BILFINGER BERGER
Power Services

International Conference POWER PLANTS 2010 in Serbia
Vrnjacka Banja, 29. October 2010

BABCOCK NOELL

# Conversion of Electrostatic Precipitators in Coal Fired Power Stations to Meet New European Emission Requirements

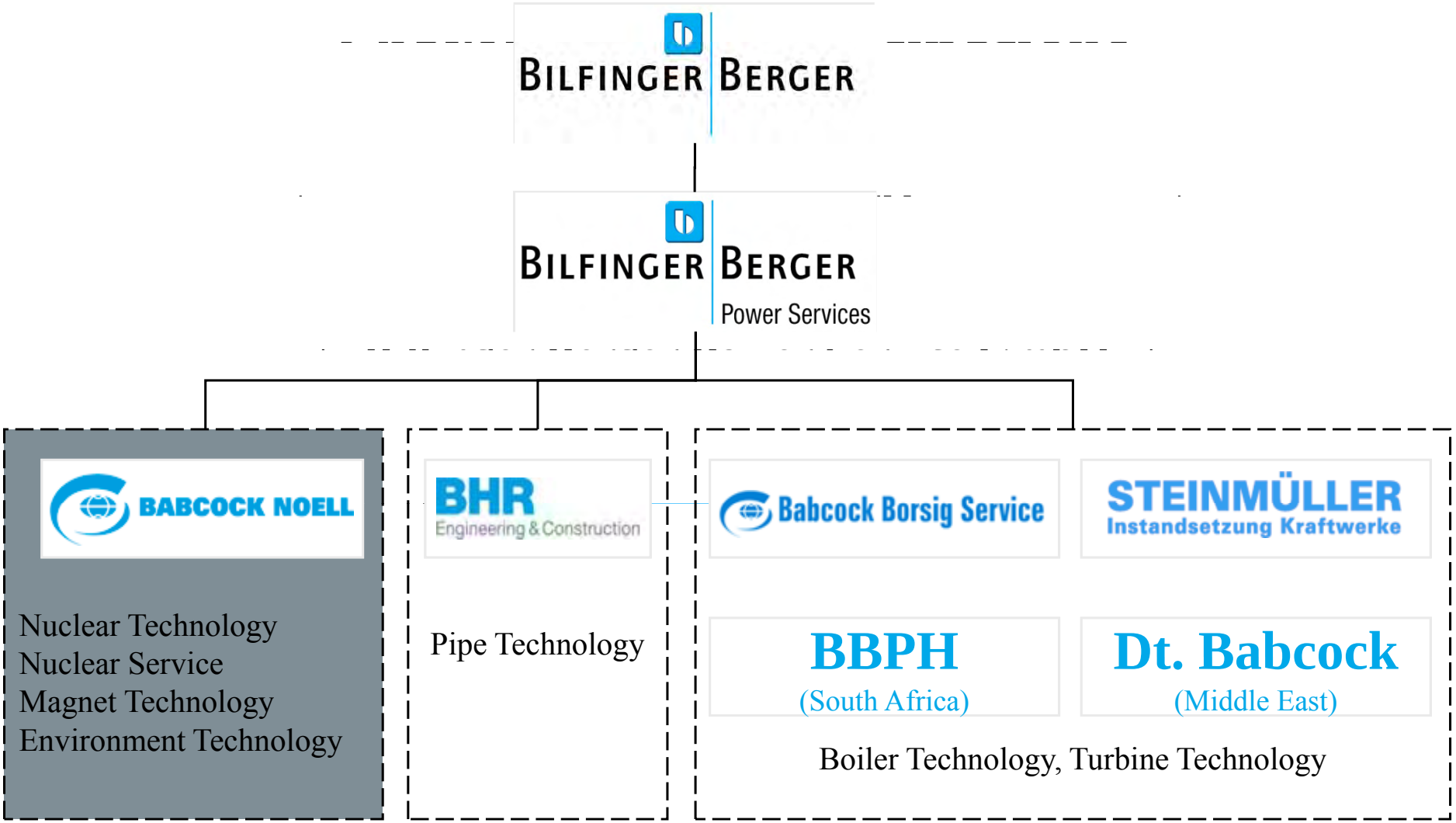
Dr.-Ing. Thomas Riepe, Oberhausen




# Agenda

1. Introduction of Babcock Noell
2. As example: The Typical Task
3. ESP Upgrade
4. ESP Conversion to FF
5. Economical Comparison of ESP and PJFF

# Babcock Noell GmbH in the Bilfinger Berger Group



# Key Data

## Bilfinger Berger Power Services GmbH

| **Bilfinger Berger Power Services GmbH** (consolidated) | **2009** in thousd. € | **2008** in thousd. € |
|---|---|---|
| Order receipt | 1,053,075 | 1,091,049 |
| Orders on hand | 1,137,446 | 1,101,307 |
| Performance | 1,016,936 | 782,190 |
| Balance sheet total | 577,341 | 501,657 |
| Employees | 7,497 | 4,582 |

# Babcock Noell

## – Experiences in Flue Gas Cleaning Plants

- Since 1981 experience in FGD, DeNOx- and Dedusting Technology for fossil power plants and waste to energy plants
- More than 20.000 $MW_{el}$ capacity equipped with “Double Loop Absorber” as Noell-KRC-Umwelttechnik, Germany (70 installations world wide)
- 2005 licence agreement with Babcock & Wilcox, USA (Tray Absorber)
- Currently more than 60 employees in the division environmental technologies, there of 80% of employees of former Noell KRC Umwelttechnik.



# BNG Environment Technology

Design, engineering, delivery, complete installation and commissioning of Flue Gas Cleaning Systems

DeSOx = wet / dry FGD,

DeNOx = SCR

DeDusting = ESP or FF

including:

- Computional Fluid Dynamics (CFD) studies for flue gas systems.
- Process optimisation and retrofitting.
- Flue gas cleaning according to dry process principles by using of limestone or other reaction granulates (packed bed filters).

# Agenda

1. Some Facts about Babcock Noell
2. As example: The Typical Task
3. ESP Upgrade
4. ESP Conversion to FF
5. Economical Comparison of ESP and PJFF

