BEST AVAILABLE TECHNOLOGIES (BAT)
Bettina Kamuk, Head of Department – Rambøll
Board Member and Chair of the Working Group
Energy Recovery, ISWA
BEST AVAILABLE TECHNIQUE (BAT) IN EU

- Best Available Techniques (BAT) Reference Document on waste incineration, August 2006 (BREF)
- Collection of information about techniques and operational experience, among others best available operational emission levels (BATOEL) – not emission limit value (ELV)
- Carried out under Article 16(2) of Council Directive 96/61/EC (IPPC Directive) to be used when permitting WTE facilities
- BAT is not just lowest possible, also a matter of costs and local circumstances
- 63 questions shall be answered according BREF
BAT QUESTIONS EXAMPLES

1. The selection of an installation design that is suited to the characteristics of the waste received, as described in 4.1.1 and 4.2.1 and 4.2.3.

2. The maintenance of the site in a generally tidy and clean state, as described in 4.1.2.

3. To maintain all equipment in good working order, and to carry out maintenance inspections and preventative maintenance in order to achieve this.

4. To establish and maintain quality controls over the waste input, according to the types of waste that may be received at the installation, as described in:
   - 4.1.3.1 Establishing installation input limitations and identifying key risks, and
   - 4.1.3.2 Communication with waste suppliers to improve incoming waste quality control, and
   - 4.1.3.3 Controlling waste feed quality on the incinerator site, and
   - 4.1.3.4 Checking, sampling and testing incoming wastes, and
   - 4.1.3.5 Detectors for radioactive materials.

5. The storage of wastes according to a risk assessment of their properties, such that the risk of potentially polluting released is minimised. In general it is BAT to store waste in areas that have sealed and resistant surfaces, with controlled and separated drainage as described in 4.1.4.1.

6. To use techniques and procedures to restrict and manage waste storage times, as described in 4.1.4.2, in order to generally reduce the risk of releases from storage of waste/container deterioration, and of processing difficulties that may arise. In general it is BAT to:
   - Prevent the volumes of wastes stored from becoming too large for the storage provided
   - In so far as is practicable, control and manage deliveries by communication with waste suppliers, etc.

7. To minimise the release of odour (and other potential fugitive releases) from bulk waste storage areas (including tanks and bunkers, but excluding small volume wastes stored in containers) and waste pre-treatment areas by passing the extracted atmosphere to the incinerator for combustion (see 4.1.4.4).

   In addition it is also considered to be BAT to make provision for the control of odour (and other potential fugitive releases) when the incinerator is not available (e.g. during maintenance) by:
   - Avoiding waste storage overload, and/or
   - Extracting the relevant atmosphere via an alternative odour control system

8. The segregation of the storage of wastes according to a risk assessment of their chemical and physical characteristics to allow safe storage and processing, as described in 4.1.4.5.

9. The clear labelling of wastes that are stored in containers such that they may continually be identified, as described in 4.1.4.6.
NEW REVISION OF BREF

• Revision of the BREF will begin early 2014 and is expected to last until end 2015/2016
• Waste Incineration Directive (WID) sets the Emission Limit Values (ELV) for WTE facilities
• The WID has been integrated (1:1) in the Industrial Emission Directive (IED)
• The ELVs are valid until the new BREF is published then the BREF shall be reflected in the new ELVs – but BREF is reporting the BATOEL?
# EU BREF - BATOEL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>BATOEL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>daily average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 %</td>
</tr>
<tr>
<td>Dust</td>
<td>mg/Nm³</td>
<td>1-5</td>
</tr>
<tr>
<td>HCl</td>
<td>mg/Nm³</td>
<td>1-8</td>
</tr>
<tr>
<td>HF</td>
<td>mg/Nm³</td>
<td>&lt;1</td>
</tr>
<tr>
<td>SO₂ + SO₃</td>
<td>mg/Nm³</td>
<td>1-40</td>
</tr>
<tr>
<td>NOₓ as NO₂</td>
<td>mg/Nm³</td>
<td>120-180¹)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40-100²)</td>
</tr>
</tbody>
</table>

**Result of spot sampling**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃</td>
<td>mg/Nm³</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Cd + Tl</td>
<td>mg/Nm³</td>
<td>0.005-0.05</td>
</tr>
<tr>
<td>Σ 9 metals</td>
<td>mg/Nm³</td>
<td>0.005-0.5</td>
</tr>
<tr>
<td>Hg</td>
<td>mg/Nm³</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Dioxins, TEQ</td>
<td>ng/Nm³</td>
<td>0.01-0.1</td>
</tr>
</tbody>
</table>

¹) With SNCR. ²) With SCR
## COMPARISON WID - BATOEL

### Comparison WID and BATOEL

<table>
<thead>
<tr>
<th>Component</th>
<th>24 h Dir.</th>
<th>24 h BREF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust</td>
<td>10</td>
<td>1-5</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>50</td>
<td>1-40</td>
</tr>
<tr>
<td>HCl</td>
<td>10</td>
<td>1-8</td>
</tr>
<tr>
<td>NO$_x$ SCR</td>
<td>200</td>
<td>40-100</td>
</tr>
<tr>
<td>NO$_x$ SNCR</td>
<td>200</td>
<td>120-180</td>
</tr>
</tbody>
</table>
## AIR POLLUTION CONTROL SOLUTIONS

<table>
<thead>
<tr>
<th>FGT - efficiency</th>
<th>System complexity</th>
<th>Consumables and residues</th>
<th>Process concept</th>
<th>Investment</th>
<th>Operating cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dry, lime</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dry, bicarbonate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Semi-dry, lime</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dry/wet combined (lime)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wet (limestone)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table:**
- **FGT - efficiency:**
- **System complexity:**
- **Consumables and residues:**
- **Process concept:**
- **Investment:**
- **Operating cost:**
De-NOx PROCESSES

