

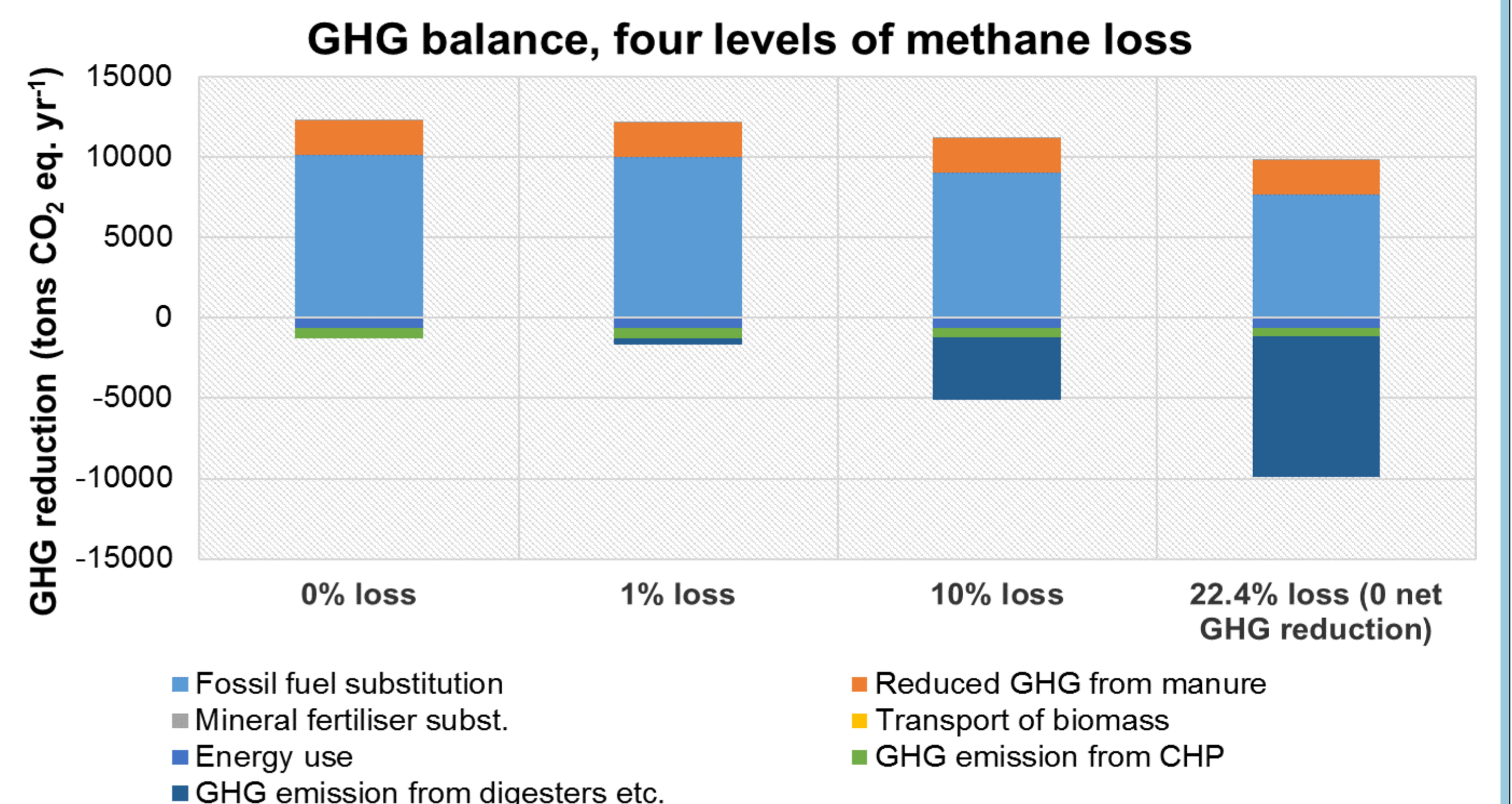
Remote sensing quantification of methane emissions from 13 biogas plants in Denmark and Germany

