Modern technologies of biogas upgrading

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Utilization of upgraded biogas

Anneli Petersson, 2009-08-24
Environmental benefits – biogas as vehicle gas

- Biogas is renewable – low CO$_2$-emissions
- 25 % less CO$_2$-emissions for natural gas compared to petrol
- Lower emissions of: NO$_x$, SO$_x$, particles
- Simultaneous production of biogas and fertilizer
- Decreased methane emissions compared to traditional manure storage
Biogas upgrading

- Biogas upgrading plants in the Task 37 countries
## Gas composition

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Biogas (vol-%)</th>
<th>Landfill gas (vol-%)</th>
<th>Natural gas (Danish) (vol-%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>60-70</td>
<td>35-65</td>
<td>89</td>
</tr>
<tr>
<td>Other hydrocarbons</td>
<td>0</td>
<td>0</td>
<td>9.4</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0</td>
<td>0.3</td>
<td>0</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>30-40</td>
<td>15-50</td>
<td>0.67</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>~0.2</td>
<td>5-40</td>
<td>0.28</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>Hydrogen sulphide</td>
<td>0-4000</td>
<td>0-100</td>
<td>2.9</td>
</tr>
<tr>
<td>Ammonia</td>
<td>~100</td>
<td>~5</td>
<td>0</td>
</tr>
<tr>
<td>Lower heating value</td>
<td>6.5</td>
<td>4.4</td>
<td>11.0</td>
</tr>
<tr>
<td>(kWh/Nm³)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Swedish standard

- Particles < 1 μm
- Methane 97+/- 2%
- Water < 32 mg/Nm³
- CO₂, O₂, N₂ < 5%
- Oxygen < 1 vol %
- Sulphur < 23 mg/Nm³
- N (except for N₂) expressed as NH₃ <20 mg/Nm³
- Odorised
- Compressed to 200 bar

For grid injection: Addition of propane to reach the energy content of the Danish natural gas (around 7-9 vol% is added)
Cleaning

- Water
- Hydrogen sulphide
- Oxygen
- Nitrogen
- Ammonia
- Siloxanes
- Particles

- Precipitation in digester
- Adsorption
- Absorption
- Biological treatment
Upgrading

- PSA
- Water scrubbing
- Organic physical scrubbing
- Chemical scrubbing
- Cryogenic
- Membranes
- Technologies under development
PSA

• Pressure Swing Adsorption
• Activated carbon or zeolites
• Regeneration by decrease in pressure
• Several vessels in parallel
Water scrubbing

- Carbon dioxide dissolves in water
- Methane dissolves to a much lower extent
- Dissolved methane recovered in flash tank
- Water regenerated in desorption column
Organic physical scrubbing

- Similar to water scrubbing, but carbon dioxide is absorbed in an organic solvent such as polyethylene glycol instead of water.
Chemical scrubbing

- Carbon dioxide binds chemically
- Selective reaction
- Low methane losses
- MEA or ETA in the liquid
- Regeneration by heating
Cryogenic

- Separation by cooling
- Carbon dioxide removed as solid or liquid
- If cooled further liquid methane gas is formed
Other upgrading technologies

- Membranes
- Technologies under development
  - *In situ* methane enrichment
  - Ecological lung

Schematic view of *in-situ* methane enrichment research plant. (Courtesy of Åke Nordberg, SLU, Sweden).
Upgrading - cost

Methane losses

![Bar chart showing methane losses for different percentage ranges.](chart.png)
Conclusions

• Biogas is upgraded for utilization as a substitute to natural gas or as a vehicle fuel
• The treatment of the biogas can be divided into cleaning and upgrading
• Upgrading technologies
  – PSA
  – Water scrubber
  – Organic physical scrubbing
  – Chemical scrubbing
  – Cryogenic
  – Membranes
• Other technologies in research phase
• Many aspects, such as economical and environmental, have to be considered when plants are evaluated, or new plants are under planning
Thank you for your attention!

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