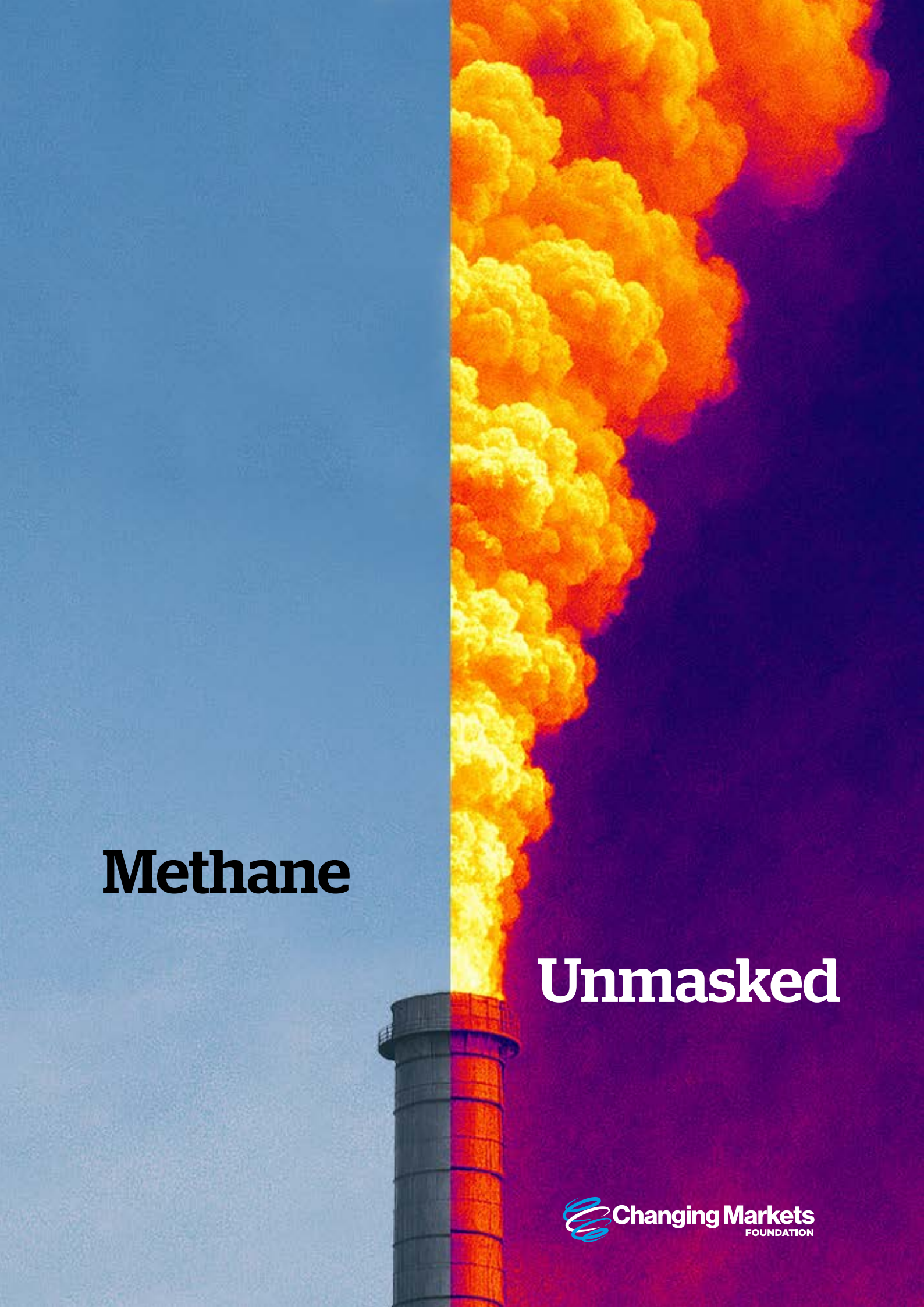

Methane Unmasked

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Changing Markets Foundation - Methane Unmasked

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Introduction

Methane is around 80 times more potent than carbon dioxide (CO2) in the short term. Urgent methane emissions reductions are critical to keeping the world within the 1.5°C warming trajectory. Atmospheric methane levels are rising continuously, with an average of 1,930 parts per billion (ppb) in 2024.[1]

