Methane measurements

Report by Deutsche Umwelthilfe

Initial field tests on various methane emission sources illustrate leakages and highlight the need for methane reduction measures.

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1. Backround

Methane (CH_4) is the second most important greenhouse gas after carbon dioxide (CO_2) and has more than 80 times more of an impact on the climate than CO_2 over a period of 20 years. Overall, man-made methane in the atmosphere today contributes to a gross temperature increase of around 0.5 degrees Celsius (Intergovernmental Panel on Climate Change (IPCC)).[1] Methane also contributes to the formation of ground-level ozone (O_3), which poses a risk to human health. The European Environment Agency (EEA) estimates 3,300 premature deaths in Germany in 2021 due to ozone concentrations above 70 µ/m3.[2] Ozone also damages biodiversity and reduces agricultural yields. Measures to reduce methane emissions therefore contribute to the protection of human health and ecosystems as well as to climate protection. As methane is a short-lived greenhouse gas that only has a half-life of around 12 years in the atmosphere, measures to reduce methane emissions can bring particularly rapid results. According to the Global Methane Assessment (GMA)[3] of the United Nations Environment Programme (UNEP), limiting the temperature increase to a maximum of 1.5 °C would require a 45 % reduction in global anthropogenic, i.e. man-made, methane emissions in all sectors by 2030. This would prevent a further global temperature rise of 0.3 °C by 2040.

For some years now, efforts have been made at European and international level to put methane emissions on the agenda. For example, the USA and the EU launched the Global Methane Pledge in September 2021. With this declaration, over 100 countries, including Germany, have committed to reducing anthropogenic methane emissions by 30 per cent by 2030 compared to 2020. The adoption of the EU Methane Regulation this year is also the result of a growing awareness of the urgency of reducing methane emissions. The Methane Regulation imposes measurement and reporting obligations on companies that produce and transport fossil fuels in the EU. These obligations are gradually being extended to producers in third countries. The measurements presented here emphasise the necessity of this regulation and send a signal to the German government and the responsible authorities: Implementation must be swift and consistent. Furthermore, it is once again clear that equivalent obligations for biogas plant operators are urgently required. These are not covered by the Methane Ordinance.

Despite the increasing recording of methane emissions by satellite, it remains important to improve the data situation so that targeted mitigation measures can be taken. This also requires measurement data that can provide more precise data than satellites, and therefore more precise information about the methane sources. In particular, there is no database, let alone a monitoring mechanism, for the countless small methane sources such as landfills or biogas plants.

[1] IPCC (2021)
[2] EEA (2023)
[3] UNEP Global Methane Assessment (2021)

This report provides initial insights into a DUH measurement campaign that aims to contribute to a better understanding of the relevance of various methane sources. In addition to measurements on natural gas infrastructure, the focus is also on biogas plants.

1.1 Main sources of methane emissions

Methane escapes from various natural and anthropogenic sources. The three sectors of waste, energy and landscape are the largest anthropogenic sources of methane.

Anthropogenic sources

Agriculture

- **Livestock farming**: Cattle, sheep and other ruminants produce methane during digestion, which is released into the atmosphere via burping and faecal excretion. This is known as enteric fermentation.
- **Manure**: The decomposition of organic materials in slurry and manure also leads to methane emissions, especially if these are stored in anaerobic conditions.

Waste management

- **Organic waste** deposited in landfills decomposes anaerobically and produces methane. These emissions are significant as landfills contain a large amount of organic materials.
- **Wastewater treatment plants** are equipped with partially airtight tanks containing anaerobic microbes that work without oxygen to break down sewage sludge or solid waste, producing methane-rich biogas. The tanks can leak and allow methane to escape.

Energy industry

- **Natural gas:** Methane is the main component of natural gas. It escapes, primarily during extraction and fracking, but also during processing, storage and distribution, through leaks or incomplete combustion.
- **Crude oil**: Methane escapes during crude oil production and processing, through leaks and in the form of fugitive emissions from production fields and during incomplete combustion of associated gas.
- **Coal mining**: Coal mining releases methane that is bound in the coal deposits. This is referred to as mining methane.
- **Biogas**: The fermentation of biomass in biogas plants produces biogas, which consists mainly of methane. This methane then escapes through leaks or through biomass that has already undergone decomposition processes before being fed into the biogas plant.

- **Upstream chain emissions:** Methane can escape along the entire supply chain of fossil fuels. Upstream chain emissions include indirect emissions caused by infrastructure and/or necessary auxiliary energy, as well as direct emissions from the provision of energy sources.
- **Reservoirs**: When water is retained in reservoirs, organic material at the bottom can decompose under anaerobic conditions. Methane is released in the process.

Natural sources

- **Moors and wetlands**: These ecosystems produce methane through the anaerobic decomposition of organic material.
- **Permafrost thawing**: global warming can release the methane bound in permafrost, which can further exacerbate the problem.
- **Microbial processes**: In oceans and freshwater, certain microbes can produce methane through anaerobic decomposition of organic substances.

1.2 Status of the regulation of methane emissions

To date, there is no comprehensive plan to reduce methane emissions at national level. Methane emissions are also not part of the EU Emissions Trading Scheme, the market-based instrument that prices CO_2 emissions and is thus intended to lead to emission reductions.

The EU Methane Regulation, which regulates methane emissions in the energy sector, has been in force since August 2024. Previously, methane emissions from the extraction and transport of fossil fuels in Germany were subject to 'technical self-administration' based on the technical regulations of the German Technical and Scientific Association for Gas and Water (Deutscher Vereins des Gas- und Wasserfachs, DVGW). The Methane Regulation now obliges companies that extract and transport fossil fuels in the EU to carry out regular measurements according to defined criteria, prepare measurement reports and have these verified by independent test centres. They must also regularly check their plants for leaks and, if necessary, repair them within fixed deadlines. By February 2025, the federal government must designate authorities responsible for monitoring the new rules and ensure that they have the resources and skills required for the new tasks.
Biogas plants are not covered by the Methane Regulation. Operators of biogas plants are therefore not subject to the measurement and reporting obligations or the obligations to search for and repair leaks. The Immission Control Act (Technical Instructions on Air Quality Control) have recently included specifications for the reduction of methane emissions from biogas plants. However, these are aimed at the authorities, not the operators. The agricultural sector is also not covered by the regulation.

