AE&E GROUP
Air Pollution Control

AIR POLLUTION CONTROL IN CEMENT INDUSTRY

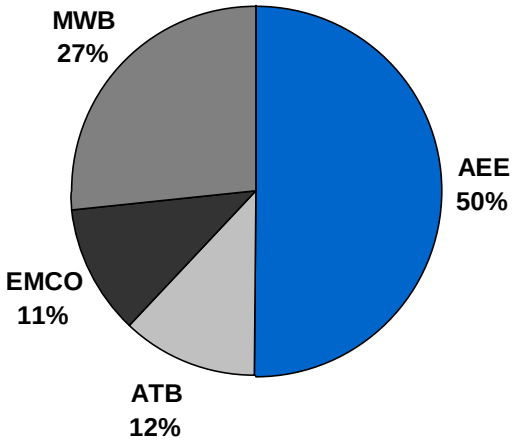
AEE Group

A·TEC INDUSTRIES

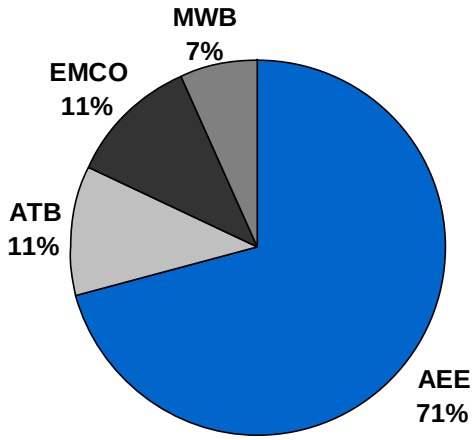
Vienna listed international industrial group with around 12,200 employees

AUSTRIAN ENERGY & ENVIRONMENT	Plant engineering & construction	ATB Technology in Motion	Electric motors
emco / DS	Machine tools	MONTANWERKE BRIXLEGG	Copper production

Revenue by Division (2008) 3,257 mill. EUR



Order Intake by Division (3,584 mill. EUR)



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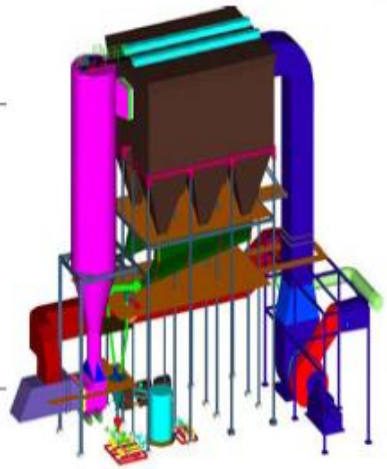
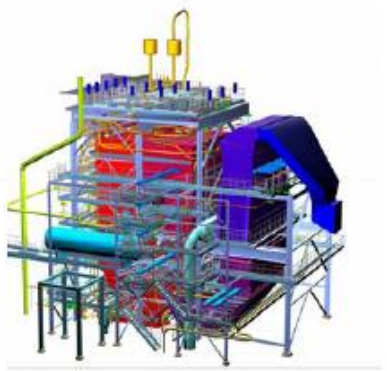
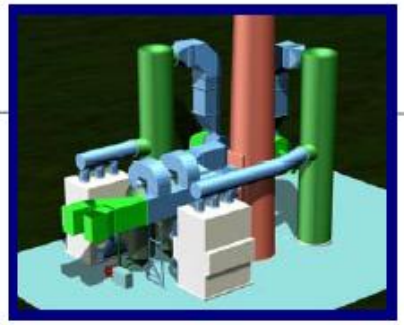
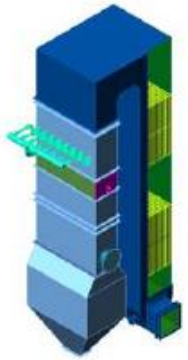
AE&E Group- APC Division

Specialist for removing SOx, HCl, HF, NOx, Dioxines, Heavy metals

	Wet Technology	Dry Technology	SCR
Power Stations			
Industry (Steel, Refinery, Cement, ...)			
Waste Incineration and Biomass			

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Proposed MACT Rule

- **Proposed Rule will affect Existing and New Sources for:**

		Existing Source	New Source
HCl		2 ppmv @ 7% O_2	0.1 ppmv @ 7% O_2
Hg		43 lb/MMton	14 lb/MMton
Particulate		0.085 lb/ton	0.080 lb/ton
THC or TOC		7 ppmv @ 7% O_2 or 2 ppmv @ 7% O_2	6 ppmv @ 7% O_2 or 1 ppmv @ 7 % O_2