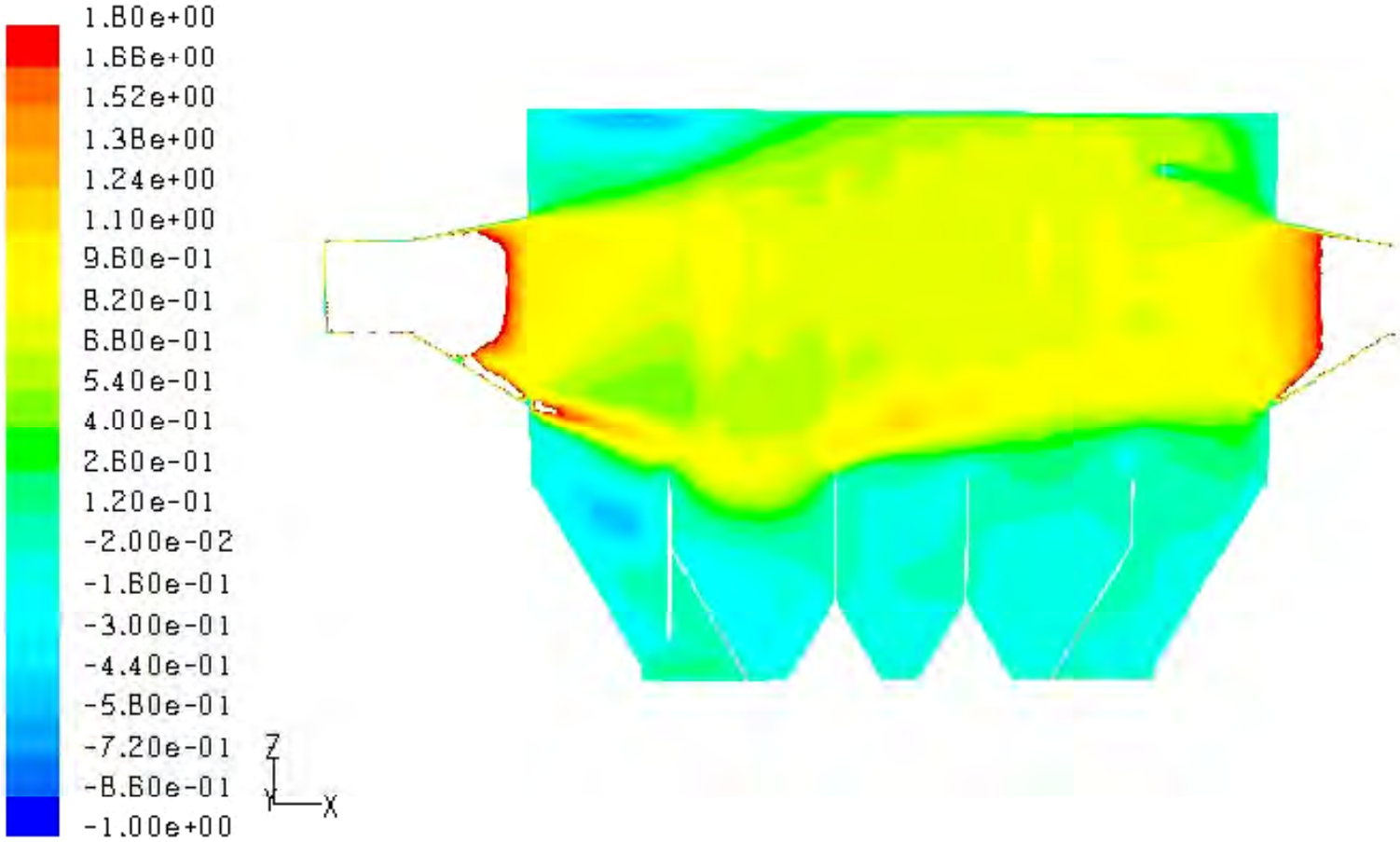
# Technical projection characteristics for exisiting electrostatic filters for one unit only)

- Type.....A3-7092; A4-7174; A5-7327,
- Manufacturer .....”ELEX AG”- Zürich,
- Year .....1966 / A3; 1967 / A4; 1970 / A5,
- Number of electrical filters for boiler .....3
- Field number per electri filter ( 3x3).....9
- Length of one electric field .....3 [m],
- Amount smoke gases..... .....3 x 650.000 [m³/h],
- Volume of electric filter .....3 x 607.5 [m³/h],
- Cross section of filter, effective.....3 x 67.5 [m²],
- Active precipitation surface.....3 x 4.860 [m²],
- Temperature of gases at the entrance of electrical filter.....165 [ºC],
- Dew-point..... .....55 – 60 [ºC],
- Sub-pressure within the filter.....- 400 [mm$H_2O$],
- Total height of emission electrodes..... .....8.350 [mm],
- Cross section of emission electrodes.....□ 3 x 3 [mm],
- Dimensions of precipitation plate.....7.500 / 490 / 1.5 [mm],
- Distance between precipitation plates.....250 [mm],
- Number of spaces between precipitation plates.....36,
- Number of rows of precipitation plates.....37,
- Concentration of ash particles at the entrance of electrical filter..... 37 [g / Nm³],
- Concentration of ash particles at the exit of electrical filter in units A3 and A4)..560 [mg / Nm³],
- Concentration of ash particles at the exit of electrical filter in unit A5..... 740 [mg / Nm³],

# Agenda

1. Some Facts about Babcock Noell
2. The Task in Kosovo Power Station
3. ESP Upgrade
4. ESP Conversion to FF
5. Economical Comparison of ESP and PJFF

