Energy-from-Waste

State of the art of best available techniques to abate dust, acid gases, heavy metals, NOx and POPs present in flue gas

Agenda

1) CNIM/ Lab Presentation
2) Energy-from-Waste (EfW) Plants in Europe
3) Waste Composition and Pollutants
4) Energy-from-Waste Scheme
5) Emission Limit Values (ELVs) to air according to IED 2010/75/EU
6) Pollutants Abatement Performances
7) Pollutants Emissions from EfW Plants
8) Air Pollution Control Technologies
9) Pollutants Abatement Cost/ Benefit Analysis

23rd EGTEI Annual Meeting Convention on Long-Range Transboundary Air Pollution 10th of October 2014 Brussels, Belgium

Christophe CORD’HOMME
CNIM Group
Business & Products Development Director
And Flavio MATOS
CNIM 2013 key figures

- 2013 revenue: 782 M€ including 67% from exports
- Revenue by sectors
  - 18% Environment
  - 15% Innovation & Systems
  - 67% Energy

- Order book: €1,109 million
- 2,800 employees (out of which 1,300 engineers)
- Listed on the stock exchange since 1986

Figures at December 31, 2013

CNIM Environment activities

Multi-channel approach to master the processing cycles of municipal and industrial waste management

- Turnkey waste valorisation plants with a unique offer of Design and Build as EPC for Waste-to-Energy, Biomass-to-Energy, Waste Sorting and Composting...
- Flue gas cleaning, Bottom ash & residues treatment
- Plant Operation & Maintenance and revamping
CNIM Environment references

CNIM is one of the top European specialists of Waste-to-Energy recovery

- 281 CNIM MSW Waste-to-Energy lines built allowing the treatment of about 25 million tons of waste per year
- 19 MSW Waste-to-Energy lines operated by CNIM
- 412 LAB Flue Gas Treatment installations built cleaning the combustion gases of around 34 million tons of waste per year

CNIM latest and ongoing WtE & BtE projects

<table>
<thead>
<tr>
<th>Waste-to-Energy Plants</th>
<th>Location</th>
<th>t/h</th>
<th>Commissioning year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marseille (FR)</td>
<td>2 x 20</td>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>Brno (CZ)</td>
<td>2 x 14</td>
<td>2011</td>
<td></td>
</tr>
<tr>
<td>Baku (AZ)</td>
<td>2 x 33</td>
<td>2012</td>
<td></td>
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<tr>
<td>St Omer (FR)</td>
<td>1 x 12.5</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>Hammeville (BE)</td>
<td>1 x 13</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>Liencres (FR)</td>
<td>1 x 19</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Faltida (IT)</td>
<td>1 x 31</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Turin (IT)</td>
<td>3 x 22.5</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>Lorient (FR)</td>
<td>3 x 10</td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>Thetfordshire (UK)</td>
<td>2 x 20</td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>Camden (UK)</td>
<td>2 x 23</td>
<td>2015</td>
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<tr>
<td>Barnsley (UK)</td>
<td>2 x 16</td>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>Hampshire (UK)</td>
<td>1 x 12</td>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>York (UK)</td>
<td>1 x 23.5</td>
<td>2016</td>
<td></td>
</tr>
<tr>
<td>Wilton - Middlesbrough (UK)</td>
<td>2 x 29.2</td>
<td>2016</td>
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<table>
<thead>
<tr>
<th>Biomass Plants in t/h</th>
<th>Location</th>
<th>t/h</th>
<th>Commissioning year</th>
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<tbody>
<tr>
<td>Kogeban (FR)</td>
<td>1 x 29.6</td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>Ridham Dock (UK)</td>
<td>1 x 22</td>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>Estrées-Mons (FR)</td>
<td>1 x 23</td>
<td>2016</td>
<td></td>
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</tbody>
</table>
An integrated FLUE GAS TREATMENT company with 3 activities

POWER

WASTE

INDUSTRY
State of the art best available techniques to abate dust, acid gases, heavy metals, NOx and POPs present in flue gas, 23rd EGTEI Annual Meeting - Brussels, 10th of October, 2014.

State of the art of best available techniques to abate dust, acid gases, heavy metals, NOx and POPs present in flue gas, 23rd EGTEI Annual Meeting - Brussels, 10th of October, 2014.

Data supplied by CEWEP members unless specified otherwise.

* From Eurostat
Waste Composition and Pollutants

Typical MSW Composition in Europe

Pollutants from MSW Combustion

- CO2
- H2O
- N2
- CO
- NOx (NO, NO₂)
- HCl
- HF
- SOx (SO3, SO2)
- Gas (Hg, Cd)
- Particles (Pb, Cu, Cr, Co...)
- Dioxins (PCDD/F)...

Fly Ash and Bottom Ash

Energy-from-Waste Scheme

State-of-the-art of best available techniques to abate dust, acid gases, heavy metals, NOx and POPs present in flue gas, 23rd EGTeti Annual Meeting - Brussels, 10th of October, 2014

