Efficiency of the biogas process - results of a monitoring program

Jan Liebetrau, Rytec

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Rytec- Waste technology and energy concepts

- Rytec offers a unique combination of innovative engineering and established experience in the operation of plants.
- Development, optimization, construction, retrofitting and control of process engineering systems in the energy and waste sectors.

**In detail:**
- Planning and Construction of Biogas plants, biological and thermal waste treatment, energy engineering as well as waste and landfill process engineering.
- Plant operations for CHP, AD plants, biomass power plants and waste water treatment plants.
- Consultancy for public and industry sector
- Emission monitoring, mitigation measures and measurement campaigns
Outline

Background
—
Methodology
—
Efficiency
—
Economics
—
Conclusion
Germany State of Biogas production

• 2018: ~ 8,980 biogas production plants incl. upgrading plants for biomethane in operation

• No significant additional capacity since 2012

• mainly flexibilisation of existing plants (motivated by premium for flexible operation)

• New construction limited to small scale manure plants (< 75 kW_{el}) and few biowaste fermentation plants

Source: DBFZ, 2019. Database: Distribution of biogas plants by plant size on the basis of the DBFZ plant database; installed plant capacity and electricity generation according to AGEE-Stat 2/2019 (UBA 2019), *DBFZ forecast (modified according to Lenz et al. 2019)
Biogas plant inventory

<table>
<thead>
<tr>
<th>Plant type</th>
<th>Number of plants</th>
<th>Electricity production $^1$ [GWh/a]</th>
<th>Heat utilization [GWh/a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>8,270</td>
<td>27,978</td>
<td>12,677</td>
</tr>
<tr>
<td>Biowaste</td>
<td>336 (136 + 200) $^2$</td>
<td>865</td>
<td>392</td>
</tr>
<tr>
<td>Biomethane</td>
<td>203</td>
<td>2,7</td>
<td>3,455</td>
</tr>
<tr>
<td>Sewage sludge</td>
<td>1,274 $^3$</td>
<td>1,490</td>
<td>2,167</td>
</tr>
<tr>
<td>Landfill</td>
<td>468</td>
<td>300</td>
<td>122</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10,431</strong></td>
<td><strong>33,345</strong></td>
<td><strong>18,813</strong></td>
</tr>
</tbody>
</table>

1) excluding efficiency losses;
2) Substrate input of 136 plants ≥ 90% of biowaste of the whole input amount per year (acc. to § 27a EEG 2012, § 45 EEG 2014, § 43 EEG 2017); biowaste is defined as separate collected municipal waste (e.g. kitchen waste, green waste); about 200 co-fermentation plants with substrate input < 90% of biowaste including plants using agro-industrial residues.
Biogas in Germany – current situation

• Change to tender system in 2017
• Cap installed for maximum capacity defined until 2022 (to low for the majority for the sector)
• Low maximum bidding prices, not attractive for plant operators (not much contribution to the tender yet)
• Numerous regulations under revision, changing and mostly increasing effort for plant operators
• No perspective for the sector and no ongoing discussion/urgency within authorities noticeable (e.g. biomethane market, manure based plants)
• Age pattern within operators/owners of plants

• Lack of perspective might lead to a severe deconstruction of the sector, even within plants with sustainable concepts
Biogas-monitoring program III

- Program I monitored the beginning of the sector, program II the new energy crop based facilities (published in 2009)

Program III:
- Focus on Efficiency (biological process) and economic situation
- Connected to microbial analysis program
- Evaluation of 60 plants including small scale manure based plants and biomethane plants
- (4 Partners, 15 plants each, period of one year per plant evaluated
- Comparison of methods for efficiency evaluation
- Transparent data acquisition and evaluation
- Ring tests between institutions to identify errors

- Duration 01.12.2015 – 30.11.2019
Biogas-monitoring program III

Project partner
- Deutsches Biomasseforschungszentrum (DBFZ) (Coordinator)
- Landesanstalt für Agrartechnik und Bioenergie (LAB)
- Kompetenzzentrum Erneuerbare Energien und Klimaschutz Schleswig-Holstein (EEK.SH)
- Bayerische Landesanstalt für Landwirtschaft (LfL)

