Knowledge grows

SCR Retrofit – Advanced DeNOx Technology

YARA Environmental Technologies GmbH
AUSTRIA





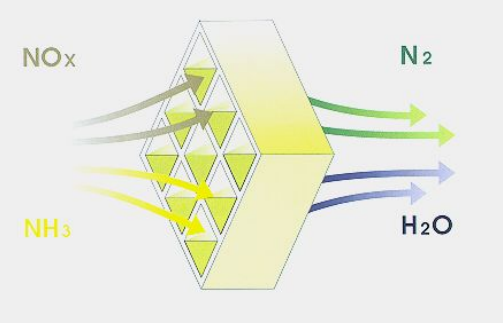
Content

- SCR Technology
- Catalysts
- SCR components incl. reagent preparation and injection
- SCR design criteria
- Examples of SCR DeNOx installations
- Catalyst regeneration

SCR catalytic reduction method

- The SCR is the best developed and most widely used method for removing NOx from flue gases.
- It consists in the reduction of NO and NO_2 to N_2 under the influence of ammonia on the catalyst layer.
- The general reactions are:
  - $4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$
  - $2\ NO_2 + 4\ NH_3 + O_2 \rightarrow 3\ N_2 + 6\ H_2O$
- The optimal temperature range for the reaction is 315 - 400 ° C.
- Typically, ammonia is added in the form of ammonia water in an amount less than stoichiometric (0.8 - 1.0 mol / mol NOx).

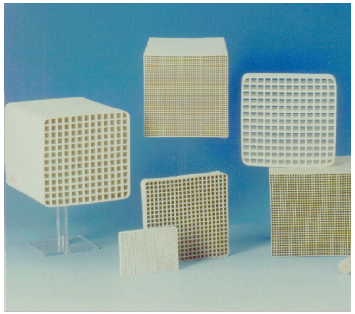
SCR Technology



Main Chemical Reaction for NOx Removal:

$$NO_X + NH_3 \Rightarrow N_2 + H_2O$$

Honeycomb Type



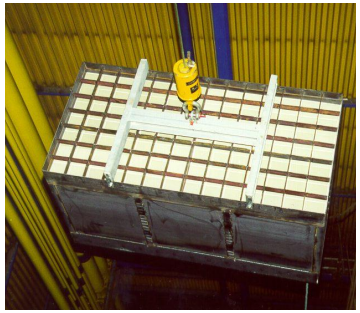
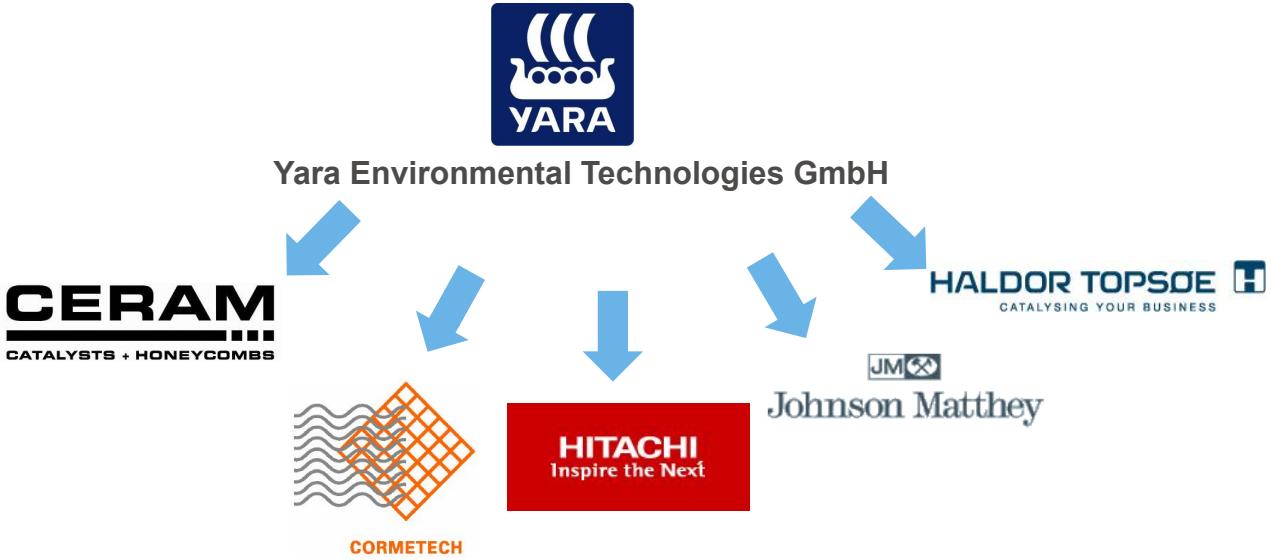


Plate Type





SCR System and Catalyst Engineering



MANUFACTURERS OF SCR CATALYSTS

Options of SCR placement

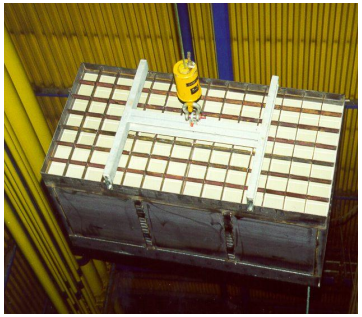
- New block with SCR system

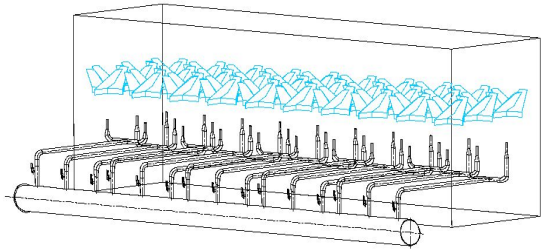
- RETROFIT - high dust DeNOx
  - **in a second draft**
  - **external reactor**

