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
CNIM Group
Business & Products Development Director
An international family-owned industrial group created in 1856

Workshop in 1895
The turn key project culture of a former Naval Shipyard!
TURNKEY PROJECT designer and supplier for Environment and Energy…

WtE Sheffield, UK
...Designing and building High Tech industrial EQUIPMENT and SYSTEMS...

Energy for the Future!
Radial plates for ITER FUSION reactor!
Completed by SERVICES like engineering, project management, commissioning, Operation & Maintenance, retrofitting...
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
recovers Energy from Municipal Solid Waste of 100 million people around the world!

Torino WtE, Italy by CNIM
Best Available Techniques for:

- Waste combustion
- Energy recovery
- Flue gas cleaning
- Power production
CNIM Group

443 Flue Gas Treatment lines in 26 countries since 1952!

WtE Amagerforbraending, Copenhagen, Denmark

Credit: BIG
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

- Kitchen waste: 25
- Paper and Cardboard: 18
- Plastic: 12
- Other combustibles: 10
- Metals: 3
- Sanitary Textiles: 3
- Textiles: 4
- Glass: 5
- Rubble: 5
- Garden waste: 6

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

<table>
<thead>
<tr>
<th>SUBSTANCES/ACTIVITIES</th>
<th>ELVs in mg/Nm³ (dioxins &amp; furans in ng/Nm³)</th>
<th>Thermal Input (MWth)</th>
<th>Dust</th>
<th>TOC</th>
<th>CO</th>
<th>HCl</th>
<th>HF</th>
<th>SO₂</th>
<th>NOx</th>
<th>Dioxins and furans</th>
<th>Cd + Tl</th>
<th>Hg</th>
<th>Heavy Metals (Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste incineration &amp; Co-incineration</td>
<td>at 11% O₂ dry</td>
<td>New &amp; Existing &gt; 3 t/h</td>
<td>~ 7</td>
<td>10</td>
<td>10</td>
<td>50</td>
<td>10</td>
<td>1</td>
<td>50</td>
<td>200 (expressed in NO₂)</td>
<td>0.1</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Combustion Plants (coal, lignite and other solid residues)</td>
<td>at 6% O₂ dry (converted &gt; 11% O₂ dry)</td>
<td>New &amp; Existing</td>
<td>&lt; 50</td>
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<td>Existing (started operation until 7/01/2014)</td>
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<td>30 (20)</td>
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<tr>
<td>Combustion plants (biomass)</td>
<td>at 6% O₂ dry</td>
<td>Existing (started operation until 7/01/2014)</td>
<td>50-100</td>
<td>30 (20)</td>
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<td>&gt; 300</td>
<td>20 (13)</td>
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<td>-</td>
<td>200 (133)</td>
<td>250 (167)</td>
<td>-</td>
</tr>
</tbody>
</table>

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

Typical Measured Values at Stack over FGT Inlet

Measured values << ELVs (Emission Limit 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

- **Range for NOₓ/NH₃-optimised operation**
- **“A”** Optimum temperature for SNCR alone (low ammonia slip)
- **Range for SNCR+SCR operation**
- **“B”** Optimum temperature for SNCR + SCR (high ammonia slip)

Source: EPPSA

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20/10/2017  3rd TFTEI Annual Meeting - Rome  ccordhomme@cnim.com
Abatement Technologies SCR de-NOx (Selective Catalytic Reduction)
Different types of SCR deNOx (and dediox)

Low dust SCR

Tail end SCR

Cold SCR

Cold SCR with regeneration

260-280 °C
High SO₂
e.g. Ivry (F)

220 – 250 °C
Low SO₂
e.g. Twence (NL)

180 – 200 °C
Very low SO₂
e.g. Aarhus(DK)

180 – 200°C
low SO₂
e.g. Torino (It)
## BREF BAT main processes for NOx treatment

<table>
<thead>
<tr>
<th>Process</th>
<th>SNCR</th>
<th>Combined SNCR +SCR</th>
<th>SCR – Low Dust</th>
<th>SCR – tail end</th>
<th>SCR – cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx reduction</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>NH3 slip</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Dioxins reduction</td>
<td>No</td>
<td>No</td>
<td>Dioxin CAT</td>
<td>Dioxin CAT</td>
<td>Dioxin CAT</td>
</tr>
<tr>
<td>Water/ Air compressed</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Dust</td>
<td>N.A.</td>
<td>ESP upstream</td>
<td>ESP upstream</td>
<td>BHF upstream</td>
<td>BHF upstream</td>
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<tr>
<td>Reactive agents Consumption</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

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**Overall INTEGRATED optimisation**

checking inter-process compatibility and interaction considering the technical and economical local situation.
# BREF BAT main processes for NOx treatment

