Increasing the Quantity and Quality of Metals Recovered at Waste-to Energy Facilities

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### Background

**Industry-academia joint research project with objectives to**

1. Increase the quantity of metals recovered from the WTE industry
2. Increase the quality/market value of WTE-metals recovered either at the WTE-site or at regional metal-processing-facilities
3. Develop physical and chemical standards for WTE metal scrap
## Status Quo: Metals in U.S. MSW

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total tons MSW generated in the U.S</td>
<td>236 mill tons/y (EPA, 2003)</td>
<td></td>
</tr>
<tr>
<td>Total ferrous metals generated in MSW (5%)</td>
<td>12.0 mill tons/y</td>
<td>$1.2 billion*</td>
</tr>
<tr>
<td>Total ferrous metals recovered (36%)</td>
<td>4.3 mill tons/y</td>
<td>$430 million*</td>
</tr>
<tr>
<td>Total ferrous metals landfilled (64%)</td>
<td>7.5 mill tons/y</td>
<td>$750 million*</td>
</tr>
<tr>
<td>Total non-ferrous metals generated in MSW (0.7%)***</td>
<td>1.7 mill tons/y</td>
<td>$1.32 billion**</td>
</tr>
<tr>
<td>Total non-ferrous metals recovered (21%)</td>
<td>346,000 tons/y</td>
<td>$277 million**</td>
</tr>
<tr>
<td>Total non-ferrous metals landfilled (79%)</td>
<td>1.3 mill tons/y</td>
<td>$1.04 billion**</td>
</tr>
</tbody>
</table>

* at $100 per ton ($180 per ton for clean iron scrap; ISSB 2005, www.steelonthenet.com)
** at $800 per ton (estimated after survey)
*** mostly alumina; not including free copper, copper as part of a component or lead from batteries; it is assumed, that 50% of the non-ferrous metals in MSW are recovered by recycling
### Status Quo: U.S. Steel consumption

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total steel production in the U.S.</td>
<td>91 mill tons/y</td>
</tr>
<tr>
<td>Total steel imports by the U.S.</td>
<td>30 mill tons/y</td>
</tr>
<tr>
<td>Total steel needs of the U.S.</td>
<td>121 mill tons/y</td>
</tr>
</tbody>
</table>

- **10%** of the U.S. steel production are landfilled every year
- **25%** of the U.S. steel imports are landfilled every year
Ferrous metal recovery by the WTE Industry

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total tons MSW processed by WTEs</td>
<td>28.8 mill tons/y</td>
<td></td>
</tr>
<tr>
<td>Total ferrous metals input (5%)</td>
<td>1.44 mill tons/y</td>
<td>$144 million*</td>
</tr>
<tr>
<td>Total ferrous metals recovered at WTEs per year (49%)</td>
<td>0.70 mill tons/y</td>
<td>$70 million*</td>
</tr>
<tr>
<td>Total ferrous metals landfilled per year (51%)</td>
<td>0.74 mill tons/y</td>
<td>$74 million*</td>
</tr>
</tbody>
</table>

* at $100 per ton ($180 per ton for clean iron scrap; ISSB 2005, www.steelonthenet.com)

Ferrous Metals Recovered from U.S. WTE Plants

- 49% Metal Recovered
- 51% Metal Lost
Non-ferrous metal recovery by the WTE Industry

Total tons MSW processed by WTEs: 28.8 mill tons/y (IWSA, 2004)

Total non-ferrous metals input per year (0.7%) ***: 0.20 mill tons/y $160 million**

Total non-ferrous metals recovered at WTEs per year (<8%): 16,000 tons/y $12.8 million**

Total non-ferrous metals landfilled per year (>92%): 0.18 mill tons/y $147 million**

** at $800 per ton (estimated after survey)
*** mostly alumina; not including free copper, copper as part of a component or lead from batteries; 50% of the non-ferrous metals in MSW are recovered by recycling
Front-end metal recovery at RDF WTEs

Metal recovery at RDF facilities is typically characterized by:
- Shredding and Screening
- Magnetic separation
- Eddy current separation
- Back-end metal recovery

