HALOSEP FLY ASH TREATMENT
AT WASTE TO ENERGY PLANTS

ERIK RASMUSSEN, STENA RECYCLING A/S
AGENDA

1. Halosep fly ash treatment

2. Halosep products (fly ash from WtE plants)
   - OS material (X-FGW > 1mm)
   - Treated fly ash (X-FGW)
   - Salt product
   - Metal product

3. Halosep full scale plant (at WtE plant Vestforbrænding DK)
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HALOSEP FLY ASH TREATMENT
FLOW SHEET (VESTFORBRÆNDING)

IN: FLY ASH AND SCRUBBER LIQUID
OUT: HALOSEP PRODUCT STREAMS

Fly ash (FA) → Reaction tank 1 → Sieve → Reaction tank 2 → Ca(OH)2/NaOH/TMT15 → Precipitation → Sedimentation → Washing 2 → Separation 3 → Washing 1 → Separation 2

HCLS → Reaction tank 1 → Sieve

Water → Reaction tank 1 → Precipitation → Sedimentation

Process water → Reaction tank 1 → Precipitation → Sedimentation

Salts product (SP2) → X-FGW (OS) >1mm

Metal product (HMP) → Treated Fly ash (X-FGW)
In the Halosep process both Fly ash and acidic Scrubber liquid are treated
Water: "Flue Gas Condensate"
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   - OS material (X-FGW > 1mm)
   - Treated fly ash (X-FGW)
   - Salt product
   - Metal product

3. Halosep full scale Plant (VF LIFE Project)
HALOSEP PRODUCTS
FROM WTE PLANTS HAVING WET / SEMI-DRY FLUEGAS CLEANING

<table>
<thead>
<tr>
<th></th>
<th>OUTPUT (FLY ASH) (VESTFORBRÆNDING)</th>
<th>OUTPUT (SEMI-DRY FGW) (GL. AMAGERFORBRÆNDING)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated fly ash (X-FGW)</td>
<td>60-61%</td>
<td>40-48%</td>
</tr>
<tr>
<td>Salt product</td>
<td>25-30%</td>
<td>42-50%</td>
</tr>
<tr>
<td>Metal product</td>
<td>~3%</td>
<td>~2%</td>
</tr>
<tr>
<td>X-FGW &gt;1 mm (OS fraction)</td>
<td>~1%</td>
<td>~1%</td>
</tr>
<tr>
<td>H$_2$O and CO$_2$(g)</td>
<td>5-8%</td>
<td>8-12%</td>
</tr>
</tbody>
</table>
# Reduktion of Selected Elements from Fly Ash to X-FGW

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>Extracted From Fly Ash in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony (Sb)</td>
<td>69</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>35</td>
</tr>
<tr>
<td>Barium (Ba)</td>
<td>60</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>25</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>86</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>Extracted From Fly Ash in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride (Cl)</td>
<td>98</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>90</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>39</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>66</td>
</tr>
<tr>
<td>Tin (Sn)*</td>
<td>77</td>
</tr>
</tbody>
</table>

Calculated substance reductions in % (average values from operation A and operation B tests) at HALOSEP treatment of Fly ash from Vestforbrænding, selected elements.
HALOSEP PRODUCTS

X-FGW > 1 MM (OS MATERIAL)

• Amount < 1 % (w/w) of Fly ash (in)
• TOC-content 4-10% (w/w)
• "OS material" to be returned to ovens
HALOSEP PRODUCTS

TREATED FLY ASH (X-FGW)

• Amount 60-61 %(w/w) of Fly ash (in)
• Pb content (tests VF, feb.2017): 0,27% (w/w) Pb Hazardous Waste limit value: 0,30% (w/w)
• No single substance content causes inherent Hazardous Waste properties of X-FGW (VF)
• PCB’s (POP): below detec. limit (<0,002 mg/kg)
• Aromatic HC’s (BTEX): < 0,2 mg/kg
• Carbon fractions "Sum Benzene-C40":20-200 mg/kg
• PAH’s (15): typical values < 0,01 – 0,03 mg/kg
HALOSEP PRODUCTS  
TREATED FLY ASH (X-FGW)  

Classification (X-FGW):

- Not relevant Hazardous Properties: HP1, HP2, HP3, HP9, HP12
- NHW (non hazardous waste): HP4, HP5, HP6, HP7, HP8, HP10, HP11, HP13
- Ecotoxic HP14/N/H410 (?): In DK it is the municipality that decides, whether HP14 should be taken into consideration in connection with classification. We expect NHW classification of X-FGW when biotests (HP14) will be used.
- X-FGW to a disposal site class MA1 or class FA1 ?
- X-FGW use for other purposes: Applications will be evaluated and tested in the Halosep full scale demonstration plant

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STENA
HALOSEP PRODUCTS

TREATED FLY ASH (X-FGW) "BATCH LEACHING L:S=10"

Landfill Classes:

- Inert waste (IA1)
- Mineral waste (MA1)
- Hazardous waste (FA1)
- Fly ash cannot go to any local Landfill.

Raw Fly ash (left column): leaching values obtained from raw Fly Ash X-FGW (right column): leaching values are compliant with current limit values (EU directive 2003/33) for disposal at local landfill class MA1.
HALOSEP PRODUCTS

TREATED FLY ASH (X-FGW) COLUMN LEACHING DATA

Landfill Classes:

- Inert waste (IA1)
- Mineral waste (MA1)
- Hazardous waste (FA1)

X-FGW (right column): The Antimony (Sb) leaching value at L:S=10 may exceed the current MA1 limit value.

All other leaching values are compliant with current limit values for disposal at local landfill class MA1.

A process technical solution to "Sb-leaching" has been developed in order to fulfill the MA1 leaching limit value for Antimony.

