technical-economic evaluation of an advanced MBT process to enrich biomass as renewable fuel
The MARSS Project

- Demonstration Project
- Biomass fuel from dried MMSW (MBT output)
Background of the MARSS project

• Municipal Solid Waste (MSW) contains >50% bio waste

• EU Landfill Directive
  – Avoidance of Biodegradable Municipal Waste from being landfilled by at least 65% in comparison to the production of BMW in 1995

• Mechanical Biological Treatment is one option to fulfill the EU demand
  – In many EU countries MBT plants are the basic technology for the MSW treatment prior to landfilling
Europe: waste treatment in 2012

Reference: Eurostat 2014
Aim of the MARSS project

• Enhance the efficiency of MBT by connected post-treatment module

• The MARSS module has been designed to separate an Refined Renewable Biomass Fuel (RRBF) from biological dried MSW with
  – High calorific value
  – High purity
  – High mass recovery
Data collection and parametrization

• Example: Losses by air sifting due to water content

![Graph showing mass distribution and water content relationship]

- biowaste content light fraction
- biowaste content heavy fraction
- recovery biowaste
- mass recovery light fraction
Demonstration plant ➔ MARSS module

- Data collection and process parameterisation
- Extrapolating MARSS module (industrial size)
Enrichment of biomass by screening

- Raw MMSW 100%
  - MBT
    - Drum screen
      - <40 mm: 47%
      - >40 mm: 18%
    - Water: 35%
  - >40 mm: 18%
  - MBT
  - Mixed: 19%
  - Fossil: 17%
  - Inert: 25%
  - Biogenic: 39%
Plant mass flow

- MSW 100%
- MBT
- Water 35%
- Coarse 18%
- Fossil 2%
- Ash 17%
- Biomass fuel 28%

Fuel test 3
Output streams

- **dried MMSW**
  - Biogenic: 53%
  - Fossil: 12%
  - Inert: 24%
  - Mixed: 11%

- **RRBF**
  - Biogenic: 91%
  - Fossil: 7%

*Fuel test 3*
Results

• Biomass fuel recovery ≈ 28% of the MSW input
• Biogenic material recovery ≈ 70-75% of the dried input
• Net calorific value 11.000 ± 1000 kJ/kg
• Ash content ≈ 27% ± 5
• Fossil content ≈ 6-9 %
• Feasible for industrial combustion using fluidized bed technology
Economic results

- A combination of RRBF sorting and metal sorting is increasing the economical efficiency of the additional treatment step
- Specific treatment costs $\approx 24-25$ €/t
- The total economic opportunities of MARSS depends on
  1) the local landfill costs and
  2) the local market demand for renewable energy

<table>
<thead>
<tr>
<th>fraction</th>
<th>costs / revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>RRBF</td>
<td>0 - 20 €/Mg</td>
</tr>
<tr>
<td>NF-Metals</td>
<td>-570 €/Mg</td>
</tr>
<tr>
<td>Fe-Metals</td>
<td>-80 €/Mg</td>
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<tr>
<td>RDF (only if costs landfill &gt; RDF)</td>
<td>70 €/Mg</td>
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</table>

<table>
<thead>
<tr>
<th>examples of landfill costs</th>
<th>fees</th>
<th>taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0 €/Mg</td>
<td>20 - 40 €/Mg</td>
</tr>
<tr>
<td>Greece</td>
<td>0 - 48,50 €/Mg</td>
<td>40 €/Mg</td>
</tr>
<tr>
<td>United Kingdom (UK)</td>
<td>4 - 29 €/Mg</td>
<td>3 - 97 €/Mg</td>
</tr>
<tr>
<td>Italy</td>
<td>1 - 10 €/Mg</td>
<td>79 - 94 €/Mg</td>
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</tbody>
</table>
Economic results

UK (high landfill tax and fees)

- Total costs (without MARSS)
- Total costs (with MARSS)

France

- Total costs (without MARSS)
- Total costs (with MARSS)
Thank you for your attention!