2. Measurement technology and method

2.1 Trace gas analyser

A portable measuring device from LI-COR is used for the measurements. The LI-COR LI-7810 $CH_4/CO_2/H_2O$ trace gas analyser provides methane measurements with an accuracy of 0.25 ppb (1σ, with 5-second averaging) at 2000 ppb CH_4 in dry air. The drift is less than 1 ppb per 24 hours. An integrated power supply enables measurements even in areas where there is no power supply.

LI-7810 Specifications	
Measurement Technique	OF-CEAS (Optical Feedback – Cavity Enhanced Absorption Spectroscopy)
Measurement Rate	1 sample per second (1 Hz)
Total Weight	10.5 kg (including batteries)
Case Dimensions	51 cm × 33 cm × 18 cm (L × W × H)
Operating Temperature Range	-25 °C to 45 °C (without solar load, under normal operating conditions)
Operating Humidity Range	0 to 85% RH (non-condensing, without solar load, under normal operating conditions)
Sample Line Humidity Range	0 to 99.9% non-condensing
Operating Pressure Range	70 to 110 kPa in Standard and Reduced Flow Rate Configurations 50 to 110 kPa in High Altitude Configuration
Connectivity	Ethernet and Wi-Fi
Power Consumption	Steady State Operation: 22 Watts at 25 °C without batteries charging Warmup: Up to 65 W without batteries charging; up to 100 W with batteries charging
Power Supply Requirements	Pins 1 and 5 (24 VDC Input): Minimum 6 A at 24 V Pins 3 and 4 (10.5 to 33 VDC Input): Minimum 14 A at 10.5 VDC; 6 A at 24 VDC
Battery Life	8 hours typical with 2 batteries

CH_4 Measurements	
Response Time (T10-T90)	all from 0 to 2 ppm ≤ 2 seconds in Standard Configuration ≤ 3 seconds in High Altitude Configuration
Range	0 to 100 ppm
Precision (1σ)	0.60 ppb at 2 ppm with 1 second averaging 0.25 ppb at 2 ppm with 5 second averaging
Maximum Drift	< 1 ppb per 24-hour period

CO_2 Measurements	
Range	0 to 10,000 ppm
Precision (1σ)	3.5 ppm at 400 ppm with 1 second averaging 1.5 ppm at 400 ppm with 5 second averaging

H_2O Measurements	
Range	0 to 60,000 ppm
Precision (1σ)	45 ppm at 10,000 ppm with 1 second averaging 20 ppm at 10,000 ppm with 5 second averaging

2.2 Measuring method

At the measurement location, the CH_4 background concentration in the ambient air is measured before and after the CH_4 measurement outside the gas plume of the emission source (see graphs of the CH_4 concentration curve in Chapter 3). The CH_4 background concentration measured on site is then subtracted from the CH_4 measured values so that only the CH_4 emissions from the source remain. The CH_4 background concentration is usually in the range of 2000 ppb. In addition, the weather conditions such as ambient temperature, wind strength and wind direction as well as the distance to the emission source are documented. Depending on accessibility and wind direction, measurements are then taken at the appropriate distance with the wind in the gas plume. The trace gas analyser draws in the air, analyses and records the gas concentration ratios. The concentration ratios can be viewed with a resolution of one heart (one data point per second) via the device's integrated display or via a terminal device connected via Wifi or Ethernet.

After the measurement, the recorded data is analysed and displayed graphically, see chapter 3.

3. Results

3.1 Biogas plants

Around 9,600 biogas plants in Germany currently supply an electrical output of a good 5,600 megawatts. In addition to the electrical output, 2.5 million households can be supplied with heat from the biogas plants. In 2021, this accounted for around 54 per cent of renewable energy from biomass. Crops such as maize, grasses, cereals, pulses and sugar beet are grown on around 1.57 million hectares of arable land and fed into the plants as biomass. In addition, there are residues such as slurry and manure as well as alternative energy crops, which, however, only make up a small proportion compared to the crops grown.[4]

In the biogas plant, the biomass fed in is decomposed by microbes in a fermenter in the absence of oxygen. This produces biogas, which mainly consists of methane and carbon dioxide. The biogas is collected and can then be used to generate energy, for example for heating or electricity generation. What remains is a nutrient-rich substance that can be used as fertiliser. In these processes, however, the volatile methane gas can escape at various points, e.g. through leaking valves and connections, leaking covers or when feeding already decomposed biomass, and enter the atmosphere unburnt.

To illustrate the problem of CH_4 emissions, five biogas plants were analysed in this series of measurements and the CH_4 concentration in the ambient air was measured. A significant increase compared to background levels was measured at all biogas plants.

[4] Bundesministerium für Ernährung und Landwirtschaft (2024)