**SCR**
- Reaction at catalyst surface
- 430° F - 480° F (220-250° C)
- Emission 15-70 ppm NOx (20-50 mg/Nm3)
- More expensive
- Large footprint
- By-effect: Dioxin removal

**SNCR**
- Thermal reaction in flue gas
- Temperature 1560-1650°F (850 - 900°C)
- Emission 70-100 ppm NOx (100-150 mg/Nm3)
- Less expensive
- Small footprint
- Risk for ammonia slip
COPENHAGEN WASTE TO ENERGY PLANT

ELECTRICITY FOR 550,000 CITIZENS, HEAT FOR 140,000 HOUSEHOLDS

400,000+ TONS OF WASTE/YEAR

WASTE IS NOT A WASTE

1 TON WASTE = 2 MWh DISTRICT HEATING + 0.67 MWh ELECTRICITY
COPENHAGEN WASTE TO ENERGY PLANT
TECHNOLOGY CHOSEN FOR COPENHAGEN
AIR POLLUTION CONTROL SYSTEM

1. Waste is fed into the Furnace.
2. Furnace output flows to the Boiler.
3. Boiler output is directed to the ESP.
4. ESP output is fed into the SCR-catalyst.
5. SCR-catalyst output is directed to the HT-ECO.
6. HT-ECO output is fed into the Steam-heater.
7. Steam-heater output is directed to ID-fan and then to the Stack.
8. NH3 is added to the system at a temperature of 260-290 °C.
9. Ash/FGT-residue is extracted from the system.
10. Water is added to the Acid scrubber at 60 °C.
11. Limestone is added to the Alkaline scrubber.
12. Water is added to the Wastewater treatment.
13. Limestone, chemicals, and Water are directed to the Wastewater treatment.
14. Gypsum is extracted from the system.
15. Clean wastewater discharge is directed to the system.
16. Power is generated from the Turbine/generator, and Low Pressure steam is directed to the system.
17. Steam is directed to the Furnace.

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ENERGY EFFICIENCY

Backpressure turbine, no flue gas condensation
Effect of live steam temperature and pressure on electrical efficiency
Efficiency change compared to 400°C / 40 bar,a

Change in Gross electrical efficiency [%point] vs. Live steam temperatures

-3.5% -2.5% -1.5% -0.5% 0.0% 1.0% 1.5% 2.0% 2.5% 3.0% 3.5%
380 390 400 410 420 430 440 450 460 470 480

p=110 bar
p=100 bar
p=90 bar
p=80 bar
p=70 bar
p=60 bar
p=50 bar
p=40 bar

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SELECTION OF OPTIMAL STEAM PARAMETERS

Net Present Value in relation to increases in live steam from 400°C/40 bar
Sensitivity: superheater life time & cost of changing (warmest) superheater

Economically optimal range of steam parameters

Cost of changing the hottest SHEr on both boilers
Prices include materials & installation

Basis case: 8 M.DKK 10 M.DKK 12 M.DKK 12 M.DKK 15 M.DKK 15 M.DKK
Best case: 5 M.DKK 5 M.DKK 7 M.DKK 7 M.DKK 16 M.DKK 19 M.DKK
Worst case: 15 M.DKK 15 M.DKK 20 M.DKK 20 M.DKK 40 M.DKK 40 M.DKK

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Bettina Kamuk, WTERT 18-10-2012 14
Corrosion in Superheaters

Super heater configuration 400°C/40bar and 480°C/70bar (with drum steam cooling)

- Negative heat transfer
- Transition zone
- Corrosion zone
- Small corrosion risk

Flue gas temperature (°C)

Steam/tube wall temperature (°C)
MEASURES TAKEN TO PREVENT CORROSION

- Super-heaters are considered as wear parts (layout prepared for fast exchange)
- Better protection of boiler wall in the evaporator section
- Better steel quality of super heaters
WTE EXPERIENCE WORLDWIDE

Grate Technology

- Advanced technology
- Approx. 1,200 plants
- Normal size per combustion line is 200 - 1000 tpd
- Few worldwide recognized equipment manufacturers
- Electricity production (per tonne of waste) for MSW 0,6-0,65 MWh/tonne
- High availability >8,000 h/y
- Gate fee 40 - 120 USD/t

Alternative Technologies

- Under development
- Number in commercial operation is unclear - but few
- Typical capacity 25-250 tpd
- Many (>100) suppliers, many relative small
- Electricity production around 0-0,5 MWh/tonne (difficult to get real data)
- Lower availability – 5,500 h/y
- Requires homogenous waste input
- Gate fee 300-500 USD/t
REMEMBER THE COMPLETE SYSTEM

Waste treatment system

INPUT

Waste
Materials
Energy
Mechanical pretreatment
Thermal pretreatment (reductive, e.g. gasification)
Combustion (oxydic)

Energy recovery
Flue gas treatment
Residues treatment

OUTPUT

Energy
Valuable Materials
Materials
Energy
Recovered resources
RECOVERY OF METALS FROM BOTTOM ASH

- Metal recovery (Fe, Al)
- Recovery of precious metals – technically possible but dependent on market price for metals
CONCLUSIONS

- The European WTE sector supports the BAT
- WTE is an increasing sector in EU (in particular in UK, East Europe, South Europe)
- Hopefully documented and comparable data from alternative technologies
- Metal recovery from bottom ash will increase
THANK YOU FOR YOUR ATTENTION!

BETTINA KAMUK

bkc@ramboll.com