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References

backup slides
Composition of MSW

- Residuals: 12%
- Metals: 13%
- High calorific: 57%
- Fossils: 52%
- Biowaste: 0%

(MSW) (separate bio waste collection)
Analysis of the input material 0-40mm

- Biowaste
- Paper
- Wood
- Textile
- Sanitary Paper
- Compound
- Residue
- Plastic 3D
- Plastic 2D
- 8-10 mm
- 6-8 mm
- 4-6 mm
- 2-4 mm
- 1-2 mm
- < 1 mm

- organic dry substance
- inert substance
- water
- net calorific value incl. water
- net calorific value, dry substance
RESULTS

Particle Size Distribution

Screening Throughput Share of Mass

Mesh Size [mm]

0 5 10 15 20 25 30 35 40

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

~ 50 %
Absolute Net Energy Content (incl. Water)

- Fossil Carbon
- Mixed Carbon
- Biogenic Carbon

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<tr>
<th>[mm]</th>
<th>Share of Energy</th>
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<tr>
<td>&lt;10</td>
<td>45%</td>
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<tr>
<td>10-20</td>
<td>15%</td>
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<tr>
<td>20-30</td>
<td>15%</td>
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<tr>
<td>30-40</td>
<td>5%</td>
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<tr>
<td>&gt;40</td>
<td>5%</td>
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</table>
Air Sifter

- Flap valve 1
- Exhaust air
- Flap valve 2
- Incoming air
- Exhauster
- Blower
- Added baffle
- Heavy fraction
- Cyclone
- Filter
- Dust
- Recirculation air
- Incoming air
- Light fraction
Results of air sifter tests

Mass recovery:
- RRBF: 37% to 64%
- Heavy F.: 63% to 36%

Air velocity:
- 7.5 m/s: 52% to 64%
- 8.7 m/s: 48% to 64%
- 10 m/s: 48% to 36%

Legend:
- Organic dry substance
- Water
- Net calorific value, dry substance
- Ash / inert substance
- Net calorific value incl. water

Values for organic dry substance, inert substance, and water are not provided in the image.
Influence of water content on screening
Influence of water content on screening

- Mass recovery screen underflow
- Screening capacity $\eta$

<table>
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<tr>
<th>Water Content (%)</th>
<th>Mass Recovery Screen Underflow (%)</th>
<th>Screening Capacity $\eta$ (%)</th>
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<tbody>
<tr>
<td>0%</td>
<td>64%</td>
<td>93%</td>
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<tr>
<td>5%</td>
<td>59%</td>
<td>90%</td>
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<tr>
<td>10%</td>
<td>55%</td>
<td>90%</td>
</tr>
<tr>
<td>15%</td>
<td>58%</td>
<td>83%</td>
</tr>
<tr>
<td>20%</td>
<td>61%</td>
<td>87%</td>
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<tr>
<td>25%</td>
<td>58%</td>
<td>86%</td>
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<tr>
<td>30%</td>
<td>58%</td>
<td>81%</td>
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<tr>
<td>35%</td>
<td>55%</td>
<td>62%</td>
</tr>
<tr>
<td>40%</td>
<td>31%</td>
<td>62%</td>
</tr>
<tr>
<td>50%</td>
<td>7%</td>
<td>62%</td>
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# Proximate and ultimate analysis of RRBF

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<th>Original matter</th>
<th>Dry matter</th>
<th>Dry ash-free matter</th>
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<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
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<tr>
<td>Water [%]</td>
<td>13.2</td>
<td>14.99</td>
<td>24.5</td>
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<tr>
<td>Ash [%]</td>
<td>23.3</td>
<td>31.88</td>
<td>21.74</td>
</tr>
<tr>
<td>C [%]</td>
<td>33.18</td>
<td>29.58</td>
<td>29.07</td>
</tr>
<tr>
<td>H [%]</td>
<td>5.55</td>
<td>5.58</td>
<td>5.89</td>
</tr>
<tr>
<td>N [%]</td>
<td>1.56</td>
<td>1.19</td>
<td>1.43</td>
</tr>
<tr>
<td>O [%]</td>
<td>35.23</td>
<td>29.39</td>
<td>41.86</td>
</tr>
<tr>
<td>S [%]</td>
<td>0.38</td>
<td>0.48</td>
<td>0.3</td>
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<tr>
<td>Cl [%]</td>
<td>0.8</td>
<td>0.71</td>
<td>0.91</td>
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<tr>
<td>Na [ppm]</td>
<td>6,290</td>
<td>5,326</td>
<td>5,616</td>
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<tr>
<td>K [ppm]</td>
<td>864</td>
<td>5,728</td>
<td>4,938</td>
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<td>P [ppm]</td>
<td>2,150</td>
<td>1,471</td>
<td>2,103</td>
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<td>LHV [MJ/kg]</td>
<td>12.88</td>
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