Biogas plant 1

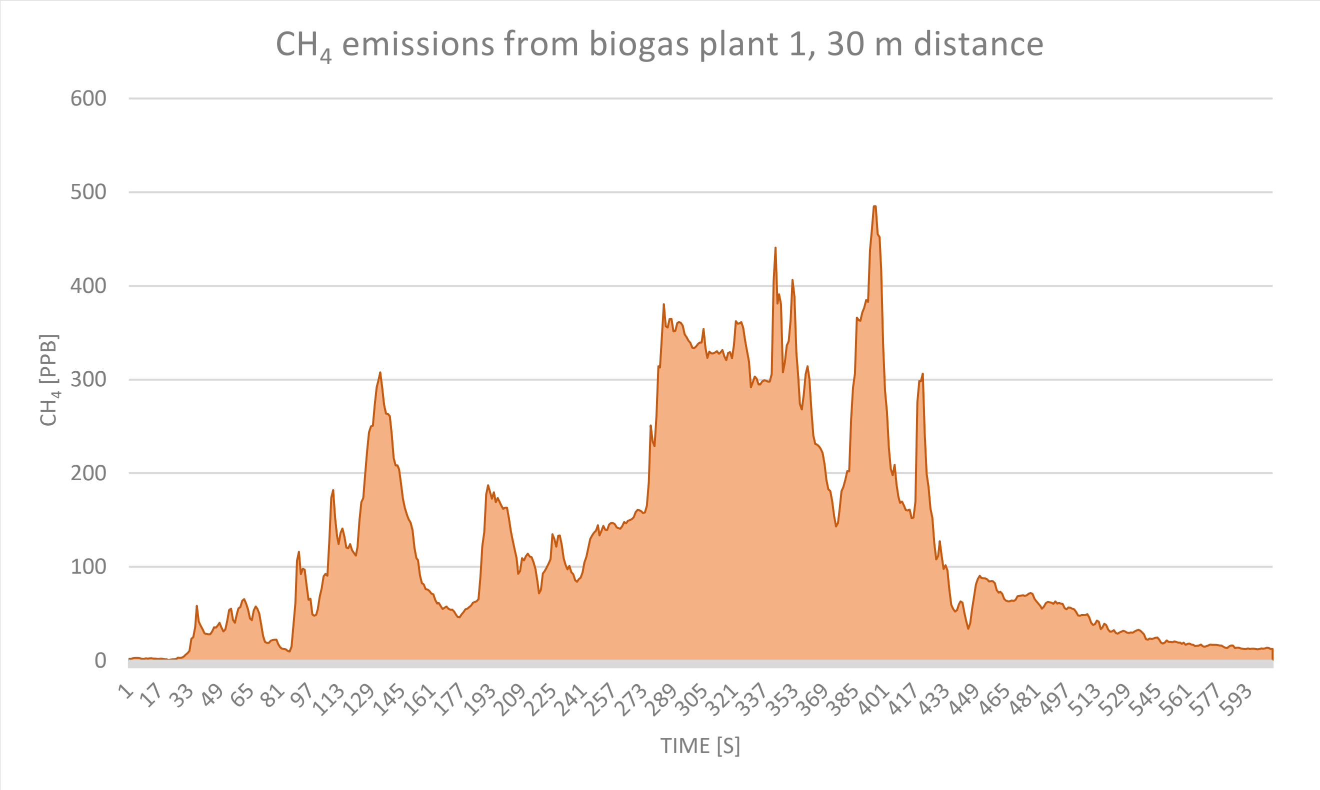

Figure 1 CH_4 emissions biogas plant 1

Approximate distance to the plant [m]	30
Weather conditions	cloudy, 19° Celsius, strong gusts from the southwest
CH_4 base concentration in the region [ppb]	2.025
Max. CH_4 concentration minus basic concentration [ppb]	485

Biogas plant 2

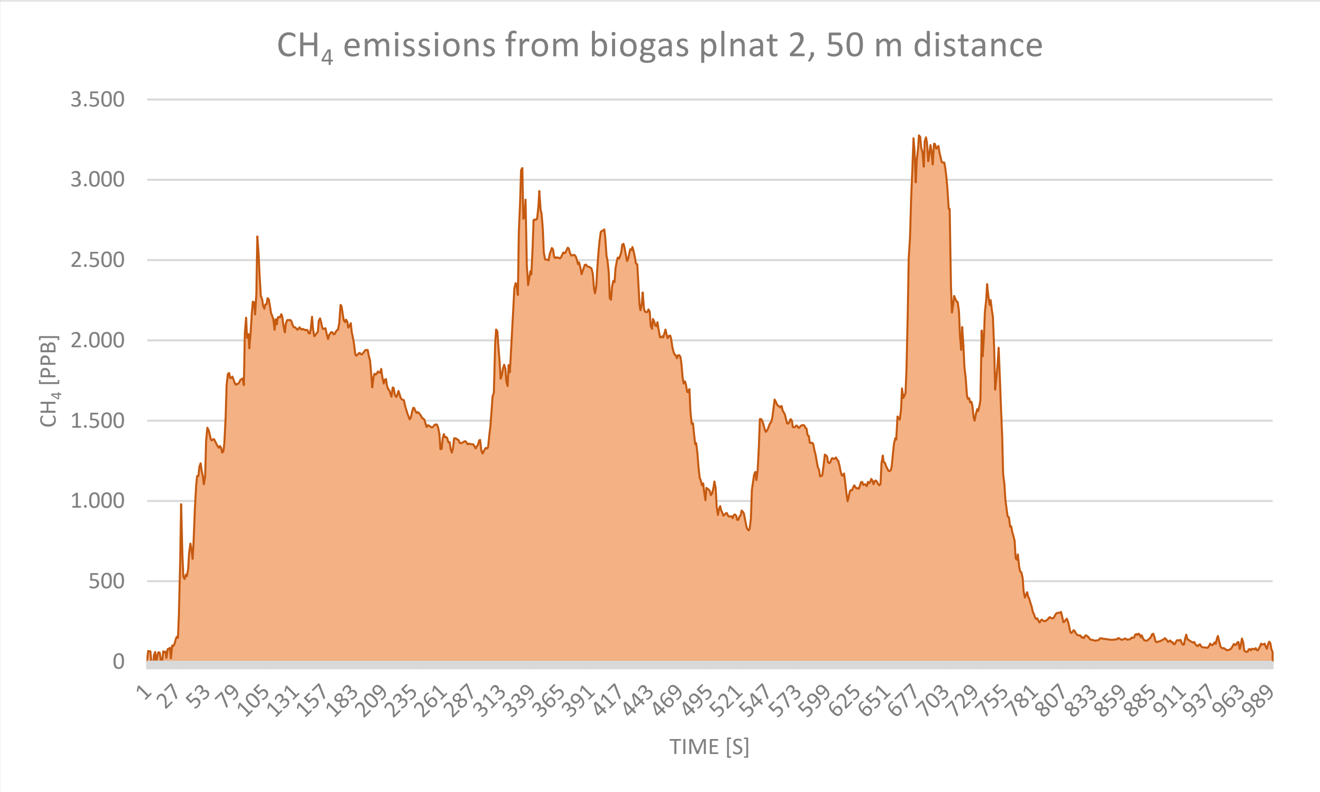

Figure 2 CH_4 emissions biogas plant 2

Approximate distance to the plant [m]	50
Weather conditions	Sunny, 18° Celsius, light easterly wind
CH_4 base concentration in the region [ppb]	2.220
Max. CH_4 concentration minus basic concentration [ppb]	3.267

