Analysis an optimization of energy flows in existing biogas plants for improved economic performance

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The biogas plant

- Reduction of thermal and electric energy due to own consumption

\[ \text{Biogas plant} \rightarrow \text{Biogas} \rightarrow \text{CHP}_1 \]

- Averaged in-plant electrical use 3%
- Averaged in-plant thermal use 11.6%
- Biogas 100%
- CHP\(_1\)
- Electrical portion 39%
- Reduced electrical portion 36%
- Losses 18%
- Thermal portion 43%
- Reduced thermal portion 31.4%

References:
1. DBFZ 5. Zwischenbericht 2011
2. Datenblatt Jenbacher 312 FWL 1251 kW

Ing. Büro Energietechnik
Area of biogas plants for analysis

- Own heat consumption
- Daily feeding protocols
- CHP heat content

Own measurements at 6 plants:
- Temperature (manure, corn silage, ambient ...)

Own measurements at 8 CHP units:
- Cooling water heat, radiant heat, intercooled heat, residual heat (exhaust gas)
Measuring points for liquid manure and corn silage. Once a week over 14 months of 5 biogas plants.

Measuring points CHP unit 4 times over 1 year on 8 CHP units.
Process heat demand

Heat consumption biogas plant

Heat consumption compared first and second digester

Heat demand for heating the substrate BP 6

Q[kW]

T Maize entering (680 kg)  T Slurry (320 kg)  Sum

BP 1    BP 2    BP 3    BP 4
BP 5    BP 6    BP 7    BP 14

BP 6 D1    BP 6 D2
BP 14 D1    BGA 14 D2

kWh/t

BP 1    BP 2    BP 3    BP 4
BP 5    BP 6    BP 7    BP 14

BP 6 D1    BP 6 D2
BP 14 D1    BGA 14 D2

Ing. Büro Energietechnik
Cooling of corn silage

– Ambient temperature -7.4 °C

BP 7

Silage storage 4 hours after feeding the biogas plant

Thermal imaging from the silage bunker

Heat transfer from digester

Thermal imaging of screw conveyors
Temperature curves of the substrates

Temperature curve of the corn silage in the silo of five biogas systems with average value

Temperatures of the corn silage in the course of the year before fermenter inlet
Heat consumption

Max. and min. heat requirement for liquid manure and corn silage
**CHP Heat sources**

- **Normally not use:**
  - Exhaust gas under 180°C
  - Intercooling 2. Stage
  - Radiation heat

*Useful heat from the biogas CHP 90- 70°C or 95- 75°C*
Energy transformation of 100% Biogas in CHP unit

Enlargement of the exhaust gas heat exchanger reduces the losses
Exhaust gas exchanger

There are two different ways to get a higher efficiency from the exhaust:

1) Sulfur content in the biogas should be close to 0 ppm,
2) The heat exchanger was made of corrosion-resistant material.

Example for an additional heat exchanger of corrosion-resistant material. Plants schematic and installation.
(bomat GmbH)
**Intercooler 2. stage**

- The intercooling 2. stage heat can be used direct in heat system for the digester.

And it can be also used to preheat the slurry in the Reception tank.

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<tr>
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<th>BP 6</th>
<th>BP 7</th>
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<tbody>
<tr>
<td>$Q_{\text{Proz.}}$ [GJ]</td>
<td>3.159</td>
<td>5.111</td>
</tr>
<tr>
<td>$Q_{\text{inter.}}$ [GJ]</td>
<td>288 (100)</td>
<td>911 (380)</td>
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<tr>
<td>Proportion [%]</td>
<td>23.46</td>
<td>28.18</td>
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Proportion of the intercooler heat to the process heat.
Every biogas CHP unit is equipped with a radiator cooling system.

The control works over a three way mixing valve.

The min. flow volume to the radiator is 2-3% of the whole cooling water energy.

An additional automatic valve in the cooling water pipe can reduce this heat losses up 95%.

Extended radiator system with automatic valve
Electrical own consumption

• Comparison of the electric own consumption on two biogas plants 2014.
• Main consumers substrate – Mixer system and CHP
Over 95% of the electrical consumption are used for motors. Some of these drivers do not need the full power over the year. Pumps and fans for example with a controlled temperature can save much energy over the year.

Fan controlled with frequency converter
Summary

• The optimization of own consumption on biogas plants shows several possibilities.
• On the thermal side, the process heat for the biogas plant can be reduce and the heat output of the CHP can be increased.
• On the electrical side can the own consumption reduced with a higher expenses of control technology.
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• Thank you for your attention!

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