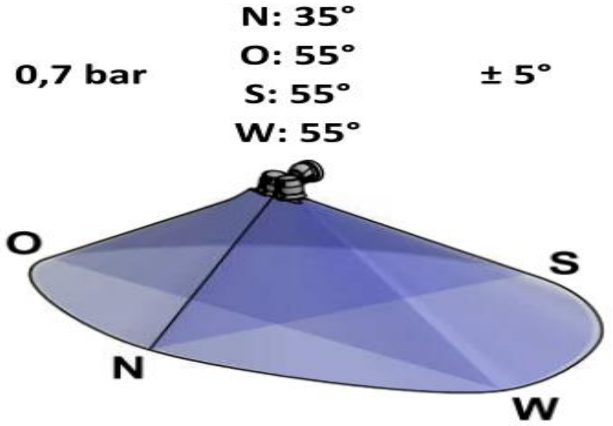
The measurements were made at full power of the unit and all spray levels in operation (stable operation minimum 4 hours). Measurement based on measuring grids (multi-point measurement).

*) Result for high pH level and high organic acid concentration.

**CONCLUSION:**

- **After modernization, the absorbers achieved the assumed ability to maintain the outlet concentration of $SO_2$ below 130 mg/Nm³ for $SO_2$ concentrations at the inlet up to 10000 mg/Nm³ as a function of the pH of the absorber suspension and the volume flow of the raw flue gas.**

## Special solutions for upgrade wet FGD systems

| SKETCH | TECHNOLOGY | COMPANY |
|---|---|---|
|   | TwinAbsorbPRO | **LECHLER GmbH**<br><br>For details please contact with:<br>Thomas Schröder<br>T: +49 (0) 7123 962- 315<br>M: +49 (0) 172 720 1993<br>E: Thomas.Schroeder@lechler.de |
|  | FGD_2.0 process technology | **RAFAKO S.A.**<br><br>For details please contact with:<br>Jerzy Mazurek<br>T: +48 32 410 1394<br>M: +48 602 760 006<br>E: Jerzy.Mazurek@rafako.com.pl |

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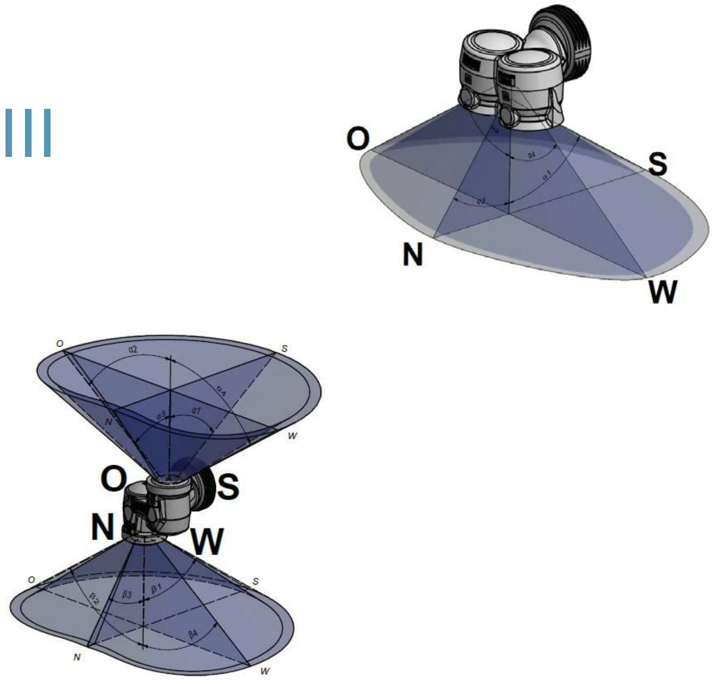
# Modernization and Process Optimization of Wet Flue Gas Desulphurization Absorbers by using new developed spray components

