Evaluation and reduction of methane emissions from different European biogas plant concepts

Acronym: EvEmBi

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- Fachverband Biogas e. V. (FvB, Germany, subcontractor of DBFZ)
- Institute of Waste Management, University of Natural Resources and Life Sciences (BOKU) (AT)
- Bioenergy and Sustainable Technologies GmbH (former Bioenergy 2020+ GmbH) (BEST) AT)
- AAT Biogas Technology (AAT) (AT)
- Kompost & Biogas Verband Österreich (KBVÖ) (AT)
- Genossenschaft Ökostrom Schweiz (ÖS) (CH)
- Berner Fachhochschule (FHB, subcontractor of ÖS (CH)
- Oester Messtechnik GmbH (Oester, subcontractor of ÖS(CH)
- Research Institutes of Sweden (RISE) (SE)
- Avfall Sverige (AVS) (SE)
- Svenskt Vatten (SV) (SE)
- Technical University of Denmark (DTU, DK), Associated Partner)
- European Biogas Association (EBA) (BE), subcontractor of DBFZ, ÖS-CH and KBVÖ)

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Introduction

Based on the Paris Agreement, the EU submitted in December 2020 its updated and enhanced Nationally Determined Contribution (NDC) with the target to reduce the greenhouse gas emissions by at least 55% by 2030 from 1990 levels [1]. This also has an impact on the biogas sector, as methane (CH4) is a main component of biogas and furthermore a very strong greenhouse gas with a global warming potential (GWP) 28 times higher than CO_2 over 100 years [2]. Unintentional methane emissions have a negative impact on the GHG balance of the biogas plants and should be kept as low as possible, both for environmentally friendly plant operation and for economic reasons. Methane emissions depend on the type of the plant, the used technology, and the emission source. The average methane loss of the plant or a specific part of the plant is expressed by emission factors (EFs), which relate the emitted gas quantity to the overall produced gas. The EFs are intended to serve the European GHG inventory for the classification of plant - and component specific methane emissions.

Results

One of the main objectives of the ERA-NET project "Evaluation and reduction of methane emissions from different European biogas plant concepts - EvEmBi" is to determine representative and verified EFs for biogas plants with different plant concepts and to set up and validate whereby a quantification system (model) to estimate methane emissions of the national plant stock. In addition, concepts for the reduction of emissions were developed, implemented at the plants to be examined, and hence a cost-benefit analysis was prepared for the plant-specific reduction measures. Another goal is the transfer of knowledge about emission mitigation at biogas plants to plant operators and other stakeholders. For that, position papers have been published in the member states (Germany, Austria, Switzerland, and Sweden) by national associations and in the European context by the European Biogas Association (EBA).

In addition, operator training on methane emissions and their reduction at biogas plants have been organized and according to the Swedish and Danish voluntary systems, national voluntary programs for emission mitigation in the biogas sector have been developed.

For the determination of component specific as well as plant concept specific methane EFs a large number of measurements has been carried out. A total of 37 biogas plants in four countries were measured using both the on-site approach for the determination of methane emissions from individual biogas plant components and the off-site approach (remote sensing method) for the entire biogas plant.

The average methane emission rates combined from all member countries measured with the off-site approach ranged from 0.1 to more than 50 kg CH_4 hr^{-1} irrespective of plant type or used technology. Relative to the amount of methane produced, this gives EFs in the range of 0.1 up to 35%. These results are comparable to those of Bakkaloglu et al. [3] who stated methane emission rates from 0.1 to 58.7 kg CH_4 hr^{-1} at ten biogas plants in the UK. Scheutz's et al. [4] results are also within the same range, with an average methane emission rate between 2.3 and 33.5 kg CH_4 hr^{-1} measured at 23 biogas plants in Denmark as well as the results of Liebetrau et al. [5] who identified, based on investigations at 10 German biogas plants, the open storage of digestates as a major single methane emission source ranging from 0.22 to 11.2%. Beside the open storage of digestate, the methane slip of combined heat and power plants (CHP) are another main single emission source and therefore from high interest. The methane slip of 25 CHPs, measured within the EvEmBi project, from different biogas plants in Austria and Germany varied from 0.1 to 3.8% related to the produced biogas amount of the plants. This is comparable to the results of Liebetrau et al [5] who stated an average emission of the utilized methane from 0.40 to 3.28% due to incomplete combustion.