According to the UN Environment Programme's Global Methane Assessment, global methane emissions must fall by 40-45% by 2030 to meet the 1.5C goal.[2] Agriculture is the most significant contributor to human-made methane emissions, contributing up to 40%, the majority (around 80%) from meat and dairy production.[3] In 2024, climate experts concluded that global greenhouse gas emissions from livestock must be cut by 50% by 2030 to align with the Paris Agreement. Achieving this requires significant reductions in the production and consumption of meat and dairy.[4]

Biogas is often promoted as a solution to reducing agricultural methane emissions.[5] The theory is that by capturing methane from decomposing organic waste, such as manure, it can be prevented from entering the atmosphere. Instead, it is upgraded into a fuel known as biomethane that can be used in the same way as fossil gas. Because biogas derives from organic waste and crops rather than fossil sources, it is considered as a form of renewable, low-carbon energy.

Meat and dairy companies are among the leading proponents of biogas. One example is the dairy giant Arla, which sees the use of manure for biogas as good for the climate and business profitability; it promotes biogas as 'climate gold' and incentivises its farmers to produce it (see Annex 2 for more information).[6] Arla played a major role in developing one of the biogas plants we inspected.[A]

A A more detailed summary with further background on Arla and its biogas claims is available at the end of this document (Annex 2). For an in-depth analysis, see Changing Markets and Greenpeace Nordic (2025) Dairytales: Arla's smokescreen for its lack of climate action. www.changingmarkets.org/report/dairytales-arlas-smokescreen-for-its-lack-of-climate-action

Biogas in Denmark

Denmark's per capita biogas production is among the highest in Europe. Biogas took off in the country in 2012 following the introduction of a subsidy scheme. Of the four types of biogas processing (agricultural, sewage, industrial and landfill), agricultural plants constituted approximately 85% of Denmark's biogas production in 2022. These plants use animal manure as the major input (around 75%), and this is likely to increase further with regulations in place to reduce the use of energy crops.[8] In 2023, biogas-derived biomethane accounted for about 11% of Denmark's total gas consumption, with projections suggesting it could supply 30–40% by 2030.[7]

In 2023, Denmark introduced new regulations to address methane leaks at biogas plants, which require an annual third-party leak detection, reported to the Danish Energy Agency, and the implementation of a self-monitoring programme.[8]

Measuring and visualising methane leakages from biogas production

Methane leakage from biogas production can occur throughout the process, from manure collection and storage, to transport, to digestion and upgrading. A 2022 study by researchers at Imperial College London found that globally biogas and biomethane plants may leak up to twice as much methane as previously estimated, with emissions occurring at various stages of the supply chain.[9]

A 2023 study in Denmark reported average methane leakage from biogas plants to be approximately 2.5% of total gas production, though emissions varied widely among plants, from as low as 0.3% to as high as 40%. The study identified persistent problem areas, including pressure relief valves and uncovered digestate storage tanks. It found that even modest methane leaks can significantly reduce or entirely negate the climate benefits of biogas.[10] Denmark's Energy Agency states that *'methane emissions losses should not exceed 1%'*.[11] More broadly, the industry itself has identified leakages as a concern for efficiency, greenhouse gas pollution, and health and safety.[12]

To investigate and visualise the issue of leakages further, Changing Markets Foundation and Deutsche Umwelthilfe (DUH) inspected two biogas plants in Denmark, which both have connections to the country's biggest dairy cooperative, Arla. Working with a thermo-imaging expert, the team used industry-standard inspection instruments: a specialised optical gas imaging (OGI) camera to pinpoint sources of methane and document evidence of these emissions, and a trace gas analyser to detect and measure potential methane leakages.

We inspected two biogas plants. At the first, we recorded significant methane leakage, identified its source, and traced additional methane emissions to a connected processing facility. At the second, we detected alarmingly high methane concentration levels but were unable to pinpoint the exact source.

Our findings reinforce existing evidence of the systemic risks posed by methane leakages in biogas production. By providing visual documentation, we were able to reveal what is typically hidden and enhance understanding of the potential significant climate impact of methane emissions from agriculture.