## RETROFIT TPP MARITSA EAST III




CO-AUDITOR

STEINMÜLLER ENGINEERING GMBH

Dr.-Ing. Stefan Binkowski

# Upgrade of 2 $SO_2$ scrubbers in Maritsa East 3 power station

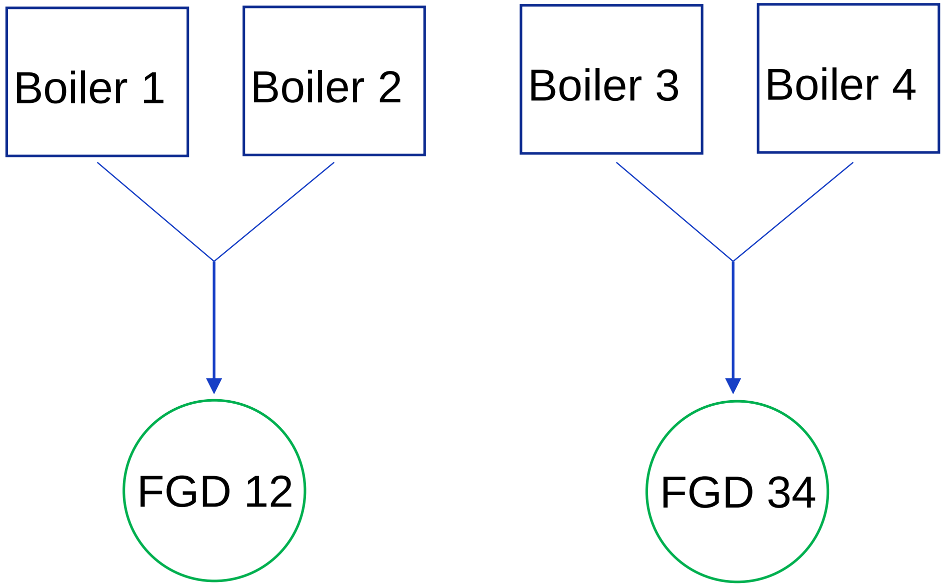
Rely on good experience with

steinmüller engineering

The Engineers Company

# Description of Power Plant

- Maritsa East 3 Power Plant (operated by Contour Global in Bulgaria)
- 908 MWe (total) lignite-fired power plant with 4 x 227 MWe units
- Two wet-limestone FGDs