- RETROFIT – low dust DeNOx
  - **tail end solution**

SCR System – main components

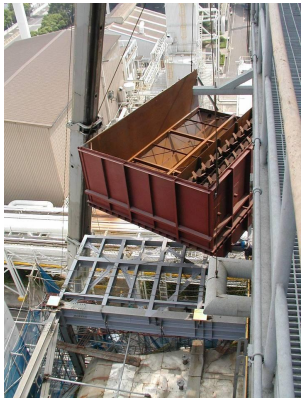
- Ammonia Storage
- Ammonia Vaporizer
- Ammonia Injection Grid
- Catalyst
- SCR Reactor







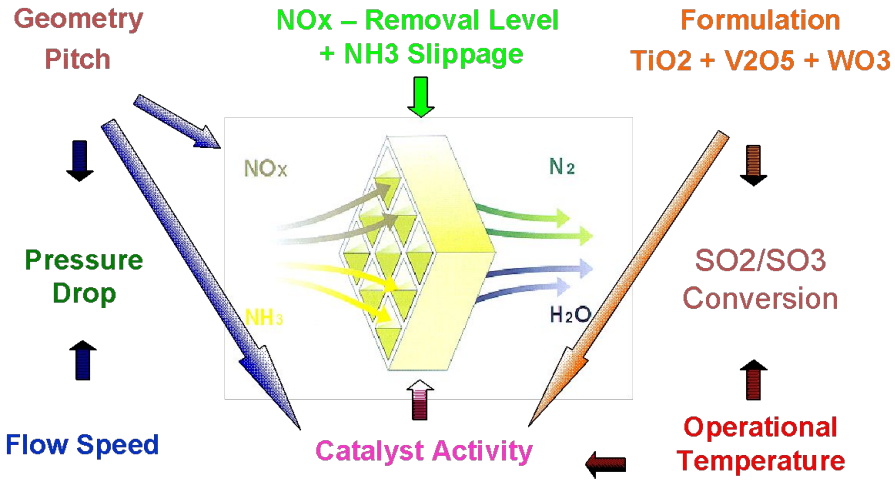






SCR design criteria

- Highest NOx removal efficiency
- Lowest possible NH3-slip
- Lowest possible pressure drop
- Highest possible availability
- Highest possible flexibility across the whole load range
- Lowest possible impact on existing system



- AND: OPTIMUM SOLUTION INVEST- vs OPERATING COSTS

Catalyst Type Selection

	Plate type	Honeycombe type
Dust plugging resistance	+	-
Dust erosion resistance	+	-
Pressure loss	+	o
NOx reduction efficiency	+	+
Specific surface area	-	+
Soot blowing frequency	+	-
Thermal shock resistance	+	o
SO2 /SO3 conversion rate	+	o

+ = good

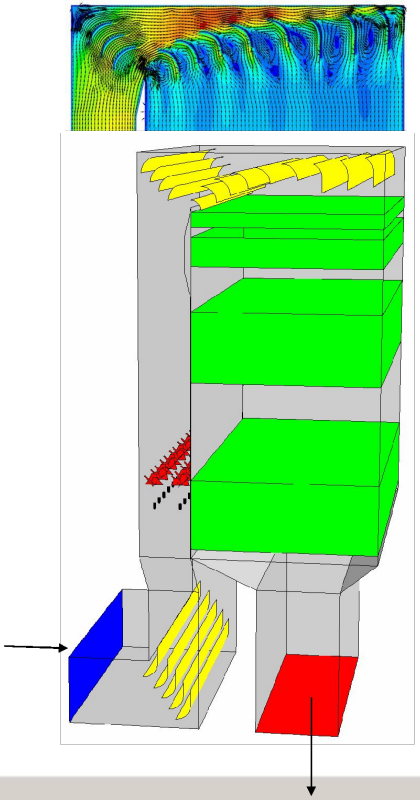
- = poor

o = equal

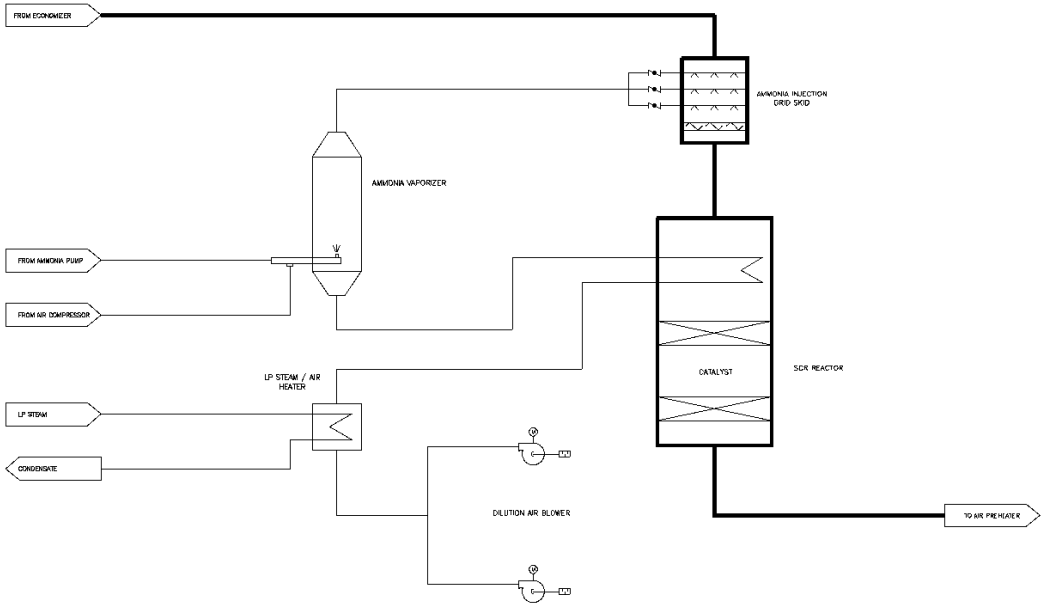
CFD Design

- CFD Design is used for modeling and design:

- an ammonia injection system
- decomposition of ammonia
- distribution of the gas flow
- optimizing the geometry and the pressure drop
- optimizing the temperature distribution in the cross-sectional
- optimizing the distribution and preventing the deposition of dust

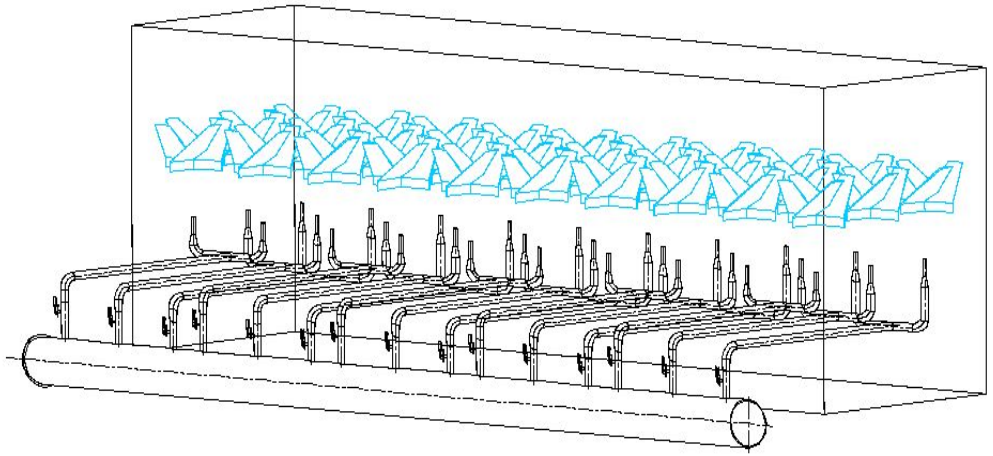


Advanced Gas/Gas Heater Technology for Aqueous Ammonia Evaporation



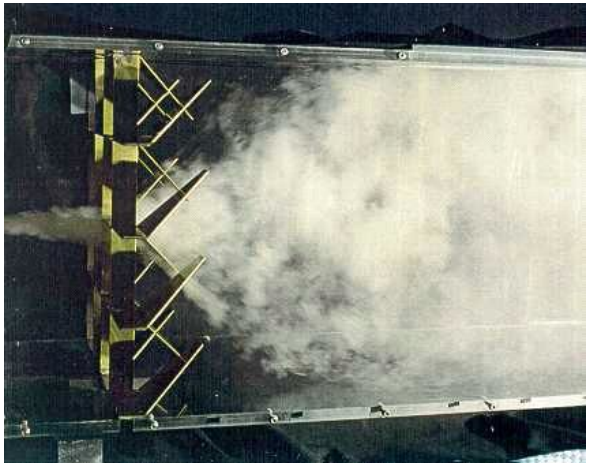
Ammonia Injection Grid (AIG)

