Some deNOx process
for large combustion systems

3rd TFTEI Annual Meeting
UN-ECE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION
- Rome, October, 20, 2017

Christophe CORD'HOMME
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Business & Products Development Director

Lab CNIM INNOVATE AND ACT

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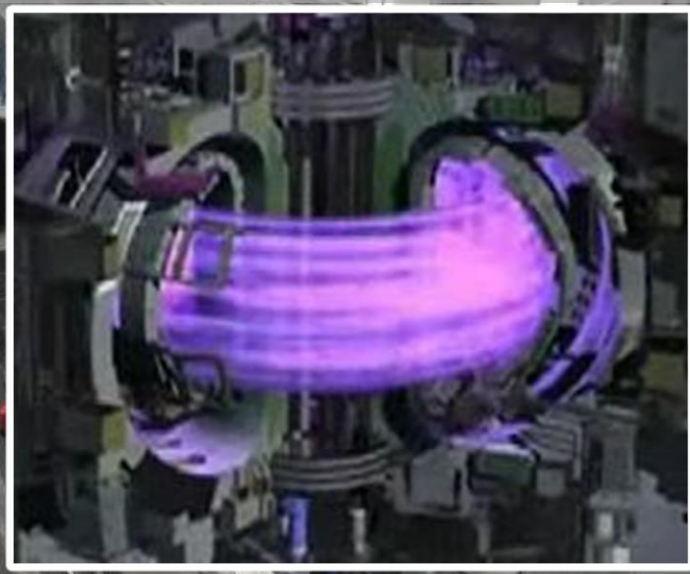

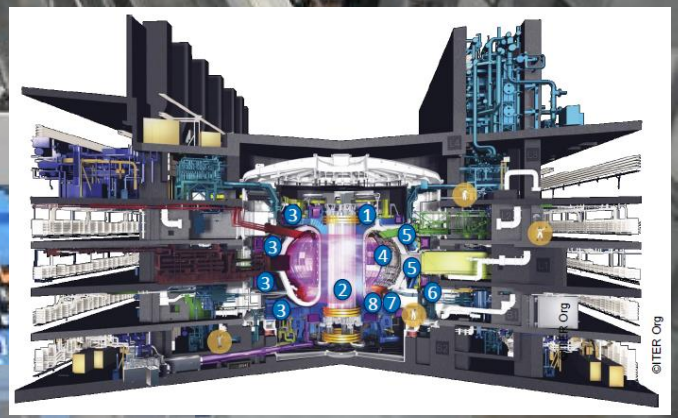

Energy for the Future !

Radial plates for ITER FUSION reactor!

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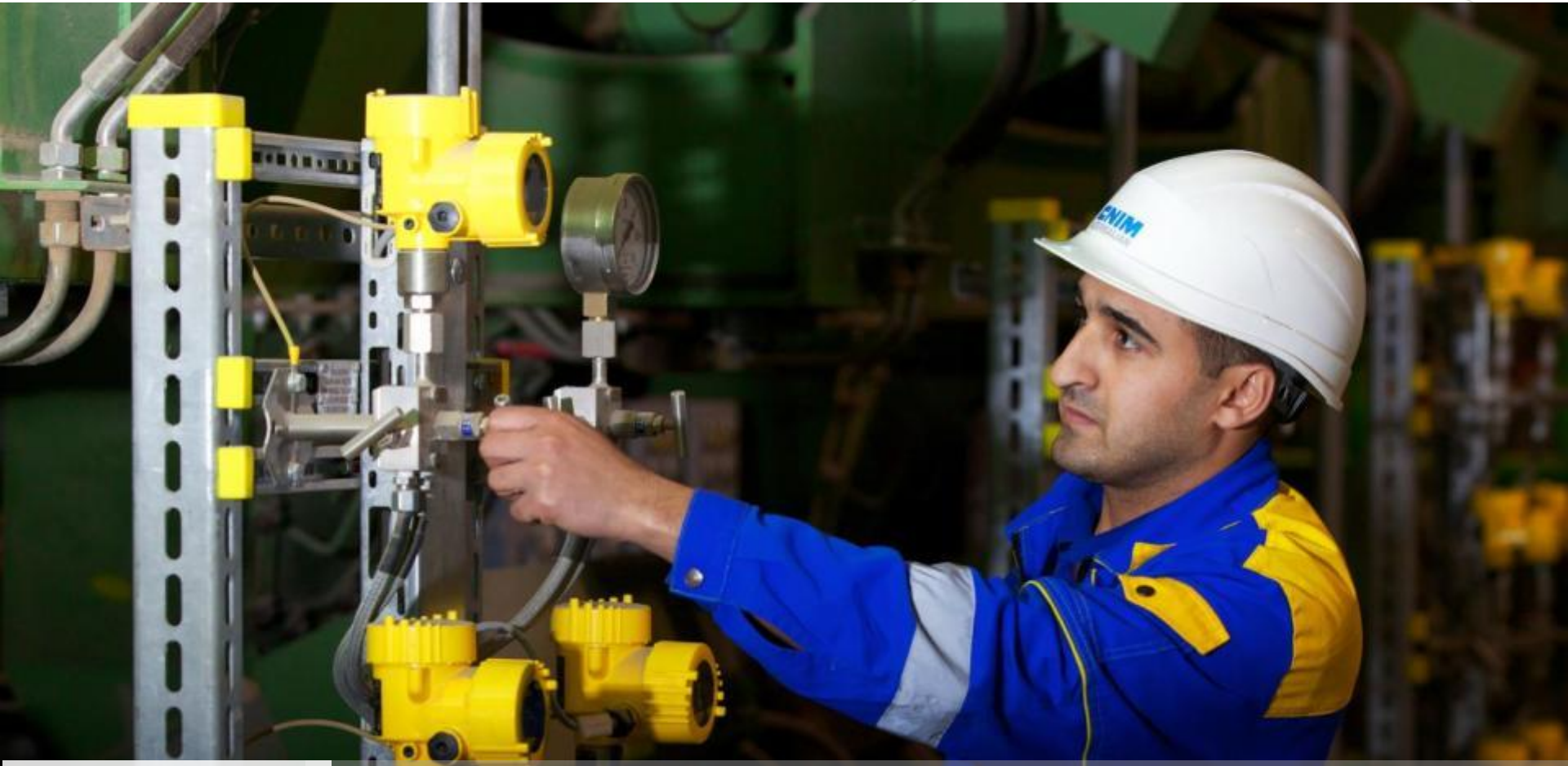
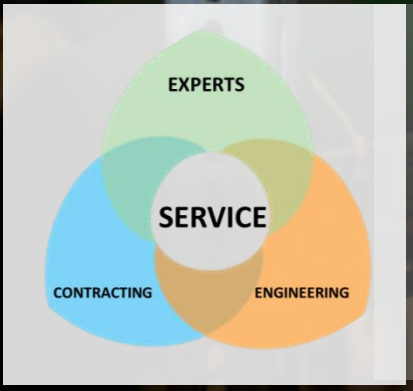




Completed by SERVICES like engineering, project management, commissioning, Operation & Maintenance, retrofitting...

CNIM : Innovate and Act for Energy Transition and Circular Economy! (80% of Group orders in 2016)

Thiverval sorting & WtE, Fr

Energy Transition :
Energy management and efficiency of power plants and industrial sites

ENIM recovers Energy from Municipal Solid Waste of 100 million people around the world!

