Recycling potentials of MSWI Bottom Ash

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EU long term ambition: legal framework

Increase **energy recovery efficiency**

- Min. energy efficiency of MSWI required to become R1 installation
- Increase **recycling** rates of **materials**
- Introducing concept of “end of waste”
- Developing EoW criteria

=> modern “RECYCLING SOCIETY”
## Bottom ash: amounts produced in EU

<table>
<thead>
<tr>
<th>Country</th>
<th>Incinerated waste [million tonnes]</th>
<th>Bottom Ash [million tonnes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium (2010)</td>
<td>3.03</td>
<td>0.51</td>
</tr>
<tr>
<td>Czech Republic (2010)</td>
<td>0.51</td>
<td>0.16</td>
</tr>
<tr>
<td>Denmark (2008)</td>
<td>3.59</td>
<td>0.63</td>
</tr>
<tr>
<td>Finland (2009)</td>
<td>0.27</td>
<td>0.05</td>
</tr>
<tr>
<td>France (2008)</td>
<td>11.60</td>
<td>2.7</td>
</tr>
<tr>
<td>Germany (2010)</td>
<td>20.04</td>
<td>5.00</td>
</tr>
<tr>
<td>Hungary (2008)</td>
<td>0.40</td>
<td>0.09</td>
</tr>
<tr>
<td>Italy (2010)</td>
<td>4.71</td>
<td>1.27</td>
</tr>
<tr>
<td>Netherlands (2011)</td>
<td>7.2</td>
<td>1.6</td>
</tr>
<tr>
<td>Norway (2010)</td>
<td>1.35</td>
<td>0.25</td>
</tr>
<tr>
<td>Portugal (2011)</td>
<td>1.13</td>
<td>0.21</td>
</tr>
<tr>
<td>Spain (2011)</td>
<td>2.42</td>
<td>0.42</td>
</tr>
<tr>
<td>Sweden (2009)</td>
<td>4.50</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Source: Amounts of bottom ash produced in Europe, CEWEP Country Reports 2010 and 2012
# Bottom ash: recovery examples (1/2)

<table>
<thead>
<tr>
<th>Country</th>
<th>Use as a secondary construction material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>No intention to reuse except as landfill structure material</td>
</tr>
<tr>
<td>Belgium</td>
<td>Use of granulates in road construction, concrete products</td>
</tr>
<tr>
<td>Denmark</td>
<td>Road subbase and embankments, Filler for marine structures (dams, ports), Construction material for parking and small building foundations</td>
</tr>
<tr>
<td>France</td>
<td>80% of bottom ash recovered in road construction</td>
</tr>
<tr>
<td>Germany</td>
<td>Road subbase construction, recovery on landfills (roads, shaping) or storage in salt mines</td>
</tr>
<tr>
<td>Italy</td>
<td>Recovery in cement kilns, road construction, landfill construction</td>
</tr>
</tbody>
</table>
# Bottom ash: recovery examples (2/2)

<table>
<thead>
<tr>
<th>Country</th>
<th>Use as a secondary construction material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>Road subbase and embankments, Noise barriers, Foundation material, Concrete products, Landfill prohibited</td>
</tr>
<tr>
<td>Portugal</td>
<td>Road construction, recovery on landfill sites (as construction layers)</td>
</tr>
<tr>
<td>Spain</td>
<td>Road construction, recovery on landfill sites (as construction layers)</td>
</tr>
<tr>
<td>Sweden</td>
<td>Reuse as landfill covering material</td>
</tr>
<tr>
<td>UK</td>
<td>55% reused as road material in 2011</td>
</tr>
</tbody>
</table>
# Bottom ash: regional legislation for recycling