Biogas plant 3

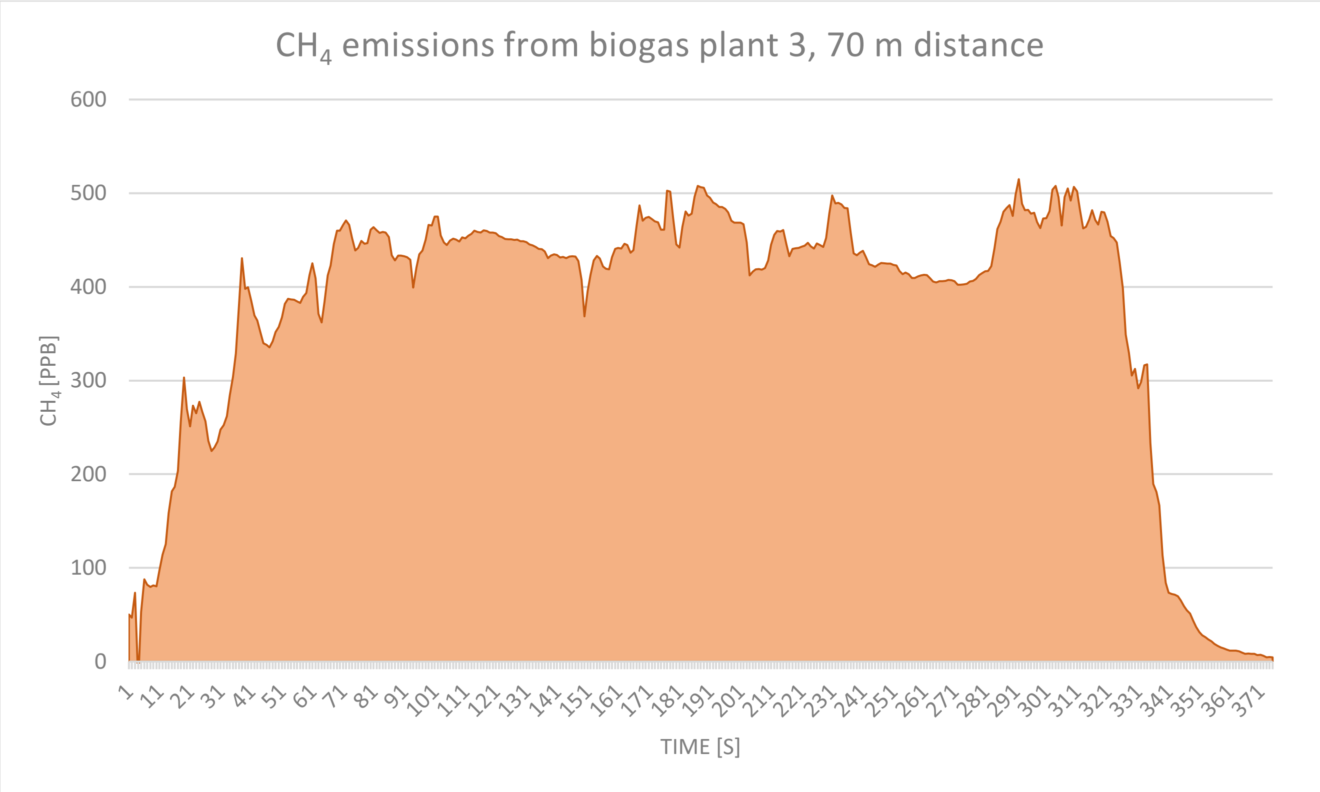

Figure 3 CH_4 emissions biogas plant 3

Approximate distance to the plant [m]	70
Weather conditions	Sunny, 20° Celsius, light easterly wind
CH_4 base concentration in the region [ppb]	2.160
Max. CH_4 concentration minus basic concentration [ppb]	515