Collect

Furnace

Boiler O

Flue gas treatment

Chimney

Export 0.60 MWh

Turbine

Internal consumption 0.10 MWh

1 Ton of MSW NCV ~ 9,4 MJ/kg

Air 5200 Nm³

Ammonia solution (25%) 4 kg

Slaked lime 1.4 kg

Activated carbon 0.45 kg

20 kg Scrap Iron

220 kg Bottom Ash

16 kg Fly Ash

32 kg AFC residue

Steel industry

Road construction

Recycle / Controlled Landfill

State-of-the-art of best available techniques to abate dust, acid gases, heavy metals, NOx and POPs present in flue gas, 23rd EGTeti Annual Meeting - Brussels, 10th of October, 2014
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/Nm³ (dioxins & furans in ng/Nm³) | Thermal input (MWth) | Dust | TOC | CO | HCl | HF | SO₂ | NOₓ | Dioxins and furans | Cd + Tl | Hg | Heavy Metals (expressed in %)
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</thead>
<tbody>
<tr>
<td>Incineration &amp; Co-incineration</td>
<td>at 11% O₂ dry</td>
<td>New &amp; Existing &lt; 32 mg/Nm³</td>
<td></td>
<td>7</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>1</td>
<td>50</td>
<td>300</td>
<td>100</td>
<td>0.5</td>
</tr>
<tr>
<td>Combustion Plants (coal, lignite and other solid residues)</td>
<td>at 6% O₂ dry (converted to 11% O₂ dry)</td>
<td>New &amp; Existing &lt; 50</td>
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<td></td>
</tr>
<tr>
<td>Effluent Treatment Plants (EFW, and industrial waste)</td>
<td>at 6% O₂ dry (and 11% O₂ dry)</td>
<td>New</td>
<td>50-100</td>
<td>20</td>
<td>15</td>
<td>-</td>
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<td>-</td>
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<tr>
<td></td>
<td></td>
<td>Existing</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Combustion Plants (biomass)</td>
<td>at 6% O₂ dry</td>
<td>New</td>
<td>100-300</td>
<td>20</td>
<td>15</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td>Existing</td>
<td>&gt; 300</td>
<td>20</td>
<td>15</td>
<td>-</td>
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- 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

**EfW**: Strictest European Environmental Legislation

### Abatement Performance of Pollutants in EfW

Measured values << ELVs (Emission Limit Values)

Typical Measured Values at Stack over ELVs EU Directive 2000/76/EC

<table>
<thead>
<tr>
<th>Substance</th>
<th>Measured Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOₓ</td>
<td>200 mg/Nm³</td>
</tr>
<tr>
<td>SO₂</td>
<td>180 mg/Nm³</td>
</tr>
<tr>
<td>Dioxins</td>
<td>25 mg/Nm³</td>
</tr>
<tr>
<td>Metals</td>
<td>0.5 mg/Nm³</td>
</tr>
<tr>
<td>Dust</td>
<td>10 mg/Nm³</td>
</tr>
</tbody>
</table>

Typical Measured Values at Stack over FGT Inlet

<table>
<thead>
<tr>
<th>Substance</th>
<th>Measured Value</th>
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<tbody>
<tr>
<td>NOₓ</td>
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Pollutants Emissions from EfW Plants

Share of EfW in Total Emissions

Data from 50 WtE plants in selected countries
(Czech Republic, France, Germany, Italy, Netherlands and Sweden)

Source: Helmut Rechberger & Gerald Schöller, TU Vienna Institute for Water Quality, Resources and Waste Management

Pollutants Emissions from EfW Plants

In Germany only 0.7% of total dioxins/furans released in the atmosphere in 2000 were from EfW plants

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C. Cord’Homme
State of the art of best available techniques to abate dust, acid gases, heavy metals, NOx and POPs present in flue gas, 23rd EGTEI Annual Meeting - Brussels, 10th of October, 2014

Abatement Technologies Dedusting

- Bag house filter
- Electrostatic precipitator

Abatement Technologies Acid Gases

- Dry
  - SecoLAB®
- Semidry
  - SemisecoLAB
- Wet
  - GraniLAB, CycloLAB, DedioxLAB
  - VapoLAB®
Abatement Technologies deNOx

DeNOx Technologies

SNCR (non catalytic) 950 – 1050 °C
TerminoLAB® 200 – 280 °C
CataLAB® (catalytic) 180 – 250 °C

Abatement Technologies : dediox

Adsorption Activated carbon
or
Catalytic Oxidation
Flue Gas Cleaning, 1st STAGE:
SNCR de-NOx (Selective Non Catalytic Reduction)
In the combustion chamber at high temperature (800 – 850°C)

State-of-the-art high performance Dry System

2nd step injection of dry additives
- Powerful removal of acidic pollutants by hydrated lime or bicarbonate
- Removal of mercury and dioxins by activated coke or activated coal

Abatement Technologies
State-of-the-art high performance **Dry System**

3rd step
Reactivation and recirculation of fabric filter dust

- Final removal of pollutants
- Buffering of pollutants peaks
- Minimization of additive consumption

**External Ecominizer**

**LAB Loop entrained suspension reactor**

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State of the art of best available techniques to abate dust, acid gases, heavy metals, NOx and POPs present in flue gas, 23rd EGTEI Annual Meeting - Brussels, 10th of October, 2014
Abatement Technologies: Aerosol in Wet System

Abatement Technologies SCR de-NOx (Selective Catalytic Reduction)
Cost / Benefit analysis

Typical ½ hourly average values over one year ≈ 17000 values

Dry FGC process

HCl ½-hr averages over 1 year


Graph by L. Kosior, SITA

Cost / Benefit analysis (assuming plant capacity is 10 t/hr)

Lowering the ELV of HCl from 60 to 10 mg/Nm³ would:
- Reduce the HCl emitted flow by 11 kg/year
- Increase the lime consumption* by 240,000 kg/y
- Increase the FGC residues by 240,000 kg/y

* Assuming 15 kg Ca(OH)₂ per t, and 20% additional consumption

Dry FGC process

HCl ½-hr average over 1 year – Data arranged by value

HCl yearly mass flow: 1137 kg/y
(yearly average: 2.7 mg/Nm³)

HCl outliers mass flow
(between 10 and 50 mg/Nm³):
11 kg/y = 0.9% of the total

11 kg
(Benefit)

2 x 240 t
(COST)