Biomass Steam Processing (BSP)

Conversion of Biomass to Coal by Steam Conditioning

Dr. George Francis
Presented by Thomas Hoffmann - BORDA
Live Energies: Mission and philosophy

Play a constructive role in the bio-economy by:
- Generating „new“ industrial and bio-energy feedstocks
- Non-conventional activity areas
- Production from wasteland or underutilized land
- Use of by-products as resources

Multicultural projects:
- Conception
- Financing
- Consortium building
- Management of Implementation
World-wide project experiences

- Biomass production from wasteland in Asia and Africa

- Expertise in evaluation and research in energy crops
  - Jatropha, Cassava, Opuntia, Euphorbia tirucalli
  - Product and by-product use strategies

- Wastes as a source of carbon enriched products
  - Biomass Steam Processing
Biocoal from organic wastes – BSP project

- **Partners:**
  - EnBW Energie Baden-Würrtemberg AG, Germany (EnBW)
  - Karlsruhe Institute of Technology, Germany (KIT)
  - Live Energies GmbH, Germany (LE)

- The BSP process was invented at KIT (Prof. H. Bockhorn/J. Steinbrueck) in a joint research project with EnBW. The process has been awarded a EU patent in 2016.

- LE has been contracted by EnBW to establish a demonstration BSP plant.

- The following slides show details on the relevance of BSP:
  - Bio-waste and issues
  - Biomass Steam Processing
  - Project
Bio-waste suitable for BSP

- Organic waste, mainly of vegetable origin
- Sources:
  - households, restaurants, markets, agriculture, food industries...
Bio-waste generation in India

**Delhi**
- Population: ca. 10.3 Mio.
- Bio-waste: 1.18 Mio t/a

**Mumbai**
- Population: ca. 12.0 Mio.
- Bio-waste: 1.21 Mio t/a

**Bangalore**
- Population: ca. 4.3 Mio.
- Bio-waste: 0.32 Mio t/a

**Kolkata**
- Population: ca. 4.6 Mio.
- Bio-waste: 0.49 Mio t/a

**Chennai**
- Population: ca. 4.3 Mio.
- Bio-waste: 0.46 Mio t/a

**India**
- Population: ca. 1.2 Mrd.
- Bio-waste: ca. 109 Mio t/a

Source:
- d-maps.com
- atlas.d-waste.com
- CPCB, India
Challenges

- Huge and increasing urban bio-waste and sewage generation
- Disposal currently in empty lands in urban suburbs
- Problems:
  - lack of space
  - health risks, environmental issues, bad odour
Biomass Steam Processing

product:
- coal character ↑
- carbon fraction/-density ↑
- heating value ↑
- biological activity ↓
- homogenous, odorless, hydrophobic

advantages:
- transport costs ↓
- storability ↑
- range of applications ↑
  - incineration, gasification
  - activated carbon
  - fertilizer
  - \(\text{CO}_2\)-sink

superheated steam
250 – 400 °C
atmospheric pressure
15 – 120 min

06.03.2017
BSP – process development

- Plant development from laboratory scale to pilot scale at KIT

- Lab reactor
  up to 5 g
  Batch - Discontinuous

- Small pilot reactor
  up to 500 g/h
  Semi - continuous

- Pilot plant
  up to 50 kg/h
  Continuous
BSP can handle varied biomass

- Wide range of biomass inputs tested
- BSP imitates natural coalification but $3.5 \times 10^{11}$ times faster

<table>
<thead>
<tr>
<th>sample</th>
<th>temperature °C</th>
<th>$\text{HHV}_{\text{DM}}$ [MJ/kg]</th>
<th>CR [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>wood pellets</td>
<td>300</td>
<td>22.04</td>
<td>72.9</td>
</tr>
<tr>
<td>wood pellets</td>
<td>350</td>
<td>28.60</td>
<td>40.8</td>
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<tr>
<td>straw</td>
<td>300</td>
<td>21.45</td>
<td>47.9</td>
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<tr>
<td>straw</td>
<td>350</td>
<td>21.15</td>
<td>40.2</td>
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<tr>
<td>leaves</td>
<td>300</td>
<td>19.76</td>
<td>66.4</td>
</tr>
<tr>
<td>leaves</td>
<td>350</td>
<td>21.01</td>
<td>56.5</td>
</tr>
<tr>
<td>orange peels</td>
<td>300</td>
<td>24.24</td>
<td>56.3</td>
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<tr>
<td>bio-waste</td>
<td>325</td>
<td>25.79</td>
<td>53.1</td>
</tr>
</tbody>
</table>
BSP pilot plant tested with sewage – bio-waste mixtures

- Successful drying of the input and increase in HHV obtained

<table>
<thead>
<tr>
<th>sample</th>
<th>dm [%]</th>
<th>HHV (as is) [MJ/kg]</th>
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</thead>
<tbody>
<tr>
<td>sewage sludge</td>
<td>25</td>
<td>3.0</td>
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<tr>
<td>wood pellets</td>
<td>95</td>
<td>16.9</td>
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<tr>
<td>bio waste</td>
<td>10</td>
<td>2.2</td>
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<tr>
<td>coal_{sludge+pellets}</td>
<td>98</td>
<td>20.7</td>
</tr>
<tr>
<td>coal_{sludge+bio waste}</td>
<td>98</td>
<td>14.4</td>
</tr>
</tbody>
</table>
BSP combines pyrolysis and HTC

<table>
<thead>
<tr>
<th>Medium</th>
<th>Slow Pyrolysis (SP)</th>
<th>Biomass Steam Processing (BSP)</th>
<th>Hydrothermal Carbonisation (HTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>300 – 500 °C</td>
<td>250 – 350 °C</td>
<td>180 – 250 °C</td>
</tr>
<tr>
<td>Reaction time</td>
<td>long (t &gt; 8 h)</td>
<td>short (t &lt; 2 h)</td>
<td>long (t &gt; 8 h)</td>
</tr>
<tr>
<td>Pressure</td>
<td>increased (p &gt; 1 bar)</td>
<td>atmospheric</td>
<td>high (p &gt; 12 bar)</td>
</tr>
<tr>
<td>Processing</td>
<td>continuous</td>
<td>continuous</td>
<td>semi-continuous</td>
</tr>
</tbody>
</table>

**BSP Advantages:**
- short reaction times, atmospheric pressure, continuous process, high moisture input, dry product
Demostration project and timeline

- **2017/18**
  - Establishment of a demonstration plant with 2000 t/y throughput capacity in Germany
  - Site: waste treatment/composting site
  - Raw material: mixed gardening, landscaping and household wastes

- **2018/19**
  - Establishment of a plant with 2000 t/y at a suitable site in India, subsequent upscaling to 20,000 t/y
  - Targeted raw material:
    - vegetable market wastes
    - sewage sludge
Important factors for success

- Availability of the required quantity of wastes on site

- Recognition of the fact that wastes present an environmental and health problem due to
  - Very low energy content
  - Bulk, high moisture content
  - High degradability, disposal problems in cities
  - Their disposal requires usually more energy than they contain

- Suitable valorisation of the intake of such wastes

- Marketability of the disposal products
Contact:

**Live Energies GmbH**
Scharnhauser Strasse 35
D-70599 Stuttgart, Germany
+49 711 94542744, office@liveenergies.de

**Live Energies Agro Services**
Private Limited, Chennai