Biogas plant 4

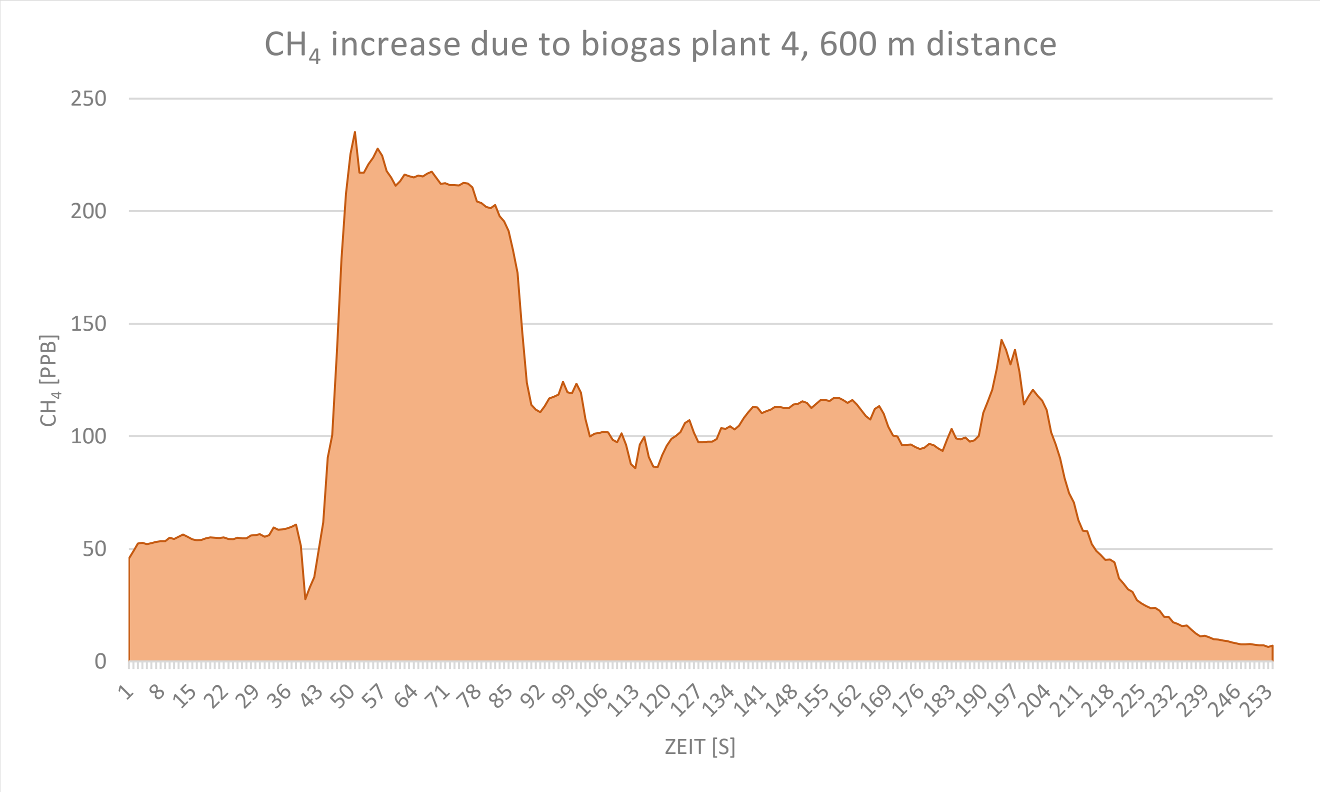

Figure 4 CH_4 emissions biogas plant 4

Approximate distance to the plant [m]	600
Weather conditions	Sunny, 20° Celsius, light easterly wind
CH_4 base concentration in the region [ppb]	2.160
Max. CH_4 concentration minus basic concentration [ppb]	235

Biogas plant 5

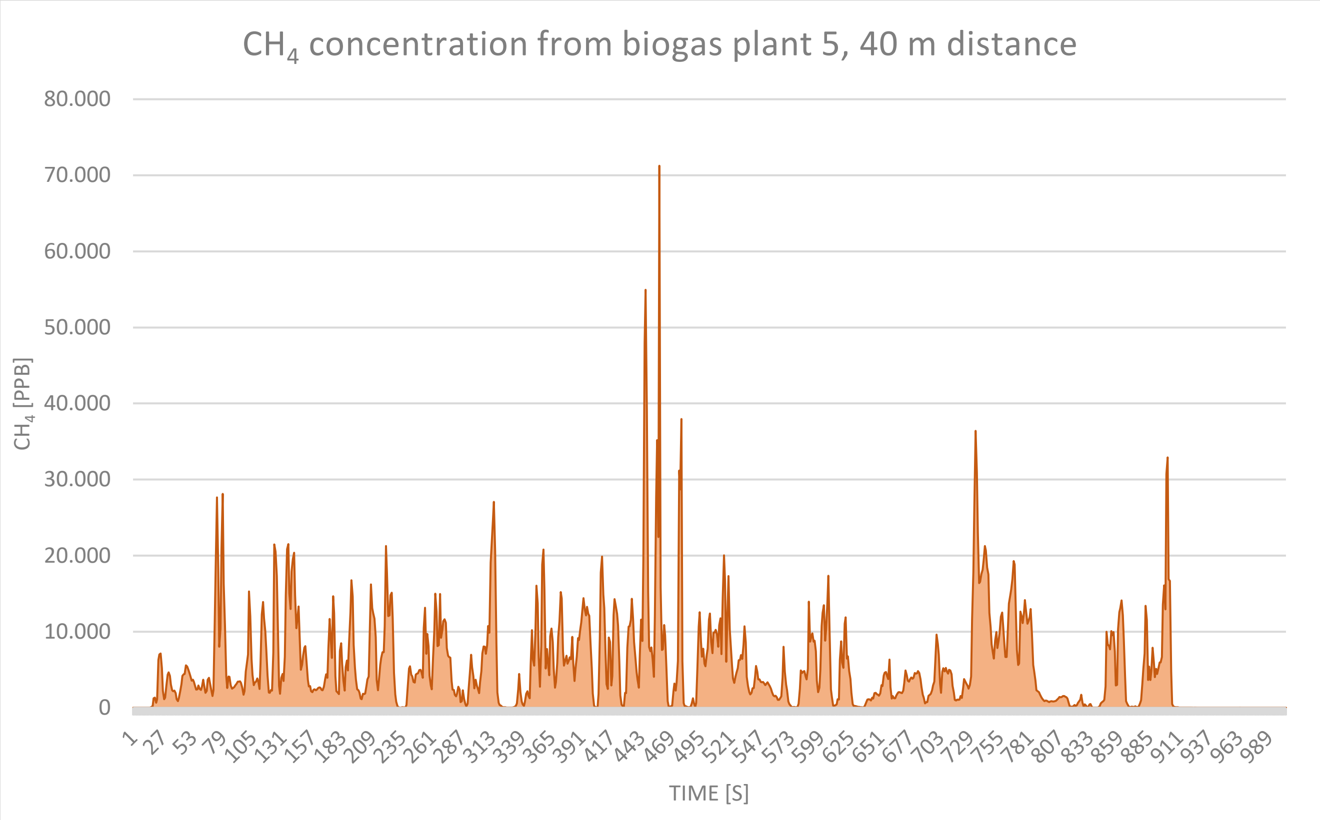

Figure 5 CH_4 emissions biogas plant 5

Approximate distance to the plant [m]	40
Weather conditions	Sunny, 21° Celsius, light easterly wind
CH_4 base concentration in the region [ppb]	2.150
Max. CH_4 concentration minus basic concentration [ppb]	71.254

As described above, the fermentation of biomass produces both CO_2 and CH_4. Figure 6 shows that the increase in CH_4 concentration is due to the decomposition processes of the biomass, as the CO_2 also increases with the CH_4. After fermentation, the CO_2 is separated and the purified CH_4 gas is discharged. The escaping CH_4 is not due to leaks after fermentation, but to leaks during fermentation.