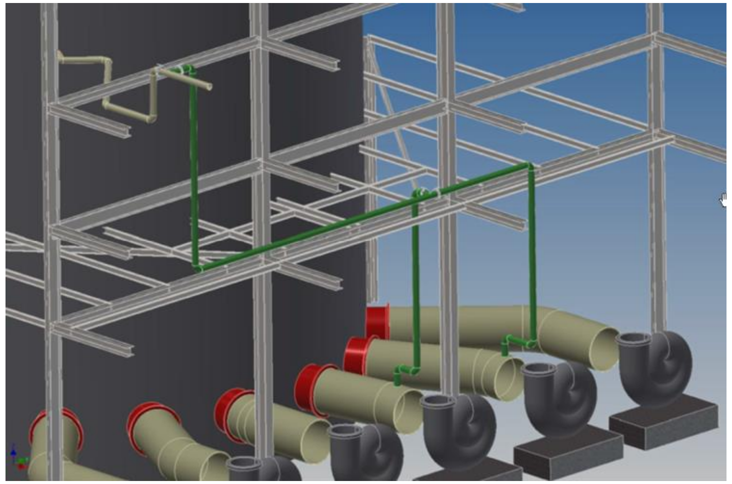


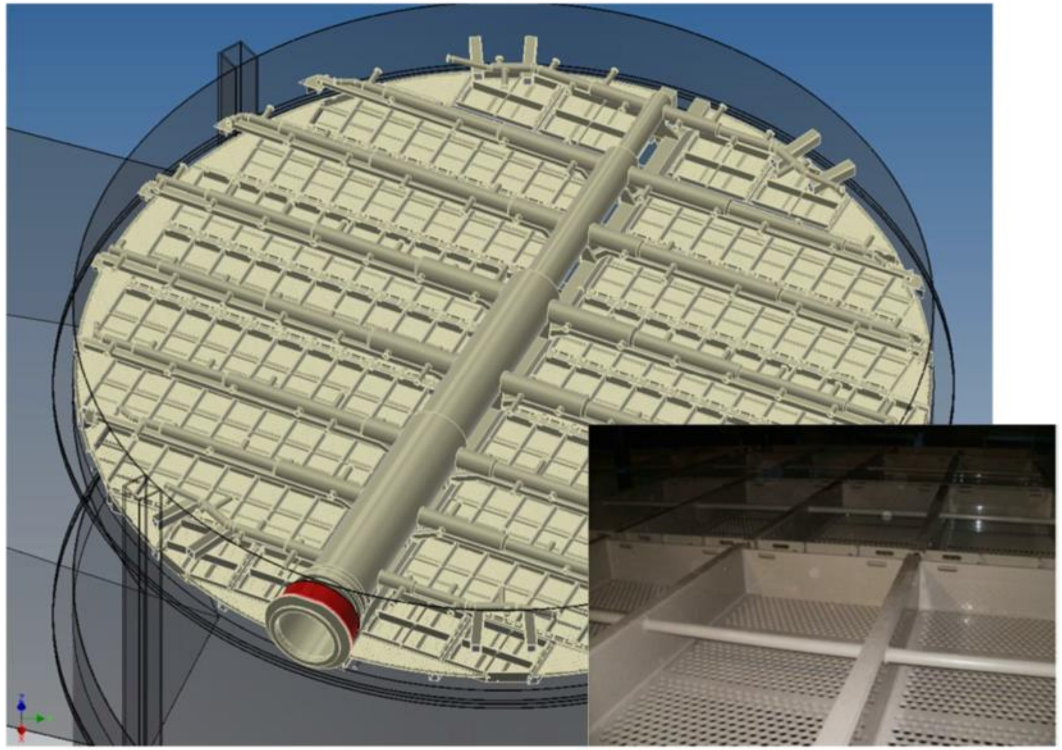

| Characteristic | Unit | Value |
|---|---|---|
| Flue gas flow rate (wet) | $m^3/h$ (Normalized, wet, act O2) | 3 223 451.19 |
| Flow rate (dry) | $m^3/h$ (Normalized, dry, act O2) | 2 542 107.24 |
| $SO_2$ | $mg/m^3$ (Normalized, dry) | 15 415.57 |
| $SO_2$ @ 6% $O_2$ | $mg/m^3$ (Normalized, dry) | 18 500 |
| Dust @ 6% $O_2$ | mg/mg (Normalized, dry) | 50 |
| $N_2$ + Ar content | Vol. %, dry | 79.9 |
| $O_2$ content | Vol. %, dry | 8.5 |
| $CO_2$ content | Vol. %, dry | 11.0 |
| $H_2O$ content | Vol. %, wet | 21.1 |
| Temperature | ˚C | 179 |
| Density | $kg/m^3$ (Normalized, wet) | 1.236 |
| Suspension flow each spray bank | $m^3/h$ | 12.000 |
| Spray banks per absorber | - | 6<br>(spraybank 1-5 with 50:50 up:down nozzles |
| Limestone suspension feeding | - | Directly into absorber |