Torino WtE, Italy by

BERTONE

ENIM


CNIM
Best Available Techniques for:
• Waste combustion
• Energy recovery
• Flue gas cleaning
• Power production

Lab CNIM Group

443 Flue Gas Treatment lines in 26 countries since 1952!

Credit : BIG

WtE Amagerforbraending, Copenhagen, Denmark

CNIM

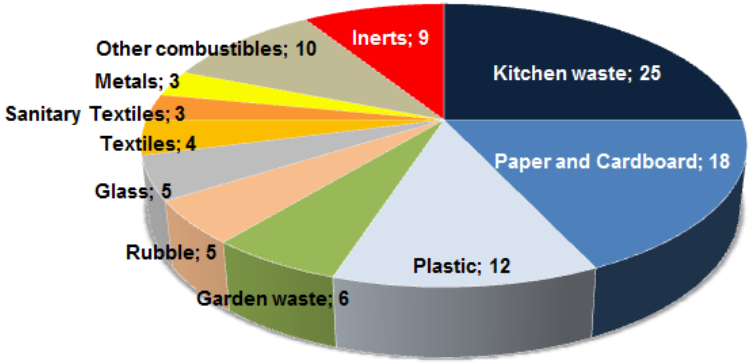
FLUE GAS TREATMENT company

Integrated and patented solutions to reduce all kind of emissions

- Turn-key flue gas treatment for
  - Waste-to-Energy Plants,
  - Biomass-to-Power Plants,
  - Fossil fuel fired Power plant (FGD)
- Scrubbers for marine industry
- Metal recovery from combustion residues

Typical Pollutants to treat after combustion such as Municipal Solid Waste (MSW)

Typical MSW Composition in Europe



Pollutants from MSW Combustion

Combustion Gas
- CO2
- H2O
- N2
- CO
- NOx (NO, NO2)

Acid Gases
- HCl
- HF
- SOx (SO3,SO2)

Heavy Metals
- Gas (Hg, Cd)
- Particles (Pb, Cu, Cr, Co…)

POPs
- Dioxins (PCDD/F) …

Fly Ash and Bottom Ash

Daily Emission Limit Values (ELVs) to air according to IED 2010/75/EU

Industrial Emission Directive of 24/11/2010 for different industrial activities using solid fuels

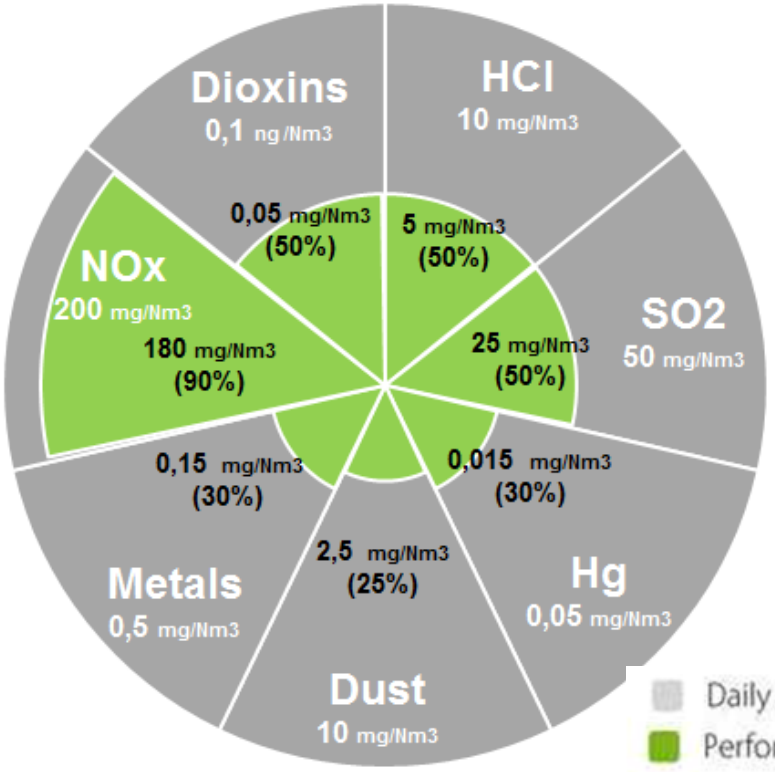
SUBSTANCES/ ACTIVITIES	ELVs in mg/Nm^3 (dioxins & furans in ng/Nm3)		Thermal Input (MW_{th})	Dust	TOC	CO	HCl	HF	SO_2	NOx	Dioxins and furans	Cd + Tl	Hg	Heavy Metals (Sb +As +Pb +Cr +Co +Cu +Mn +Ni +V)
Waste incineration & Co-incineration	at 11% O_2 dry	New & Existing > 3 t/h	~ 7	10	10	50	10	1	50	200 (expressed in NO2)	0.1	0.05	0.05	0.5
Combustion Plants (coal , lignite and other solid residues)	at 6% O_2 dry (converted to 11% O2 dry)	New & Existing	< 50	-	-	-	-	-	-	-	-	-	-	-
		Existing (started operation until 7/01/2014)	50-100	30 (20)	-	-	-	-	400 (267)	450 (300) [pulverized lignite]	-	-	-	-
			100-300	25 (17)	-	-	-	-	250 (167)	200 (133)	-	-	-	-
			> 300	20 (13)	-	-	-	-	200 (133)	200 (133)	-	-	-	-
		New	50-100	20 (13)	-	-	-	-	200 (133)	400 (267) [pulverized lignite]	-	-	-	-
			100-300	20 (13)	-	-	-	-	200 (133)	200 (133)	-	-	-	-
			> 300	10 (7)	-	-	-	-	150 (100) [200 (133) fluidized bed]	150 (100) [200 (133) pulverized lignite]	-	-	-	-
Combustion plants (biomass)	at 6% O_2 dry	Existing (started operation until 7/01/2014)	50-100	30 (20)	-	-	-	-	200 (133)	300 (200)	-	-	-	-
			100-300	20 (13)	-	-	-	-	200 (133)	250 (167)	-	-	-	-
			> 300	20 (13)	-	-	-	-	200 (133)	200 (133)	-	-	-	-
		New	50-100	20 (13)	-	-	-	-	200 (133)	250 (167)	-	-	-	-
			100-300	20 (13)	-	-	-	-	200 (133)	200 (133)	-	-	-	-
			> 300	20 (13)	-	-	-	-	150 (100)	150 (100)	-	-	-	-

'EfW': Strictest European Environmental Legislation

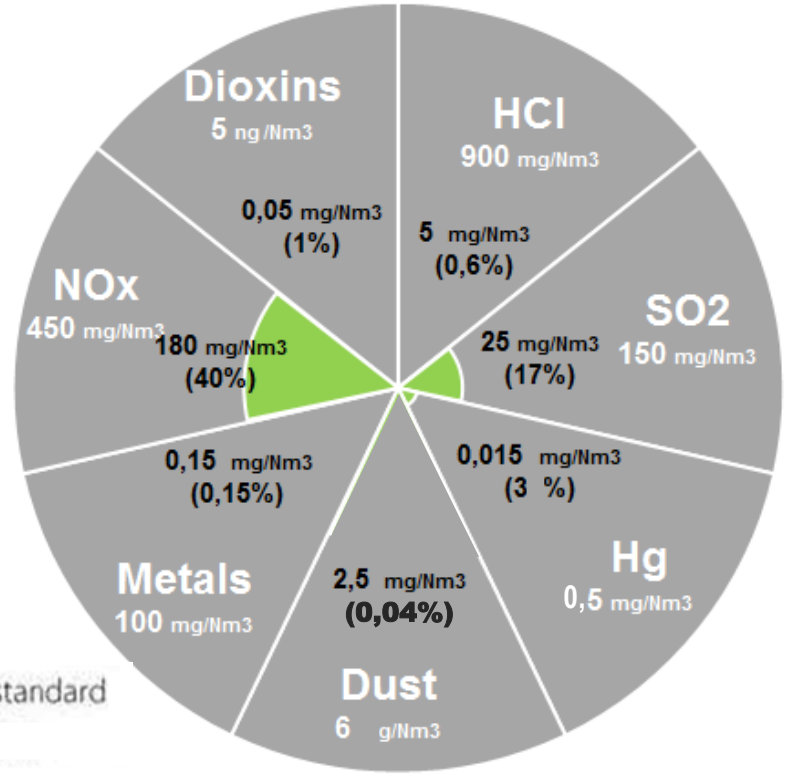
- **Incineration:** 20 components and lower ELVs **(most stringent EU environmental Legislation)**
- **Combustion Plants > 50 MWth.** Higher ELVs and for 3 pollutants only
- **Combustion Plants < 50 MWth**: no emissions limits