The main fractions are:
- Ferrous metals
- Non-ferrous metals
- RDF
- Non-processables

Advantages:
- Metals, especially aluminum, are less oxidized
- Less ash adherence on the metals
  
  higher Market Value
Metal recovery at mass burn facilities is typically characterized by:

- Ferrous metals recovery from bottom ash by
  a) “Grizzly feeder” and
  b) magnetic separation

The main fractions are:

- Ferrous metals
- Ash
- Oversize fraction

Disadvantages:

- Metals are oxidized or not recoverable, if combustion temperature too high
  lower Market Value
- Ash adherences on the metals
Metal recovery at regional metal recovery facilities is typically characterized by:

- Shredding and Screening
- Magnetic separation,
- Eddy current separation,
- Manual separation (copper, stainless steel)

The main fractions are:

- Ferrous metals,
- Non-ferrous metals, copper, stainless steel
- Ash

Disadvantage:

- Shipping costs

Advantages

- Less ash adherences,
- Regional recovery facility can serve several WTE plants,
- Savings with economies of scale
## Status Quo WTE Industry Summary

<table>
<thead>
<tr>
<th>Description</th>
<th>No.</th>
<th>Processed MSW</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of WTE facilities in the U.S.</td>
<td>89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of RDF plants in the U.S.</td>
<td>15</td>
<td>6.95 mill tons/y</td>
<td>22.6%</td>
</tr>
<tr>
<td>Number of mass burn plants in the U.S. with some metal recovery</td>
<td>58</td>
<td>20.64 mill tons/y</td>
<td>67.0%</td>
</tr>
<tr>
<td>Number of mass burn plants without any metal recovery</td>
<td>16</td>
<td>3.0 mill tons/y</td>
<td>10.4%</td>
</tr>
</tbody>
</table>
Some WTE facilities with very high metal recovery rates – mostly RDF plants

Many mass burn WTEs recover metals but do not have the appropriate equipment to recover metals in high quantities and quality

Some mass burn WTEs cooperate successfully with regional metal recovery facilities and obtain revenues without installing additional equipment

Some mass burn WTEs do not recover metals from the bottom ash and thus pay tipping fees to landfill metals

<table>
<thead>
<tr>
<th>Type of WTE facility</th>
<th>No. of WTE facilities</th>
<th>Total capacity million tons MSW per year</th>
<th>Metal input at 5% of FE of MSW, million tons per year</th>
<th>Percent of total capacity</th>
<th>Metal recovered, million tons per year</th>
<th>Percent of input metal recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDF</td>
<td>15</td>
<td>6.95</td>
<td>0.35</td>
<td>24.1</td>
<td>0.26</td>
<td>75</td>
</tr>
<tr>
<td>Mass burn</td>
<td>60</td>
<td>21.83</td>
<td>1.09</td>
<td>75.9</td>
<td>0.45</td>
<td>41</td>
</tr>
</tbody>
</table>
There is indication that **0.9 mill tons/year** of ferrous and non-ferrous metals are landfilled annually by the U.S. WTE industry with the consequences of:

- **Environmental penalties** (loss of non-renewable resources, unnecessary landfill space) …

- … and the **Economic handicaps** of
  - paying unnecessary tipping fees for landfilling metals **$30 million/year**
  - loss of the potential revenues of **$220 million/year**

* at a national average of $34 per ton (NSWMA’s 2002 Tipping Fee Survey)
Potential to improve the Quantity at the Front-end

- At RDF plants it is not realistic to improve the quantity, as it is already very high.
- For mass burn plants, pre-shredding will improve metal recovery at the back-end

Additional benefits of shredding at the front-end:
- Homogenized MSW (material mix, particle size),
- Increase combustion efficiency,
- Decrease carbon content in the ash
  (<6% C is required as aggregate substitute in concrete),
Experience at RDF plants show that metals remain in the RDF fed and end up in the ash (e.g. SEMASS: 50% of the metals are recovered at front- and back-end).