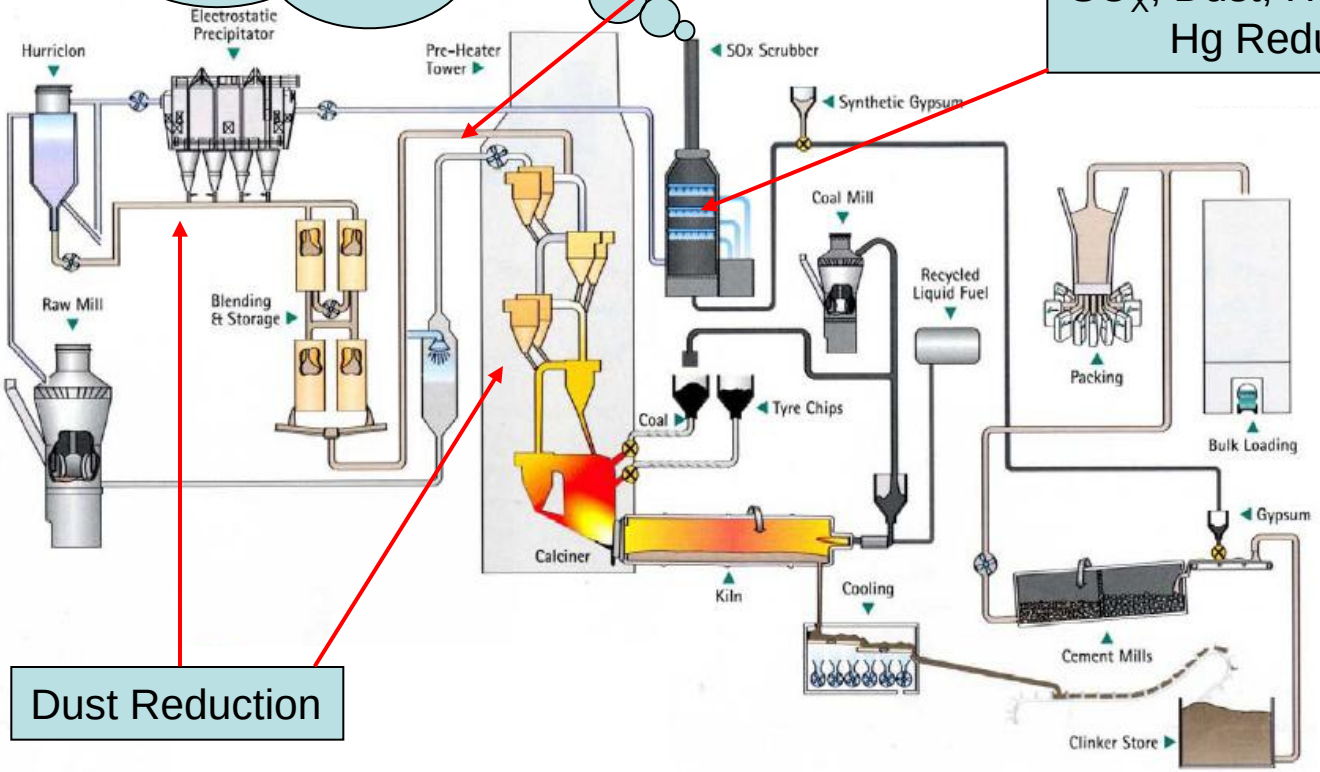
- *Action expected June 2010*
- *Affects 93 facilities operating 163 kilns and clinker coolers (2005)*
- *HCl control has replaced SOx limits in proposed rule*
- *Other Pollutants to consider??? (NOx , Dioxin/Furan other Heavy Metals)*

Gaseous Emissions in Cement Production

Emissions:
- SO_X
- NO_X
- Dust
- HCl
- HF
- TOC
- Hg
- Dioxine and Furan

NO_X and NH_3 Reduction
(if SNCR or SCR are implemented)

SO_X, Dust, HCl, HF, and Hg Reduction



Dust Reduction

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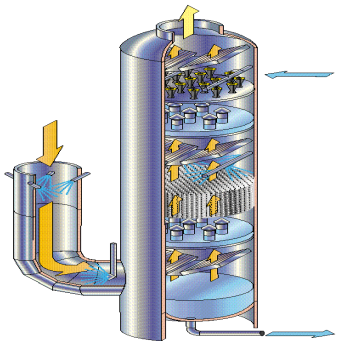
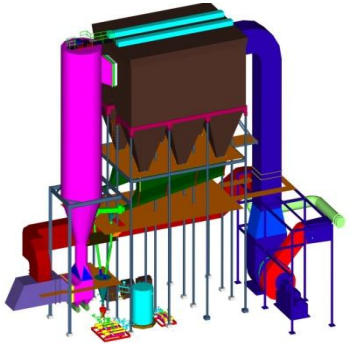
Control Strategies