Typical Abatement Performance of Pollutants in EfW

Typical Measured Values at Stack over ELVs EU Directive 2010/75/EC



Typical Measured Values at Stack over FGT Inlet



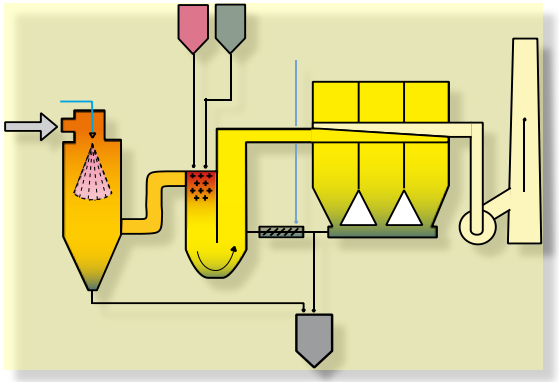
Daily average standard

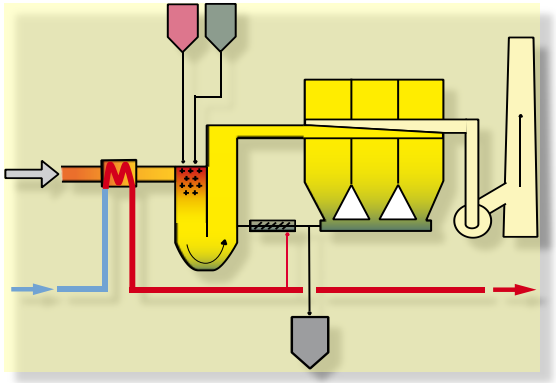
Performance

Measured values << ELVs (Emission Limit Values)

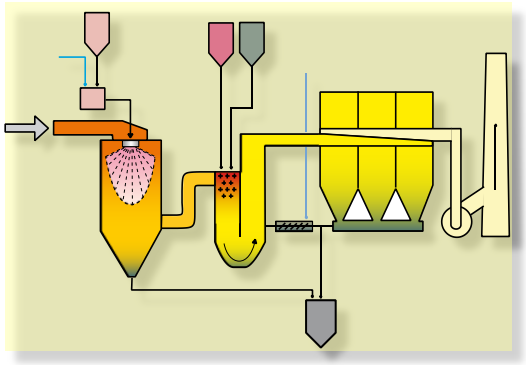
Abatement Technologies for Acid Gases, Heavy metals, POP…

Dry / Semi-dry (Vapolab)

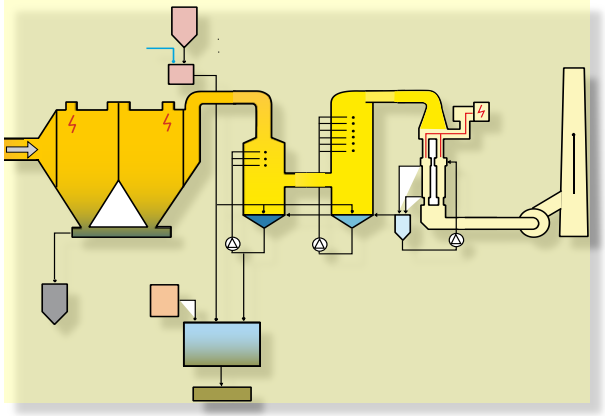




Semi-wet



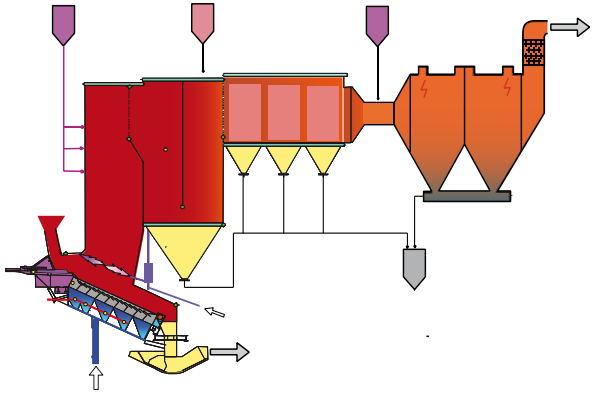
Wet



Reactive agents

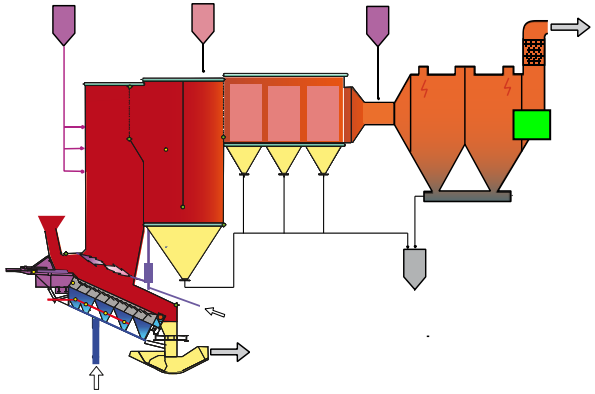
- Lime
- Sodium Bicarbonate
- Calcium carbonate
- Soda
- Activated carbon, lignite coke

Abatement Technologies for deNOx (Secondary measures)



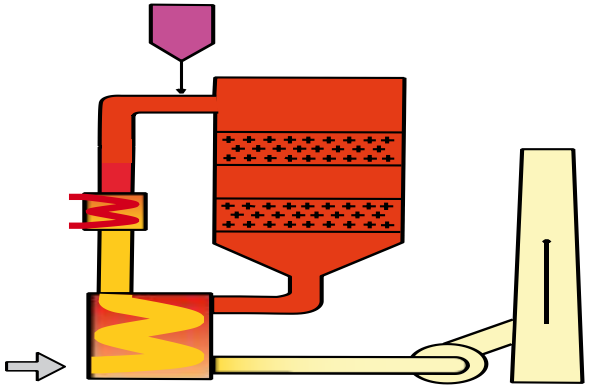
SNCR (non catalytic)