Figure 1: Group picture at the second project meeting in Freising, organized by the FvB

Figure 2: Measurement of the methane concentration from a not gastight digestate storage tank

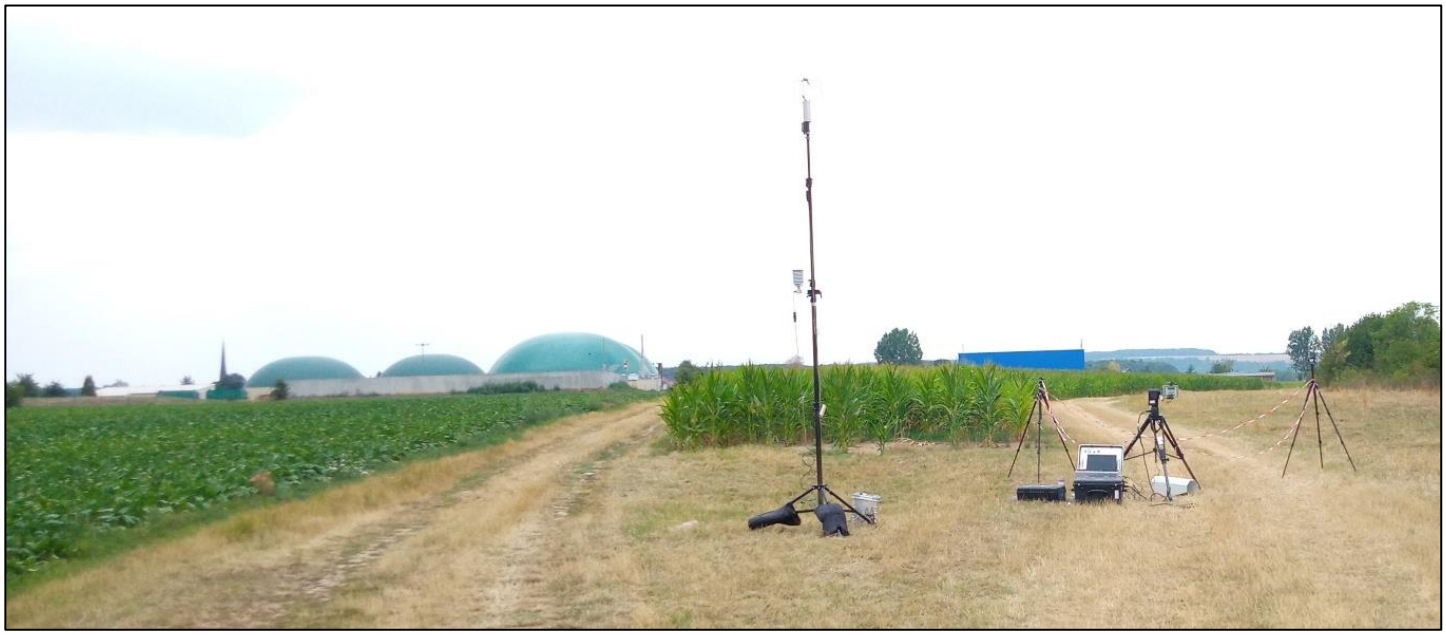

Figure 3: Determination of the total methane emissions with remote sensing from the

All measured data were analysed for further use in the emission quantification model. For selected technologies, the probability density function, relevant for the Monte-Carlo simulation, have already been calculated and methane emission estimations for different biogas plant concepts were carried out.

After the first measurement campaign, mitigation measures were implemented at selected plants. Thus, in the second campaign, some successful reduction measures could be proven and included in the cost-benefit analysis. Mitigation measures included gas-tight covers for digestate storage tanks, in addition to, replacing the amine scrubbing solution in the chemical scrubber, replacing membranes or sealing roof covers. Certain components have an increased risk of methane emissions, so regular leak detection is important to keep the plant operating cost-effectively and safely.

In summary therefore, it can be said that the successful provision of cross-national comparable emission factors based on harmonised guideline for the European Biogas Plant Inventory has attracted EU-wide interest. In addition to the emission measurements, however, the knowledge transfer of methane mitigation measures also played a major role in the EvEmBi project. The publication of the national and European position papers triggered a discussion with the European commission about a European (voluntary) monitoring system especially for the biogas sector, which can be considered a great success. The consistently positive feedback from the operator training sessions shows that there is both interest on behalf of plant operators and a need for action in terms of knowledge exchange. The continuation of the emissions workshops is considered very positive by the national associations and holds great potential for the avoidance of unintentional methane emissions.

References

[1] European Commission. Paris Agreement | Climate Action. Im Internet: https://ec.europa.eu/clima/policies/international/negotiations/paris_en; Stand: 08.04.2021

[2] Myhre G, Shindell D, Bréon F-M et al. Anthropogenic and Natural Radiative Forcing. In: Stocker TF, Qin D, Plattner G-K, Tignor MMB, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM, Hrsg. Climate change 2013. The physical science basis; Working Group I contribution to the fifth assessmnt report of the Intergovernmental Panel on Climate Change. New York NY: Cambridge Univ. Press; 2013: 659–740

[3] Bakkaloglu S, Lowry D, Fisher RE et al. Quantification of methane emissions from UK biogas plants. Waste Manag 2021; 124: 82–93. doi:10.1016/j.wasman.2021.01.011

[4] Scheutz C, Fredenslund AM. Total methane emission rates and losses from 23 biogas plants. Waste Manag 2019; 97: 38–46. doi:10.1016/j.wasman.2019.07.029

[5] Liebetrau J, Reinelt T, Clemens J et al. Analysis of greenhouse gas emissions from 10 biogas plants within the agricultural sector. Water science and technology 2013; 67: 1370–1379. doi:10.2166/wst.2013.005

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