European harmonisation of methods to quantify methane emissions from biogas plants

Acronym: MetHarmo

Coordinator:
DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH (D)

Partners:

- ISWA, University of Stuttgart (D)
- BOKU University of Natural Resources and Life Sciences (A)
- ZAMG Central Institute for Meteorology and Geodynamics (A)
- BEST - Bioenergy and Sustainable Technologies GmbH (former Bioenergy 2020+ GmbH (A)
- RISE, Research Institutes of Sweden AB (S)
- Energiforsk AB – Swedish Energy Research Centre (S)
- Avfall Sverige (S)

Associated partners:

- Technical University of Denmark (DK)
- Boreal Laser Inc. (CND))
- IRSTEA (F)

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Introduction

The detection and quantification of greenhouse gas (GHG) emissions in the energy, agricultural or waste treatment sector is very important for reaching climate protection objectives. Related to the biogas sector, methane is the most important GHG due to its high global warming potential of 28 according to the Intergovernmental Panel on Climate Change. Anaerobic digestion (AD) plants can have several emission sources like leakages, open storage of digestate or the methane slip from the gas utilization units. Due to different plant concepts and different conditions at the sites, different measurement methods for the determination of an overall methane emission rate were developed and used by research institutions in the past years. These single methods can be related either to the on-site approach (investigation of single emission sources) or to the remote sensing approach (investigation of whole plant emissions). However, to date, no uniform method procedure was available, and results obtained were difficult to compare.

Therefore, the ERA-NET research project "European harmonization of methods to quantify methane emissions from biogas plants – MetHarmo" had two main objectives. On the one hand, based on comparative emission measurements, the deviations of the single approaches and methods should be determined. On the other hand, a guideline with a harmonized and recommended measurement procedure should be developed.

Results

A guideline with a harmonized and recommended measurement procedure is published in the DBFZ publication series as DBFZ Report 33 and can be downloaded here. Thereby, comparable emission measurement results from different methods and institutions should be allowed in the future.

Two comparative emission measurement campaigns with overall eight measurement teams and four different measurement methods took place:

- The project partners DBFZ, RISE and IRSTEA used the on-site approach. DBFZ and RISE tried to quantify all single emission source to determine the overall emission rate. In contrast, IRSTEA focused exclusively on one source type only namely the biogas leakages.
- The project partners DBFZ, UStutt, BOKU and ZAMG used the remote sensing approach, namely the Inverse Dispersion Modelling Method (IDMM) using open path laser spectrometers and the dispersion models Windtrax and LASAT to determine the methane emission rates.
- The project partner DTU used the remote sensing approach as well, namely the Tracer Gas Dispersion Method (TDM) using a cavity ring down spectrometer and acetylene as tracer gas.

- The subcontractor NPL used Differential Absorption LIDAR (DIAL), which is also a remote sensing approach.

Furthermore, the project partner BEST (fotmer BE2020+) took digestate samples and investigated the residual biogas potential at different temperatures.

The measured emission factors (EF) from the participating measurement teams from both measurement campaigns are summarized in Table 1.

The first AD plant was an agricultural type with a biogas upgrading unit (chemical scrubbing) and a combined heat and power (CHP) unit with thermal post combustion as gas utilization. The digestate storages were gastight covered. Consequently, AD plant 1 met the requirements of the state of the art regarding the mitigation of methane emissions. In contrast, AD plant 2 used the biogas exclusively in flexibly operated CHPs without effective exhaust gas treatment for the reduction of the methane slip. The last stage of the digestate storage was open. Consequently, higher EFs for AD plant 2 were expected.

The average of the measured EFs from measurement campaign 1 range between 0.3 % CH4 (on-site approach) and 1.2 % CH4 (DIAL). The mean EFs from measurement campaign 2 range between 1.1 % CH4 (IDMM) and 2.7 % CH4 (IDMM and TDM) and between 2.1 % CH4 and 2.3 % CH4 for the on-site approach (only for teams A and B with the full investigation scope). Thereby, the measured EFs from AD plant 2 were higher than from AD plant 1 as expected.

On the one hand, the results from the comparative emission measurements confirmed already known insights. For instance, for the on-site approach the quantification of the main emission sources is very important for the determination of the overall emission rate. On the other hand, new findings were achieved. For instance, for the IDMM the positioning and configuration setup of ultra-sonic anemometer is very important for the modelling of the overall emission rate. These insights directly run into the development of the harmonized guideline.

Furthermore, during extended emission measurements in Germany and Austria carried out by University of Stuttgart and BOKU the harmonized IDMM measurement procedure was tested for the first time and also was further optimized.

Acknowledgment

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Campaign	Average of the methane EF in % CH_4 (related to the methane production of the AD plant; normal operating conditions, without artificial methane release)							
	On-site approach (sum of measured single sources)			Remote sensing approach (Range of daily averages)				
	On-site A	On-site B	On-site C	IDMM A[1]	IDMM B[1]	IDMM C[1]	TDM A	DIAL
I (2016)	0.3	0.4	---[3]	1.2[4] – 1.2	0.6[4] – 1.2	0.6[4] – 0.9	0.3 – 0.7	1.2
II (2017)	2.2 – 2.3[5]	2.1	0.2[2]	1.2 – 2.5	1.1 – 2.7	1.1 – 1.2	1.9 – 2.7	---[3]

[1] ... The presented EFs are based on the harmonised evaluation and modelling procedure.
[2] ... On-site team C focused on the quantification of biogas leakages only.
[3] ... The team did not participate in the measurement campaign.
[4] ... IDMM A had the optimal distance of 100 m to the plant (best measurement conditions). IDMM B had a too long distance (150 m) and IDMM C a too short distance to the plant (no optimal measurement conditions).
[5] ... Indication of a minimum and maximum value

Table 1: Determined methane emission factors from all participating measurement teams.

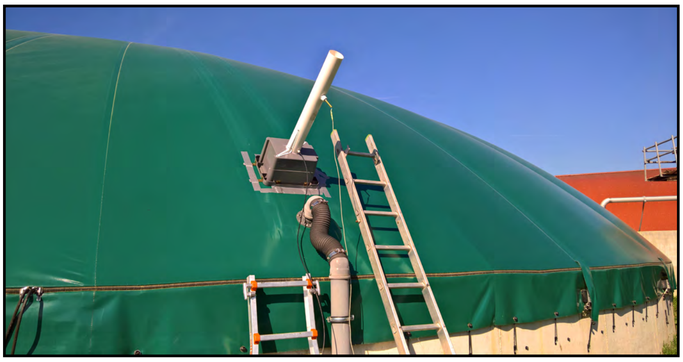

Figure 1: Measurement of the methane diffusion rate from an air-inflated double membrane dome.

Figure 2: Determination of the overall methane emission rate by means of the Inverse Dispersion Modelling Method. The open-path laser spectrometer measures the atmospheric methane concentration downwind of the investigated biogas plant.