- **One or more Technology approaches may be required to meet the new MACT requirements:**
  - HCl
    - Wet Scrubber System
    - Two Stage or Multi Stage Wet Scrubbing System
    - Dry Scrubbing System/Fabric Filter
  - Mercury
    - Hallogen (Bromine) Injection on Limestone Feed
    - Activated Carbon Injection
  - Particulate
    - Enhanced filter bag technology
    - Baghouse Conversion
  - THC or TOC
    - RTO
    - Activated Carbon



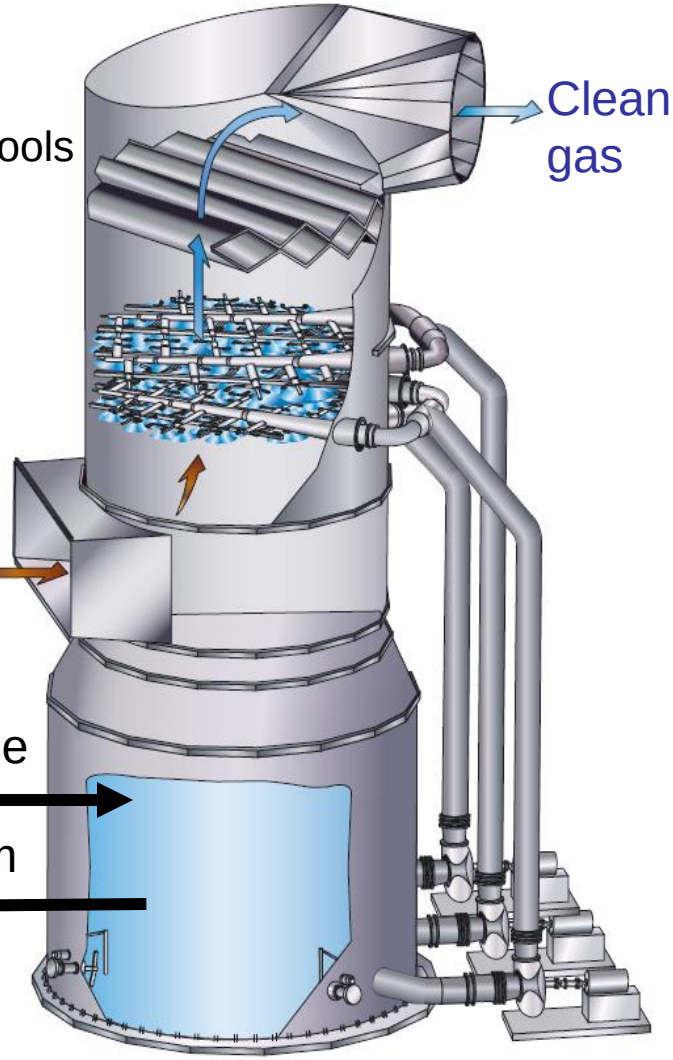


NOx emissions are not currently addressed, however SCR's may be required in the future or for new system permitting

Wet Scrubbing- Limestone Process

Process Characteristics

- Open spray tower optimized by using advanced CFD tools
- Removing of acid gaseous pollutants (SO_2, HCl, HF)
- Low operation cost
- Low maintenance costs
- Long operation period between routine maintenance
- Limestone as available and low cost absorbent
- Producing marketable gypsum
- Reaching SO_2 removal up to 99 %
- Reaching HCl removal greater than 95%
- Reaching dust removal up to 80 %
- Most used technology worldwide



Capacity

- Flue gas volume — up to 4.8 million m^3/h
- SO_2 concentration — up to 30,000 mg/m^3

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Tie-in of FGD Plant into the Cement Production

Usage of FGD gypsum in cement production:

- FGD gypsum can be used instead of natural gypsum in cement
- Coagulation time of cement is slightly increased
- Color changes → slow change in recipe necessary

Waste water can be used in the cement process:

- Injection on the clinker apron conveyor
- Injection into the cement finish mill
- Injection the clinker cooler
- Injection into the raw mill