- ADVANCED AIG DESIGN – NOZZLE / MIXER TYP



AIG Details



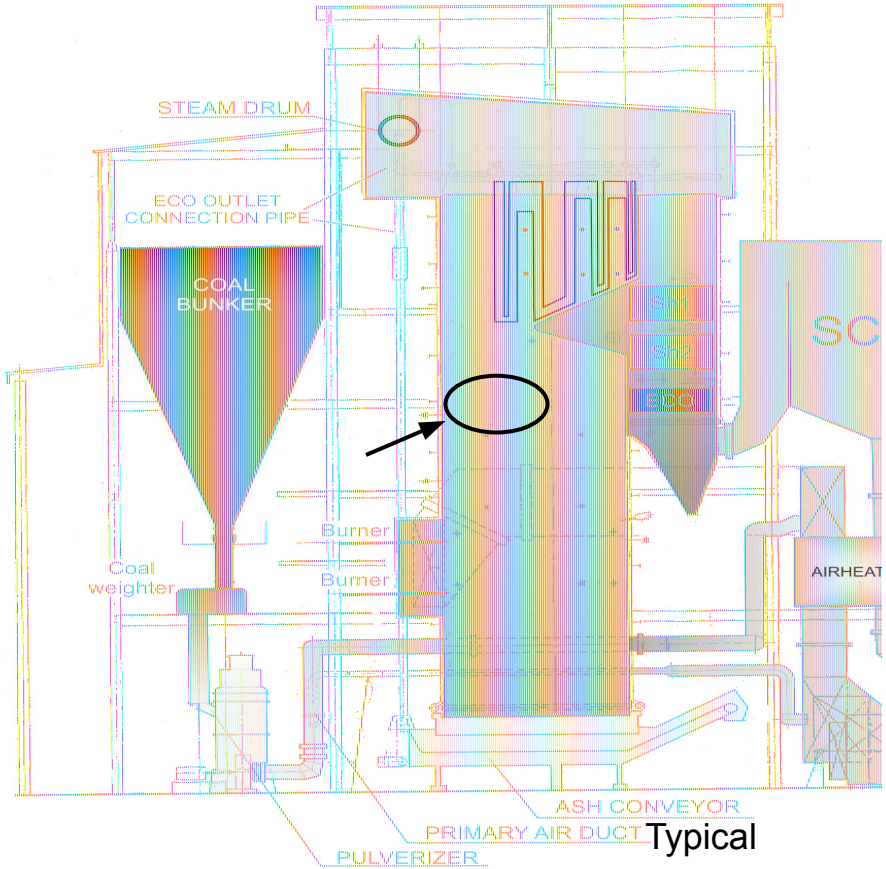


Top: AIG nozzle & Mixer during model testing

Left: AIG (mixer) before installation

Options of SCR placement

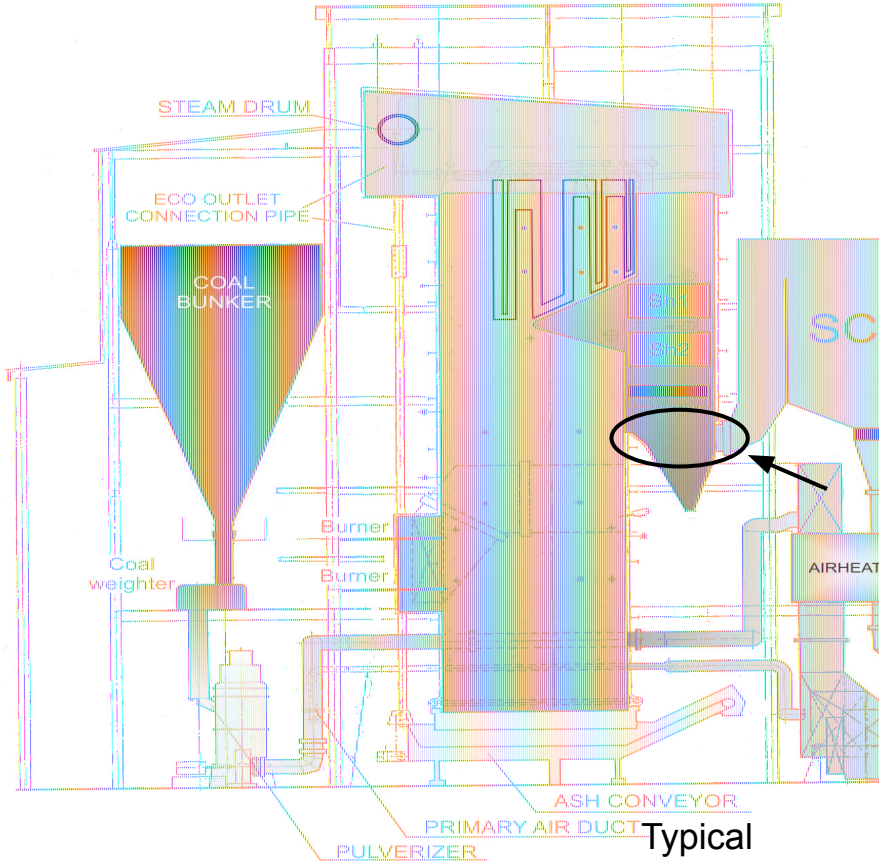
- New block with SCR system
- RETROFIT –
  high dust DeNOx
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Typical

Options of SCR placement

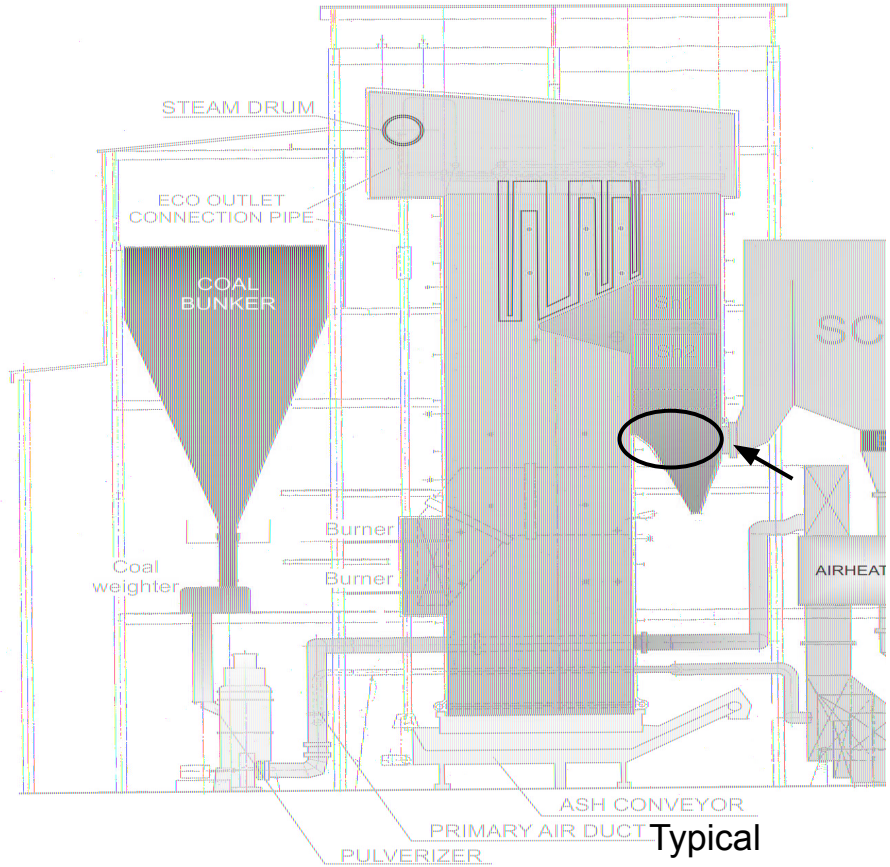
- ECO split



Typical

Options of SCR placement

- ECO after SCR



Typical

DENOX Plant for the boiler OOG-420 K8 of the PKN Orlen Refinery PLOCK



PROJECT DESCRIPTION:

- **YARA delivers the engineering and the**
- **equipment for the NH4OH storage and the SCR**
- **DeNOx flue gas cleaning system for an oil and**
- **gas fired steam boiler to RAFAKO S.A.**

MAIN QUANTITIES:

- **Combustion: Heavy oil & Gas**
- **NOx emission (400 mg/Nm³): ≤150 mg/Nm³**
- **NH3 slip: ≤1 ppm**
- **Pressure drop: ≤7 mbar**
- **Emission levels are based on dry flue gas at 0°C, 1,013 mbar and 3 vol% oxygen.**

Customer: **RAFAKO S.A., Racibórz, Poland**
Construction Period: **2009 - 2011**

SCR Laziska

PROJECT DESCRIPTION:

- **Ammonia storage and 4 SCR units for 4 boilers type OP650k**
- **Fuel: hard coal and up to 10wt% clean biomass**
- **Boilers to be adapted with DeNOx system till 2015 in accordance with LCPD**
- **Boilers are equipped with low NOx burners and OFA**
- **Successful operation of 3 boilers today**



MAIN QUANTITIES:

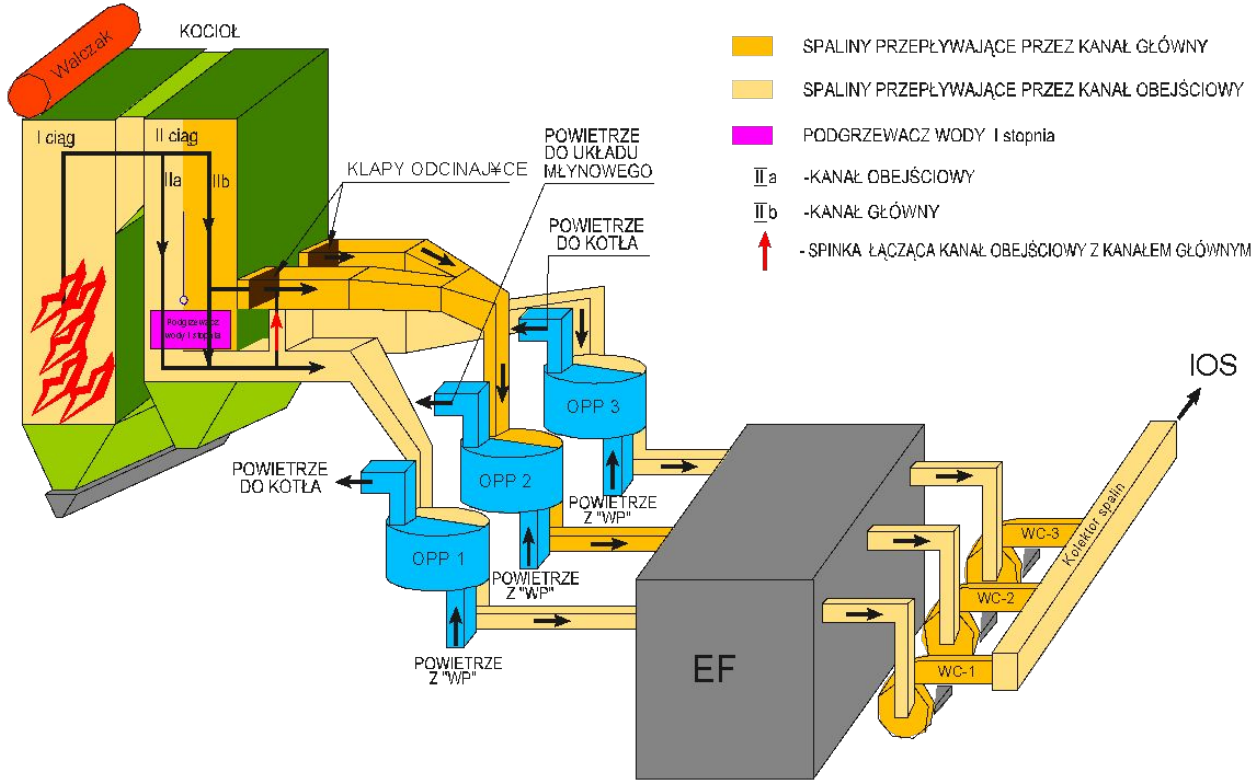
- **Exhaust flow rate/unit: up to 1 Mio Nm³/h**
- **NOx Removal rate: < 58%**

Employer: **TAURON Wytwarzanie S.A.**

Construction Period: **11/2010 - 09/2015**

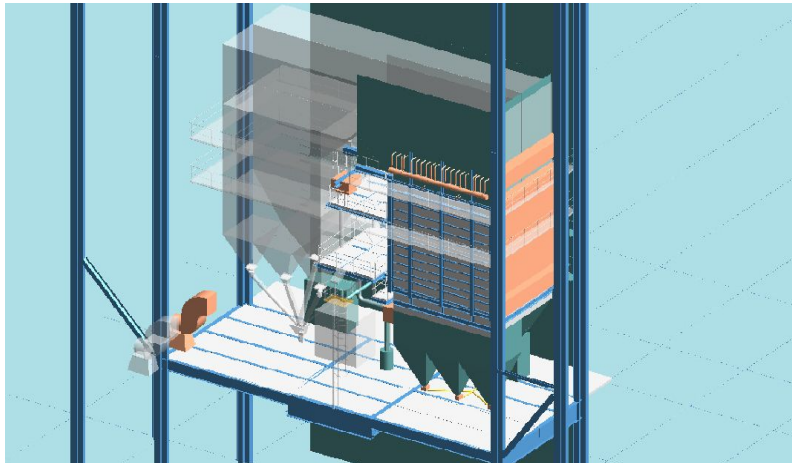


Retrofit - combination of primary & secondary measures
Example - Łaziska Power Plant