# Gas flow distribution by means of CFD-Analysis of the ESP



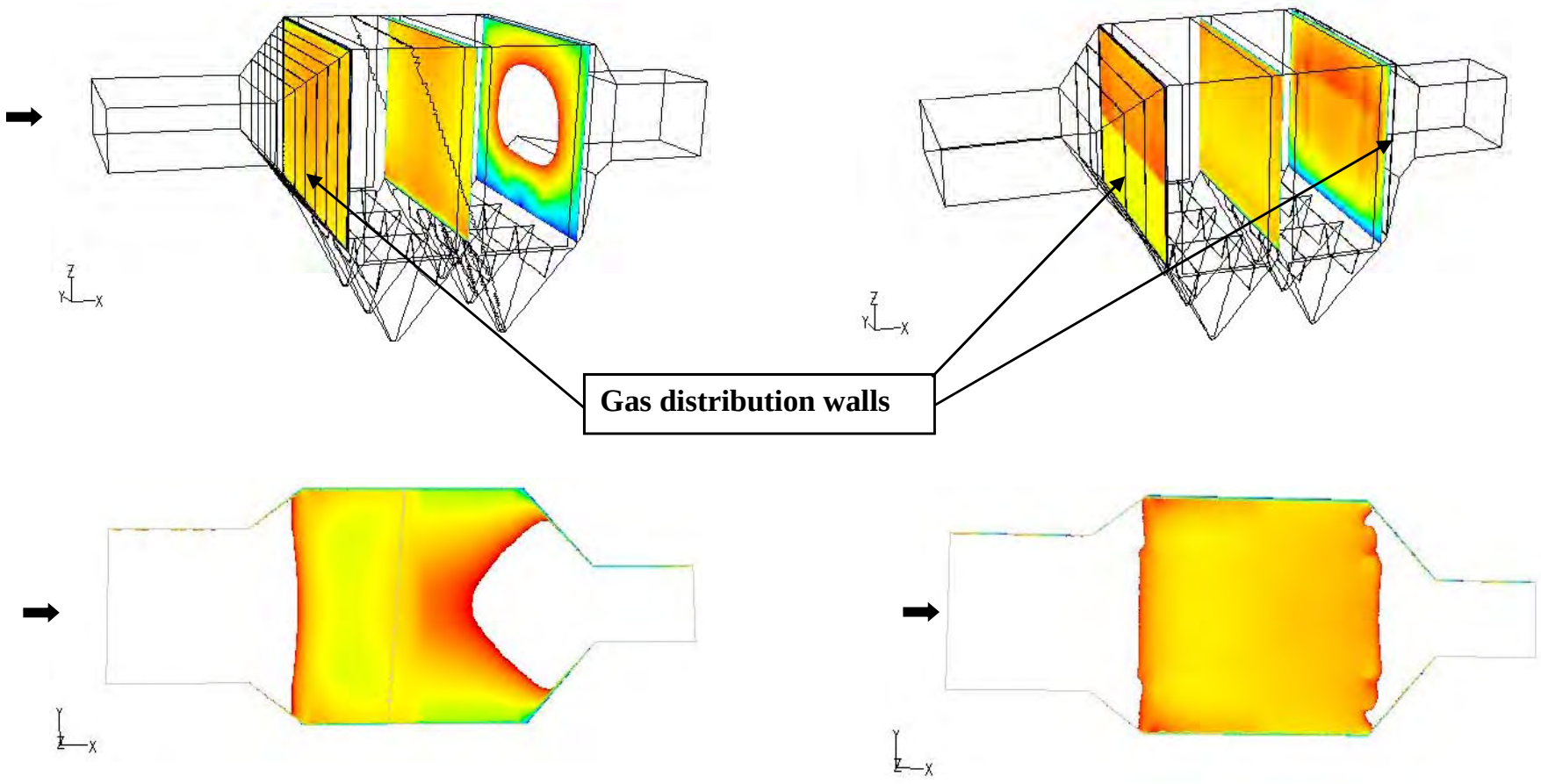

**Goal:**

**Correct velocity distribution = Good performance of the ESP**

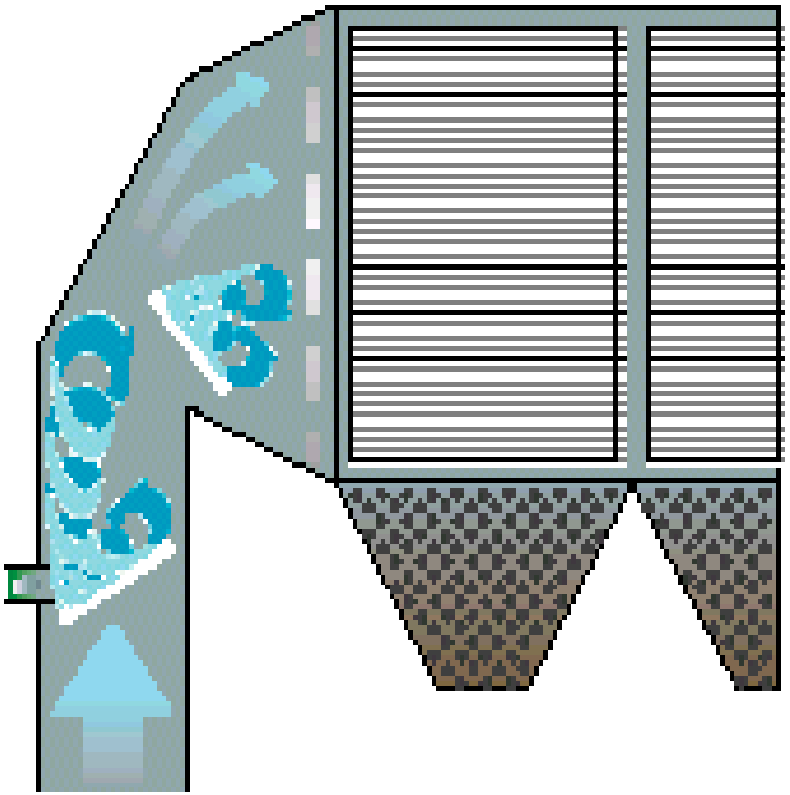
# ESP Gas flow optimisation with new distribution walls

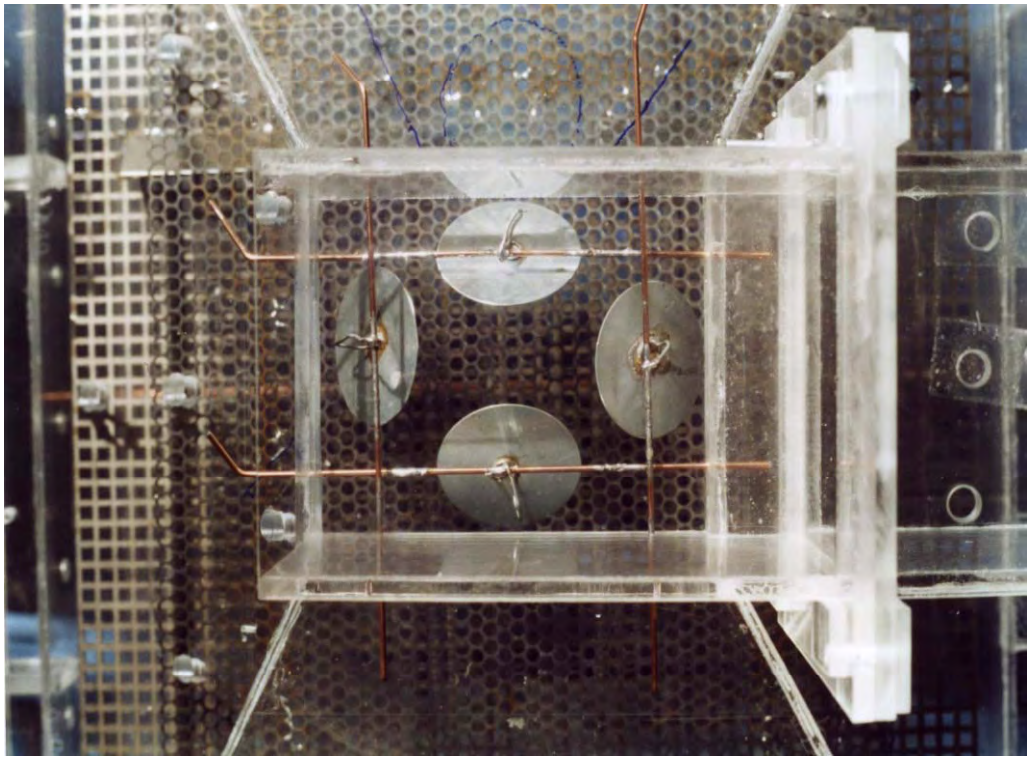

**Before optimisation**

**After conversion of gas distribution walls**



# ESP Dust Distribution Optimization & Modeling



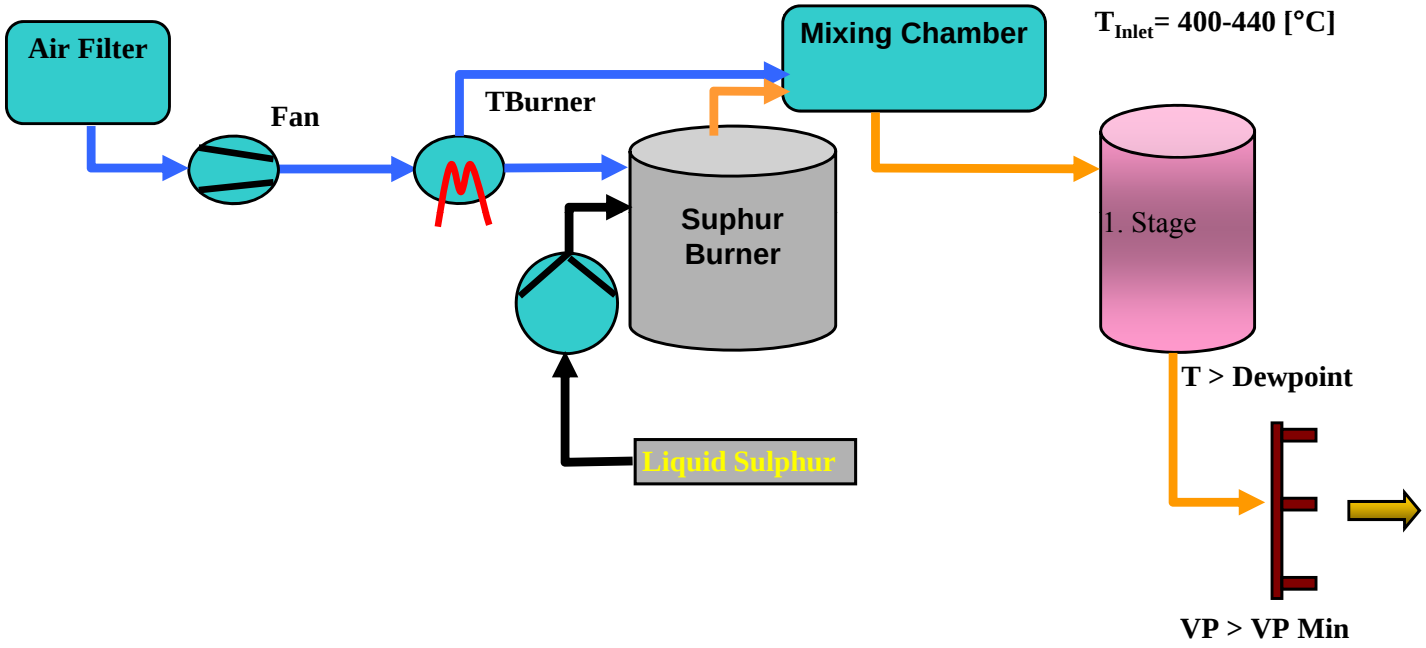


**Fluid homogenisation and destruction of dust streaks by means of vortex generation**

Original by
BALCKE DÜRR

# ESP Optimization with Flue Gas Conditioning (SO3-conditioning)

- Used to increase ESP efficiency in cases of high dust resistivity.
- Successfully used for low sulphur hard coal fired boilers.
- Dosing of some ppm of $H_2SO_4$ into the raw gas channel in front of the ESP.
- By means of adsorption of $H_2SO_4$ on the surface of the dust particles the electric charge transportation and thus the pricipitation will be increased.