## Comparison of leaching criteria

<table>
<thead>
<tr>
<th>Element</th>
<th>Belgium Flanders (coming soon)</th>
<th>The Netherlands</th>
<th>France (EN 12457-2 mg/kg d.s.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shaped applications</td>
<td>Non-shaped applications</td>
<td>Shaped applications</td>
</tr>
<tr>
<td></td>
<td>NEN 7345 (mg/m²)</td>
<td>NEN 7345 (mg/kg d.s.)</td>
<td>NEN 7373 (mg/kg d.s.)</td>
</tr>
<tr>
<td>As</td>
<td>27</td>
<td>0,80</td>
<td>260</td>
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<tr>
<td>Cd</td>
<td>1,1</td>
<td>0,03</td>
<td>3,8</td>
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<tr>
<td>Cr III</td>
<td>55</td>
<td>2,6</td>
<td>120</td>
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<tr>
<td>Cu</td>
<td>25</td>
<td>0,80</td>
<td>98</td>
</tr>
<tr>
<td>Hg</td>
<td>0,80</td>
<td>0,02</td>
<td>1,4</td>
</tr>
<tr>
<td>Pb</td>
<td>60</td>
<td>1,3</td>
<td>400</td>
</tr>
<tr>
<td>Ni</td>
<td>15</td>
<td>0,75</td>
<td>81</td>
</tr>
<tr>
<td>Zn</td>
<td>90</td>
<td>2,8</td>
<td>800</td>
</tr>
<tr>
<td>Sb</td>
<td>8</td>
<td>1</td>
<td>8,7</td>
</tr>
<tr>
<td>Ba</td>
<td>100</td>
<td>20</td>
<td>1.500</td>
</tr>
<tr>
<td>Co</td>
<td>35</td>
<td>0,5</td>
<td>60</td>
</tr>
<tr>
<td>Mo</td>
<td>510</td>
<td>55</td>
<td>144</td>
</tr>
<tr>
<td>Se</td>
<td>2,5</td>
<td>2</td>
<td>4,8</td>
</tr>
<tr>
<td>Sn</td>
<td>10</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>V</td>
<td>25</td>
<td>2,5</td>
<td>3.201</td>
</tr>
<tr>
<td>Br</td>
<td>250</td>
<td>20</td>
<td>6.702</td>
</tr>
<tr>
<td>Cl</td>
<td>20.000</td>
<td>1.000</td>
<td>1.100.002</td>
</tr>
<tr>
<td>F</td>
<td>500</td>
<td>55</td>
<td>25.002</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>7.000</td>
<td>2.200</td>
<td>1.650.002</td>
</tr>
</tbody>
</table>

Governments strive towards high quality
The Netherlands: Highlights of the ‘Green Deal’

Make the ‘IBC’ (Encapsulate, Protect, Control) category obsolete:
• By January 1st, 2017:
  50% of IBA has to find useful application, other than ‘IBC’
• By 2020:
  100% of the IBA finds other applications than ‘IBC’
• (Halfway: evaluation of the economical consequences)

Enhance the recycling of NF metals:
• By January 1st, 2017:
  75% recycling of non-ferrous metals fraction > 6 mm
• Before 2020:
  Set goals for the recycling of non-ferrous metals < 6 mm

➤ Clear regulation leads to technical choices and progress: the market evolves
Growth of useful application of bottom ash

Applied IBA in the Netherlands
Kton/year

[Graph showing the growth of applied IBA in the Netherlands from 1986 to 2015, with a steady increase over the years.]
Clear environmental and civil demands: allows certification: assured quality!

Certification is institutionalized ‘trust’ and refers to regulation: i.e. clarity for customer.
Bottom ash: treatment techniques

How to fulfill the new environmental targets?
Conventional method (used in most of the WtE plants in Europe) bottom ash is removed from the grate by a wet discharge and follows a dry treatment process. In this approach the final goal is to achieve a high quality material that can be used as a secondary construction material in selected applications.

Application of this technology results in a positive business case: the yield of metals (both Fe and NF) makes it worthwhile.
An innovative approach to bottom ash treatment removes the bottom ash from the grate by a wet discharge and follows a wet treatment process. The goal is to further improve the quality of the secondary construction material and recyclability of the metals (proven in Flanders (Belgium), Netherlands, Germany).

+ Washing / fractionating based on wet soil cleaning technology
+ Can remove salts from bottom ash
- Uses water/ needs water
- A sludge (< 63µm) fraction (10 - 15%) has to be landfilled. This contains heavy metals

Application of this technology may render a positive business case: depending of the yield of NF metals
Bottom ash: treatment techniques 3/3

In two WtE plants in Switzerland (KEZO, Hinwill and SATOM, Monthey) bottom ash is removed from the grate by **dry extraction** and can follow a dry treatment process:

- metal separation and metal quality
- higher leaching values for Sb, Br and Pb
- Risk

This technology finds application when the remaining IBA residue (after recovery of the fine metals) has to be landfilled anyway (reuse possibility not yet proven).
How to fulfill the new environmental targets?