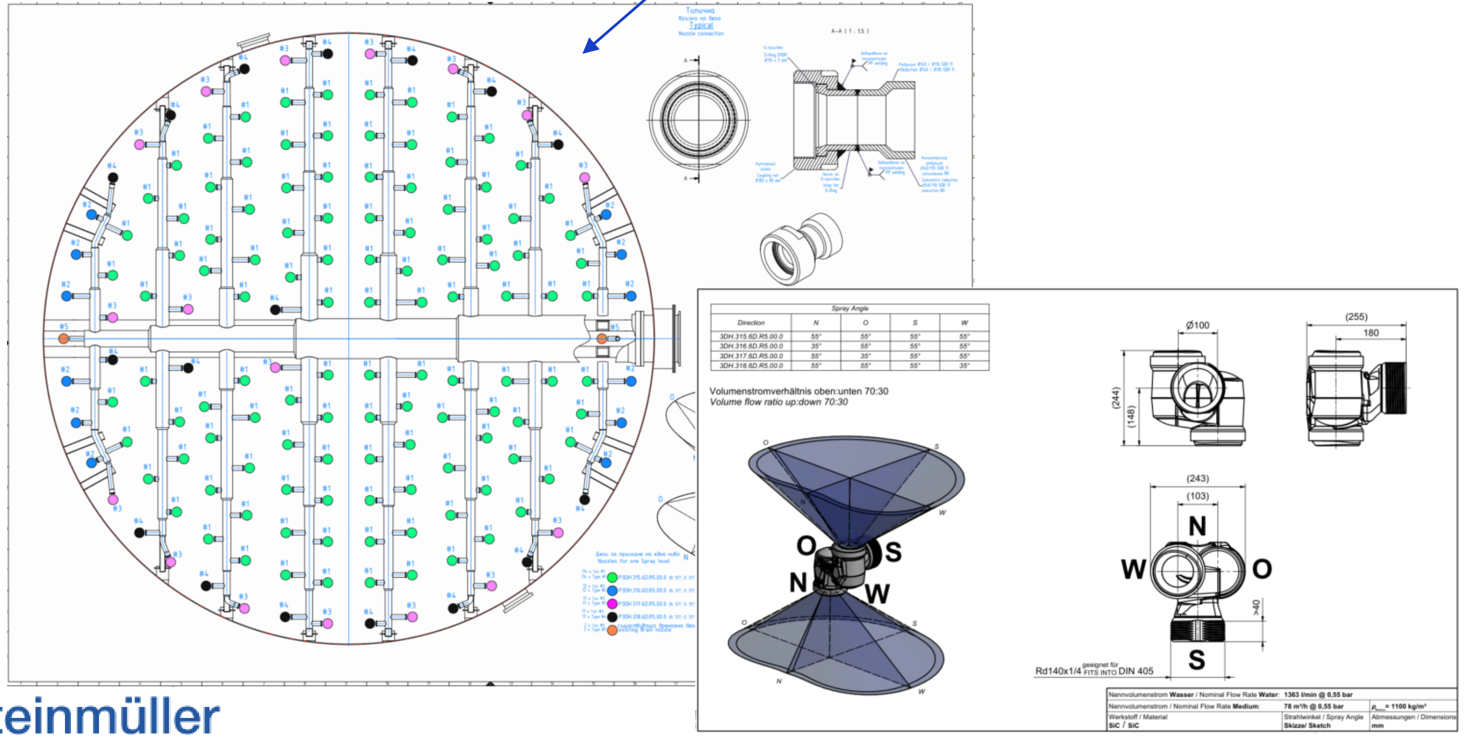
# Optimisation measures

- Increase of $SO_2$ removal efficiency by > 2 % **( to min 97 %)**
- Combination of 3 upgrades:

1. Limestone dosing directly into recirculation lines
2. Implementation of a tray level below the first spray bank
3. Replacement of spray nozzles at spray level 1-5







# Results:

- Improvements by tray installation:
  - Homogenization of the flue gas flow through the complete absorber
  - Increase of SO2 removal efficiency
  - Better utilization of limestone

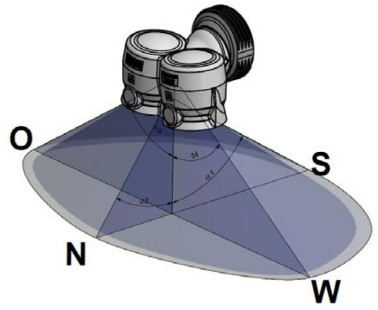
  due to maximized reaction surface

- Improvements by feeding limestone suspension into recirculation lines:
  - Direct contact of the absorbens with the flue gas → better utilization of the absorbent

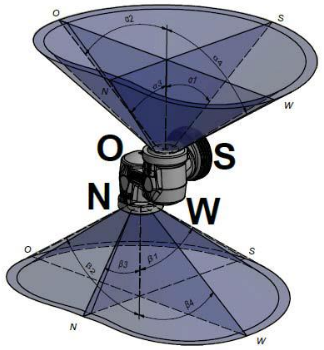
- Improvements by changing the spray nozzles:
  - 70:30 ratio (up:down) increases the amount of upwards sprayed droplets and thus the reaction time with the flue gas → improvement of SO2 efficiency
  - Decrease of pressure drop of the complete system due to higher portion of upwards directed droplets
  - Less abrasion of absorber wall and support beams due to asymmetric spray cones