950 – 1050 °C



SNCR + SCR Terminox®

200 – 280 °C

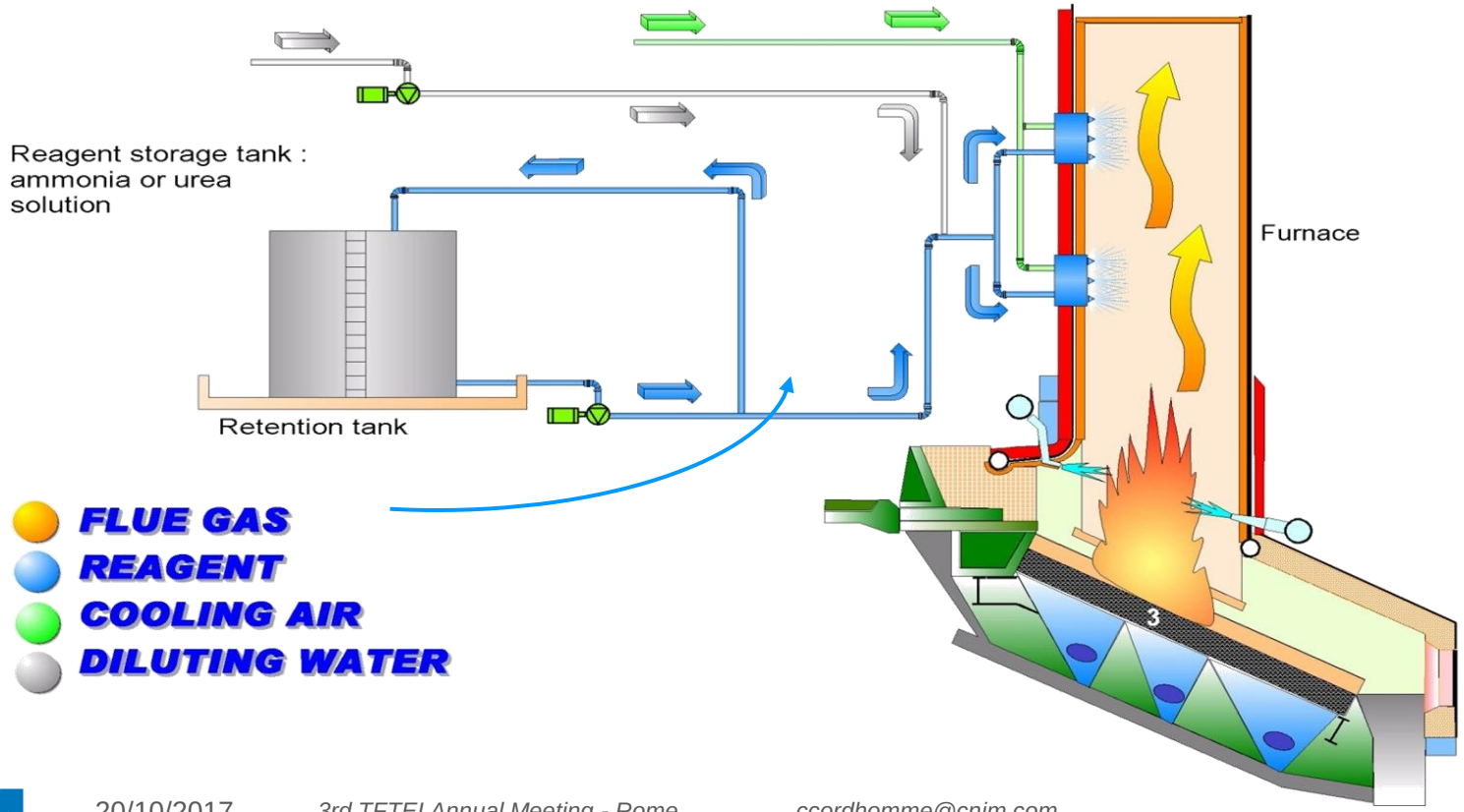


SCR (catalytic) CataLAB®

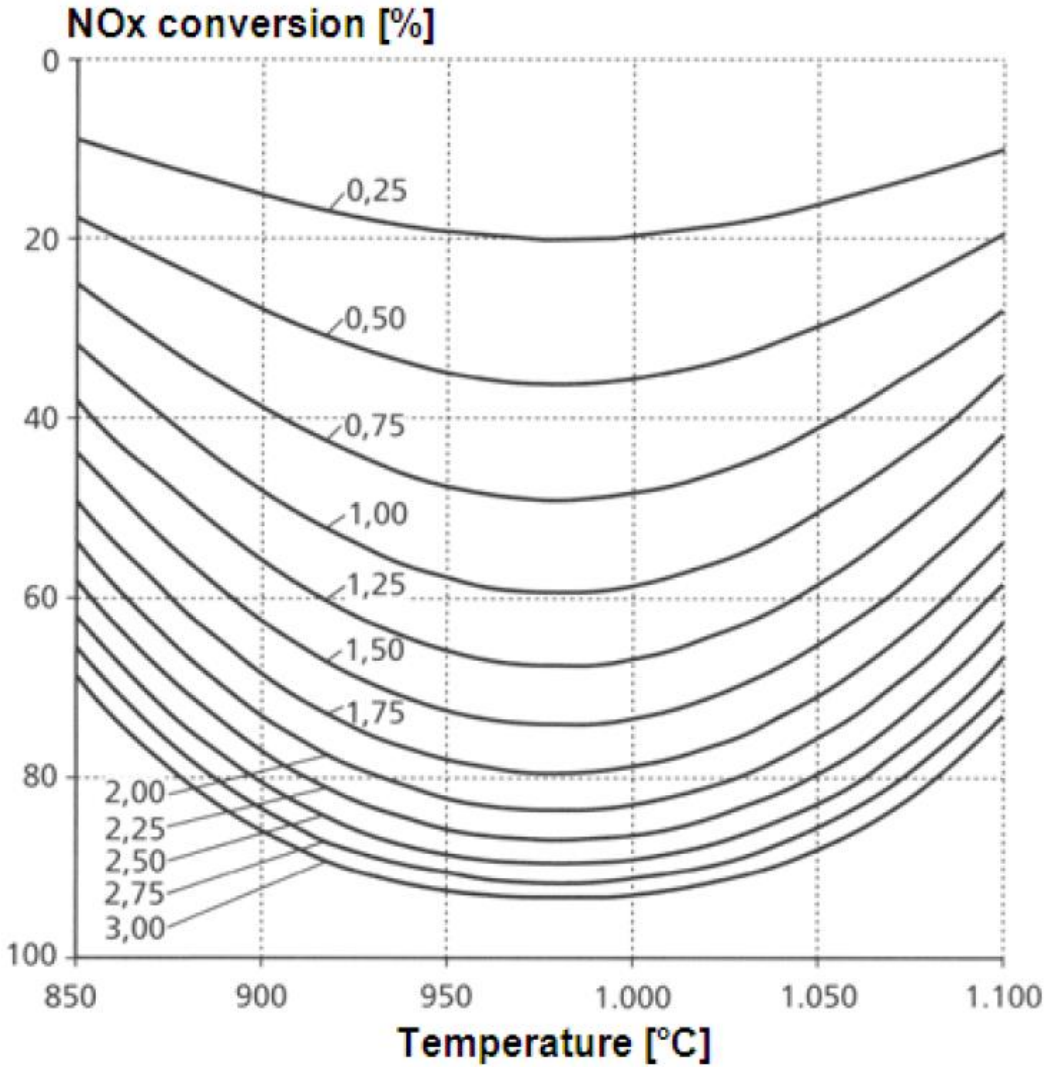
180 – 250 °C

SNCR deNOx (Selective Non Catalytic Reduction)