# ESP Retrofit / Conversion Options

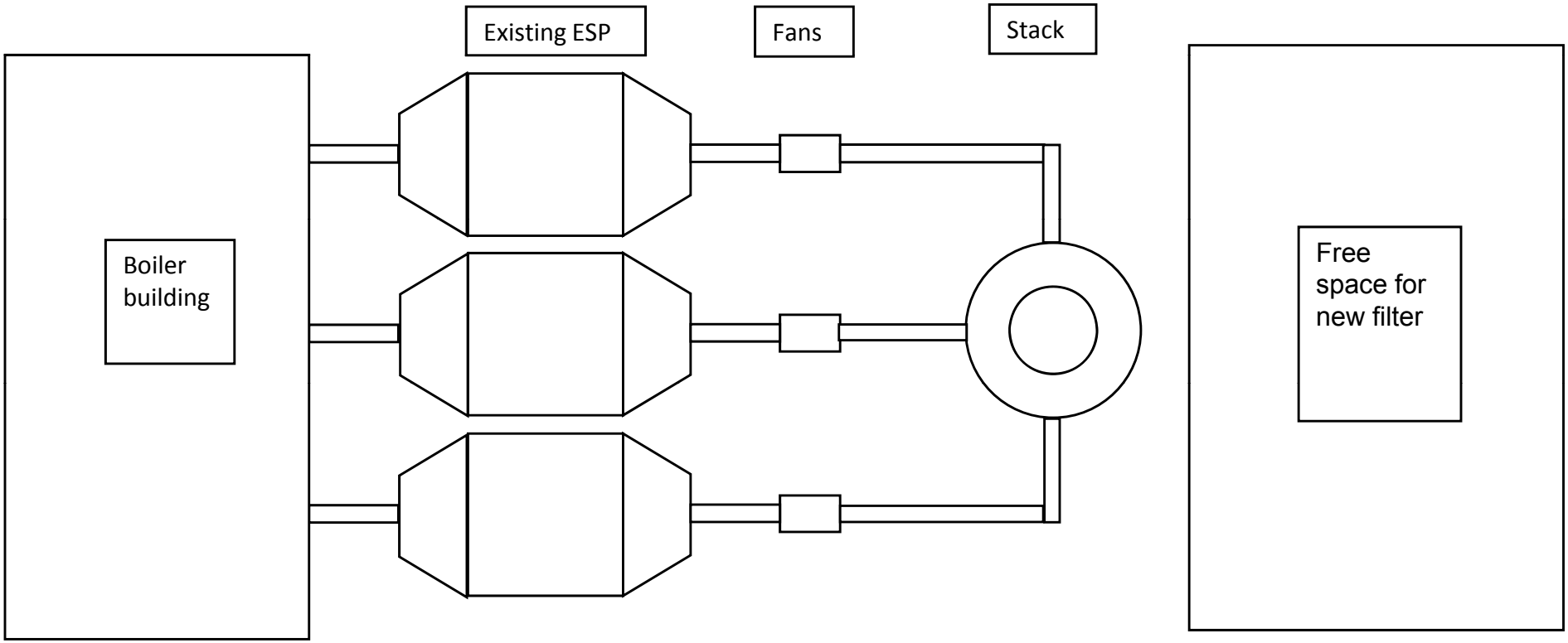
Problem:

The existing electrostatic precipitators (ESP) have been designed for the emission limits of the 1970´s (150 up to 750mg/Nm³). The future limits of <50mg/Nm³ or even less cannot be reached with those filters, not even with all technical modernization measures available today, without significant increase of the size.

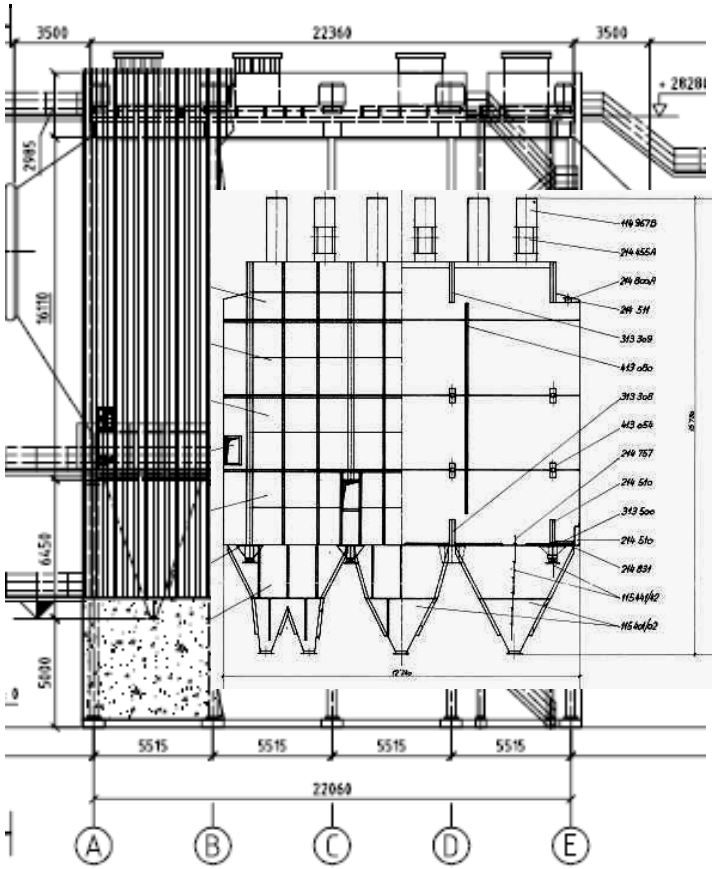
Options:

- Replacement of the ESP with one or more new ESP or FF.
- Place one or more ESP or fabric filter (FF) behind (Back-up) or in parallel (Slip stream) to the existing ESP.
- Conversion of the existing ESP into fabric filters.