# Modernization and Process Optimization of Wet Flue Gas Desulphurization

# Absorbers by using new developed spray components




## RETROFIT TPP POLAND

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# DUST SEPARATION

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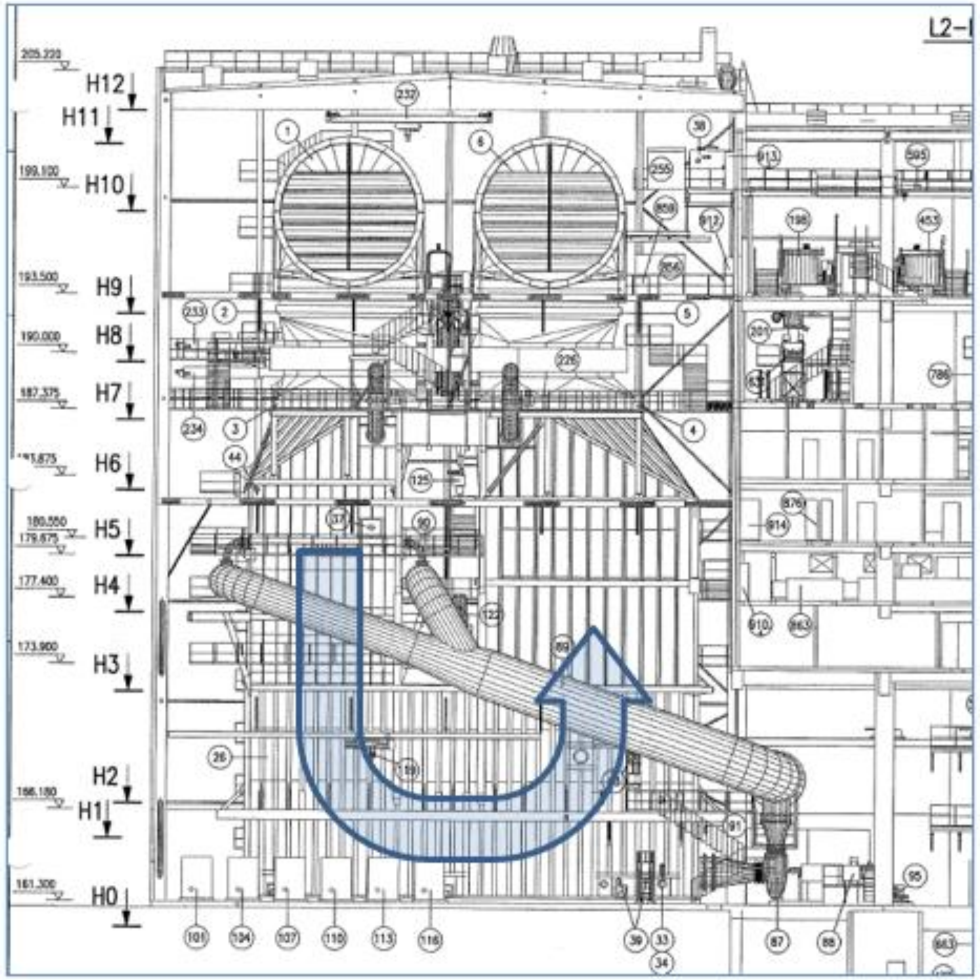
2023