Three possibilities for mass burn and RDF facilities:

- **In-house** metal recovery (no shipping costs, max. revenue)
- **In-house** metal recovery and collaboration with an regional metal recovery facility (some added value remains for the WTE facility, shipping costs),
- **Outsourcing** of the metal recovery to a regional metal recovery facility (least revenue, highest shipping costs).

**Potential to improve the Quantity at the Back-end**

- **Input 0-45 mm**
- **Drying**
- **Sizing**
- **Magnetic separation**
- **Eddy-current separation**
- **Crushing**
- **Non-ferrous materials**
- **Processed ashes to storage and homogenising**
- **Magnetic materials**
Potential to improve the Quality at the Front-end

- **Front-end metal recovery is preferable** to back-end recovery (pre-combustion scrap is comparable to traditional shredder scrap)
- It is **not realistic** that existing RDF/mass burn WTEs would **install additional equipment** to increase quality at the front-end
- For **new WTE facilities** should be considered to improve quality by:
  - Advanced shredding,
  - Further separation of ferrous, aluminum, copper (!) and stainless steel to **minimize diversions**,  
  - Further **separation of any contamination** like plastics, wood, coatings, etc.
Potential to improve the Quality at the Back-end

- Installation of a **dry ash extracting system** in combination with:
  - **Advanced** in-house ash treatment,
  - **Simple** in-house metal recovery and collaboration with regional metal recovery facility,
  - Outsourcing of the metal recovery to a regional metal recovery facility.

- Advantages:
  - Reduce **ash adherence**, 
  - Reduce **oxidation** of the metals,
  - Simplify **cleaning** of the recovered metals,
  - Increase **market value** of recovered metals
Dry ash extracting system

- Is used at coal fired power plants

Disadvantages

- Installation is realistic only for new WTE facilities

Additional benefits:

- **Save tipping fees** by landfilling dry ash (water content of 30-40% in the ash, that represents landfilling cost of approx. **$72 million/y**)

- **Recover the heat** left in the ash and used for pre-heating additional combustion air
• Recovery rate of ferrous metals only at 49%,
• Recovery rate of non-ferrous metals only at <8%, since many WTE facilities do not recover non-ferrous metals,
• Potential for improving the quantity and quality of the metals recovered from ash, either by additional equipment at WTE facility or by collaboration with regional metal recovery facilities:
  - RDF facilities: further mechanical separation and sorting of different metals to remove contaminations (plastics, paper, wood, coatings)
  - Mass burn facilities (presently not recovering metals): Install grizzly feeder, magnetic separation
  - Mass burn facilities (presently do recover metals): install eddy current separator and equipment to reduce contaminations or collaborate with regional metal recovery facilities
• The costs for installing and operating equipment or shipping to regional metal recovery facilities could be covered by the savings and revenues,
Conclusions (cont.)

- By not improving quantity and quality of the metals recovered:
  - **Environmental penalties** (loss of non-renewable resources, taking up landfill space),
  - **Economic handicaps** for the U.S. WTE industry by paying unnecessary tipping fees for landfilling metals ($30 million/y) and loss of the potential revenues of ($220 million/y),

- There would be **additional benefits** by further **mechanical separation** and exposure to increase quantity and quality of the metals recovered at the **front-end**
  - homogenized MSW (material mix and particle size),
  - higher combustion efficiency,
  - lower carbon content in the ash,

- There would be **additional benefits** by installing **dry ash extracting** equipment
  - **Save the tipping fees** for landfilling water (approx. $72 million/y in the U.S),
  - **Recover the heat** left in the ash to preheat additional combustion air
Ongoing Research

• Check and refine the current data,

• Determine **where the most metals are recovered** at the U.S. WTE facilities. At the **front-end** before combustion or the **back-end** after combustion,

• Determine the feasibility of installing a **dry ash extracting** system,

• Examine estimated **costs** of installing and operating new metal recovery **equipment** at WTE facilities,

• Develop a **sampling protocol** that results in representative samples of recovered metals,

• Define different **grades of WTE scrap** that might improve the **marketability of WTE scrap**, if accepted in the industry
Thank You!