<table>
<thead>
<tr>
<th>Process</th>
<th>SNCR</th>
<th>Combined SNCR+SCR</th>
<th>SCR –Low Dust</th>
<th>SCR –tail end</th>
<th>SCR –cold</th>
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</thead>
<tbody>
<tr>
<td><strong>Costs</strong></td>
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<tr>
<td>• OPEX</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>• CAPEX</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td><strong>Footprint</strong></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
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<td><strong>Catalyst life time</strong></td>
<td>NA</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Other equipment</strong></td>
<td>-</td>
<td>Upstr. ESP</td>
<td>Upstr. ESP</td>
<td>Gas/gas</td>
<td>Catalyst regeneration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Downstr. Eco</td>
<td>Downstr. Eco</td>
<td>HEX or steam</td>
<td>regen</td>
</tr>
</tbody>
</table>

- BREF BAT main processes for NOx treatment
- SNCR: Selective Non-Catalytic Reduction
- Combined SNCR+SCR
- SCR: Selective Catalytic Reduction
- SCR –Low Dust
- SCR –tail end
- SCR –cold
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)

630,000 t\textsubscript{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.
Main pollutants to treat:
Dust and SOx (a few), dioxins and NOx 80mg/Nm³ (PPA)

<table>
<thead>
<tr>
<th>Solution</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performances Dioxins</td>
<td>++</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Performances Mercury</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Performances Dust and SOx</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Performances NOx</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Energy Consumption</td>
<td>++</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>
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) 730,000tₑMSW/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
Main pollutants to treat:
Dust (with an additional ESP),
dioxins and NOx 80mg/Nm$^3$ (PPA)

<table>
<thead>
<tr>
<th>Solution</th>
<th>Catalytic Treatment</th>
<th>Non Catalytic Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On Wet Process</td>
<td>On Dry Process</td>
</tr>
<tr>
<td></td>
<td>Tail-end SCR</td>
<td>Low dust SCR</td>
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<tr>
<td></td>
<td>Selective Catalytic Reduction</td>
<td>dedioxLAB scrubber with active carbon slurry</td>
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<tr>
<td></td>
<td></td>
<td>Downstream</td>
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<td></td>
<td></td>
<td>Upstream</td>
</tr>
<tr>
<td><strong>Performances Dioxins</strong></td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td><strong>Performances Mercury</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Performances Dust and SOx</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Performances NOx</strong></td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><strong>Memory Effect Treat.t</strong></td>
<td>++</td>
<td>+*</td>
</tr>
<tr>
<td><strong>Energy Consumption</strong></td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>
Flue gas treatment of
SMITOM VAUX LE PENIL-MELUN
new plant (FRANCE)
130,000 t\textsubscript{MSW}/y

- 2 new combustion lines: capacity 8 t MSW/h each started in 2003 with grate furnace and energy recovery boilers, producing each HP steam for electricity production (10 MWe 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. NO\textsubscript{x} treated with SNCR deNO\textsubscript{x}, consisting in an injection of ammonia-water in the furnace.

- In conformity with European directive 2010 but not concerned by the PPA requirement
**Choice reasons:**
NOx level, integrated process giving optimum ratio for investment/operation costs

<table>
<thead>
<tr>
<th>Solution</th>
<th>Performances Dioxins</th>
<th>Performances Mercury</th>
<th>Performances Dust and SOx</th>
<th>Performances NOx</th>
<th>Energy Consumption</th>
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</thead>
<tbody>
<tr>
<td>Catalytic Treatment</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Non Catalytic Treatment</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Selective Catalytic</td>
<td>On Wet Process</td>
<td>Low dust SCR</td>
<td>dedioxLAB scrubber</td>
<td>Downstream Bag-House filter + active carbon</td>
<td>deNOx SNCR</td>
</tr>
<tr>
<td>Reduction</td>
<td>On Dry Process</td>
<td>SCR</td>
<td>with active carbon</td>
<td>Upstream Bag-House filter + active carbon</td>
<td></td>
</tr>
</tbody>
</table>

| Energy Consumption        | E                    | F                    | 0                         | ++               | 0                 |
| Performances Dioxins      | ++                   | ++                   | 0                         | ++               | ++                |
| Performances Mercury      | 0                    | ++                   | 0                         | ++               | 0                 |
| Performances Dust and SOx | 0                    | ++                   | 0                         | ++               | 0                 |
| Performances NOx          | +                    | 0                    | 0                         | 0                | +                 |
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

Mont St Michel – Marine Scrubbers – STX France

Pont Aven – STX France

Armorique – STX France
- **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/Nm³ with NH₃ slip lower than 2 mg/Nm³
COPENHAGEN (DK) by 2025: 1st CO₂-neutral capital & 100% renewable and recovery heat in District Heating! (98% of city’s demand!)

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

BIO4 “Plant power“
500 MWth Wood Boiler with flue gas condensation
guarantees Flue Gas emissions compliant to the most stringent standards of the European Best Available Techniques

Kara Noveren, Denmark