Small Biogas Upgrading Systems
for gas grid injection or vehicle refuelling
«good things come in small packages»
Content

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• Demand for small systems in Switzerland
• Installation examples
• Range of upgrading systems
• Challenges / Outlook
1 kg Biomass -- 1 km by Car

20 kg Biomasse (Mist; 0.1 m³ gas/kg)  2 m³ Rohgas (5 kWh/m³)  1 m³ Biomethan (10 kWh/m³)  20 km PW-Fahrt (2 km/kWh)
Large CO$_2$-Reductions with Biomethane as Vehicle Fuel

### CO$_2$-Auszüsse von Fahrzeugen

<table>
<thead>
<tr>
<th>Kraftstoff</th>
<th>THG-Emissionen WTW in gCO$_2$ äq/km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossile Kraftstoffe</td>
<td></td>
</tr>
<tr>
<td>Benzin</td>
<td>164*</td>
</tr>
<tr>
<td>Diesel (mit Partikelfilter)</td>
<td>156</td>
</tr>
<tr>
<td>Autogas</td>
<td>141</td>
</tr>
<tr>
<td>Erdgas (EU Erdgasmix)</td>
<td>124 - 24 %</td>
</tr>
<tr>
<td>Biokraftstoffe</td>
<td></td>
</tr>
<tr>
<td>Erdgas mit 20 % Bio-Erdgas</td>
<td>100 - 39 %</td>
</tr>
<tr>
<td>100 % Bio-Erdgas (bi-fuel Mix)</td>
<td>5 - 97 %</td>
</tr>
<tr>
<td>Ethanol (Basis: Weizen)</td>
<td>111</td>
</tr>
<tr>
<td>Biodiesel (Basis: Raps, Glycerin, Verfütterung)</td>
<td>95</td>
</tr>
</tbody>
</table>

* Referenzfahrzeug: Ottomotor (Benzin, Saugmotor), Verbrauch: 7 l / 100 km. Quelle: dena

Small biogas upgrading systems, 03.09.2019, SCCER Biosweet Lucerne, U. Oester, Apex AG
Horse Power Fuelled by Biomass

- Farmers can use their own fuel (again)
- Switzerland: Small farms and sewage plants need small upgrading units
Motivation of Apex

• Swiss gas industry: strong demand for biomethane
  – today approx. 20% of CNG is biomethane
  – Goal by 2030: 30% of district heating is with biomethane

• Apex builds and maintains CNG-refuelling systems
  – maintaining 80 out of 155 public CNG stations
  – Dispensers: Fuel choice with biomethane upgrade

• Built 6 small upgrading plants
Closing Gaps with biogas

Example: biogas filling station aside the nat. gas grid
BlueBONSAI BB12 Frutigen
Biogas Mobility – CNG Cars Are Available
(>22 Mio. vehicles worldwide, >26’600 filling stations; source: ngvjournal.com)
CNG Tractors Are Near Series-Production
(Example New Holland)
Need For Small Units in CH

• Typical small biogas plants in Switzerland produce from 40... 100 (200) Nm$^3$/h biogas

• Connecting biogas plants through pipelines is difficult (geographically and re: regulations)

• Transporting biomass to larger biogas plants is rare

→ Hence: upgrading systems must fit smaller biogas production rates
Design For Purpose ("Reduce To The Max")

- Innovation BlueBONSAI / BlueFEED
- Focus on flow rates $< 100 \text{Nm}^3/\text{h}_{\text{Rawgas}}$
- System design optimized for small units
  - components, sensors, controls
  - modular design, ease of maintenance
  - design for series production
  - still meeting Swiss regulation requirements
- Leads to affordable systems
  → Hence: opens the (economical) door for smaller biogas projects
Application BlueBONSAI / BlueFEED
Biogas Refuelling Station
Type BlueBONSAI BB1; Rawgas: approx. 3 Nm$^3$/h

Reiden (LU), installation in parallel to a CHP (no nat. Gas grid available). Agricultural biogas plant, privately used filling station (4 cars)
Biogas Refuelling Station at Sewage Treatment Plant
Type BB12; Rawgas: approx. 20 Nm$^3$/h

Schönenwerd (SO), installation in parallel to a CHP (no nat. gas grid available). Waste water treatment plant, semipublic (badge registry), now installed in Frutigen (BE)
Sewage Treatment Plant with Gas Grid Injection
Type BlueFEED BF40; Rawgas: approx. 70 Nm$^3$/h

Reinach (AG)
Biogas Grid Injection
Type BF35; Rohgas: ca. 50 Nm$^3$/h

New: «Plug & Play»-Design
## Sizes BlueBONSAI / BlueFEED

| Rawgas [Nm³/h] | 10,0 | 20,0 | 40,0 |
| Biomethane [Nm³/h] | 6,0 | 12,0 | 24,0 |
| type BlueBONSAI | BB6 | BB12 | BB24 |

| Rawgas [Nm³/h] | 36…50 | 53…67 | 70…125 |
| Biomethane [Nm³/h] | 22…30 | 32…40 | 42…50 |
| type BlueFEED | BF22…30_withFC | BF32…40_withFC | BF42…50_withFC |