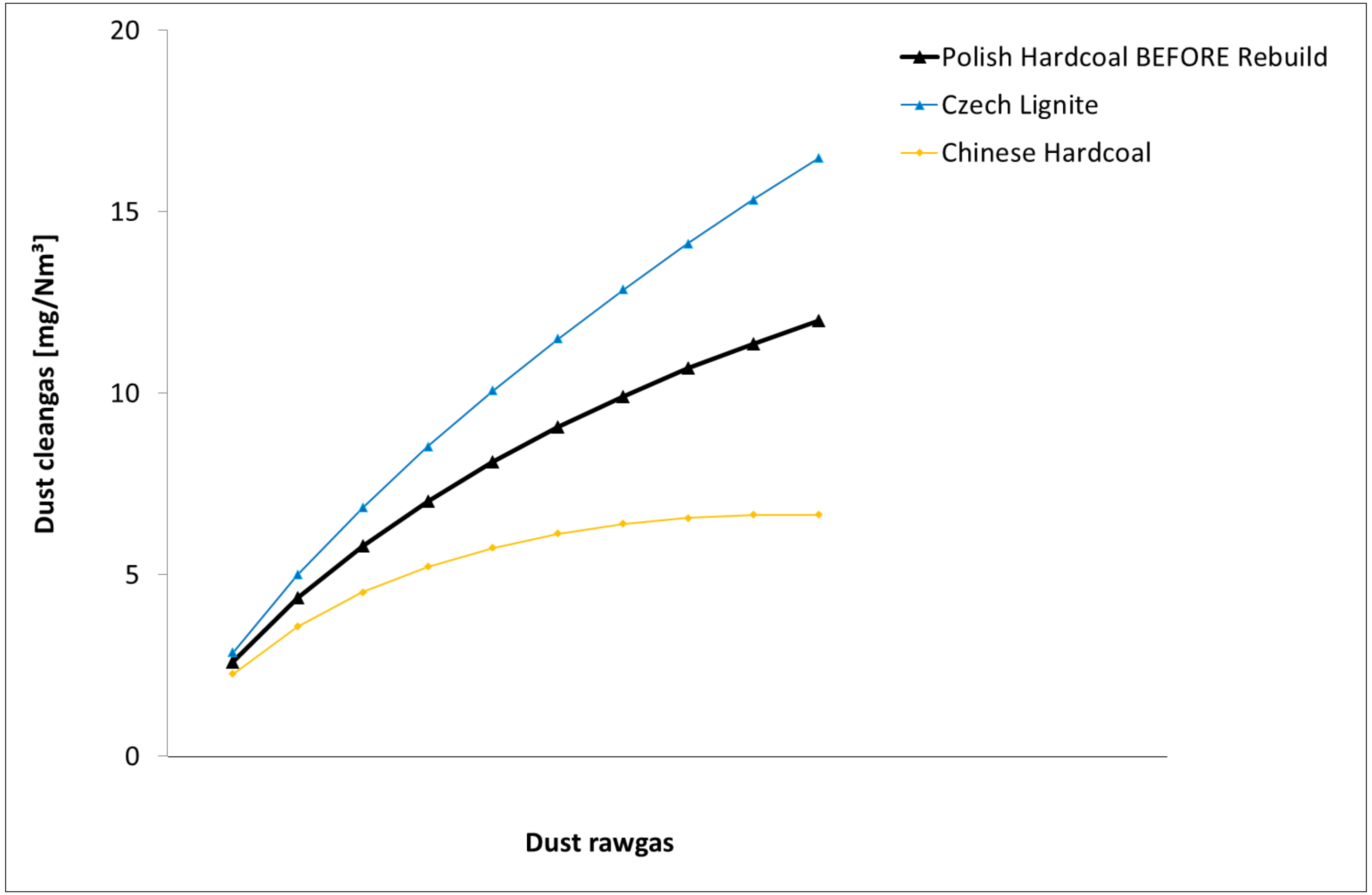
ENGINEERED SUCCESS

# START SITUATION

- U-shaped scrubber
- Packing in co-current part
- Volume flow 2.8 million Nm³/h
- Hard coal / biomass
- Dust inlet: ~ 75 mg/Nm³, tr, 6% O2
- Dust clean gas: ~ 13.5 mg/Nm³, tr, 6% O2
- GAVO in front of scrubber (with Scavenging Fan)
- Bypass flap in front of scrubber



# DUST SEPARATION - EXAMPLES




## Factors influencing dust separation:

- KGV ratio on scrubber entry
- Dust content at scrubber inlet
- Number of spray levels (l/g)
- Pressure at nozzle
- Spray pattern of nozzles, nozzle configuration (hollow cone/full cone) secondary atomization)
- ….

