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1. The Pyrofab technology

Pyrolysis is the thermal conversion of biomass or wastes in the absence of air or oxygen.

Products are:
- Pyrolysis liquid
- Char
- Gas
1. The Pyrofab technology

- Intermediate pyrolysis in an auger screw reactor, Pyroformer™
- Condensing system: quenching column and wet electrostatic precipitator
- Feedstocks with high ash content can be processed in the Pyroformer™
- Products yield depends mainly on the feedstock

![Diagram showing the Pyrofab technology process]

- Feedstock → Pyrolysis process → Vapours → Condensation process → Biochar
- Pyrolysis liquid → Gas (Gas: CO, CO₂, H₂, N₂, hydrocarbons)
Feedstock (waste materials) → Products from intermediate pyrolysis

Moisture
Volatile matter
Fixed carbon
Ash content

Energy

Gas
Pyrolysis liquid
Char

Aqueous
Organic
The pyrolysis liquid usually comprises an organic and an aqueous phase.
2. Utilisation of the products

- **The char** can be used as a soil improver, as fertiliser or as a solid fuel.

- **The aqueous phase** can be used in an anaerobic digester.

- **The organic phase** can be used for combined heat and power generation.
2. Utilisation of the products
2. Utilisation of the products

Agronomic studies of biochar on tomatoes and bananas.

Anaerobic digestion studies of the aqueous phase
3. The Pyroformer™ reactor within the Pyrofab

- **Materials.** Material in the form of pellets: diameter 5-8 mm, length 10 - 30 mm. Maximum plastic content, 10 %. Moisture, 30 %.
- **Feeding rate.** 3 - 20 kg/h
- **Maximum temperature.** Reactor, 500 C. Vapours, 400 C.
- **Char recirculation.** Outer screw recirculates material into inner screw.
3. The Pyroformer™ reactor within the Pyrofab

Outer and inner screws
### Transparent reactor to study material flow in the Pyroformer™

<table>
<thead>
<tr>
<th>Pre-steady state</th>
<th>Steady state</th>
</tr>
</thead>
</table>

#### Pre-steady state

The fill and distribution change during this state.

#### Steady state

The fill and distribution are constant during this state.

**Note:** The volume of outer and inner screw fill depend on the feeding rate and screw speeds.
4. Pyrolysis tests

<table>
<thead>
<tr>
<th>BioenNW project partner</th>
<th>Feedstock tested (and acronym)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden - Belgium</td>
<td>Forestry residues (FRBT)</td>
</tr>
<tr>
<td>France</td>
<td>Digestate from chicken litter and sawdust (DCLS)</td>
</tr>
<tr>
<td>Germany</td>
<td>Digestate from energy crops containing some slurry and manure (DSM)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Pig manure (PM)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Digestate from arable crops (corn and green rye) (DAC)</td>
</tr>
</tbody>
</table>
4.1. Pyrolysis products

Forest residues  Digest. energy crops  Pig manure  Digest. chiken litter
4.2. Properties of products

Averaged properties for the organic phase and the char

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Organic phase</th>
<th>Char</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High heating value</td>
<td>Viscosity</td>
</tr>
<tr>
<td></td>
<td>(MJ/kg)</td>
<td>(cP)</td>
</tr>
<tr>
<td>FRBT</td>
<td>28.5</td>
<td>51.11</td>
</tr>
<tr>
<td>DSM</td>
<td>25.8</td>
<td>120.59</td>
</tr>
<tr>
<td>PM</td>
<td>23.7</td>
<td>299.46</td>
</tr>
</tbody>
</table>
## 4.3. Further tests

<table>
<thead>
<tr>
<th>Project partner</th>
<th>Tests on site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feedstock</td>
</tr>
<tr>
<td><strong>Sweden - Belgium</strong></td>
<td>Forestry Residues</td>
</tr>
<tr>
<td><strong>France</strong></td>
<td>Food waste from restaurants around Les Mureaux</td>
</tr>
<tr>
<td><strong>Germany</strong></td>
<td>Digestate (mainly maize silage)</td>
</tr>
<tr>
<td><strong>Netherlands</strong></td>
<td>Pig manure</td>
</tr>
</tbody>
</table>
5. Future developments

- Testing more mixtures in diesel engines.
- Testing different quenching liquids in the condensing system.
- Use of the biochar or gas to heat the reactor.
- Testing different feedstocks, without the need of being pelletised.
- More agronomic studies of the char.
- New applications for the aqueous phase.
Thank you

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Questions?
Comments?