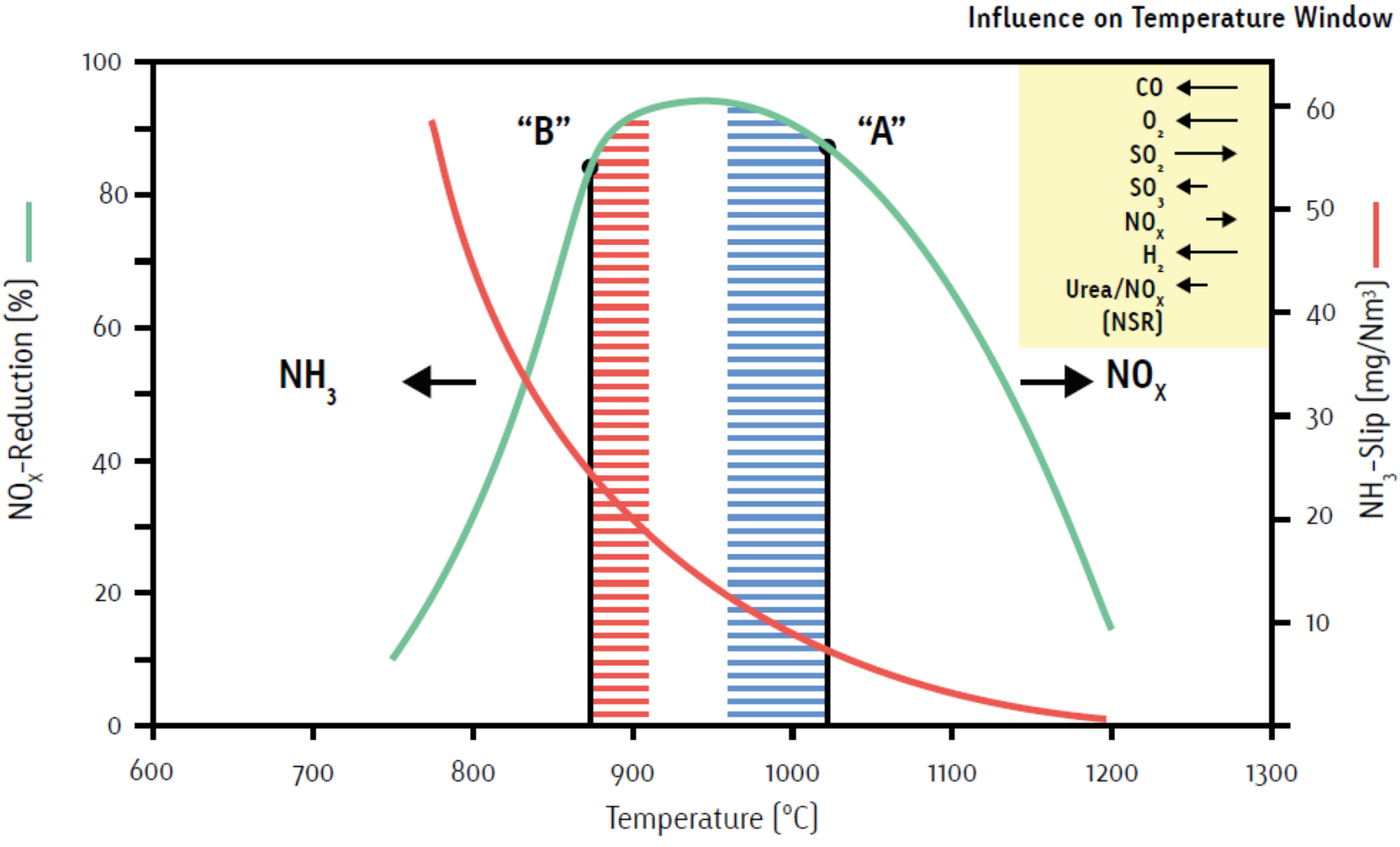
Reagent injection in the combustion chamber at high temperature (850 – 950°C)



SNCR NOx conversion vs temperature & stoichiometry

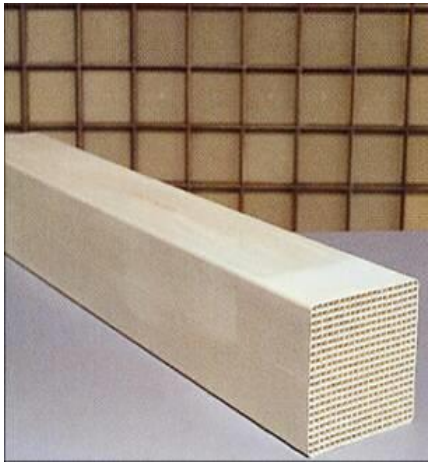


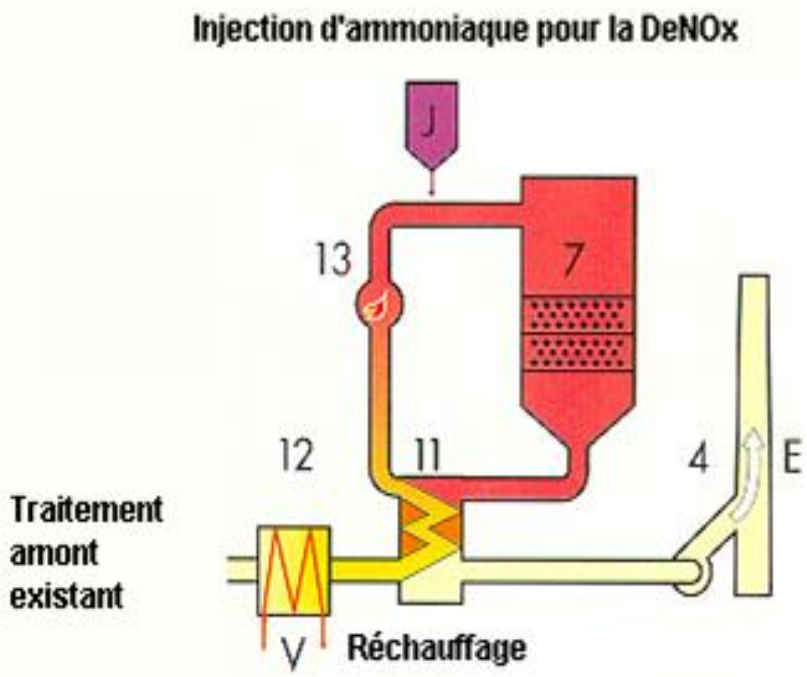
SNCR efficiency and ammonia slip



Source EPPSA

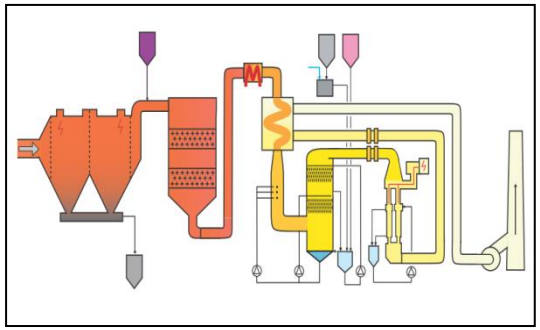
Abatement Technologies SCR de-NOx (Selective Catalytic Reduction)





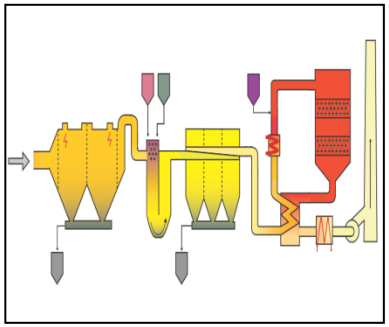
Different types of SCR deNOx (and dediox)

Low dust SCR



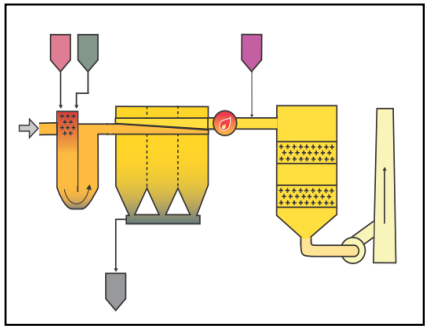
260-280 °C
High SO_2
e.g. Ivry (F)

Tail end SCR



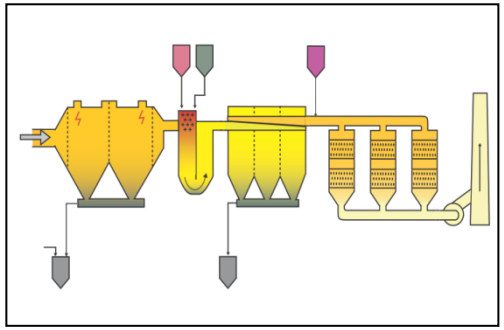
220 – 250 °C
Low SO_2
e.g. Twence (NL)

Cold SCR



180 – 200 °C
Very low SO_2
e.g. Aarhus(DK)

Cold SCR with regeneration



180 – 200°C
low SO_2
e.g. Torino (It)