Bleedstream Injection on Clinker Apron Conveyor

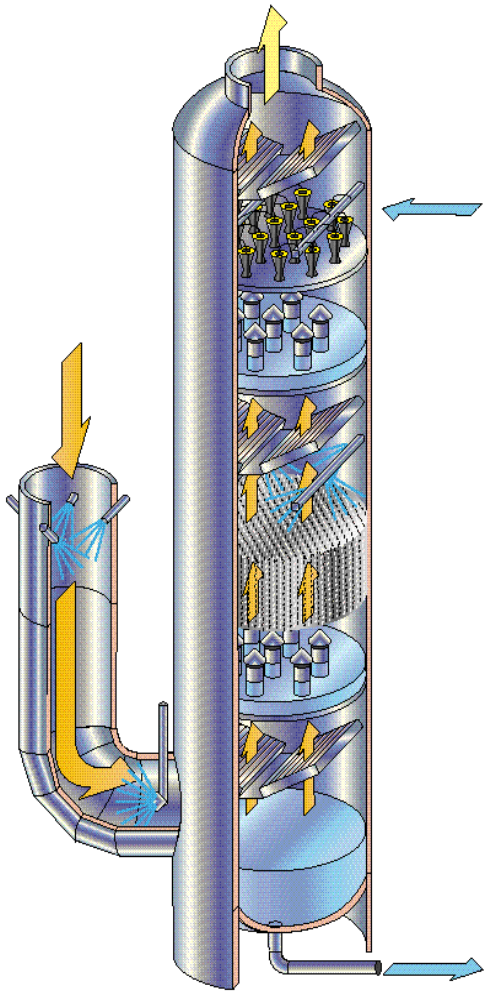
Low operational costs:

- Waste water replaces process water
- Saved raw material costs almost equal operation costs

Multistage Flue Gas Scrubber

Customised Concepts

- For flue gas from different combustion processes, mainly waste incineration
- Multifunctional: quenching, gas absorption, dust separation, dioxin removal, optional condensation
- Neutralisation agent: sodium hydroxide, (hydrated lime or limestone for external neutralisation)
- Absorbent (for additional dioxin and mercury removal) introduction upstream or as slurry into scrubber
- Very low emissions achievable
- In combination with further residue treatment: recovery of useful materials (e.g. gypsum, sodium chloride, hydrochloric acid, heavy metals)



Capacity

- Flue gas volume up to 180,000 m^3phr (std. wet)

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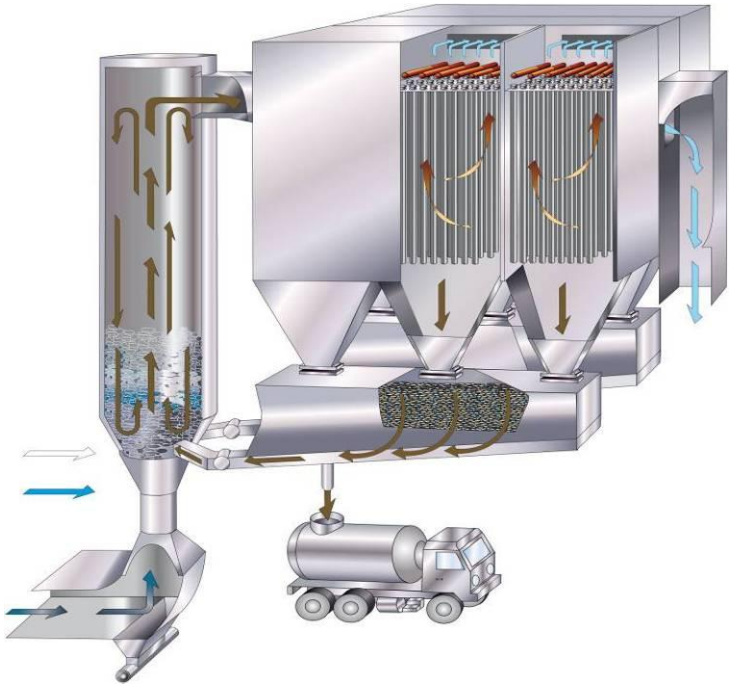
Dry Scrubbing Technology- Turbosorp®

Cleaning of Flue Gases from Energy from Waste, Biomass, Industry
- Power plants



- System based on fluidised bed technology
- Removal of all pollutants in one step
- Safe fulfilling of EU emission guidelines
- Reliable operation by minimisation of moving parts
- Waste water free system
- Operation above the dew point – no corrosion
- High removal rate of SO_2 (> 95 %)
- High removal rate of HCl (>95%)
- High removal rate of SO_3 (up to 99 %)
- High removal rate of dust (> 99+ %)
- High removal rate of Hg (>90 %)
- Waste water free system

Capacity
- Flue gas volume up to 1.2 million m^3phr (std. wet)

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Mercury Removal

- In 2000 2.269 t of mercury were anthropogenically emitted

- 5% (113.5 t) from Cement Industry
- Mercury exists in a chemical equilibrium.