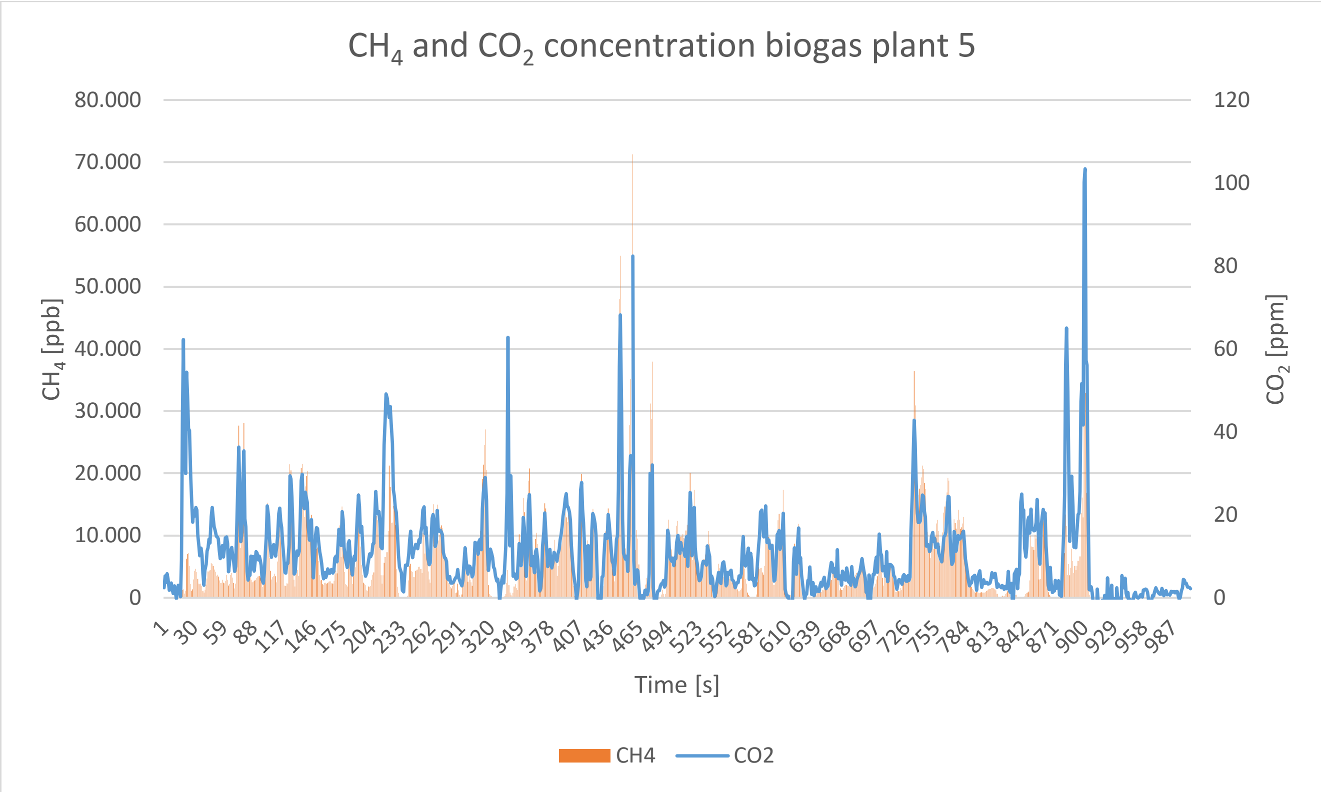

Figure 6 CH_4 and CO_2 concentration biogas plant 5

3.2 Gas compressor stations

The German gas supply network, which is over half a million kilometres long, is responsible for the supply of natural gas. Around 70 compressor stations are operated to ensure security of supply.[5] A gas compressor station has the task of increasing the pressure in the natural gas pipeline so that it can be transported through pipelines. These stations are crucial for a continuous and stable gas flow, especially over long distances. Compressors also help to compensate for pressure losses caused by friction and height differences in the pipelines. In addition to compression, such stations can also be used to monitor and control the gas flow and for quality assurance of the gas.

Leaks at gas compressor stations can cause natural gas to escape, most of which consists of CH_4 gas. To illustrate the problem of CH_4 leakage, the CH_4 concentration in the ambient air near a gas compressor station was measured in this series of measurements. A significant increase in the CH_4 concentration was measured at a distance of 30 metres.

So far, only one measurement has been carried out at a gas compressor station. Further measurements will follow.