# ESP-Retrofit Kosovo A



# Replacement of the 3 ESP with new ones



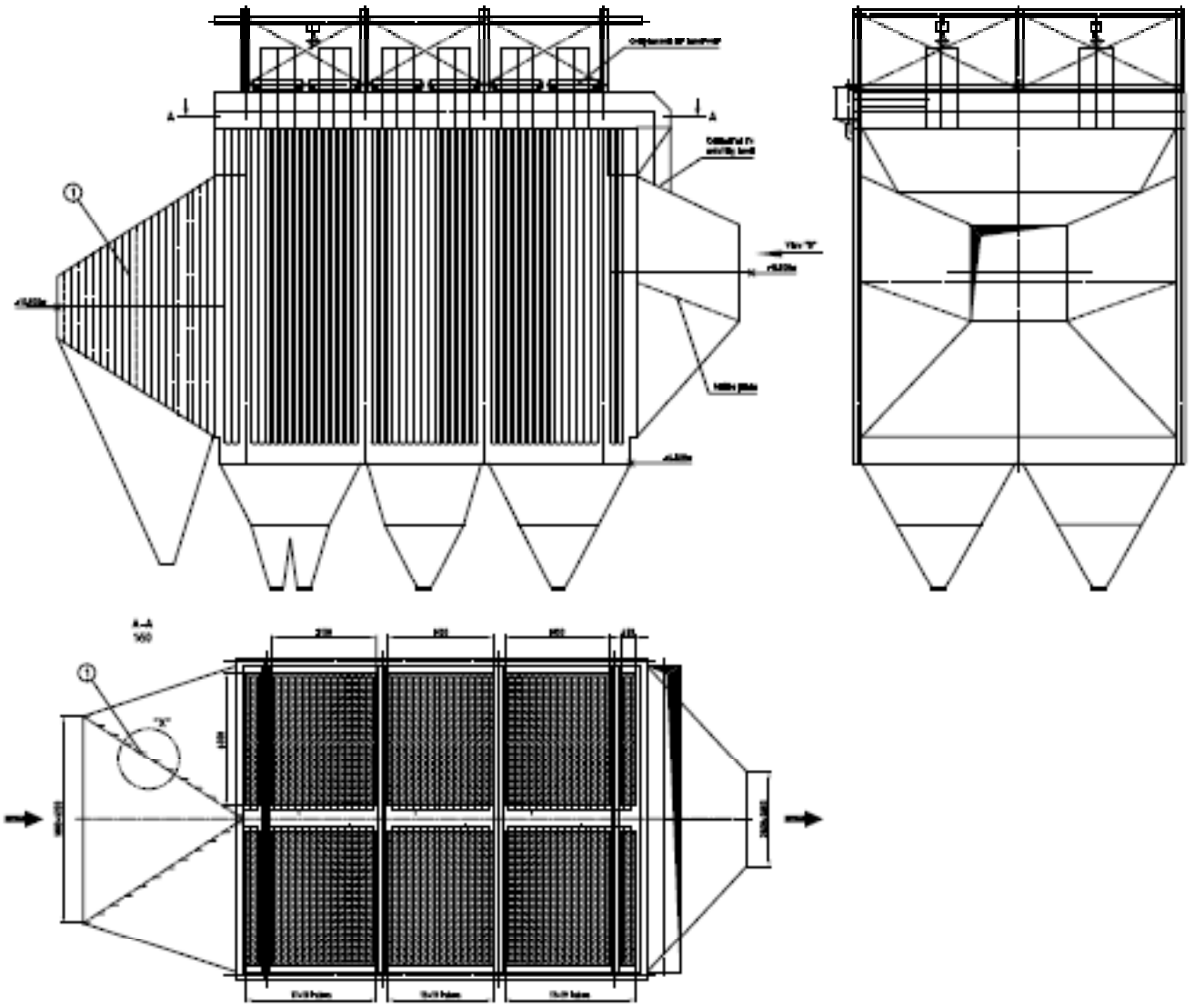

| Technical parameters | existing ESP | Dim. | new ESP |
|---|---|---|---|
| Number of ESP per boiler | 3 | | 3 |
| Field number per ESP | 3 | | 4 |
| Length of one electric field | 3.000 | [mm] | 4.000 |
| Off-gas volume per hour | 3 x 650.000 | [m³/h] | 3 x 650.000 |
| Volume of ESP | 3 x 607,5 | [m³/h] | 3 x 1.971 |
| Cross section of ESP, effective | 3 x 67,5 | [m²] | 3 x 123,2 |
| Active precipitation surface | 3 x 4.860 | [m²] | 3 x 9.856 |
| Temperature of gases at the entrance of ESP | 165 | [°C] | 165 |
| Dew-point | 55 – 60 | [°C] | 55 - 60 |
| Sub-pressure within the filter | -400 | [mmH2O] | -400 |
| Total height of emission electrodes | 8.350 | [mm] | 14.000 |
| Cross section of emission electrodes | □ 3 x 3 | [mm] | P&S 22 |
| Dimensions of precipitation plate | 7.500 / 490 / 1.5 | [mm] | 14.000 / 500 / 1,25 |
| Distance between precipitation plates | 250 | [mm] | 400 |
| Number of spaces between precipitation plates | 36 | | 22 |
| Number of rows of precipitation plates | 37 | | 23 |
| Concentration of ash particles at the entrance of electrical filter | 37 | [g / Nm³] | 37 |
| Concentration of ash particles at the exit of electrical filter in units A3 and A4 | 560 | [mg / Nm³] | 30 |
| Concentration of ash particles at the exit of electrical filter in unit A5 | 740 | [mg / Nm³] | 30 |

# Agenda

1. Some Facts about Babcock Noell
2. As example: The Typical Task
3. ESP Upgrade
4. ESP Conversion to FF
5. Economical Comparison of ESP and PJFF

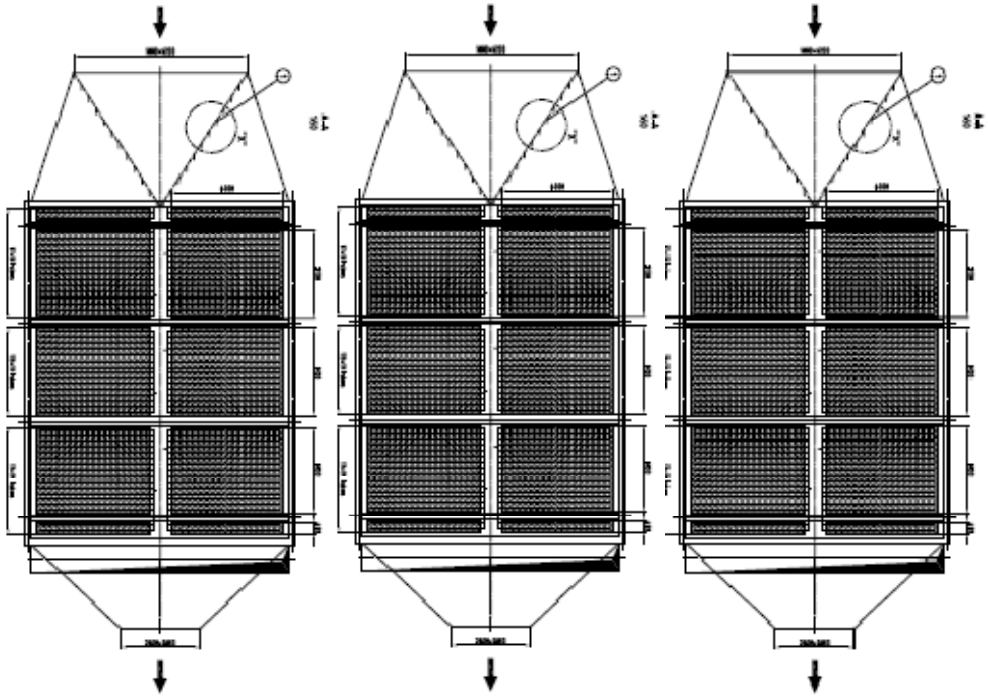
# Conversion of the 3 ESP to Fabric Filter

- Space inside existing ESP housing is limited but big enough.
- In combination with 10m filter bags the space fits.
- Gas and dust distribution has to be optimized.
- For on-line maintenance one of three filters can be isolated by raw- and clean gas dampers.
- Detailed checking of reusability of existing equipment necessary.