$$Hg_2 \leftrightarrow Hg^{2+} + Hg^0$$

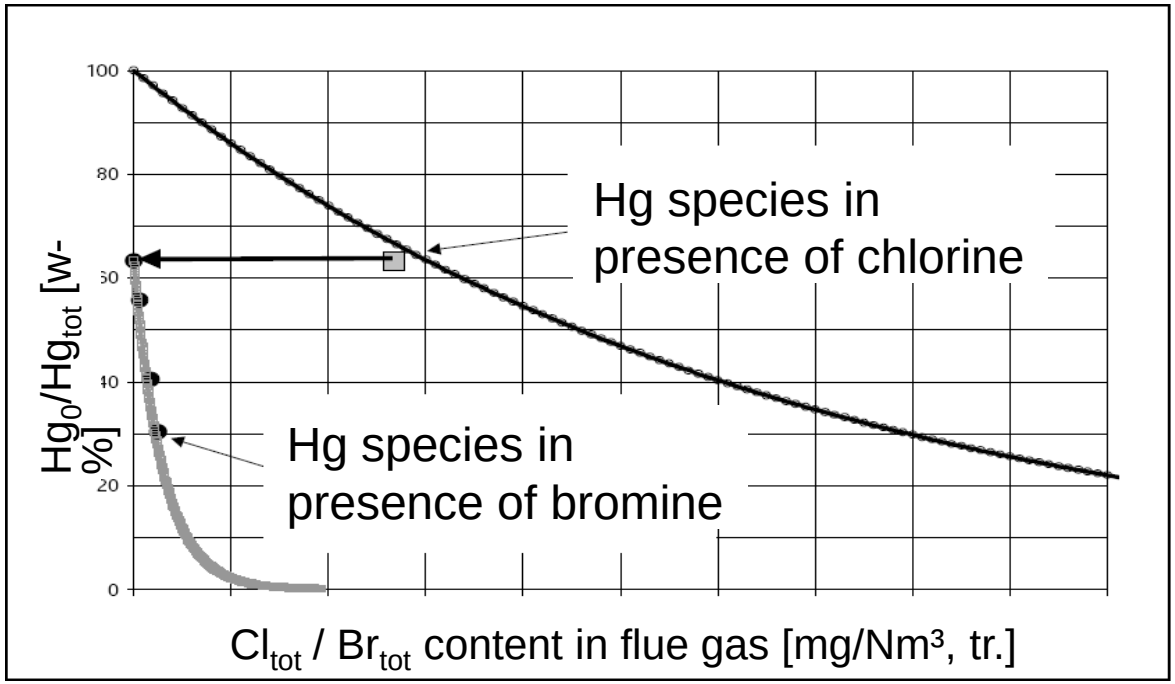
- Hg^{el}/Hg^0: Not water soluble; Cannot be captured in WFGD units

- Hg^{ion}/Hg^{2+}: Water soluble; Can be captured in WFGD units

Increased mercury capture by shifting the chemical equilibrium towards Hg^{2+} e.g. by adding halogenes into the kiln/furnace/boiler

Halogenation of Mercury in Flue Gas

- Halogens are an effective instrument to reduce Hg^0 species in flue gas
- Efficiency of halogenes: F < Cl < Br due to the stability of the mercury complex.
- Bromine technology patented by Vosteen with AE&E as partner in Europe
- Possibility to dose according to current emissions.



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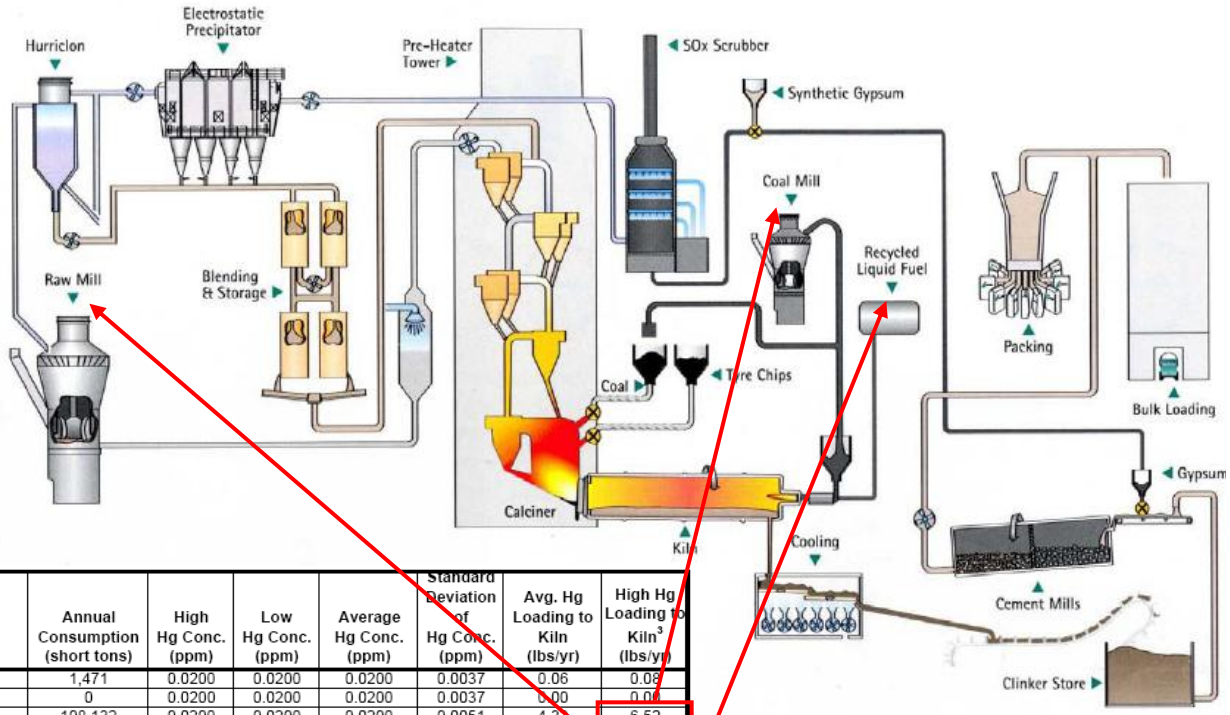
Origin Of Mercury Emissions in Cement Production