► CASE STUDIES:
  • INDAVER
  • HVC (Boskalis)

► Using a wet separation process to:
  • Convert process residues into useful “secondary raw materials”
  • Minimising the need for landfill space
  • Replacing raw ‘primary’ materials
  • Recover metals (fines, precious) as much as possible
Non-Ferrous recycling

Enhancement of recycling of non-ferrous metals (75% of the NF > 6 mm):

- **(Add-on) NF separation techniques**
  e.g. Enhanced Dry Recovery (InAshco) or Steinert, … as an add-on(s) to the classical dry treatment of IBA.
  Subsequently, the gravel fraction can be applied in concrete

- **Improvement of the ballistics of NF particles**
  Washing / fractionating based on wet soil cleaning technology purifies the NF particles
  Subsequently, the washed IBA can be applied as a ‘normal’ building material
Wet treatment of bottom ashes: actual performance

100% IBA (fresh, raw)

1.6% non-ferro 6-50mm
1.4% non-ferro 2-6mm
9% ferrous
2% weak ferrous
39% sand (63 µm – 2 mm)
30% granulate (2 mm – 50 mm)
10% sludge (< 63 µm)
4% Organic fraction
3% Rest fraction

Mass balance 2013/2014 IBA INDAVER
Figures based on dry matter
Wet fractionating & washing

Boskalis Dolman – HVC results

100% IBA (dry pretreated)

Conventional (dry) pretreatment: 7% Fe and 1,8% NF recycled

Mass balance 2013 IBA  HVC
Figures based on dry matter

0,7% non-ferro 40% extra

0,5% ferrous

39,5% sand (63 µm – 3 mm)

48% granulate (3 mm – 20 mm)

12,5% sludge (< 63 µm)
Maximum F+NF recycling.....

Conventional (dry) pretreatment:
7% Fe and 1.8% NF recycled

Intrinsic Value of (precious) metals
Comparison NF vs. IBA (0 - 6 mm)

Conventional (dry) pretreatment
Does not cope with these fines:
Additional pretreatment to remove the sticky sludge fraction is required (washing or ADR) to recycle (part of) this NF fraction
Overview of the analysis

Conventional separation

Intrinsic value of (precious) metals
Comparison value of analyzed fractions

- IBA 2-6: 57%
- IBA 0-2: 34%
- NF 2-6: 3%
- NF 6-20: 6%
Precious metals

Intrinsic value of (precious metals) division by potential value:

- Au: 59%
- Al: 16%
- Fe: 7%
- Cu: 10%
- Zn: 2%
- Pb: 1%
- Ni: 1%
- Sn: 1%
- Ag: 3%
- Cr: 0%
Restrictions: legal

► No harmonization on environmental standards between EU member states:
  • Application allowed or not
    (ranges from ban on landfill <-> ban on application)
  • Leaching conditions (which test method)
  • Parameter set: metals, organics, POP’s, ...
  • Limit values

► Result: uncertainty and, hence, risks are considered too high for entrepreneurs...
Restrictions: market

► Perception on the use of W-t-E granulates still negative

► At the moment low to negative prices for mineral fractions from bottom ash (competition of other secondary materials and/or IBC measures)

► Good market prices for ferrous / non ferrous necessary to keep facility economically feasible
Restrictions: socio - economical

Need for further facilitating role of authorities e.g:
- Act predictable and consistently
- Legislate leaching behavior rather than composition
- ‘Ease’ regulation towards technical achievable targets (but not in the extent that innovation is obsolete)
- Award use of bottom ash in public works

Promote application of bottom ash fractions in balance with the aim of protecting the environment
Concluding remarks

- A change in IBA treatment is imminent, driven by:
  - Environmental pressure on the quality of the mineral fraction (applied as building material)
  - The (intrinsic) value of the metals present in the IBA

- ‘Winning techniques’ make progress on both fronts: metal recycling can (in part) compensate the costs of quality improvement of the mineral fraction.