### BlueBONSAI (BioCNG station): ~10 (to approx. 40) Nm³/h Rawgas in combination with CHP parallel, 1- or 3-stage membranes

### BlueFEED (grid injection): from ~20... 36 to approx. 125 Nm³/h Rawgas optional also in combination with small CNG filling station
Energy Consumption

- **BlueBONSAI:**
  - 0.6…0.8 kWh/Nm$^3_{\text{Rawgas}}$ or 1…1.3 kWh/Nm$^3_{\text{Biomethane}}$
  - 12….16 % of the produced energy
- **BlueFEED:**
  - 0.3…0.4 kWh/Nm$^3_{\text{Rawgas}}$ or 0.5…0.7 kWh/Nm$^3_{\text{Biomethane}}$
  - 6……8 % of the produced energy

Values depending on flow-rate and offfgas-quality

(recycling rate)
Goal: Cost of Biomethane (BlueBONSAI)

- Investment: 400’000 CHF
- Operation: 4’000 h/a (50% utilisation)
- Flowrate: 12 Nm³/h
- Amortisation: 40’000 CHF/a (10 years) 60%
- Maintenance: 15’000 CHF/a 22%
- El.power: 12’000 CHF/a (0.2 CHF/kWh) 18%
- Total 67’000 CHF/a 100%

- Specific costs: 1.40 CHF/Nm³ or 0.14 CHF/kWh
  1.75 CHF/kg or 1.19 CHF/L gasoline aequiv.

(Without cost of the rawgas; approx. 0.04...0.12 CHF/kWh or 0.34...1.02 CHF/L)
(With cost of the rawgas; approx. 0.18...0.26 CHF/kWh or 1.53...2.21 CHF/L)
Goal: Cost of Biomethane (BlueBONSAI)

<table>
<thead>
<tr>
<th>Flowrate Nm³/h</th>
<th>Investment Cost CHF</th>
<th>Spec.Cost CHF/kWh</th>
<th>Biomethane GWh/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB6 (*)</td>
<td>6</td>
<td>200’000</td>
<td>0.15</td>
</tr>
<tr>
<td>BB12</td>
<td>12</td>
<td>400’000</td>
<td>0.14</td>
</tr>
<tr>
<td>BB24</td>
<td>24</td>
<td>500’000</td>
<td>0.095</td>
</tr>
<tr>
<td>BB48</td>
<td>48</td>
<td>600’000</td>
<td>0.064</td>
</tr>
</tbody>
</table>

(*) Without «comfort» options (simple, manuel fuelling option)

Without installation on site (approx. CHF 50’000)
Without cost of rawgas
Goal: Cost of Biomethane (BlueFEED)

• Investment: 600’000 CHF
• Operation: 8’000 h/a
• Flowrate: 50 Nm³/h
• Amortisation: 60’000 CHF/a (10 years) 50 %
• Maintenance: 20’000 CHF/a 17 %
• El.power: 40’000 CHF/a (0.2 CHF/kWh) 33 %
• Total 120’000 CHF/a 100 %

• Specific costs: 0.3 CHF/Nm³ or 0.03 CHF/kWh (Without cost of the rawgas)
Goal: Cost of Biomethane (BlueFEED)

<table>
<thead>
<tr>
<th>Flowrate Nm³/h</th>
<th>Investment Cost CHF</th>
<th>Spec.Cost CHF/kWh</th>
<th>Biomethane GWh/ year</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF10 10</td>
<td>400’000</td>
<td>0.075</td>
<td>0.8</td>
</tr>
<tr>
<td>BF20 20</td>
<td>400’000</td>
<td>0.042</td>
<td>1.6</td>
</tr>
<tr>
<td>BF30 30</td>
<td>500’000</td>
<td>0.039</td>
<td>2.4</td>
</tr>
<tr>
<td>BF40 40</td>
<td>600’000</td>
<td>0.036</td>
<td>3.2</td>
</tr>
<tr>
<td>BF50 50</td>
<td>600’000</td>
<td>0.030</td>
<td>4.0</td>
</tr>
<tr>
<td>BF60 60</td>
<td>600’000</td>
<td>0.027</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Without installation on site (approx. CHF 50’000)
Without cost of rawgas
Challenges / Wrap up

• Costs of biogas upgrading still too high:
  – Biogas upgrading in comparison to natural gas
  – Need series production
  – Need more field experience
  – Many request, few orders: exit «NATO»-scenario
    («no action, talk only»)

• Goal: biogas upgrading to become competitif with CHP

• Biogas, the forgotten alternative («electro-mobile hype»)
  – «Power-to-Gas» and hydrogen are part of the future
  – biogas is available today and in the future
Thank You for Your Attention
Contacts/ Further Information

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