Example of cement plant and mercury emissions



Raw Material and Fuel	Annual Consumption (short tons)	High Hg Conc. (ppm)	Low Hg Conc. (ppm)	Average Hg Conc. (ppm)	Standard Deviation of Hg Conc. (ppm)	Avg. Hg Loading to Kiln (lbs/yr)	High Hg Loading to Kiln[3] (lbs/yr)
Alumina	1,471	0.0200	0.0200	0.0200	0.0037	0.06	0.08
Catalyst Fines	0	0.0200	0.0200	0.0200	0.0037	0.00	0.00
Coal	108,132	0.0200	0.0200	0.0200	0.0051	4.33	6.52
Non-hazardous Liquid Fuel	5,176	0.0215	0.0200	0.0201	0.0037	0.21	0.28
Limestone	1,440,913	0.1300	0.0200	0.0558	0.0342	160.81	357.92
Mill Scale	6,134	0.4180	0.0200	0.1244	0.0997	1.53	3.97
Oil Filter Fluff	4,999	47.5415	0.0200	2.1510	8.6014	21.50	193.48
Sand	33,670	0.0200	0.0200	0.0200	0.0051	1.35	2.03
Shale	130,904	0.0277	0.0200	0.0203	0.0040	5.31	7.38
Wood Chips	10,533	0.0590	0.0200	0.0213	0.0080	0.45	0.78
TDF[2]	0	0.3300	0.0100	0.0600	0.0600	0.00	0.00
Spent Activated Carbon	148						
Pet Coke	7,186			0.0248	0.0059	0.36	0.53
Spent Filter Cake	275						
Total Feed[4]	**1,613,093**					**195.89**	**572.98**

(Table does not necessarily correspond to displayed flow sheet.)

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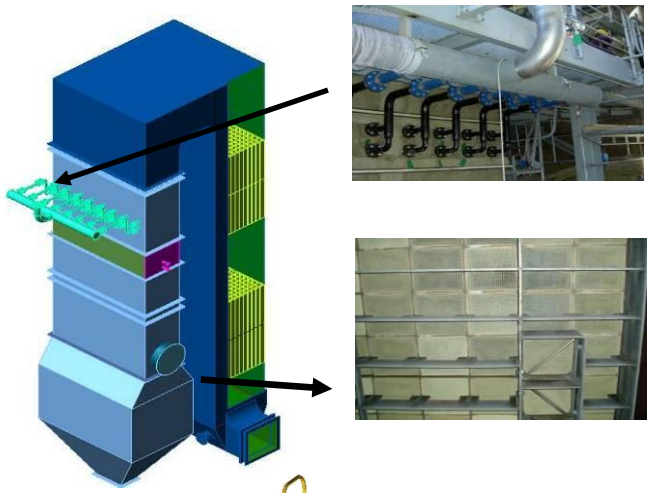
NO_x Removal Technology