Conclusion: X-FGW (from VF) can be disposed on a landfill class MA1.

<table>
<thead>
<tr>
<th>Element</th>
<th>VF 8A</th>
<th>Operation A</th>
<th>0.1 L/KG</th>
<th>2 L/KG</th>
<th>10 L/KG</th>
</tr>
</thead>
<tbody>
<tr>
<td>As</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
<tr>
<td>Ba</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>mg/kg</td>
<td>MA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
<tr>
<td>Hg</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td>MA1</td>
</tr>
<tr>
<td>Mo</td>
<td>mg/kg</td>
<td>MA1</td>
<td>MA1</td>
<td>MA1</td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
<tr>
<td>Sb</td>
<td>mg/kg</td>
<td>MA1</td>
<td>MA1</td>
<td>FA1</td>
<td></td>
</tr>
<tr>
<td>Se</td>
<td>mg/kg</td>
<td>MA1</td>
<td>MA1</td>
<td>MA1</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
<tr>
<td>Cl</td>
<td>mg/kg</td>
<td>MA1</td>
<td>MA1</td>
<td>MA1</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>mg/kg</td>
<td>MA1</td>
<td>MA1</td>
<td>MA1</td>
<td></td>
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<tr>
<td>SO4</td>
<td>mg/kg</td>
<td>MA1</td>
<td>MA1</td>
<td>MA1</td>
<td></td>
</tr>
<tr>
<td>DOC</td>
<td>mg/kg</td>
<td>IA1</td>
<td>IA1</td>
<td>IA1</td>
<td></td>
</tr>
</tbody>
</table>
HALOSEP PRODUCTS

SALTPRODUCT RECYCLING OR DISCHARGE (OPER. "A"/"B")

• Saltproduct amount is 25-50 % (w/w) of fly ash (in)
• Trace metals in Saltproduct SP2-VF are all below max. Limits for De-Icing agents shown in table 4.4
• Saltquality (DS) is OK according to EUSALT CEN TC337 "Standard for De-Icing agents”

<table>
<thead>
<tr>
<th>Soluble Heavy metals</th>
<th>Max Limit mg/kg DS</th>
<th>Saltproduct SP2-VF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>50</td>
<td>0,03</td>
</tr>
<tr>
<td>As</td>
<td>2,5</td>
<td>0,01-0,05</td>
</tr>
<tr>
<td>Cd</td>
<td>2</td>
<td>0,03-0,9</td>
</tr>
<tr>
<td>Cr</td>
<td>5</td>
<td>0,02-0,03</td>
</tr>
<tr>
<td>Cu</td>
<td>5</td>
<td>&lt; 0,01</td>
</tr>
<tr>
<td>Hg</td>
<td>0,5</td>
<td>&lt; 0,01</td>
</tr>
<tr>
<td>Ni</td>
<td>5</td>
<td>&lt; 0,01</td>
</tr>
<tr>
<td>Pb</td>
<td>5</td>
<td>0,01</td>
</tr>
<tr>
<td>Zn</td>
<td>20</td>
<td>0,1-0,3</td>
</tr>
<tr>
<td>Co</td>
<td>2</td>
<td>0,02</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>100</td>
<td>&lt; 20 (DOC)</td>
</tr>
<tr>
<td>Sulfate Type 1</td>
<td>Max. 1,5%</td>
<td>0,5-1% (w/w)*</td>
</tr>
</tbody>
</table>
HALOSEP PRODUCTS

METAL PRODUCT (HMP)

- Amount approx. 3% (w/w) of fly ash (in)
- Zinc content 37-45 % (w/w)
  - Lead content 0,4-3,0% (w/w)
  - Cadmium content 0,3-1,0 % (w/w)
  - Other Mg, Ca, Si, Cl, S, Al
- To Zinc recycling
AGENDA

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3. Halosep full scale plant (LIFE Project at Vestforbrænding)
LIFE HALOSEP

- **PROJECT PURPOSE**
  “To successfully demonstrate how two waste streams from incineration plants, fly ash and flue gas waste scrubber liquid, can be co-treated leading to a reduction of waste (DS) going to landfills by approximately 40–60%”

- **PROJECT INFORMATION**
  Project start: 01/07/2016
  Expected end date: 31/12/2020

- **COORDINATING BENEFICIARY**
  Stena Recycling Int. AB, Sweden

- **ASSOCIATED BENEFICIARIES**
  Stena Recycling A/S, Denmark
  I/S Vestforbrænding, Denmark

- **PROJECT BUDGET & FINANCING**
  Total project budget: 5.4 million EURO
  Total eligible budget: 3.8 million EURO
  EU (LIFE) support: 2.3 million EURO
HALOSEP FULL SCALE PLANT (DENMARK)

LIFE HALOSEP - EXPECTED RESULTS

• Built an approx. 13,000 ton/yr Halosep plant in an existing Fluegas cleaning building at VF
• Integrate the Halosep plant with the existing Flue Gas cleaning plant and the existing WWTP
• Total costs for treatment of fly ash (incl scrubber liquid) to be reduced by approx. 20%
• Chemicals consumption to be reduced by > 80%
• Treated Fly ash amount (DS) is 60-62% of Fly ash input, ie. the reduction in DS will be 38-40%
• Metal product (HMP) will be upgraded to about 45% zinc content. The zinc yield will be optimized during the Halosep test period.

• Show that the salt product can be recycled as a brine with about 10% salt content. It will be evaluated during the test period if up to 2,000 tons salt can be used as roadsalt during the winter period
• Treatment of Fly ash from other WtE plants will be tested during the test period.
• Use of the treated Fly ash (X-RGA) as an additive in concrete, cement or as construction material will be tested and evaluated during the test period.
THANK YOU FOR YOUR ATTENTION

CONTACT INFORMATION:

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