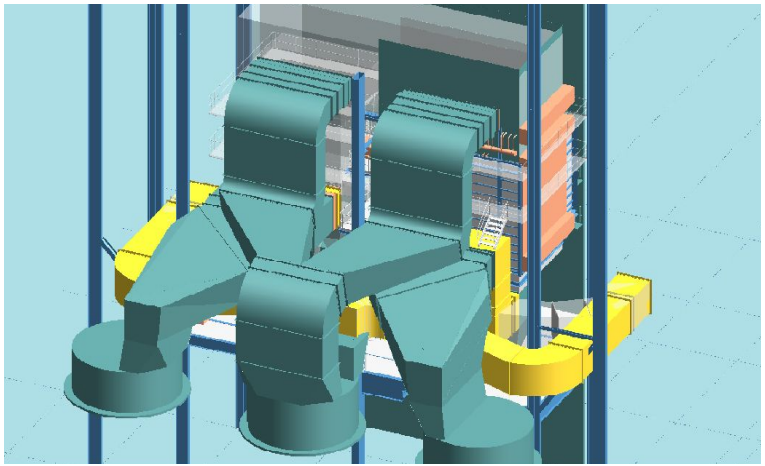


Visualization – before & after SCR retrofit Łaziska

2nd boiler pass



including Flue gas and air ducts



Construction – before & after SCR retrofit Łaziska

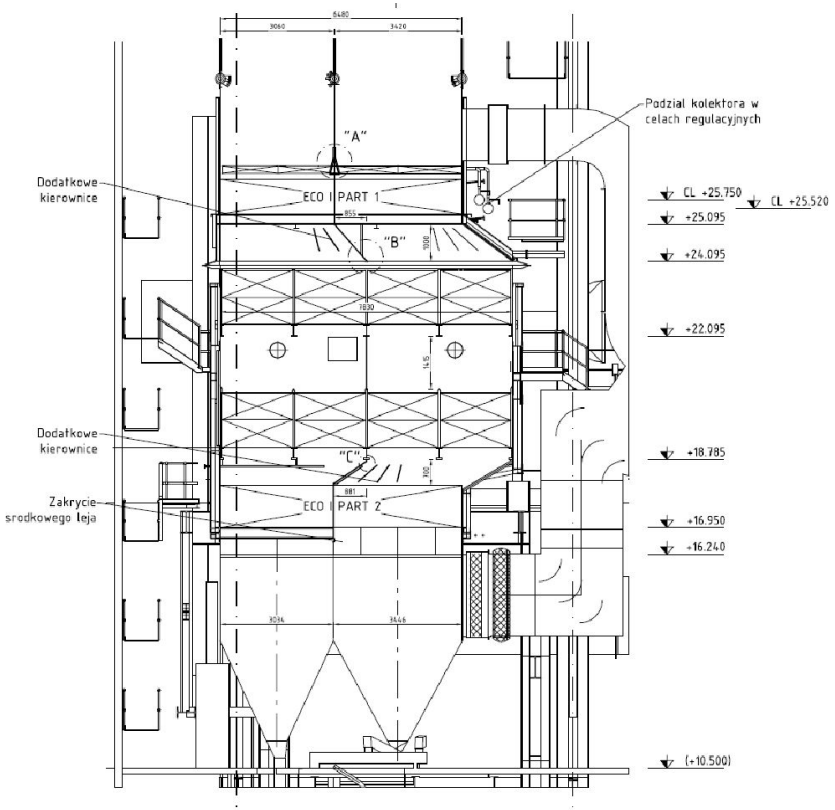
BEFORE



AFTER



Layout drawing of SCR reactor Łaziska

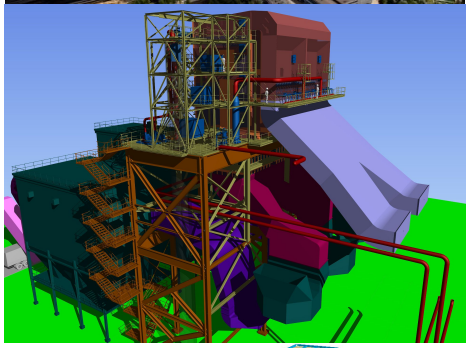


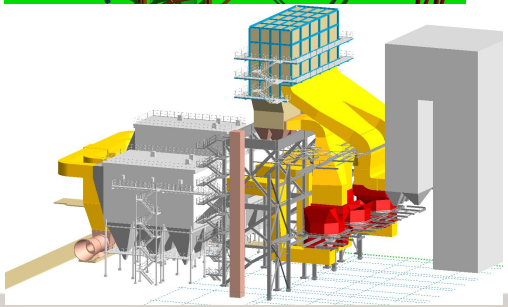
Łaziska Power Plant – plant data validation

Parameter	Guarantee	Actual
NOx at boiler outlet **mg/Nm³,dry@6%O_2**	**< 450**	**350 - 450 (from boiler)**
NOx at SCR outlet **mg/Nm³,dry@6%O_2**	**≤ 190**	**160 – 180 (controlled)**
NH_3 slip at SCR outlet **mg/Nm³,dry@6%O_2**	**≤ 5**	**< 1**
NH_3 content in fly ash **mg/kg**	**≤ 100**	**< 30**
NH_3 content gypsum **mg/kg**	**≤ 10**	**Not detectable**
SO_2 – SO_3 conversion **%**	**≤ 1**	**< 1 at lab test** **at plant not measured, yet**

Reference plant Rybnik
RYBNIK, / POLAND







PROJECT DESCRIPTION

- **Design and erection of SCR DENOX plants for 4 coal fired boilers type OP-650k (K7, K8 and optionally K5, K6) inclusive NH4OH-storage, modernization of rotary air preheater and ID-fans.**
- **Turnkey contract incl. storage area and building permit, incl. ID-fans and RAPHs**
- **1st boiler under erection**

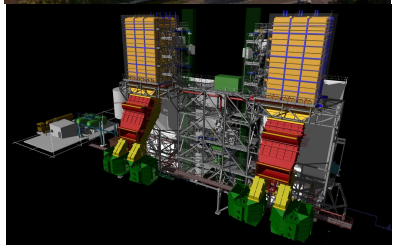
MAIN QUANTITIES:

- **2 x 225 MWel coal fired boilers, 650 t/h steam each**
- **Exhaust flow [Nm³/h]: 780,000**
- **Inlet NOx [mg/Nm³]: 400**
- **Outlet NOx [mg/Nm³]: <= 100**
- **NH3 Slip [ppmvd]: <= 2**