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Background

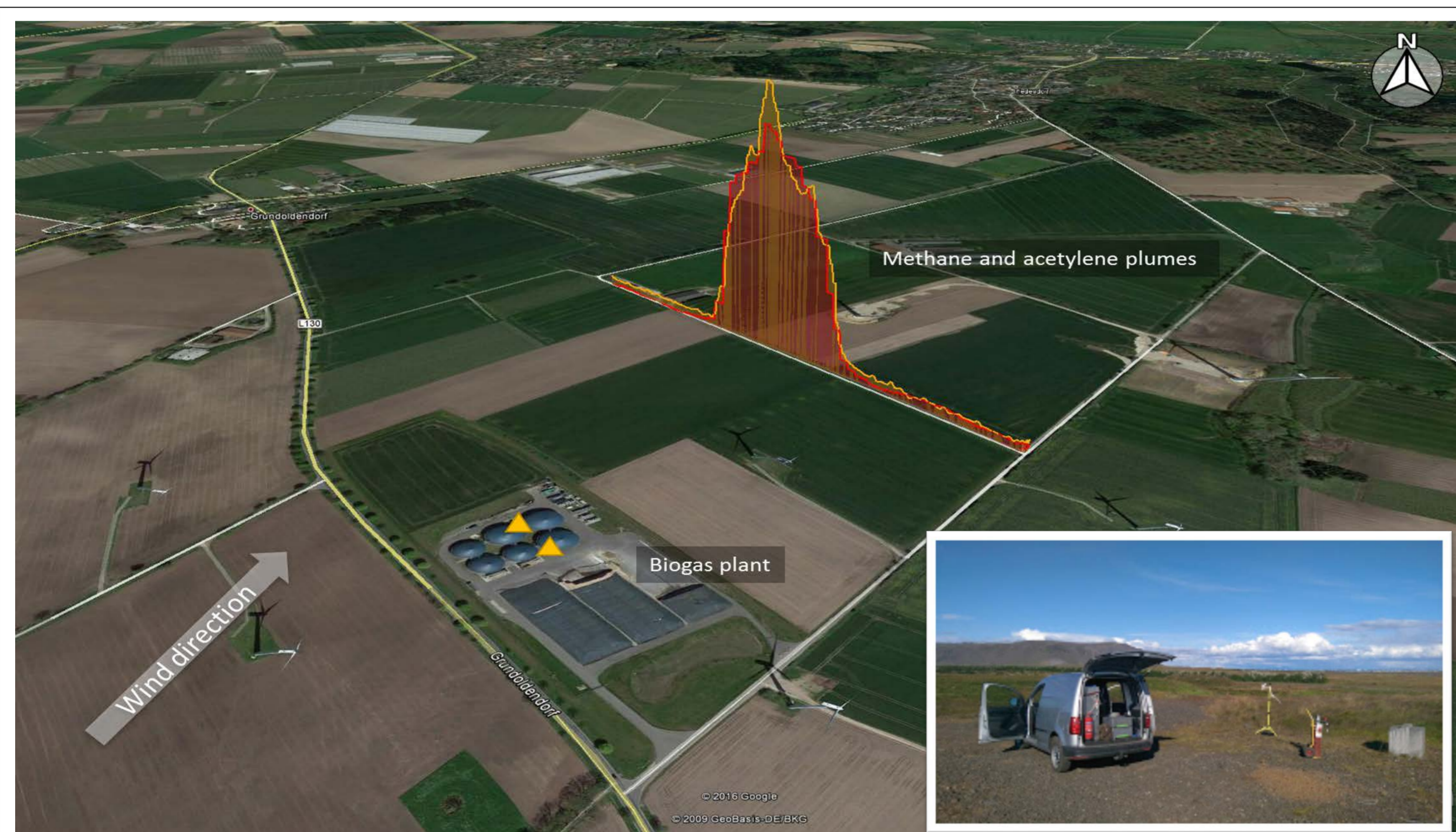
The production of biogas may provide several benefits concerning mitigation of greenhouse gas (GHG) emissions including fossil fuel substitution and reduction of GHG emissions from manure storage. Biogas is also a fuel that can be utilised for a variety of energy purposes, and can improve energy security. Due to the high global warming potential of methane (CH₄), emission of this gas from biogas production facilities may significantly reduce the GHG mitigation effect, and CH₄ loss should be minimised. Relatively few quantitative studies have been reported on the total loss of CH₄ from biogas production.

We used a ground-based remote sensing method often referred to as the tracer gas dispersion (TGD) method to measure CH₄ emission from 13 biogas plants. The two overall purposes of this work was to (1) test the TGD methods' applicability to determine CH₄ emission from biogas plants and (2) to assess CH₄ loss from biogas plants of various types and sizes.



GHG reductions and emissions at different levels of methane loss for a single biogas plant

Calculation example: manure based biogas plant with combined heat and power biogas utilisation. Calculation method: Fredenslund, A. M., Kjær, T., 2013. Development of a biogas planning tool for project owners. Paper presented at Sardinia 2013 – 14th International Waste Management and Landfill Symposium, S. Margherita di Pula (Ca) Italy



Main picture: measurement example – TGD measurement. The height of the red curve is proportional to the measured concentration of CH₄ above background level, whereas the height of the yellow curve is proportional to measured concentration of tracer gas (C₂H₂). Yellow triangles denote locations of tracer gas release. Insert: mobile analytical platform and tracer gas release system used for TGD measurements.

Tracer gas dispersion method

TGD relies on a continuous release of a gaseous tracer combined with cross-plume measurements of tracer and target gas concentrations. To ensure mixing of target and tracer gases, measurement distances are preferably >500 m from the source, whereby the used instrumentation to measure gas concentration needs to be precise (precision < 1 ppb)

In this study, a cavity ring down spectrometer was used to measure concentrations of CH₄ and tracer gases. The tracer gas used was acetylene (C₂H₂)

CH₄ emission in kg CH₄ h⁻¹ (E_{CH₄}):

$$E_{CH_4} = Q_{tracer} \cdot \frac{\int_{Plume\ end\ 1}^{Plume\ end\ 2} C_{CH_4} dx}{\int_{Plume\ end\ 1}^{Plume\ end\ 2} C_{tracer} dx} \cdot \frac{MW_{CH_4}}{MW_{tracer}}$$

Q_{tracer}: tracer release rate (kg h⁻¹), C: concentrations above background level (ppb), MW: molecular weight (g mol⁻¹)

Results

CH₄ emissions were measured from 11 Danish and two German biogas plants. At 10 of the plants, measurements were performed on several days, whereby daily variation in emissions could be monitored. The biogas plants varied with regards to size (gas production between 64 and 1491 kg CH₄ h⁻¹), substrates (manure, wastes, sludge, energy crops) and energy utilisation (combined heat and power, upgrade to bio-methane).

Measured emission rates varied between 1.3 and 25.5 kg CH₄ h⁻¹ for each measurement campaign, whereas CH₄ losses (defined as measured emission/gas production) varied between 0.3 and 21.0%. The weighed average loss (sum of emission/sum of production) was 1.7%. Our results suggest that it is possible to operate biogas plants with CH₄ losses that should be considered acceptable (below the 1% target set by the Danish Biogas Association), but losses varied between plants. The TGD method was found applicable to determine total CH₄ emission from biogas plants, and may be useful to combine with leak detection to find mitigation options.