B Since 2025, crop use for biogas been reduced to 4% in Denmark, and the use of maize (corn) for biogas is already prohibited, with other crop use to be reduced further in the longer term. For more information see the Danish Energy Agency: www.ens.dk/en/energy-sources/biogas-denmark

Main findings

Nature Energy (Shell) biogas plant, Videbæk

The Nature Energy biogas plant in Denmark's Videbæk region is one of the country's largest facilities. Arla developed the plant in partnership with the former biogas company Xergi and Nature Energy, and promoted it as a flagship initiative to reduce its emissions.[13] In 2017, the company presented the plant as a step toward 'carbon-neutral' production, claiming it created a *'fully closed loop'* by cutting waste and reducing reliance on fossil fuels, describing it as *'revolutionary in helping fuel a greener future'*.[14]

When the plant opened, 90 local farmers were reported to be supplying slurry (from cattle, pigs and mink) to the plant several times a week[15] with Arla providing other biomass types, such as leftovers from the production of whey.[16] Arla owned a 5–10% stake in the plant until 2023[17] when Nature Energy was acquired by Shell.[18] The fossil fuel giant's acquisition of Nature Energy has drawn scrutiny, with investigations suggesting it may be exploiting an EU green-energy subsidy loophole.[19] [C]

Although Shell now fully owns the company, Nature Energy retains its original branding, under which it positions itself as a market leader in biogas. It is one of the largest producers in Europe, owning and operating 13 biogas plants in Denmark, one in the Netherlands and one in France, with more in the pipeline.[20]

Freedom of information requests

As part of this investigation, and to learn more about the feedstocks the company processes, Greenpeace Denmark submitted a freedom of information request about Nature Energy Videbæk. The request to Denmark's Energy Agency was made in May 2025, with the results received in mid-August 2025. They included the following information:

- Multiple fugitive leaks were recorded at Nature Energy Videbæk in 2023 and 2024 in inspections conducted by the Danish Gas Technical Centre (DGC) and submitted to the Danish Energy Agency. In 2023, three distinct leaks were identified, two of which were considered 'significant'. In 2024, inspections found six leaks, including one major leak, although in both years the methane slip[D] remained below the regulatory limit of 1% (.02% and .03%, respectively).

- The Videbæk plant received a 'partially compliant' certification under the REDcert-EU scheme in 2023. Several areas of concern were identified:

  - Systematic failures in feedstock verification' - Staff in the purchasing and finance teams were not fully trained to conduct essential checks to reliably verify the origin and sustainability of materials processed by the plant.

  - 'Major feedstock misclassification' - A supply chain discrepancy led to a significant amount of residue being wrongly classified as sustainable, compromising the integrity of the plant's mass balance system and greenhouse gas calculations.

  - 'Flawed sustainability documentation' - As a result of the misclassification, official proofs of sustainability for biomethane were issued using incorrect information.

However, not all requested information was received. A query about the feedstock used by the Videbæk plant was refused after Nature Energy asked the Danish Energy Agency to withhold it claiming 'business competitiveness'. After Greenpeace pressed for disclosure, the information was released in a heavily redacted form, preventing determination of the amount or origin of manure entering the facility.

The investigation

Our inspection of the Videbæk plant took place over two days: 13 May 2025 at around 16:20, lasting about one hour, and 14 May 2025 at 10:38, for approximately 20 minutes.

As a baseline, the background level of the methane concentration around the plant measured during the inspection was 2,077 ppb.[E] On the first day, the gas analyser detected peaks up to 3,500 ppb of methane leakage for the duration of the inspection, with two peaks of more than 5,000 ppb, well over double the baseline.

C Under current rules, companies with a strong connection to a sustainability project in another country can be exempted from certain trading requirements and still qualify for subsidies. In this case, a British/Dutch company owns Denmark-based Nature Energy, allowing it to bypass trading rules while benefiting from subsidies tied to 'green' projects, such as biogas.

D This is usually a small, expected and constant emission of methane from a specific part of the plant, namely the upgrading unit that separates methane (CH4) from carbon dioxide (C2O).

E To take the measurement, the gas analyser was used in the area surrounding the plant to create a baseline.