# Conversion of the 3 ESP to Fabric Filter

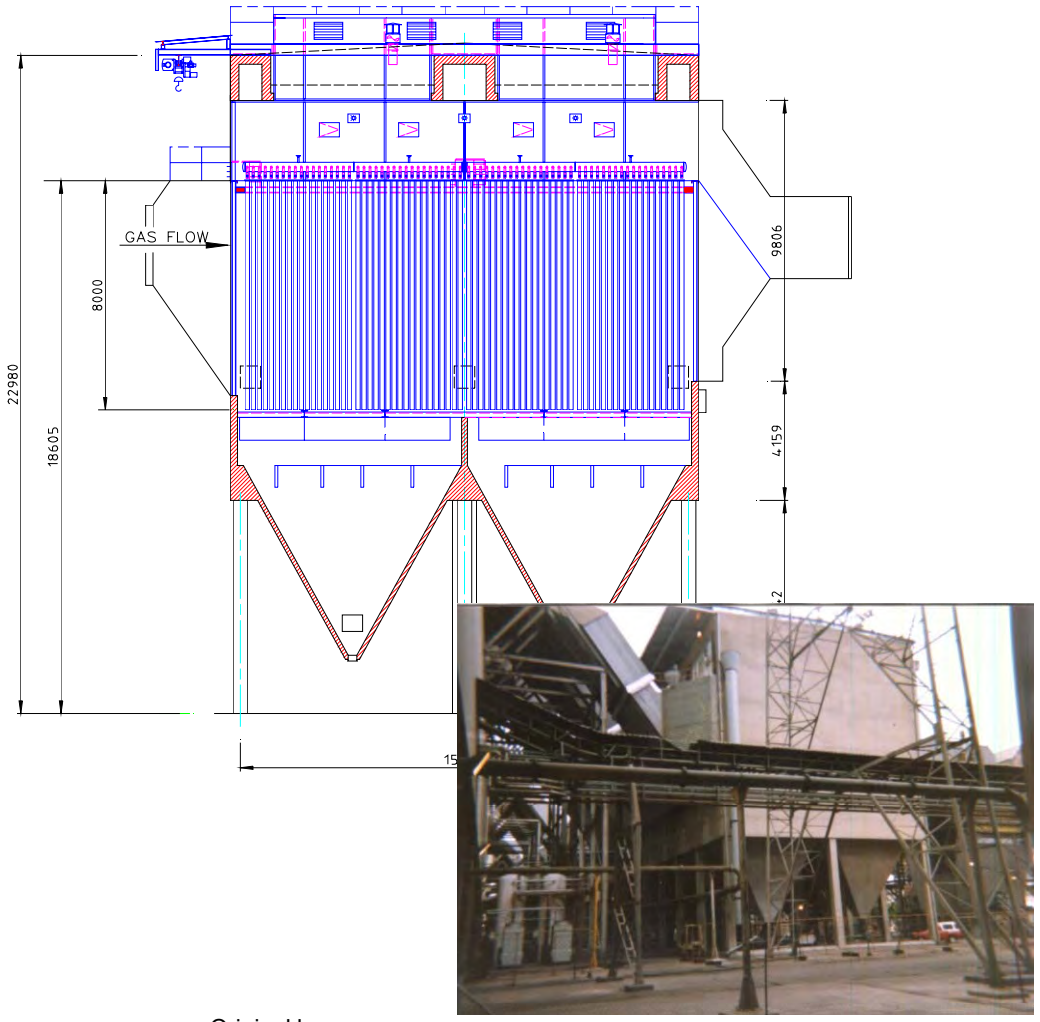
| | | | |
|---|---|---|---|
| Bag filter type | BNG ecojet 1/1862/10.0 | | |
| Manufacturer | Babcock Noell | | |
| Bag material | Glass/PTFE | | |
| Bag diameter/length | 165/10.000 | | mm |
| max. gas temperature | 200 | | °C |
| raw gas dust content | 37 | | g/Nm³ |
| clean gas dust content | <10 | | mg/Nm³ |
| | per filter | per boiler | dim. |
| Quantity per boiler | | 3 | pc(s) |
| Gas volume, normal | 417.000 | 1.250.000 | Nm³/h |
| Gas volume | 650.000 | 1.950.000 | m³ (ac) |
| Gas temperature | 165 | 165 | °C |
| Actve filter area | 9.652 | 28.956 | m² |
| air-to-cloth-ratio | 67,3 | 67,3 | m³/m²h |
| pressure loss, max. | 18 | 18 | hPa |
| quantity of bags | 1.862 | 5.586 | pc(s) |



# Example: Conversion from ESP to Fabric Filter

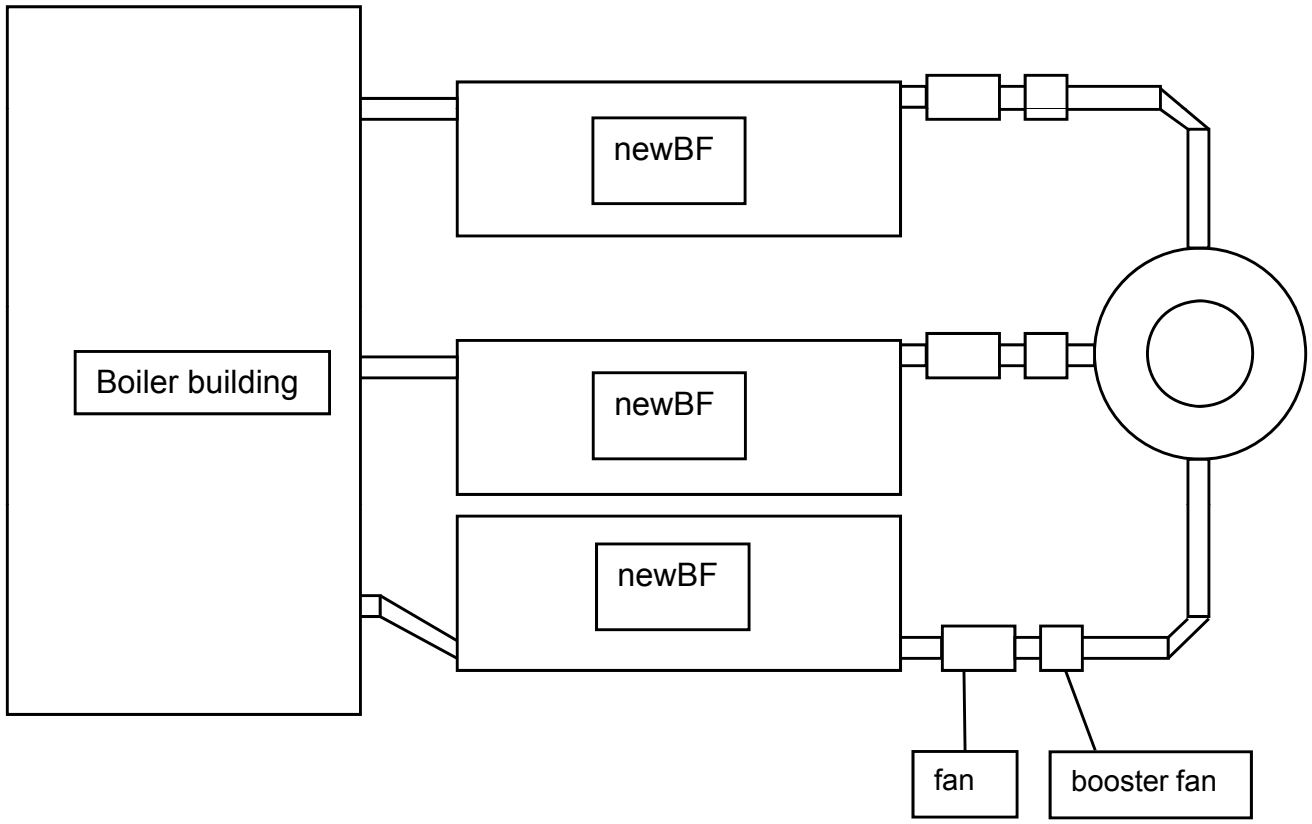
## Arnot Power Station, RSA

- 350 MW - PCFB Units 4,5 and 6
- FF-Retrofit into Concrete ESP-Casing
- Bag Length : 8,0 m; Material PPS/PPS; 11.000 Bags per Unit
- Temperature 130 - 145°C; max. 160°C Peak
- Project Duration: 13 Months incl. Erection