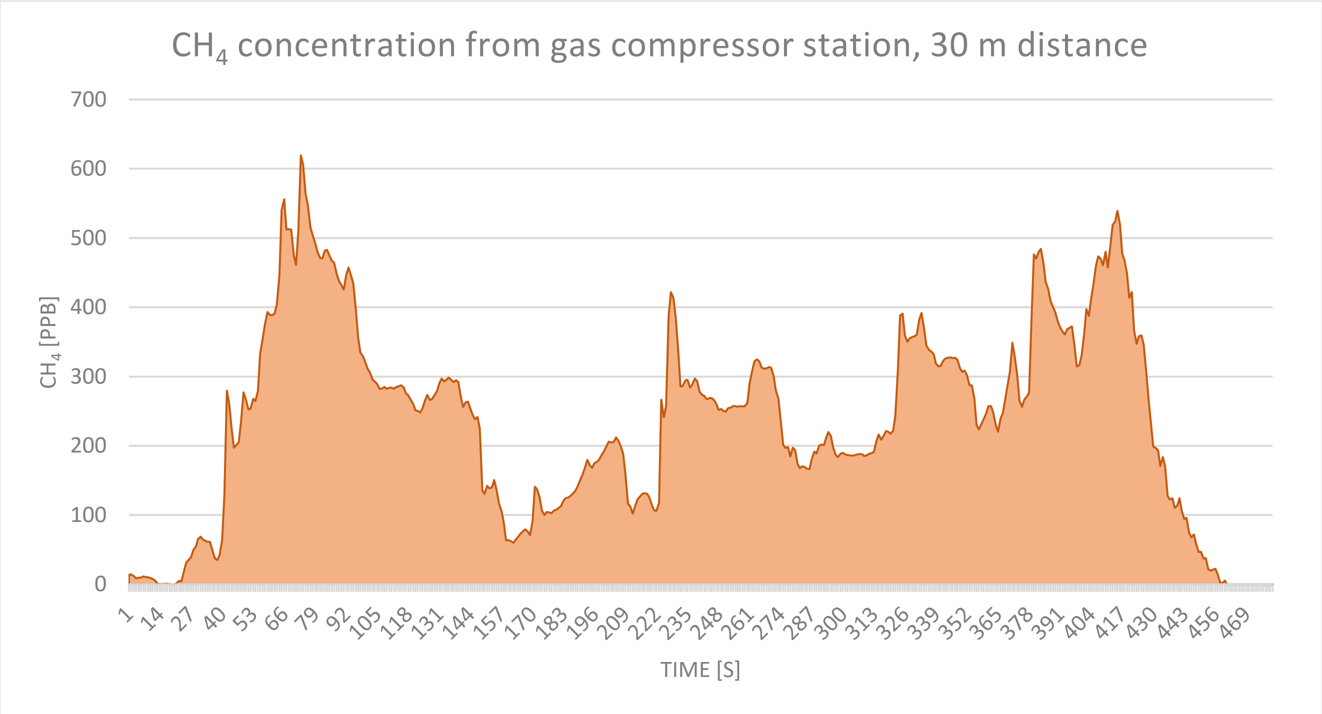

Figure 7 CH_4 emissions gas compressor station

Approximate distance to the station [m]	30
Weather conditions	Sunny, 22° Celsius, light easterly wind
CH_4 base concentration in the region [ppb]	2.150
Max. CH_4 concentration minus basic concentration [ppb]	619

[5] DVGW: Verdichterstationen als Antrieb der Gasversorgungsnetze (2019)

3.3 FSRU

A Floating Storage and Regasification Unit (FSRU) is a floating terminal used for the storage and regasification of liquefied natural gas (LNG). LNG tankers transport gas to the FSRU, which combines the functions of an LNG storage facility with the possibility of converting LNG back into gas form in order to feed it into the gas grid.

In Germany, such FSRUs are located in Brunsbüttel, Rügen, Stade and Wilhelmshaven. Leaks can occur during the unloading of the LNG ships as well as during the storage, regasification and transport of the gas in pipelines, where natural gas and therefore methane can escape. A measurement around one kilometre away from the FSRU in Brunsbüttel confirms the continuous escape of CH_4 gas. At the time of the measurement, no LNG ship was moored at the FSRU; regasification was only taking place at around a quarter of the possible capacity. Despite the reduced turnover without an adjacent LNG ship, a significant increase in the CH_4 concentration was measured at a distance of one kilometre.

So far, only one measurement has been carried out at an FSRU. Further measurements will follow.

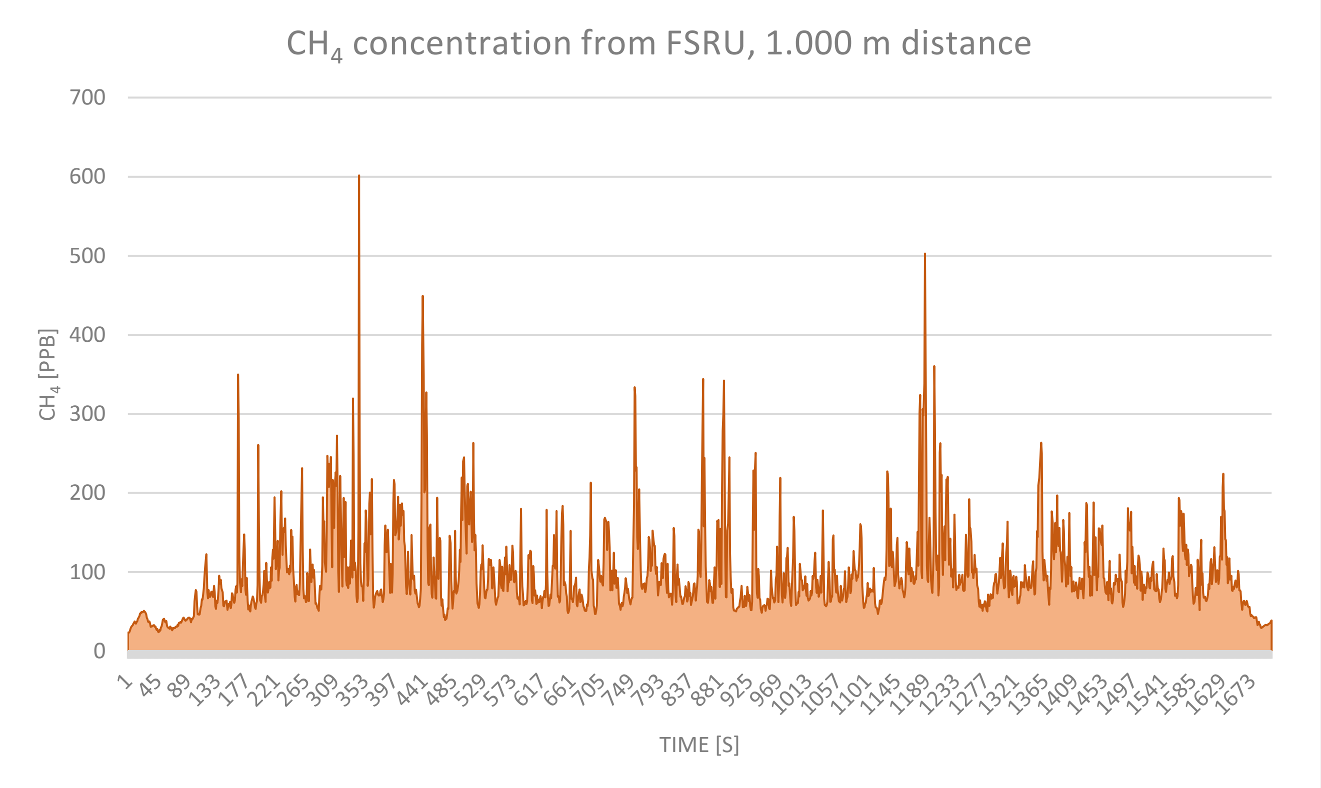

Figure 8 CH_4 emissions FSRU

Approximate distance to the ship[m]	1000
Weather conditions	cloudy, 18° Celsius, strong gusts from the southwest
CH_4 base concentration in the region [ppb]	2.040
Max. CH_4 concentration minus basic concentration [ppb]	602

In addition to the CH4 concentration, the following figure also shows the CO_2 concentration of the FSRU at a distance of approx. 1,000 metres. The CO_2 concentration hardly changes compared to the CH_4 concentration in Figure 6 (biogas plant 5). This indicates that the escaping CH_4 does not originate from a combustion process.