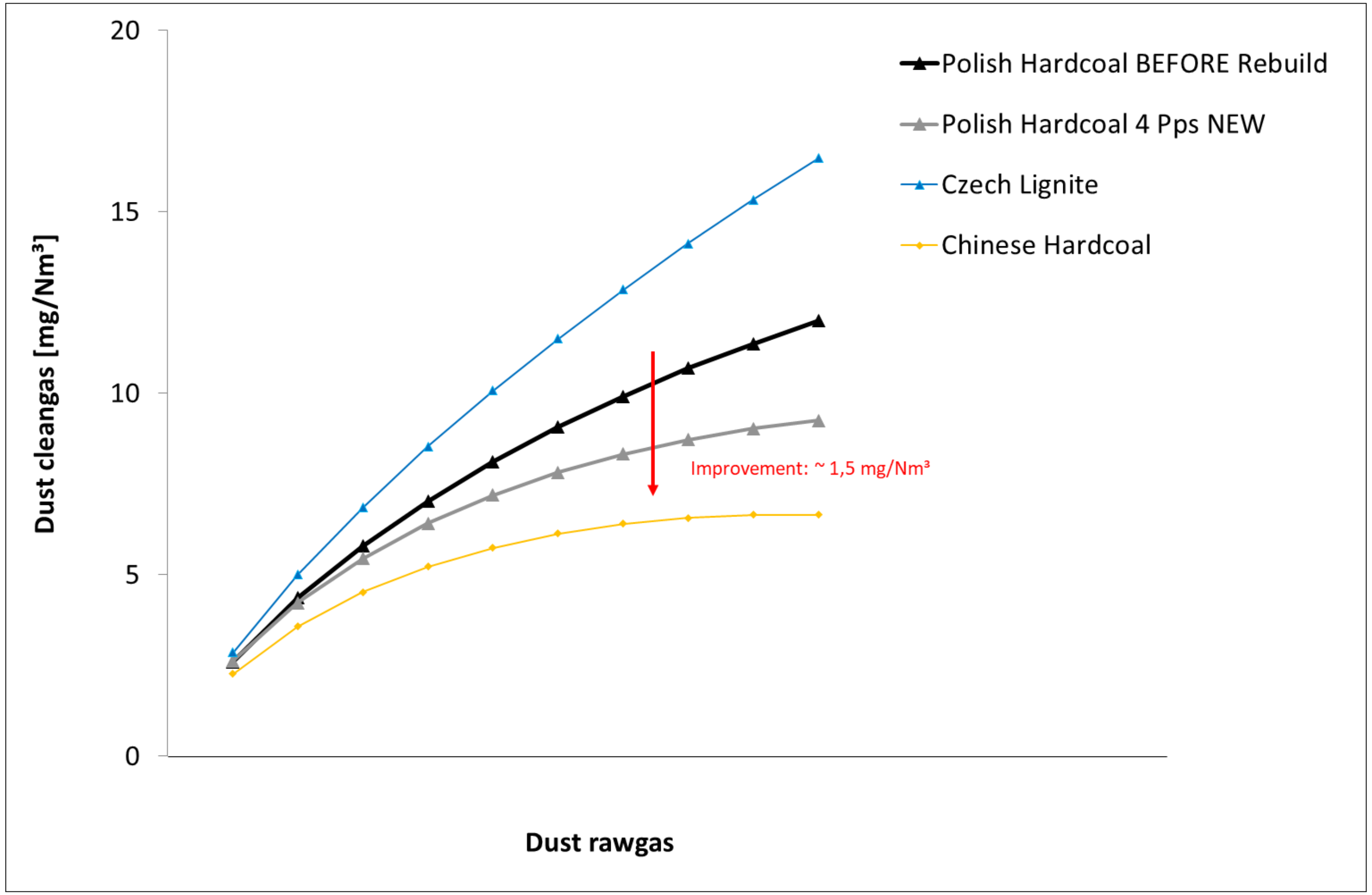
**Conclusion:**
**Dust separation can be very different**

# OBJECTIVE

## Measures

- Conversion to spray scrubber concept in combination with ANDRITZ patented REAplus System
- Total 3 spray level, 1 REAplus
- Supply of the 3 spray levels by 1 supply line
- Significant influence on the nozzle inlet pressure when different number of pumps in operation
- Special nozzle concept with maximum secondary atomization (exclusively hollow cone nozzles with variable spray angle)
- Nozzle pressures at 4 pump operation: 0.96 to 1.4 bar or ~ 0.7 to 1.15 bar at 3-pump operation (depending on spray level)

# DUST SEPARATION – AFTER




## Results:

- Raw gas dust content has been lowered
- Separation efficiency has been increased (nozzle concept, spray levels, REAplus)

- Gas dust content reached < 8 mg/Nm³, despite leaks via GAVO and bypass flap

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# WE WILL BE GLAD TO ASSIST YOU

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