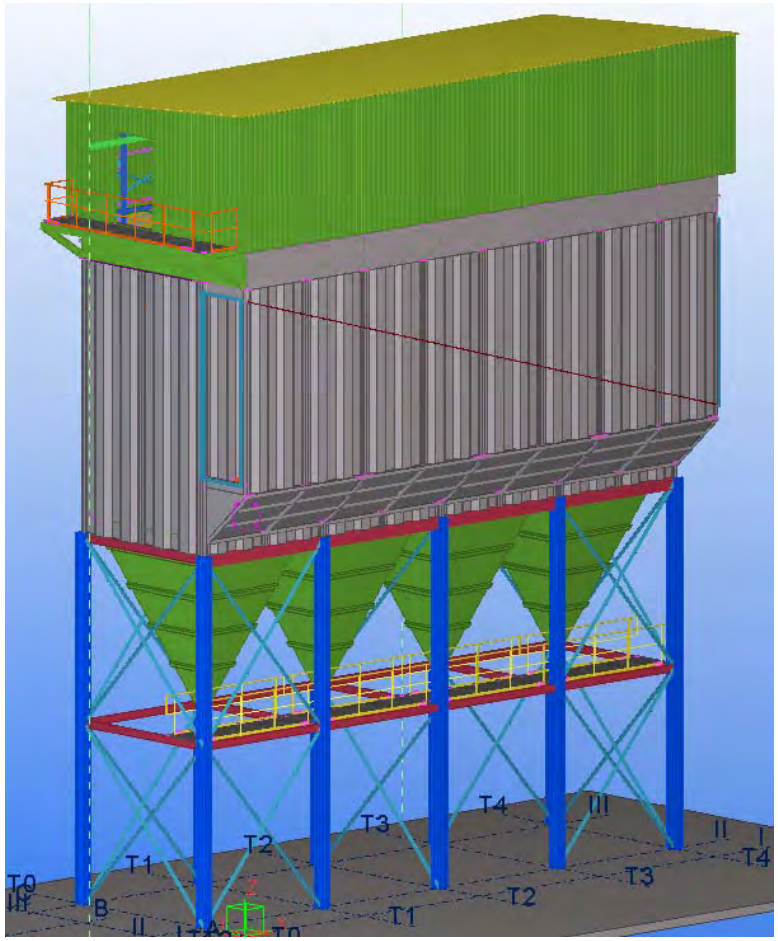

Original by
BALCKE DÜRR

# Schematic Principle of the Replacement of existing ESP with new Fabric Filters one-by-one

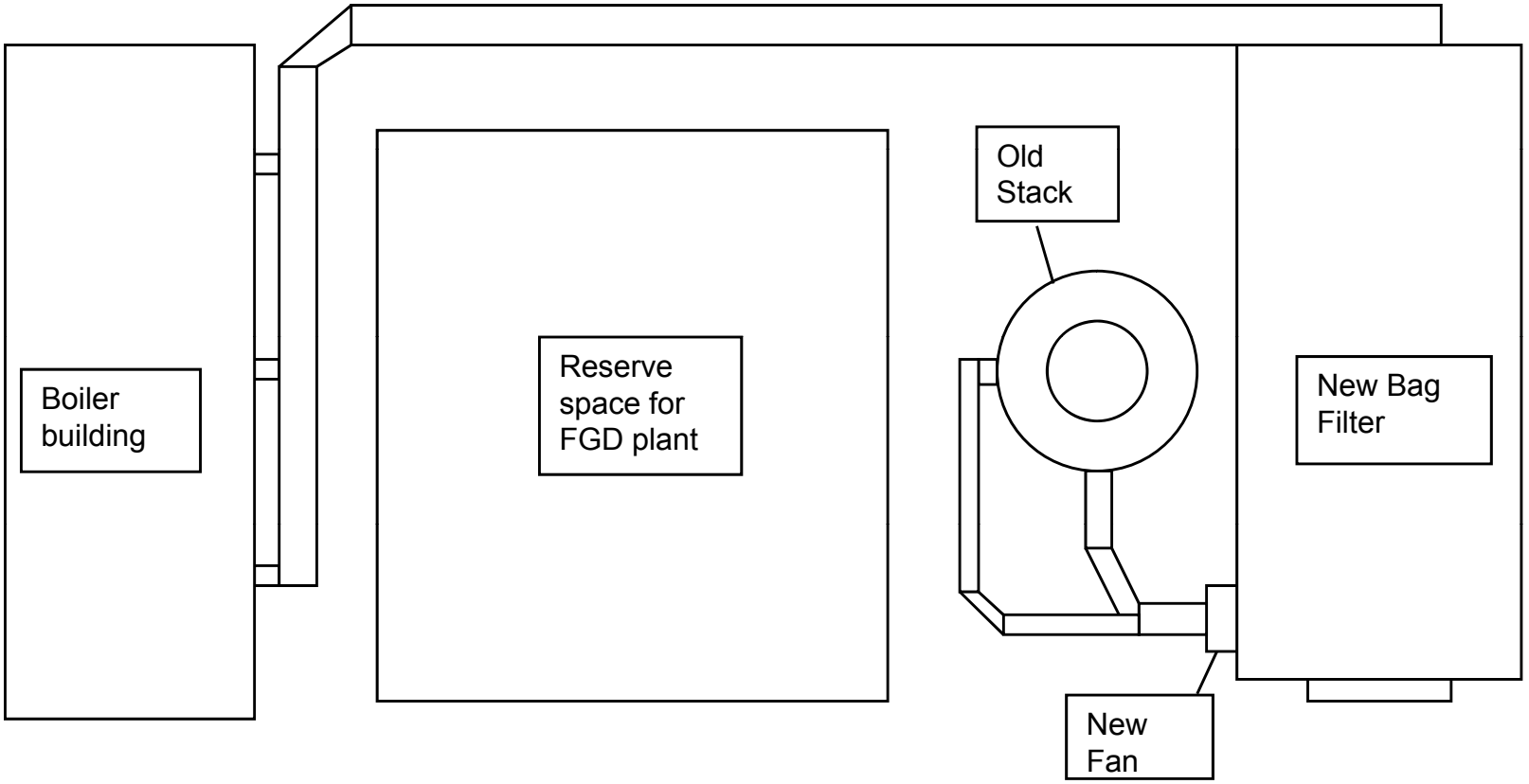


# 3 new PJFF for Kosovo A as Replacement for ESP

| | | | |
|---|---|---|---|
| Bag filter type | BNG ecojet 4/624/8.0 | | |
| Manufacturer | Babcock Noell | | |
| Bag material | Glass/PTFE | | |
| Bag diameter/length | 165/8.000 | | mm |
| max. gas temperature | 200 | | °C |
| raw gas dust content | 37 | | g/Nm³ |
| clean gas dust content | <5 | | mg/Nm³ |
| | per filter | per boiler | dim. |
| Quantity per boiler | | 3 | pc(s) |
| Gas volume, normal | 417.000 | 1.250.000 | Nm³/h |
| Gas volume | 650.000 | 1.950.000 | m³ (ac) |
| Gas temperature | 165 | 165 | °C |
| Main dimensions: | | | |
| length/width/height | 24.000/8.200/24.000 | | mm |
| Actve filter area | 10.333 | 31.000 | m² |
| air-to-cloth-ratio | 62,9 | 62,9 | m³/m²h |
| pressure loss | 14 | 14 | hPa |
| quantity of bags | 2.496 | 7.488 | pc(s) |



