REVIEW OF SMALL-SCALE BIOMASS GASIFICATION

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Technology description

What is gasification?

Heat supply:
- internal combustion
- via exchange area
- through moving heat carrier

Ideal:
1 - no tars left
2 - no nitrogen
3 - no methane
4 - no ash melting problems
5 - \( \text{CO} + \text{H}_2 + \ldots \) > 80%

Pyrolysis and heating up
O\(_2\) (air)
H\(_2\)O (steam)
Heat
Biomass

Gasification
Char
Tars
Permanent gases
H\(_2\)O (steam)
O\(_2\) (air)
Heat
Cat?

Gasifier types

<table>
<thead>
<tr>
<th>Moving beds</th>
<th>Fluid beds</th>
<th>Entrained beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-current</td>
<td>Counter current</td>
<td>dense</td>
</tr>
<tr>
<td>T°C</td>
<td>700-1200</td>
<td>700-900</td>
</tr>
<tr>
<td>tars</td>
<td>low</td>
<td>very high</td>
</tr>
<tr>
<td>control</td>
<td>easy</td>
<td>very easy</td>
</tr>
<tr>
<td>scale</td>
<td>&lt; 5 MW(_i)</td>
<td>&lt; 20 MW(_i)</td>
</tr>
<tr>
<td>feedstock</td>
<td>very critical</td>
<td>critical</td>
</tr>
</tbody>
</table>

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State-of-the-Art

Heat gasifiers

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Number in operation</th>
<th>Type</th>
<th>Main application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioneer</td>
<td>10</td>
<td>Updraft</td>
<td>District heating</td>
</tr>
<tr>
<td>PRM Energy</td>
<td>18</td>
<td>Updraft</td>
<td>Industrial heating</td>
</tr>
<tr>
<td>Foster Wheeler</td>
<td>4</td>
<td>CFB</td>
<td>Lime kilns</td>
</tr>
<tr>
<td>Lurgi Umwelt</td>
<td>3</td>
<td>CFB</td>
<td>Lime kiln, cement</td>
</tr>
<tr>
<td>Several</td>
<td>hundreds</td>
<td>Downdraft</td>
<td>Cooking, drying</td>
</tr>
</tbody>
</table>

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State-of-the-Art

Power gasifiers

Eckenförde
Germany

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State-of-the-Art

Power gasifiers

Xylowatt, Bulle

200 kWe
Just installed

Viking, DTU

17 kWe
Just installed
Achievements (1)

- > 100 units installed in Europe, USA, Switzerland
- Hundreds are installed in developing countries
- Maximum cap. for downdraft gasifier: 10 MWt
- Separation of pyrolysis, combustion and reduction in 2 and 3-stage processes
- Gasifiers for “difficult” fuels (poultry litter, straw)
- New gas cleaning devices (ESP, RPS, RFR scrubbers, solid bed filters, fabric filter)
- Cleaning of condensate water

Achievements (2)

- Feedstock characterisation for biomass gasification
- Fully automatic control for continuous operation
- Standard methods for monitoring
- Exchange of knowledge and experience by networks
- Commercial operation of several community fixed bed gasifiers
- Avoidance of condensate by keeping the gas temperature above the dewpoint
- Fiscal measures to stimulate biomass gasification
Technical barriers (1)

- External reverse flow
- Internal thermal
- External thermal
- External catalytic
- Internal catalytic
- "Physical" separation

Tar conversion elimination concepts

Tar-free gasification

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Technical barriers (2)

- Ash melting (slag formation)
- Low gas heating value (power de-rating, flame stability)
- Sustainable feedstock supply (characteristics, price, pretreatment, logistics, long-term contracting, standardization, quality-control)
- Gas cleaning (technical/economic evaluation of options)
- Prime mover (unclear specs, strict emission limits)
- Reliability (lack of confidence, operating experience)
Non-technical barriers (1)

- Financial aspects
  - High initial investment
  - Limited private investments
  - Remuneration of CHP
  - Feedstock availability
  - Small subsidies are not stimulating

- Permitting procedures & emission limits
  - Complex, time consuming
  - Unknown technology to authorities
  - Strict emission limits from incineration
  - No one common legislation

- Safety, health & environment
  - Which directive is valid to gasification?
  - Guideline for safe operation and construction is needed

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Non-technical barriers (2)

Health & Safety Impact
Conditions for commercialization (1)

• Technology implemented must be mature
  • Proven prototype models
  • Long-term duration tests

• Adequate infrastructure
  • Local manufacturing capacity
  • After-sale service
  • Training facilities

• Motivated & skilled labor
  • Operators
  • Management
  • Incentives

• Scale-up, demonstration, replication, optimization
  • Economy of numbers
  • Reduced capital costs
  • Improvement from learning by doing

Conditions for commercialization (2)

• Information & knowledge exchange
  • Performance, limitations, opportunities
  • Evaluation with competing options
  • Set-up monitoring program of successes in India, China

• Loan finance for customers
  • Reduce risk for ‘first-of-its-kind’

• Clear regulations
  • Permitting procedures
  • Emission according to “ALARA”
  • HSE

• Sale of electricity and heat
  • Any legal obstacle should be removed
  • Long-term fixed price is prerequisite
Conditions for commercialization (3)

- Product quality must meet client specifications
  - Technical performance
  - Financial/economic performance
  - Operational performance

- Certification
  - stimulation
  - product must meet defined quality standards

- Standardization
  - Technology, components
  - Acceptance tests, guarantee measurements
  - Ultimately one dominant design