LCA of Burning Different Solid Biomass Substrates

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Introduction

- LCI’s for direct combustion of biomass substrates
- Environmental impacts of direct combustion
- Quantify emissions and impacts
- Comparison biomass substrates to wooden and fossil fuels
- Influence of the substrates and combustion technology
Preliminary Study

- Potential Substrates:
  - About 40 substrates
  - Kernels, Shells, Pomaces and other wastes
  - Mainly by-products and wastes
- Selected: Olive pomace, coffee grounds, poultry litter, horse dung and pig slurry
- Based on data availability
Life cycle inventory analysis

- New LCI for combustion of different solid biomass substrates
- Processes included:
  - substrate preparation
  - biomass combustion
  - ash disposal
- Cut-Off approach for substrates
System overview olive pomace

Olive pomace

Olive Pomace

System Boundary

Drying

Dried Olive Pomace

Combustion

Emissions

Ash

Ash disposal

Emissions

Heat

Heat
System overview pellets

Coffee grounds

Poultry litter

System Boundary

Coffee Grounds
Poultry Litter

Pellet production

Pellets

Combustion

Ash disposal

Emissions

Emissions

Heat
System overview dung and slurry

Horse dung

Pig slurry

Mixing with Wood Chips

Dung / Slurry Mixture

Combustion

Ash disposal

Heat

Emissions

Emissions

Wood Chips

System Boundary

Horse Dung / Pig Slurry

Horse dung

Pig slurry
Disposal routes for the ash

- Sanitary Landfill: 25%
- MSWI: 50%
- Landfarming: 25%

Ash disposal for biomass substrates modeled like for wood according to ecoinvent
Flue gas treatment

Cyclone

Electrostatic filter
## Combustion technology

<table>
<thead>
<tr>
<th>General description</th>
<th>Device</th>
<th>Cyclone</th>
<th>Electrostatic filter</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olive pomace</td>
<td>tubular reactor</td>
<td>no</td>
<td>no</td>
<td>experiment in lab</td>
</tr>
<tr>
<td>Coffee ground pellets</td>
<td>automatic furnace</td>
<td>no</td>
<td>no</td>
<td>wood combustion</td>
</tr>
<tr>
<td>Poultry litter pellets</td>
<td>grate furnace</td>
<td>yes</td>
<td>no</td>
<td>pilot plant</td>
</tr>
<tr>
<td>Horse dung and wood chips</td>
<td>grate furnace</td>
<td>yes</td>
<td>yes</td>
<td>wood combustion, filters did not work</td>
</tr>
<tr>
<td>Slurry solids and bark chips</td>
<td>boiler furnace</td>
<td>no</td>
<td>no</td>
<td>wood combustion</td>
</tr>
</tbody>
</table>

- combustion technology and flue gas treatment with improvement potentials
### Elemental composition

<table>
<thead>
<tr>
<th>Elemental composition</th>
<th>Olive pomace</th>
<th>Coffee ground pellets</th>
<th>Poultry litter pellets</th>
<th>Horse dung &amp; wood chips</th>
<th>Pig slurry solids &amp; bark chips</th>
<th>Wood, Logs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit</strong></td>
<td>kg/kg fuel, dry</td>
<td>kg/kg fuel, dry</td>
<td>kg/kg fuel, dry</td>
<td>kg/kg fuel, dry</td>
<td>kg/kg fuel, dry</td>
<td>kg/kg fuel, dry</td>
</tr>
<tr>
<td><strong>Carbon C</strong></td>
<td>47.00%</td>
<td>51.20%</td>
<td>40.00%</td>
<td>48.00%</td>
<td>46.50%</td>
<td>49.80%</td>
</tr>
<tr>
<td><strong>Hydrogen H</strong></td>
<td>5.70%</td>
<td>5.50%</td>
<td>6.50%</td>
<td>5.50%</td>
<td>5.50%</td>
<td>6.00%</td>
</tr>
<tr>
<td><strong>Oxygen O</strong></td>
<td>38.40%</td>
<td>40.40%</td>
<td>35.50%</td>
<td>37.30%</td>
<td>35.00%</td>
<td>44.00%</td>
</tr>
<tr>
<td><strong>Nitrogen N</strong></td>
<td>1.10%</td>
<td>0.00%</td>
<td>3.83%</td>
<td>0.18%</td>
<td>2.20%</td>
<td>0.08%</td>
</tr>
<tr>
<td><strong>Sulphur S</strong></td>
<td>0.10%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.03%</td>
<td>0.43%</td>
<td>0.01%</td>
</tr>
<tr>
<td><strong>Ash content</strong></td>
<td>7.70%</td>
<td>2.90%</td>
<td>14.20%</td>
<td>9.00%</td>
<td>10.40%</td>
<td>0.10%</td>
</tr>
<tr>
<td><strong>Total dry mass</strong></td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Moisture content</strong></td>
<td>14.00%</td>
<td>14.60%</td>
<td>15.00%</td>
<td>45.00%</td>
<td>61.00%</td>
<td>14.00%</td>
</tr>
</tbody>
</table>

- **Biomass substrates have a higher nitrogen, sulphur and ash content**
- **Manure mixtures are extremely wet fuels**
Life cycle impact assessment

- Functional unit: Provision of 1 MJ of useful heat
- Indicators: Ecological Scarcity 2006 and IPCC GWP
- Main contributors: ecological scarcity and GWP
- Heavy metal emissions into soil
High emission during combustion lead to higher total impacts than for conventional fuels.
Particle, NO$_x$, and Benzene emissions cause more than 50% of the environmental impacts in case of the biomass substrates.
Fossil fuels cause higher GWP than wood and biomass.
Results: Soil emissions

Biomass substrates tend cause higher heavy metal emissions than wood but the emissions are still comparable.
Conclusions 1

- Biomass substrates cause higher impacts compared to wooden and fossil fuels according to ecological scarcity 2006
- Biomass substrates cause lower greenhouse gas emission compared to fossil fuels according to IPCC GWP
- Trade-off between GWP and overall environmental impacts
Conclusions 2

- Particulate matter emissions cause the highest share of the impacts according to ecological scarcity.
- High uncertainty because lacking data regarding particle distribution for biomass substrates.
- Some of the biomass substrates cause higher heavy metal emissions than wooden fuels but for most of the substrates the heavy metal emissions are equal or lower compared to wooden fuels.
Conclusions 3

- No recommendation can be made regarding the furnace type
- Data mainly for pilot plants without flue gas treatment
- High potential to reduce particle emissions with basic flue gas treatment
Conclusions

Flue gas treatment is essential to minimize particle emissions during biomass combustion.

The use of biomass substrates can reduce greenhouse gas emissions, at the cost of increased particulate matter emissions.
Thanks for your attention!

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Download the study and electronic data: http://www.lc-inventories.ch/

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Additional Slides
Results: Coffee grounds

Direct combustion vs MSWI

- Combustion of coffee grounds in MSWI causes lower impacts
Results: Scenarios for Ash Disposal

Ecological Scarcity 2006
Results: Scenarios fuel preparation

Ecological Scarcity 2006 and IPCC GWP

Graphs showing UBP per MJ of heat and IPCC GWP in kg CO2-eq per MJ of heat for regional storage and on site storage with coffee ground pellets and poultry litter pellets.
Substrates considered in this study (1)

Olive pomace  Coffee grounds  Poultry Litter pellets
Substrates considered in this study (2)

Horse dung and wood chips    Slurry solids and wood chips