BREF BAT main processes for NOx treatment

Process	SNCR	Combined SNCR +SCR	SCR – Low Dust	SCR –tail end	SCR –cold
• NOx reduction	+	++	++	++	++
• NH3 slip	o	+	+	+	+
• Dioxins reduction	No	No	Dioxin CAT	Dioxin CAT	Dioxin CAT
• Water/ Air compressed	+	+	+	+	+
• Dust	N.A.	ESP upstream	ESP upstream	BHF upstream	BHF upstream
• Reactive agents Consumption	+	++	++	++	++

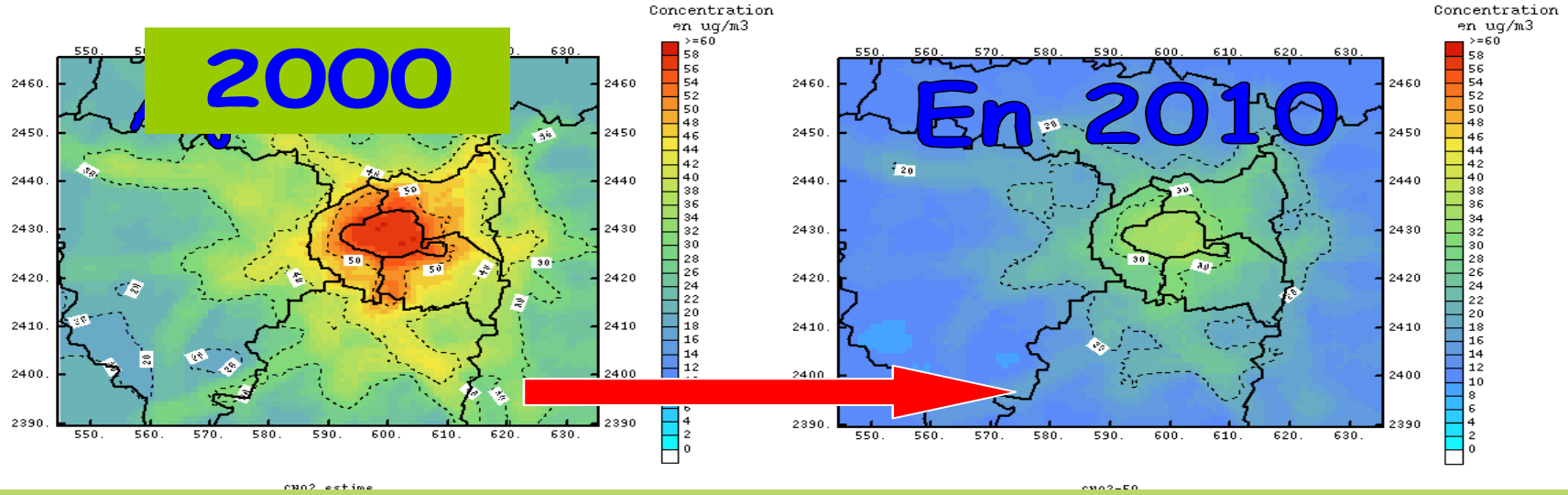
Overall INTEGRATED optimisation
checking inter-process compatibility and interaction
considering the technical and economical local situation.

BREF BAT main processes for NOx treatment

Process	SNCR	Combined SNCR+SCR	SCR –Low Dust	SCR –tail end	SCR –cold
Costs					
• OPEX	+	++	++	++	+
• CAPEX	+++	+	+	o	+
Footprint	++	+	+	o	o
Catalyst life time	NA	+	+	++	+
Maintenance	++	+	+	o	o
Other equipment	-	Upstr. ESP Downstr. Eco	Upstr. ESP Downstr. Eco	Gas/gas HEX or steam	Catalyst regeneration

Plan of Protection of the Atmosphere (PPA) in Paris Area

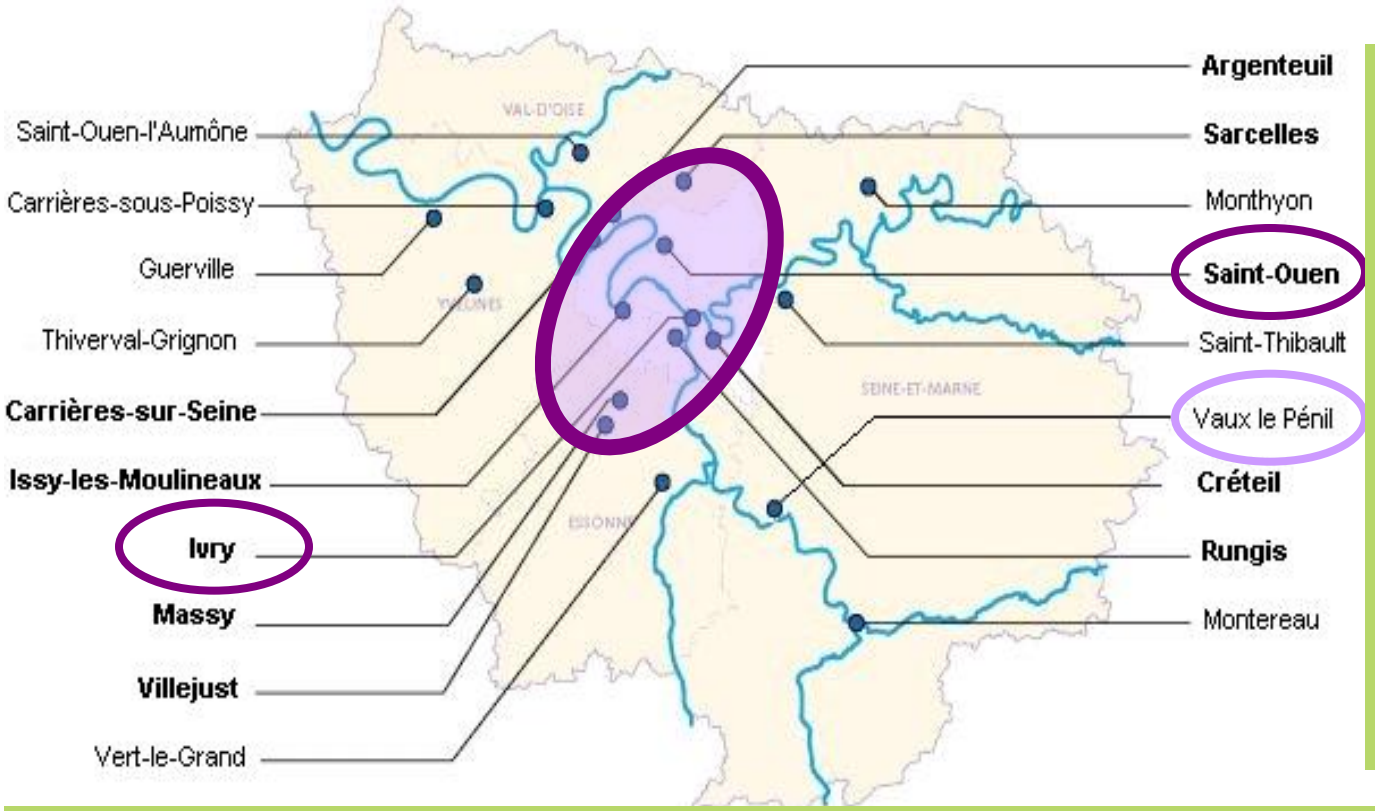
- **Average ambient air quality objective of 40µg/m3 of NOx in Paris Region for 2010 (11 millions of inhabitants on 12.000km²).**
- **Main source of NOx pollution (>50%) : dense traffic.**



Requires a reduction of 40% of the total emissions of NOx compared to the situation in 2000

EfW plants and PPA in Paris Area

- **19 EfW plants in Ile-de-France (IdF) - 4 millions of tons of MSW treated (1/3 of the national capacity) - Around 4% of the NOx emission in IdF in 2000.**



10 EfW plants in the near suburb of Paris (70% of the IdF capacity) with NOx ELV down to 80 mg/Nm^3 instead of 200 mg/Nm^3 required by the directive.