- Employer**: EDF Polska S.A**.
- Realization Period: **07/2013 – 08/2015**

Reference SCR Bialystok
BIALYSTOK / POLAND



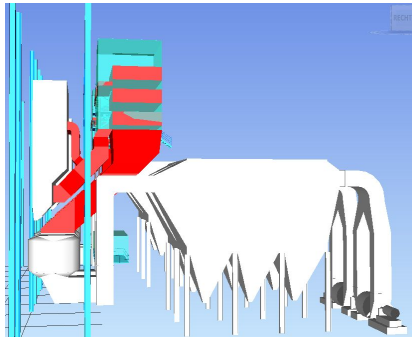


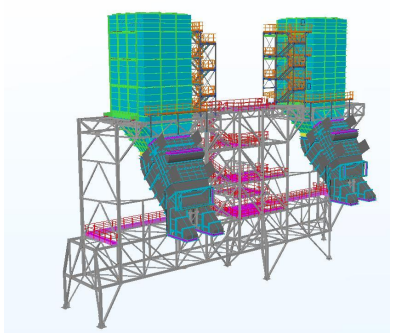
PROJECT DESCRIPTION

- **Design and erection of SCR DENOX plants for 2 coal fired boilers type OP-230 (K7, K8 inclusive NH4OH-storage and modernization of rotary air preheater and ID-fans**
- **Turnkey contract incl. storage area, ID-fans, RAPHs**
- **1st boiler under erection**

MAIN QUANTITIES:

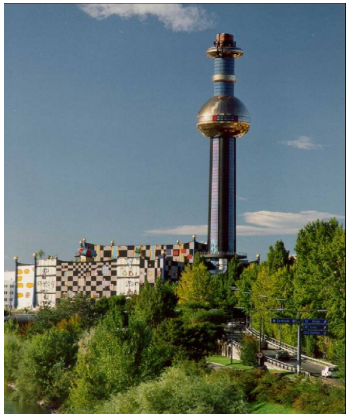
- **2 x100 MWel coal fired boilers, 230 t/h steam each**
- **Exhaust flow [Nm³/h]: 236,000**
- **Inlet NOx [mg/Nm³]: 620**
- **Outlet NOx [mg/Nm³]: <= 95**
- **NH3 Slip [ppmd]: <= 3**





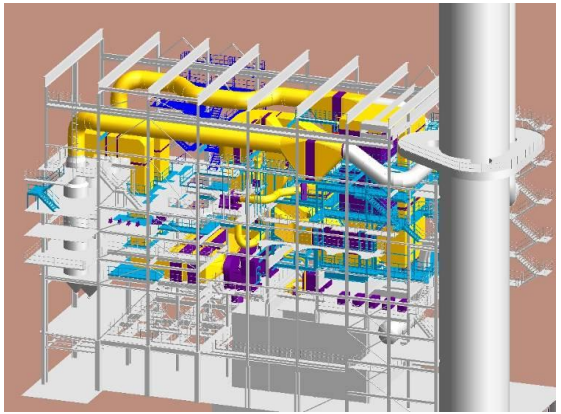
- Employer: **ENEA Wytwarzanie S.A.**
- Realization Period: **11/2013 – 06/2015**

SCR SPITTELAU, VIENNA/AUSTRIA



PROJECT DESCRIPTION

- **1SCR plant for 2-lines waste-to-energy plant**
- **Within the years 2011-2015 Spittelau plant will be completely technically renewed and economically optimized including a new SCR-DeNOx system as low-temperature process incl. a heat transfer system.**



MAIN QUANTITIES:

- **Flue gas flow rate: 220.000 (2x110.000) Nm³/h**
- **NOx reduction: <70 mg/Nm³, dry 11% O2**
- **NH3 Slip: <4 mg/Nm³, 11% O2**

Customer: **WIEN ENERGIE - Fernwärme Wien GmbH, Vienna**

Commissioning: **2012 - 2015**

LP 2 (70 MW), Taiwan

- Customer: Formosa Plastics Corporation
- Location: Kaohsiung
- Fuel: Coal
- Flue gas flow rate: 191,000 Nm³/h
- High-dust, retrofit

- NOx: 500 □ 70 mg/Nm³
  NH3 Slip : 4 ppm
  SO2/SO3 Conv.: <1%
  Pressure loss: 600 Pa
- Commissioning: 2004
- Plate type catalyst