Funding body:
## Biogas Monitoring Programme III
### Methodology

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD plant selection</td>
<td>Analysis of AD plant stock, plant selection, contact with operators</td>
</tr>
<tr>
<td>Method development</td>
<td>Definition of methods, round robin tests</td>
</tr>
<tr>
<td>Measuring period 1 (2016/2017)</td>
<td>Operator’s survey, monthly sampling, data measurement</td>
</tr>
<tr>
<td>Method development</td>
<td>Comparison of results, review of methods, round robin tests</td>
</tr>
<tr>
<td>Measuring period 2 (2017/2018)</td>
<td>Operator’s survey, monthly sampling, data measurement</td>
</tr>
<tr>
<td>Data analysis, documentation, presentation of results, publishing</td>
<td>Lab analyses, interpretation and publication of analyses/measured data/surveys</td>
</tr>
</tbody>
</table>
Efficiency - approach

What data is required to evaluate a biogas plant resp. give performance indications?

• Mass balance of in- and output
• Energy balance of the biogas plant
• Data of the plant performance and reliability of the equipment (hours/year)
• Normative-actual value comparison

What data is needed for the mass/energy balances?

• Characterization of substrates and digestate (TS, VS, Feed value analysis for FVS, methane potential test, heating value, residual methane potential)
• Analysis and evaluation of process characteristics
• Assessment / Evaluation of the overall biogas plant concept
Efficiency - approach

Substrate → Digester → Gas utilization

Potential (average specific methane potential)

Yield (specific methane yield)

Substrate type; mass; TS; VS

VS based standard values (KTBL) → Standard KTBL

„Weissbach method“ for energy crops based on Ash, raw fiber, for selected substrates: standard values (KTBL) → FVS

VS, methane potential test → Batch

Heating value, (plus digestate mass, TS and heating value) → Energy

Grid kWh fed in
→ Factor transformer
→ Factor efficiency CHP
→ Heating value methane
→ methane mass flow into engine
Efficiency - results

Basis of masses is VS to be able to compare results directly

Batch, FVS, Standard Values show similar tendency, but also quite differing results

Heating value much higher and different trend

Source: Jan Liebetrau, based on data from BMP 3 project team
KTBL values known to underestimate slightly; still:

Masses need to be checked

Representative samples (?)

Errors likely in all areas:
Masses
Representative Sampling
Potential determination

evry plant has to be checked in detail

Source: Jan Liebetrau, based on data from BMP 3 project team
Economy - results

- Participation of rather better plants
- Economic evaluation based on one year (reinvests have large impact)
- Basic information not easy to collect (e.g. costs for labour at small scale plants integrated in agriculture operation)

Source: Tino Barchmann; DBFZ
Economy - results

Production costs ($\text{€}/\text{kWh}_{\text{el}}$)

High operational hours help, but expensive substrates, breakdown, or high reinvestments can ruin the balance. Present maximum bid in the tendering system: 0.1639 $\text{€}/\text{kWh}$

Source: Tino Barchmann; DBFZ
Conclusions

• Mass balance as a critical point
  – Actual mode of operation and key figures of AD plants often poorly measured
  – Analytical (lab) errors insignificant in comparison to errors made on site/during sampling
  – Different methods for potential analysis can vary to large extend
  – In particular input masses seem to be questionable

• Recommended procedure for plant evaluation
  – First check procedure with standard values to identify uncertainties
  – In case of plausible data, proceed with more detailed, precise analysis

• Economics
  – Even without plausible mass balance the plants can be cost efficient
  – Large variation in production costs (tender system should level that out(?))
  – No clear correlation of a single parameter to profitable business
  – Most plants have production costs higher than future tariffs allow
  – Investigated plants have a positive balance due to high tariffs in the past
Thanks to all participants and contributions to the project in general and the presentation in particular -

and thank you for listening.

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