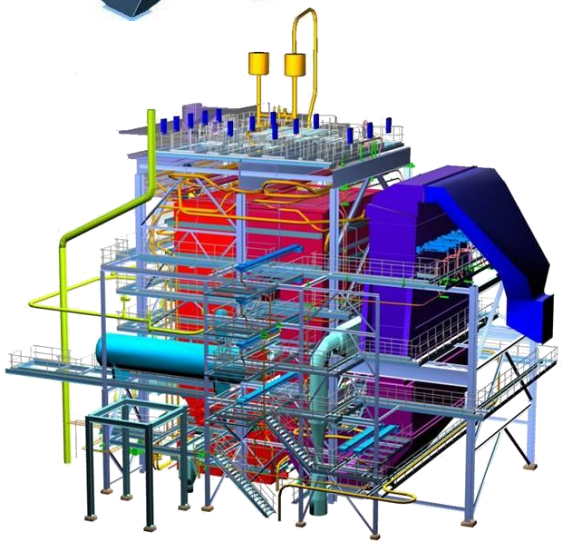
SNCR (Selective Non-Catalytic Reduction)

- For waste incineration and biomass plants
- Injection of ammonia water or urea solution into combustion chamber
- With or without ammonia recovery
- Reaching NO_x removal up to 85%



SCR (Selective Catalytic Reduction)

- Catalysts for NO_x-removal and dioxin destruction
- Arrangement on hot or cool side
- Reaching NO_x removal up to 90%
- For Power Stations and Industries
- For Energy from Waste Plants and biomass plants



Capacity

- Flue gas volume 20,000 – 2,500,000 m³phr (std. wet)

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OPEN POINTS

- Compliance strategy will vary based on plant configuration and pollutant levels at each facility
- Pollutant levels vary based on availability/source of raw materials and fuel types
  - Mercury content in raw material highly dependend on source of limestone
  - Secondary fuels (individually and in combinations) used in kiln
- Zero liquid emission may be possible? (where to inject the waste water stream)
- Necessity to discharge small amounts of waste water with high mercury content

FGD Reference Plant In Cement Industry

KEY DATA	
UNIT:	**TRBOVLJE, SLOVENIA**
CUSTOMER:	Lafarge Cement D.D. Start-Up 2007
TECHNOLOGY/SUPPLY:	Absorber island, limestone preparation, dewatering, electrical and I&C, erection, commissioning
Fuel:	cement raw materials, coal, plastics
Capacity (cement production):	560.000 [t/a]
Flue Gas Volume:	240,000 m^3/h (std_{wet})
SO_2 inlet:	3,000 mg/m^3 (std_{dry})
Removal Efficiency:	93.3 %

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SCR- SEMI Dust application (in tendering phase)

Mannersdorf/ Lafarge Perlmooser

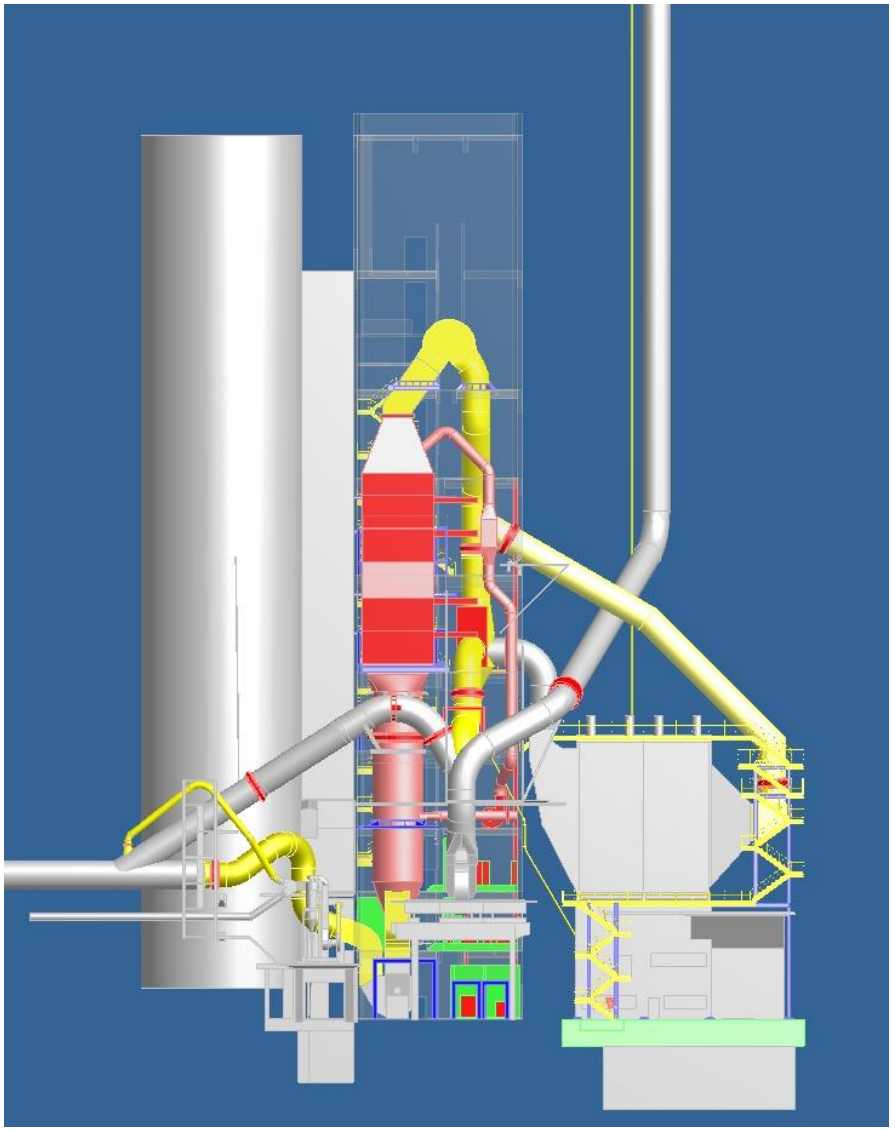
- Flue gas flow: 180.000 Nm³/h,wet
- Flue gas temperature: > 290 °C
- Dust concentration: 1 - 70 g/Nm³*)
- NO_X raw gas max. 500 mg/Nm³,dry, 10% O_2