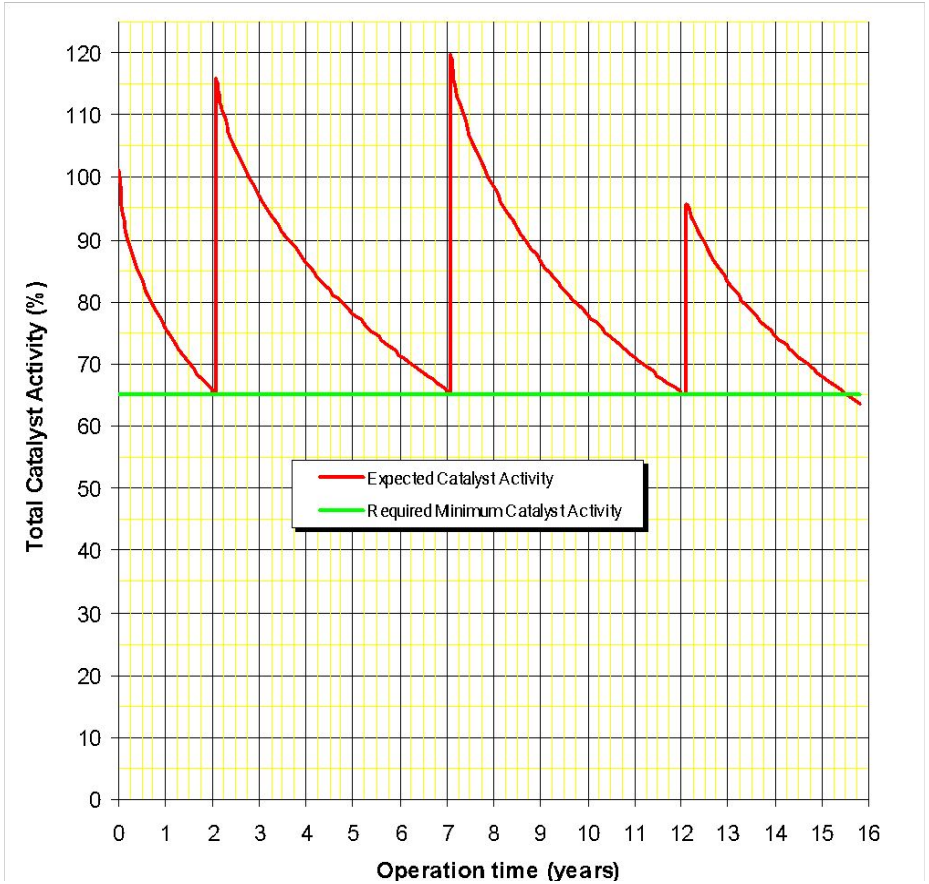
Before Retrofit



After Retrofit



Catalyst Management



SCR catalyst regeneration process

Mechanical cleaning



SCR catalyst regeneration process

1 stage: oscillation



2 stage: saturation



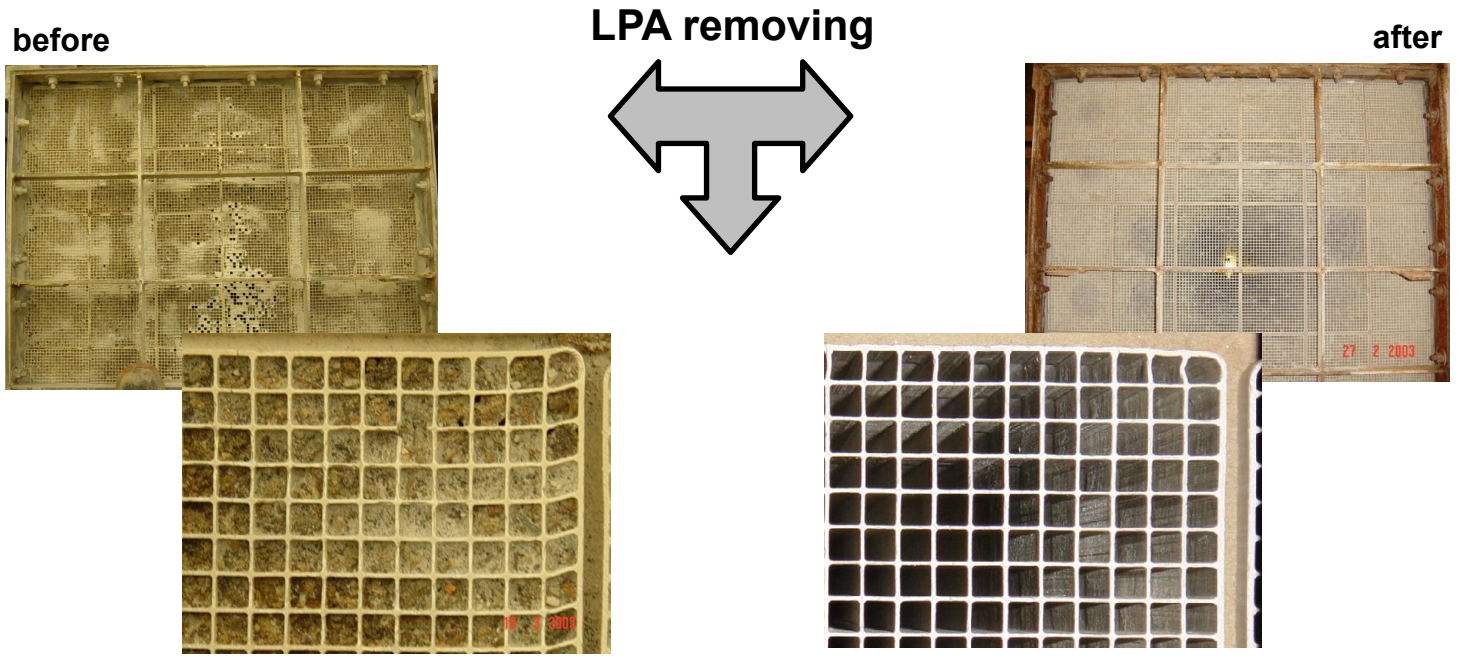
SCR catalyst regeneration process

Drying of Catalyst



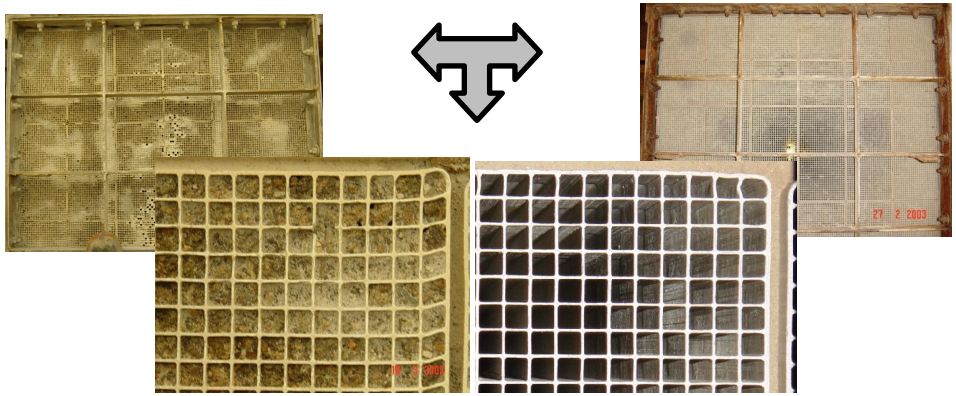


SCR catalyst regeneration process



Catalyst regeneration – Bowen USA

- Client: Southern Company
- Location: Bowen, Georgia, USA
- Fuel: coal
- Volume: ok. 900 m³
- Regeneration effect: > 95 %
- Period of regeneration: February – March2003



Catalyst regeneration– Bowen USA