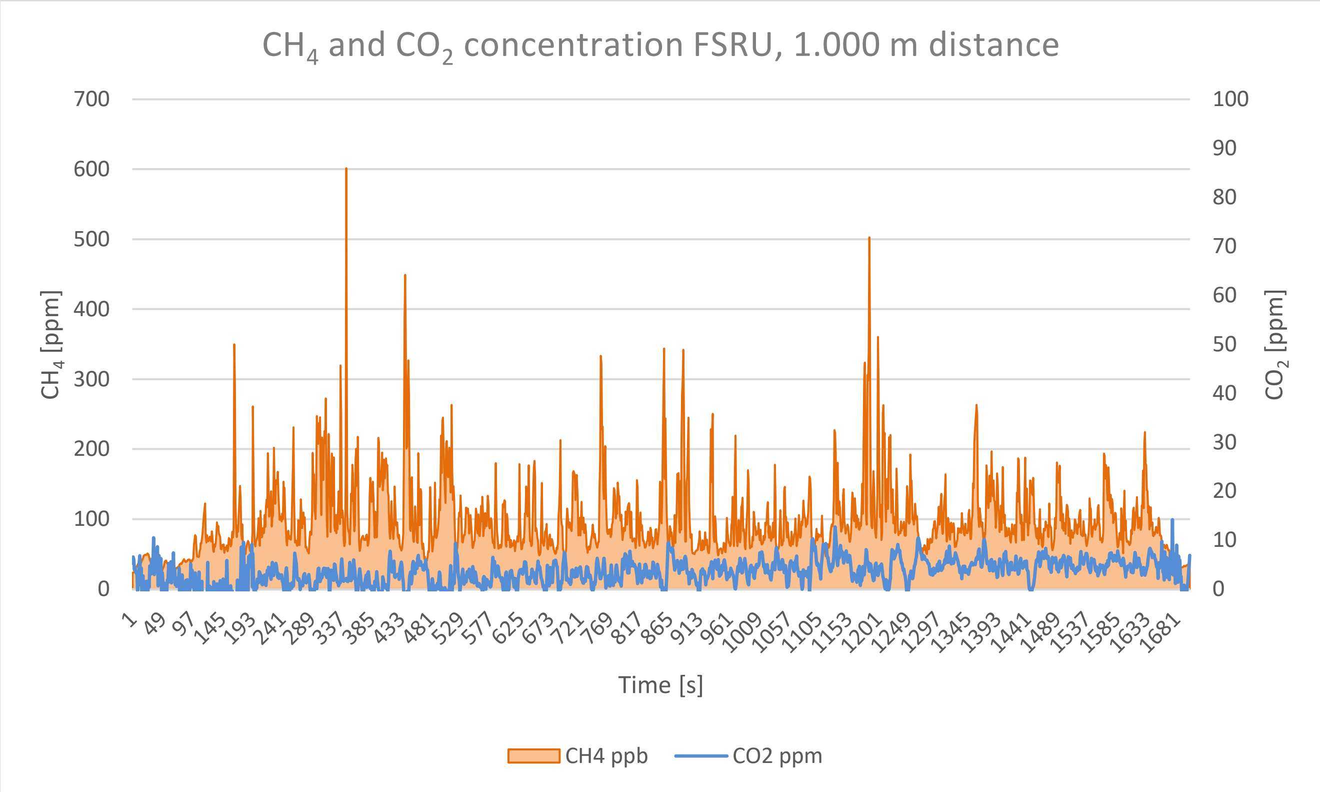

Figure 9 CH_4 and CO_2 concentration FSRU

4. Conclusions

The level of methane concentration in the atmosphere has a major impact on global warming and is second only to carbon dioxide. As methane is a relatively short-lived greenhouse gas with a half-life of around 12 years in the atmosphere, mitigation measures offer great potential to slow the increase in global warming. The risks of methane and the potential of mitigation measures are now internationally recognised, but concrete measures are largely lacking.

The measurements presented here show that methane is still escaping uncontrolled from various sources. A significant increase in methane concentrations in the ambient air was measured at all randomly selected plants, even at greater distances of up to one kilometre from the emitter.

There is an urgent need for action and the federal government has a responsibility to take action.

1. The Federal Government must ensure that the Methane Regulation is implemented quickly. The Federal Government must appoint the responsible authorities by February 2025. The authorities must then fulfil their new tasks. These tasks are extensive and technically demanding. If necessary, the authorities must be provided with additional resources and staff must be trained. Strong coordination by the Federal Environment Agency (Umweltbundesamt) is needed to ensure efficient and competent implementation.

2. Maintenance, inspections and measurements must also become mandatory for biogas plants in order to counteract the uncontrolled escape of methane.

3. The Federal Government must organise measurement campaigns at various emission sources (biogas plants, compressor stations, LNG import terminals, production sites). This is the only way it can recognise the extent of the problem and react appropriately.

4. The measures listed above must be embedded in a methane reduction plan. The Federal Government must define a methane reduction target that is compatible with the Paris Agreement and formulate and implement corresponding reduction measures.

Status: 24 October 2024

Methane Matters Supported by Global Methane Hub

Deutsche Umwelthilfe

Deutsche Umwelthilfe e.V.

Federal office Radolfzell
Fritz-Reichle-Ring 4
78315 Radolfzell
fon: 07732 9995-0

Federal office Berlin
Hackescher Markt 4
Entrance: Neue Promenade 3
10178 Berlin
fon: 030 2400867-0

Methane measurement project

Simon Annen
Senior Expert | Deputy Head of the Emissions Control Institute
Hackescher Markt 4
10178 Berlin

Project manager

Dr. Axel Friedrich
fon: +49 152 29483857
email: axel.friedrich.berlin@gmail.com

Contact person

Dorothee Saar
Head of transport and air quality
Hackescher Markt 4
10178 Berlin
fon: +49 30 2400867-72
email: saar@duh.de

www.duh.de **info@duh.de** **umwelthilfe** Wir halten Sie auf dem Laufenden: **www.duh.de/newsletter-abo**