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The Re-injection Loop concept
Economically efficient biogas production from manure fibres and straw

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Introduction
There is a huge unexploited biogas potential from manure and agricultural residues in Europe and worldwide. However, these substrates consist of a large fraction of fibres (range 5-80%) of dry matter content) with a low methane potential and represent a marginal economy due to their low biogas yield per ton. Based on previous studies on using pretreatment for enhancing the biogas yield of these feedstocks, a new concept called Re-Injection Loop was developed by combining separation and recirculation of the digested fiber fraction with pretreatment of the recalcitrant lignocellulosic fiber fraction. The EU project BIOMAN is currently investigating different technologies for separation, mechanical pretreatment and enzymatic hydrolysis to establish an economically viable concept for manure-based biogas plants.

The Re-Injection Loop Concept
The Re-injection Loop concept combines solid separation and treatment of the solid fraction in a new innovative approach, see Figure 1.
1. Digestion of the easily degradable fraction of manure in the biogas process.
2. Separation of the residual recalcitrant digested fiber fraction.
3. Mechanical and/or enzymatic treatment of the digested fiber fraction.
4. Recirculation of the treated fiber fraction into the reactor.

Figure 1. Overview of the Re-injection Loop concept

Table 1. Calculated increase in methane production for recirculation of the digested fiber fraction using different separation techniques

<table>
<thead>
<tr>
<th>Separation method</th>
<th>Inlet TS (% w/w)</th>
<th>Solid fraction TS (% w/w)</th>
<th>Liquid fraction TS (% w/w)</th>
<th>% VS of total in solid fraction</th>
<th>Potential CH4 yield increase % (only recirculation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifugation</td>
<td>5.8</td>
<td>27</td>
<td>2.9</td>
<td>62</td>
<td>20</td>
</tr>
<tr>
<td>Screw press</td>
<td>5.1</td>
<td>31.3</td>
<td>3.7</td>
<td>39</td>
<td>11</td>
</tr>
<tr>
<td>Bow Screen</td>
<td>5.8</td>
<td>8.2</td>
<td>4.4</td>
<td>58</td>
<td>20</td>
</tr>
</tbody>
</table>

Figure 2. Potential agricultural residues and organic waste in Denmark and in EU Member States applicable for the Re-Injection Loop.

Figure 3. BMP of separated digested manure fibers (DMF), untreated and treated by PureteQ Minimeizer technology

Figure 4. BMP of separated digested manure fibers, untreated and treated with enzymes (dosage 0.1% (g/g-TS), for 0.5 h at 50°C and 42°C

Conclusions and perspectives
• Recirculation of the DMF in the Re-Injection Loop can increase methane production per ton of manure by up to 21%
• Mechanical pretreatment of DMF showed an increase of the methane yield of the DMF by 15%.
• Enzymatic treatment of DMF showed an increase of the methane yield of DMF up to 20%
• The most effective combination of separation, mechanical pretreatment and enzymatic hydrolysis will be tested in 30 L pilot scale reactors and full scale implementation will be at HTN.
• Economical analysis for a manure based biogas plant and the potential for the EU market will be conducted based on the pilot and full scale results

Acknowledgement

Table 2. Potential CH4 yield of BioMethane (CH4, m3/ton)

<table>
<thead>
<tr>
<th>DMF 15%</th>
<th>DMF 30%</th>
<th>DMF 45%</th>
<th>DMF 60%</th>
<th>DMF 75%</th>
<th>DMF 90%</th>
<th>DMF 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>0.9</td>
<td>1.1</td>
<td>1.3</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Figure 5. Potential application of the Re-Injection Loop in Europe.