# Schematic Principle of the Replacement of the ESP with one single new Fabric Filter and Fan



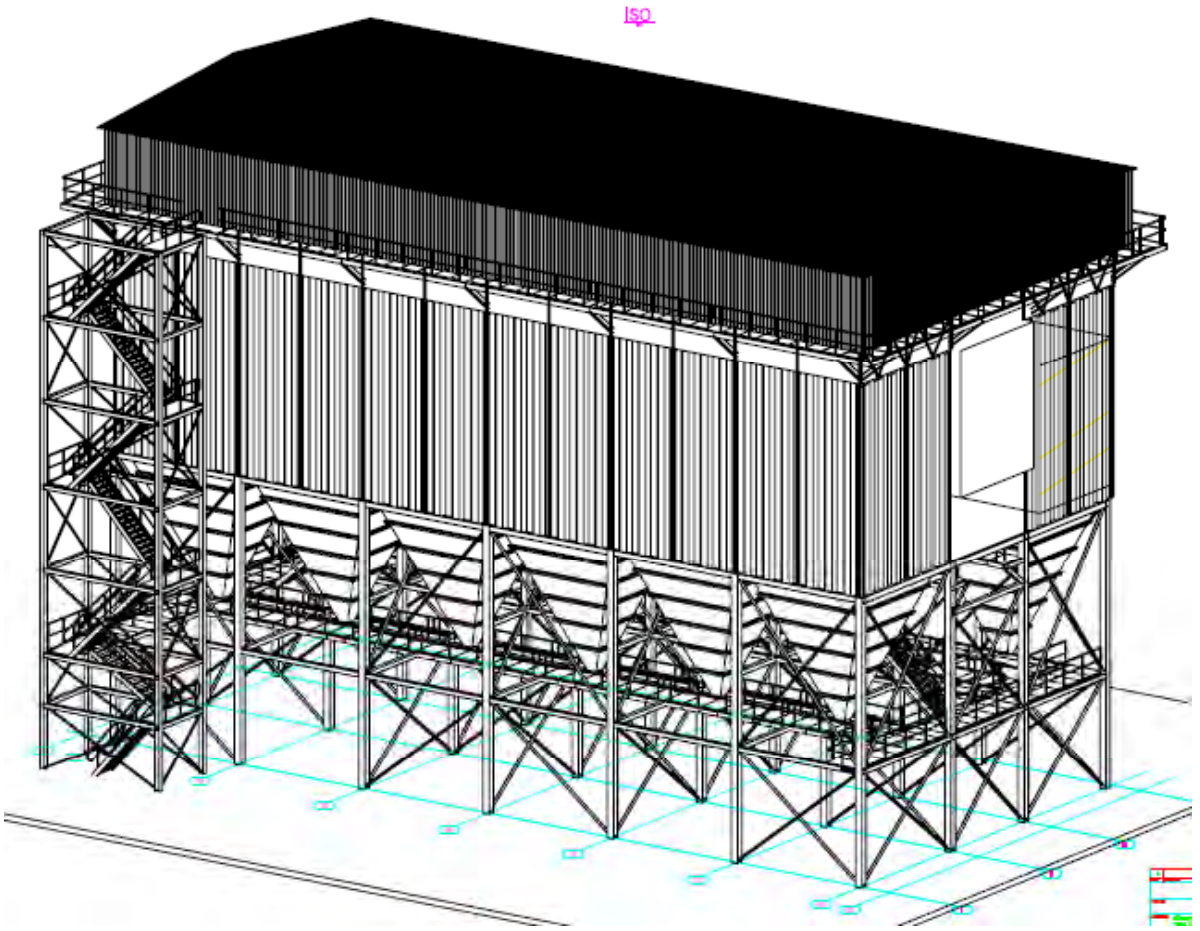
# Single PJFF for 330MW Coal Fired Boiler

One new bag filter will be less expensive than three smaller ones.

Everything can be erected with boiler in full operation.

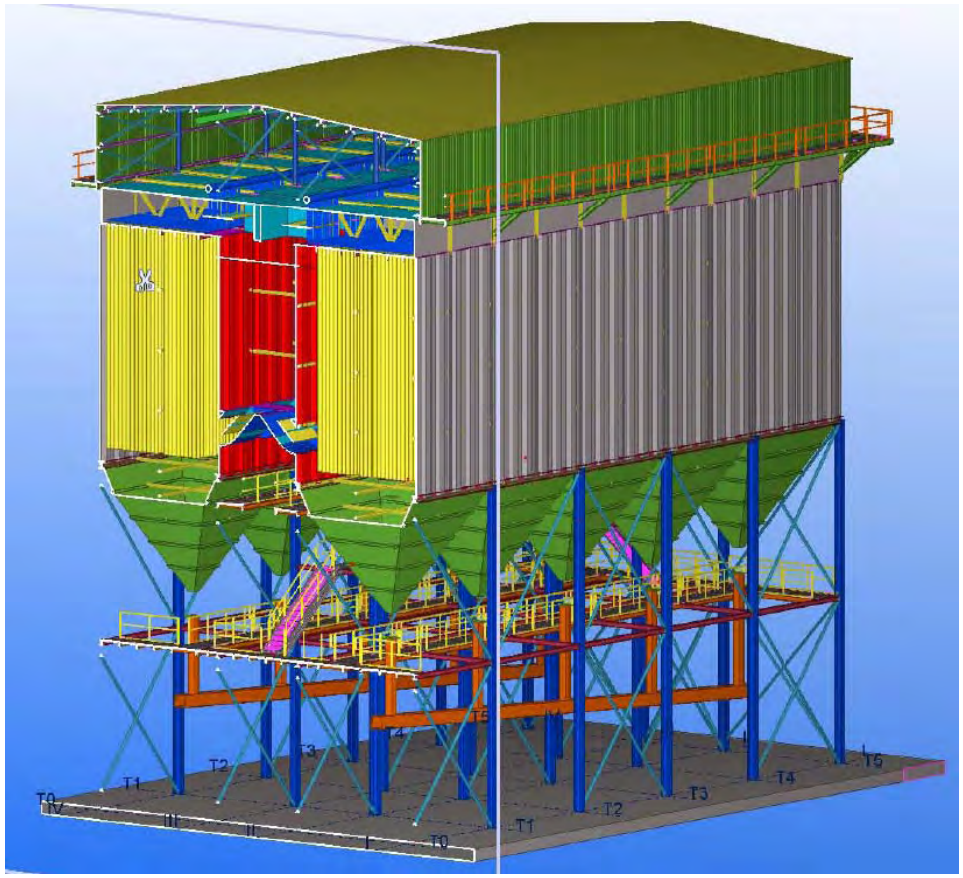
Only short boiler stopps for swiching the raw- and cleangas ducts.

Receive free space back after demolishing the old ESP



# Single PJFF for 330MW Coal Fired Boiler

| | | | |
|---|---|---|---|
| Bag filter type | BNG ecojet 12/624/8.0 | | |
| Manufacturer | Babcock Noell | | |
| Bag material | Glass/PTFE | | |
| Bag diameter/length | 165/8.000 | | mm |
| max. gas temperature | 200 | | °C |
| raw gas dust content | 37 | | g/Nm³ |
| clean gas dust content | <5 | | mg/Nm³ |
| | per filter | per boiler | dim. |
| Quantity per boiler | | 1 | pc(s) |
| Gas volume, normal | 3 x 417000 | 1.250.000 | Nm³/h |
| Gas volume | 3 x 650000 | 1.950.000 | m³ (ac) |
| Gas temperature | 165 | 165 | °C |
| Main dimensions: | | | |
| length/width/height | 36.000/16.600/24.000 | | mm |
| Actve filter area | 31.000 | 31.000 | m² |
| air-to-cloth-ratio | 62,9 | 62,9 | m³/m²h |
| pressure loss | 14 | 14 | hPa |
| quantity of bags | 7.488 | 7.488 | pc(s) |



# Agenda

1. Some Facts about Babcock Noell
2. The Task in Kosovo Power Station
3. ESP Upgrade
4. ESP Conversion to FF
5. Economical Comparison of ESP and PJFF

# Comparison of the ESP Conversion Alternatives for the Existing 330MW Coal Fired Boiler

| | 3 new ESP as replacement | Conversion of the ESP to bag filters | New bag filters as replacement | New single bag filter<br><br>Greenfield | New ESP<br><br>Greenfield |
|---|---|---|---|---|---|
| **Residual dust emissions** | **<30 mg/Nm³** | **<10** mg/Nm³ | **<5 mg/Nm³** | **<5 mg/Nm³** | **<30 mg/Nm³** |
| **Pressure loss** | **<4 hPa** | **<18 hPa** | **<14 hPa** | **<14 hPa** | **<4 hPa** |
| **Boiler outage duration** | **6 x 2 weeks** | **6 x 2 weeks** | **6 x 2 weeks** | **2 weeks** | **2 weeks** |
| **Period of reduced boiler load (approximately)** | **24 months** | **9 months** | **12 months** | **no** | **no** |
| **Reuse of ESP equipm. possible (benefit & risk)** | **no** | **yes** | **no** | **no** | **no** |
| **Investment cost factor approximately** | **100** | **55** | **80** | **75** | **95** |
| **Life cycle cost factor approx.** | **1** | **1,2** | **1** | **1** | **1** |

## Babcock Noell GmbH

Alfred Nobel Str. 20
97080 Würzburg
Germany

Tel: +49 931 9030
Fax: +49 931 9036000

info@babcocknoell.de
www.babcocknoell.de

Registergericht Würzburg, HRB 7156
USt-Id. Nr.: DE211420259

Managing Directors:
Dr. Ronald Hepper
Peter Stephan
Helmut Welp