Reduction of the NOx contribution of EfW in Ile-de-France from 4% in 2000 to around 1%, instead of 2% obtained with the directive limit of 200mg/Nm^3

Retrofit of the wet flue gas treatment of SYCTOM of PARIS – Saint-Ouen plant (France) 630.000t_{MSW}/y

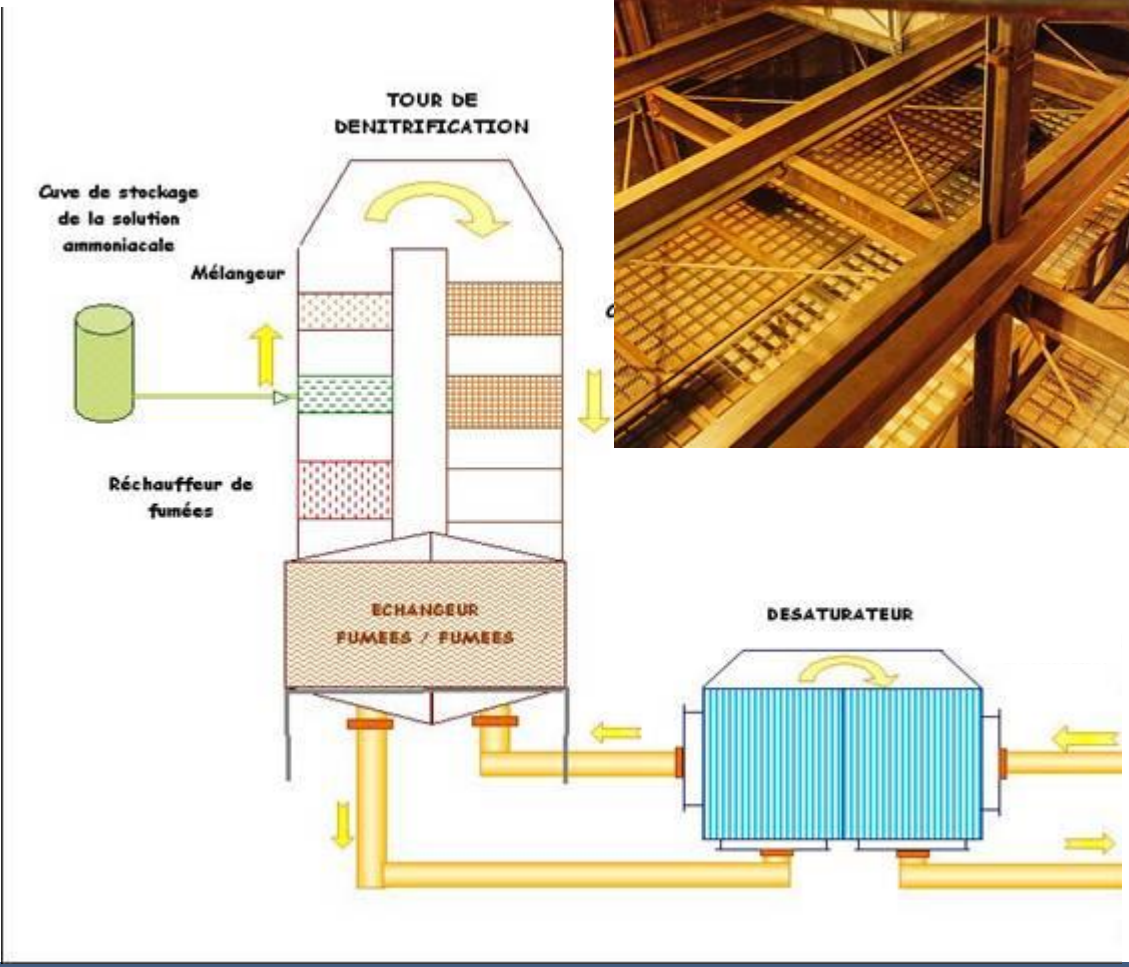
- 3 combustion lines capacity 28t MSW/h started in 1990 with grate furnace and steam boiler for cogeneration
- Existing wet flue gas treatment with liquid effluent discharge including electrostatic precipitator, quench and 1 wet scrubber started in 1990. Was in conformity with European directive 1989

SYCTOM PARIS Saint-Ouen - Process

Main pollutants to treat :
Dust and SOx (a few), dioxins and NOx 80mg/Nm^3 (PPA)

	Catalytic Treatment		Non Catalytic Treatment			
	Selective Catalytic Reduction		On Wet Process		On Dry Process	
	Tail-end SCR	Low dust SCR	***LAB scrubber without active carbon slurry***	*Downstream Bag-House*	deNOx	Upstream Bag-House
Solution	***A***	B	***C***			
Performances Dioxins	***++***	+	***0***			
Performances Mercury	***0***	0	***+***			
Performances Dust and SOx	***0***	0	***+***			
Performances NOx	***++***	++	***0***			
Energy Consumption	***++***	+	***0***			

SYCTOM PARIS Saint-Ouen - Installed equipment



Choice reasons of the tail-end SCR deNOx: NOx level, space available & flue gas temperature

Retrofit of the wet flue gas treatment of SYCTOM of PARIS XIII – IVRY plant (France) 730.000t_{MSW}/y

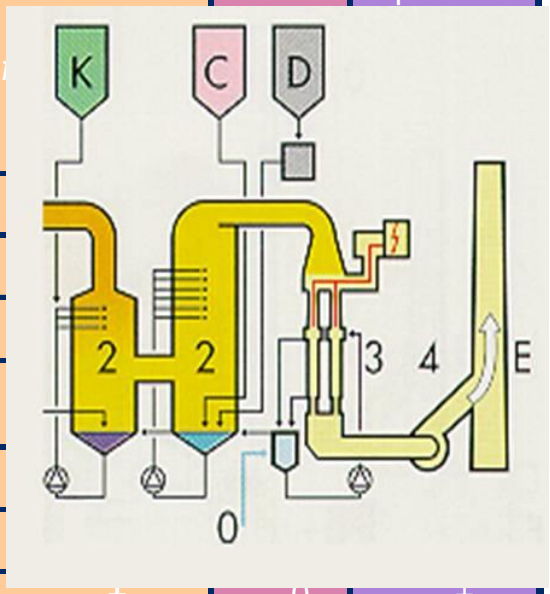
- **2 combustion lines, started in 1969 :**
  50t MSW/h /line (WORLD RECORD SINCE ALMOST 48 YEARS), with grate furnace and steam boiler for cogeneration

- **Existing wet flue gas treatment started in 1995 with liquid effluent discharge including electrostatic precipitator, quench and wet scrubber. Was in conformity with European directive 1989**

SYCTOM PARIS XIII - Process

Main pollutants to treat : Dust (with an aditionnal ESP), dioxins and NOx 80mg/Nm³ (PPA)

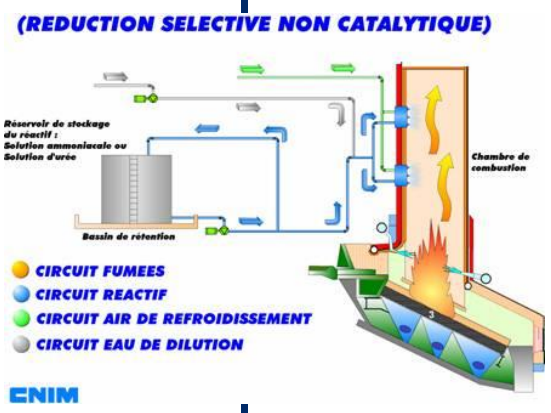
	Catalytic Treatment		Non Catalytic Treatment			
	Selective Catalytic Reduction		On Wet Process		On Dry Process	
	Tail-end SCR	***Low dust SCR***	***dedioxLAB scrubber with active carbon slurry***	*Downstream*		Upstream
Solution	A	***B***	***C***			
Performances Dioxins	++	**+**	**++**			
Performances Mercury	0	***0***	**+**			
Performances Dust and SOx	0	***0***	**+**			
Performances NOx	++	**++**	***0***			
Memory Effect Treat.t*	++	**+***	**++**			
Energy Consumption	++	**+**	***0***	+	0	+