➢ NO_X outlet <170 mg/Nm³,dry,10 % O_2

➢ NH_3-slip <20 mg/Nm³, dry, 10% O_2

➢ Expected lifetime of catalyst 8.000 hours max. 1 year

**test runs required to verify operability ! (period of approx. 12 months)*



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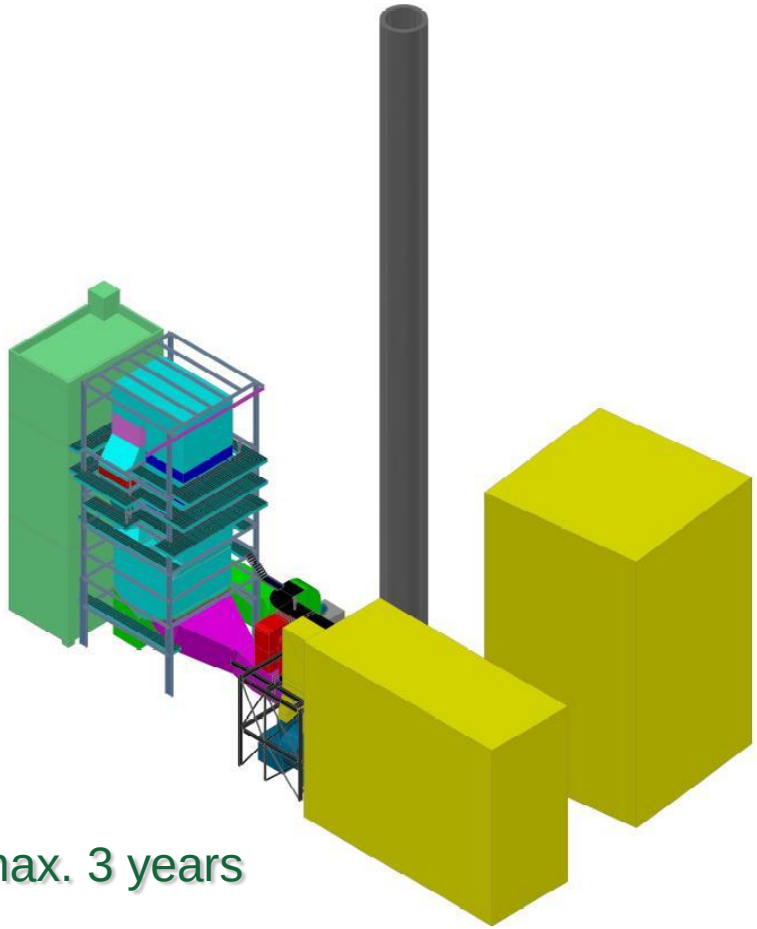
SCR- Tail End application

Example For Possible Application At Portland Cement Plants

- Flue gas temperature: > 240 °C
- Dust concentration: < 5 mg/Nm³
- NO_X raw gas max. 800 mg/Nm³,dry, act. O_2
- SO_2 raw gas max. 50 mg/Nm³,dry,act. O_2



- ➢ NO_X outlet <100 mg/Nm³,dry, act. O_2
- ➢ NH_3-slip <10 mg/Nm³, dry, 0% O_2
- ➢ PCDD/PCDF <0,1 ng TE/Nm³,dry, act. O_2
- ➢ Expected lifetime of catalyst 24.000 hours max. 3 years

Inlet conditions vary and need to be checked for any plant

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