Comparing the Environmental Impacts of Residual Waste Management Options

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IEA Task 36

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IEA Task 36 wanted to examine environmental impacts of treatment options for residual waste. They used an integrated waste management life cycle tool WRATE. A representative set of treatment options was considered, with common elements (e.g. collection) excluded. They also looked at the impact of higher energy and material recovery rates and of electricity mixes.
- Energy from Waste plant exporting electricity
- Energy from Waste plant exporting heat and power
- Mechanical Biological Treatment plant where recyclable materials such as metals are first separated out and the remaining waste is
  - biodried to produce a refuse derived fuels which is burnt in an energy from waste plant
  - sorted into an organic component which is anaerobically digested and a fraction which is burnt in an energy from waste plant
  - sorted into an organic component which is composted and a fraction which is burnt in an energy from waste plant
### Key characteristics for EFW plant

<table>
<thead>
<tr>
<th></th>
<th>Typical efficiency</th>
<th>High efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power only</td>
<td>23.40%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>21% elec</td>
<td>20% elec</td>
</tr>
<tr>
<td></td>
<td>22% heat</td>
<td>70% heat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Typical recovery</th>
<th>Higher recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous metal recovery rate</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Non-ferrous recovery rate</td>
<td>35%</td>
<td>50%</td>
</tr>
</tbody>
</table>

### Key characteristics for MBT plant

<table>
<thead>
<tr>
<th></th>
<th>Typical Recovery rate</th>
<th>Higher Recovery rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous metal recovery rate</td>
<td>82%</td>
<td></td>
</tr>
<tr>
<td>Non-ferrous recovery rate</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>Plastics recovery rate</td>
<td></td>
<td>50%</td>
</tr>
</tbody>
</table>
Composition of Residual Waste

- Organic – Food waste: 25%
- Paper/Card: 18%
- Plastic Film: 8%
- Dense Plastics: 7%
- Textiles: 3%
- Combustibles: 5%
- Glass: 3%
- Organic – Garden waste: 8%
- Fines (<10mm): 8%
- Non-Ferrous metals: 1%
- Ferrous metals: 3%
- Non-Combustibles: 3%
- WEEE: 1%
- Absorbent hygiene products: 5%
- Wood: 2%
- NCV: 8.8 MJ/kg
Energy recovered

%- % of Energy in Waste

- Landfill
- EfW
- MBT biodrying; RDF to EfW
- MBT AD + RDF to EfW
- MBT IVC + RDF to EfW
- All options better than landfill
- EfW better MBT options (because of greater energy recovered)
- Use of CHP improves all options
Breakdown of climate change impacts

[Diagram showing various environmental impacts and recovery methods, including landfill, MBT, EfW, etc., with CO2 equivalent emissions presented in a bar graph.]
Impact of improved efficiency and material recovery

- Landfill
- EfW
- MBT biodrying - RDF to EfW
- MBT AD + RDF to EfW
- MBT IVC + RDF to EfW
- EfW - CHP
- MBT biodrying - RDF to EfW - CHP
- MBT AD + RDF to EfW - CHP
- MBT IVC + RDF to EfW CHP

kt CO2 eq

- Typical energy and material recovery
- Higher energy recovery
- Higher material recovery
When low carbon electricity is displaced (e.g. hydro), benefits of EfW are reduced, unless it is CHP, when it is still ‘preferred’ option.
Acidification

-120
-100
-80
-60
-40
-20
0
20
40
60
80

Landfill EfW MBT
biodrying;
RDF to EfW

MBT AD +
RDF to EfW

MBT IVC +
RDF to EfW

Other processes
Energy recovery (landfill)
Energy recovery (MBT)
Energy recovery (EfW)
Non-Fe metal recycling
Fe metal recycling
MBT process
EfW process
Net impact
Recovering plastics at MBT offers very large reduction in acidification benefits
Acidification and electricity mix

With ‘cleaner’ electricity mixes, EfW performs has worse acidification impact than other options
Eutrophication

The diagram illustrates the net impact of various processes related to waste management, including landfills, MBT (mechanical biological treatment), and EfW (energy from waste) processes. The y-axis represents the t PO4 eq (tonnes of phosphorus equivalent) on a scale ranging from -20 to 40. The chart shows different emissions and energy recovery impacts for each process, categorized by color codes:

- Magenta: Other emissions
- Light blue: Energy recovery (landfill)
- Light green: Energy recovery (MBT)
- Blue: Energy recovery (EfW)
- Red: Non-Fe metal recycling
- Green: Fe metal recycling
- Yellow: Landfill
- Purple: MBT process
- Pink: EfW process
- Red and blue: Net impact

The net impact is indicated by the diamond shape at the top of each column, with positive values indicating a net gain and negative values indicating a net loss in terms of t PO4 eq.
As landfilling contributes significantly to impact, extra energy and materials recovery make relatively little difference.
EfW has least impact regardless of electricity mix
How important are other impacts

Resource depletion and aquatic toxicity also important.
How do options compare (electricity only EfW)

<table>
<thead>
<tr>
<th>Option</th>
<th>Global warming</th>
<th>Aquatic toxicity</th>
<th>Acidification</th>
<th>Human toxicity</th>
<th>Eutrophication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill</td>
<td>-4000</td>
<td>-2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MBT AD + RDF to EfW</td>
<td>-2000</td>
<td>0</td>
<td>-4000</td>
<td>-4000</td>
<td>-2000</td>
</tr>
<tr>
<td>MBT IVC + RDF to EfW</td>
<td>-4000</td>
<td>0</td>
<td>-2000</td>
<td>0</td>
<td>-2000</td>
</tr>
<tr>
<td>MBT biodrying - RDF to EfW</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(AEA Logo)
Conclusions

- No unique hierarchy: depends on
  - electricity mix
  - level of materials and energy recovery
  - ‘ranking’ of environmental impacts

- If reducing global warming is of key importance then:
  - EfW offers significant benefits if coal or coal/gas is displaced
  - If can utilise heat and have EfW – CHP plant then there are also benefits even if electricity mix is gas based
  - Where electricity from the EfW plant would displace a very low carbon electricity mix, other MBT technologies where less waste is combusted may have a lower net climate change impact.