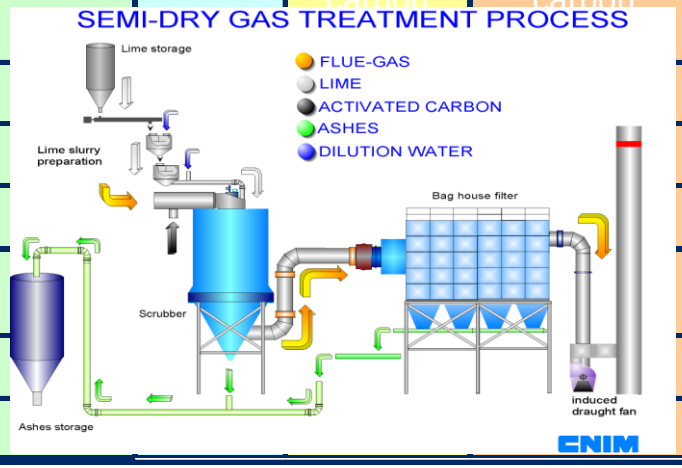
Flue gas treatment of SMITOM VAUX LE PENIL-MELUN new plant (FRANCE) 130.000t_{MSW}/y

- 2 new combustion lines : capacity 8t MSW/h each started in 2003 with grate furnace and energy recovery boilers, producing each HP steam for electricity production (10MWe exported).
- 2 flue gas treatment lines based on semi-wet process, including an injection of atomised lime milk and active carbon in a reactor and a dedusting with a bag house filter. NOx treated with SNCR deNOx, consisting in an injection of ammonia-water in the furnace.
- In conformity with European directive 2010 but not concerned by the PPA requirement

SMITOM VAUX LE PENIL - Process



Catalytic Treatment	Non Catalytic Treatment			
Selective Catalytic Reduction	On Wet Process			On Dry Process
Tail-end SCR	Low dust SCR	dedioxLAB scrubber with active carbon	Downstream Bag-House filter + active carbon	***deNOx SNCR***	***Upstream Bag-House filter + active carbon***
Solution				***E***	***F***
Performances Dioxins				***0***	***++***
Performances Mercury				***0***	***++***
Performances Dust and SOx				***0***	***++***
Performances NOx				***+***	***0***
Energy Consumption				***0***	***+***



Choice reasons:
NOx level, integrated process giving optimum ratio for investment/operation costs

For each situation, a BAT solution









Some recent Dry/Semi-dry + SNCR FGT

- Gloucester - Urbaser (2019)
- South London - Viridor (2018)
- Leeds - Veolia (2016)
- Wilton - Suez (2016)
- Shropshire - Veolia (2015)
- Cardiff - Viridor (2015)
- Suffolk - Suez (2014)
- Plymouth - MVV (2014)
- Oxford - Viridor (2014)
- Stafford - Veolia (2014)
- Lincoln - WRG FCC (2013)
- Jersey - Government (2011)

Some recent deSOx Marine scrubbers

Some recent FGD for Power Plants

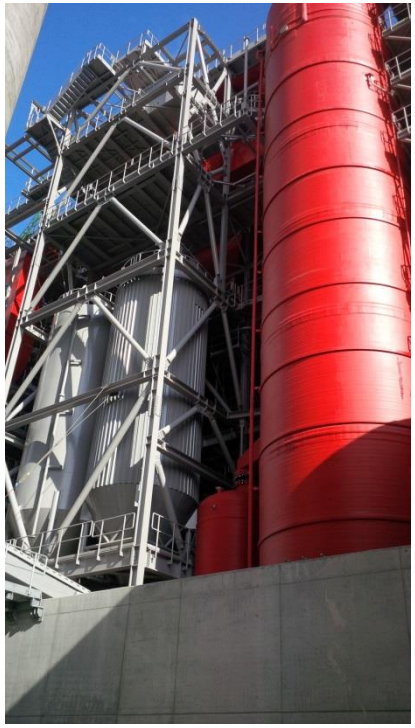
- SECOLAB with conditioning tower
  - SOLVAY Dombasle (2013): 2x78 MWth
  - DALKIA Trebovice (2015): 1x160 MW
  - SOLVAY Tavaux (2016): 1x134 MWth

- Limestone / Lime scrubbing system
  - ALBIOMA Le Moule (2012): 1 x 38 MWel
  - CEH Paroseni (2015): 1 x 150 MWel
  - ALBIOMA Le Gol (2016): 1 x 58 MWel

- Sea water scrubber
  - LOKALSTYRE Longyearbyen (Spitzberg) - 2015

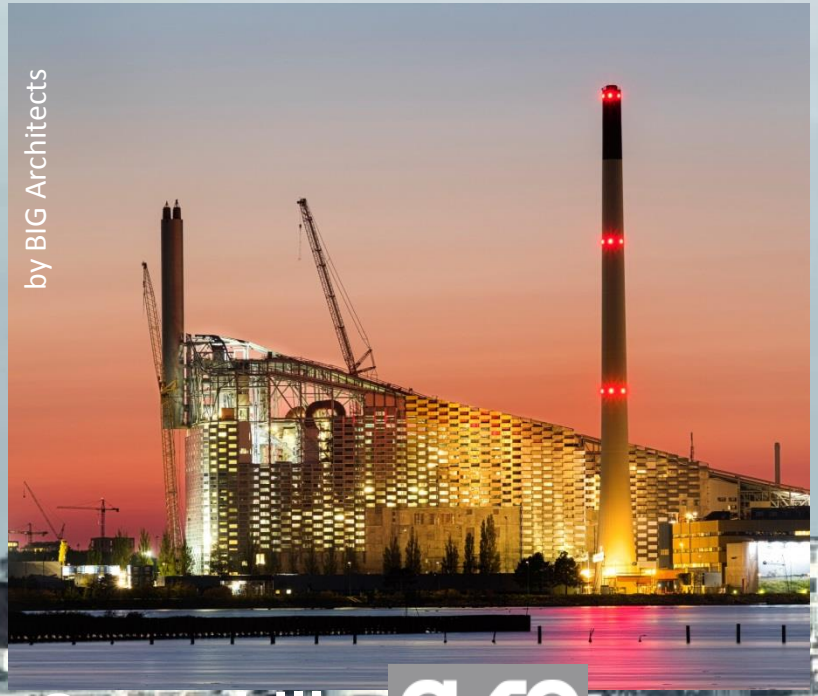
Some recent projects for Biomass boilers

- Biomass AVA Lisbjerg (DK)
  - 1 line 110 MWth (137‘000 Nm3/h)
  - Straw fire boiler
  - Dry system + SCR deNOx + flue gas condensation combined to combustion air humidification



- Biomass Vattenfall Fynsvaerket Odense (DK)
  - Existing Straw fire boiler 117 MWth equipped with SCR unit between BHF and condensation - Levy 3.35€/kg NOx
  - NOx guarantee : 15 mg/Nm^3 with NH_3 slip lower than 2 mg/Nm^3

COPENHAGEN (DK) by 2025: 1st CO_2-neutral capital & 100% renewable and recovery heat in District Heating! (98% of city's demand!)



by BIG Architects

by Gottlieb Paludan Architects

Copenhill

250MWth Waste to Energy with flue gas condensation & absorption heat pumps

BIO4 "Plant power"

500 MWth Wood Boiler with flue gas condensation

Lab guarantees Flue Gas emissions compliant to the most stringent standards of the European Best Available Techniques

Kara Noveren, Denmark

CNIM