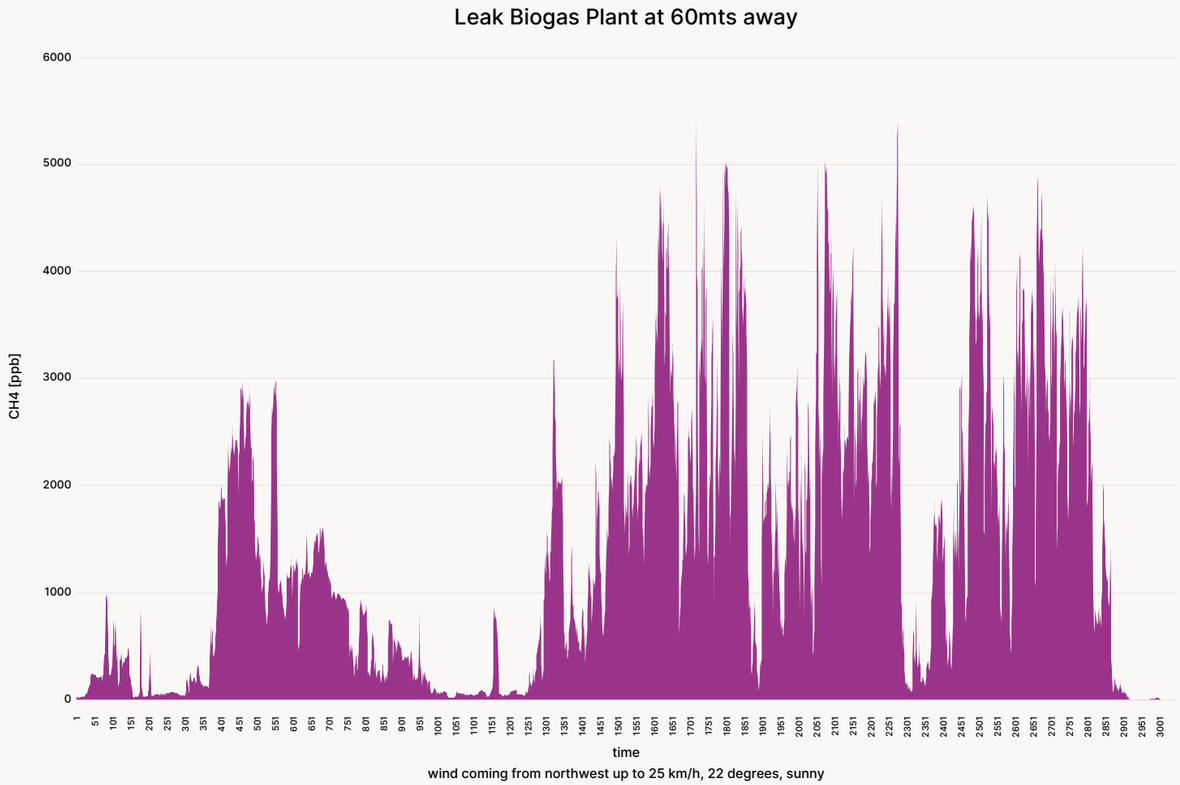
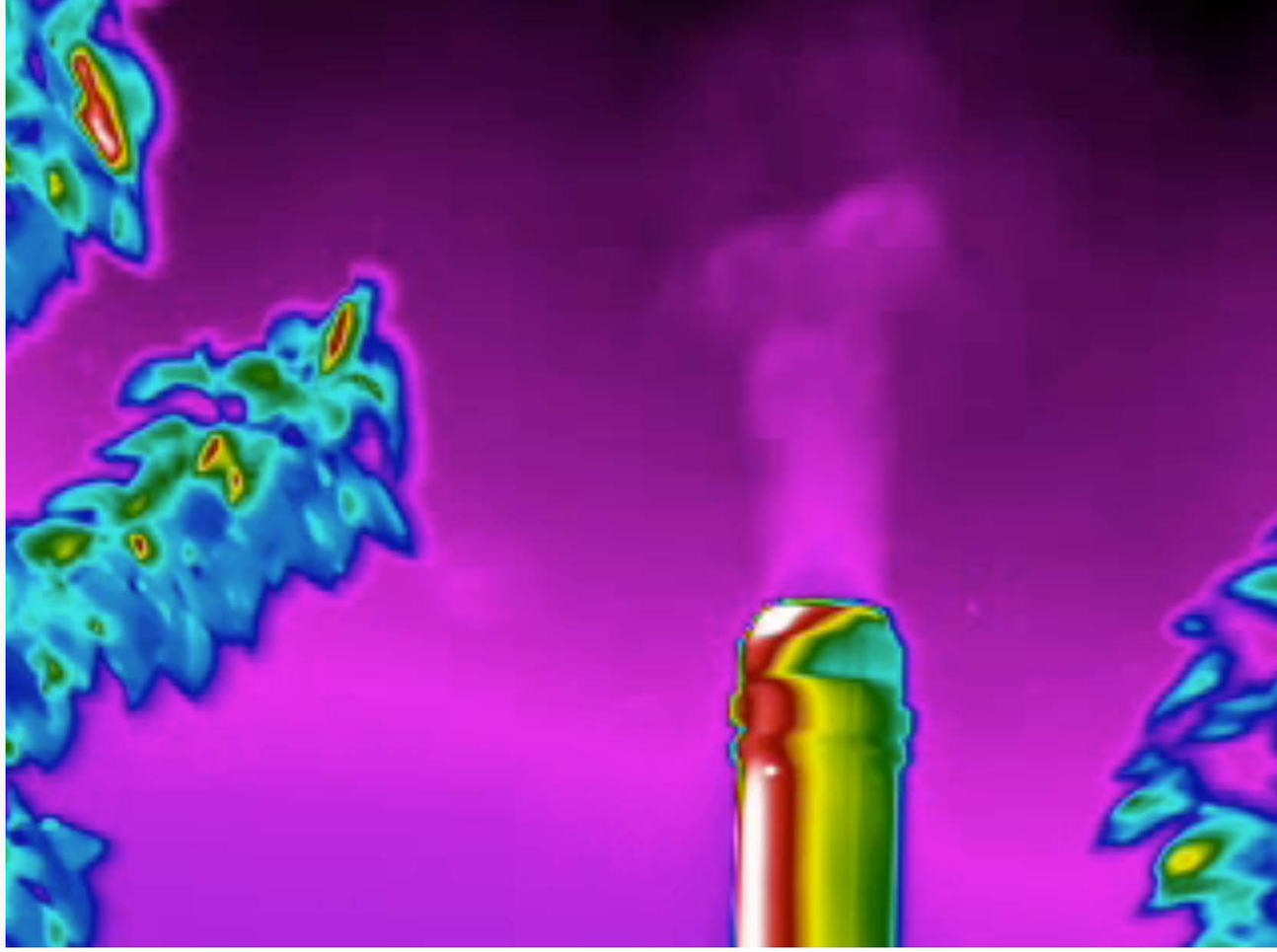


Figure 1: Methane concentration values for the Nature Energy Videbæk biogas plant recorded on 13 May 2025



Source of methane release identified at Nature Energy, Videbæk

The OGI camera was also able to identify the source of the leak, recording significant amounts of methane being released via a stack connected to the compressor unit.[F]

On the second day, the OGI camera again detected significant amounts of methane being released through the same stack. The fact that we detected methane releases on more than one day and at different times of the day means it is likely to be what is known as an 'intentional release'. In other words, it is unlikely to have been an emergency incident but a regular occurrence, possibly with the knowledge of the company.[G]

Together, the camera and gas analyser provide a cohesive picture of the methane emissions and their source at the Videbæk plant. The data from the gas analyser provides evidence of a concentration of methane close to the facility, and the OGI camera documents an emission source.

F Because biogas at atmospheric pressure has very low energy density, it is impractical to store or transport in its raw form. Compression increases its pressure and energy density, enabling storage in cylinders, injection into pipelines, or use as vehicle fuel. See www.abc-compressors.com/en/noticiaseventos/compressors-for-biogas-plants.

G It seems highly likely that the methane emissions are a mix of leakage and intentional venting (i.e. known to the operator). Both raise serious questions.

Arla's Arinco processing plant

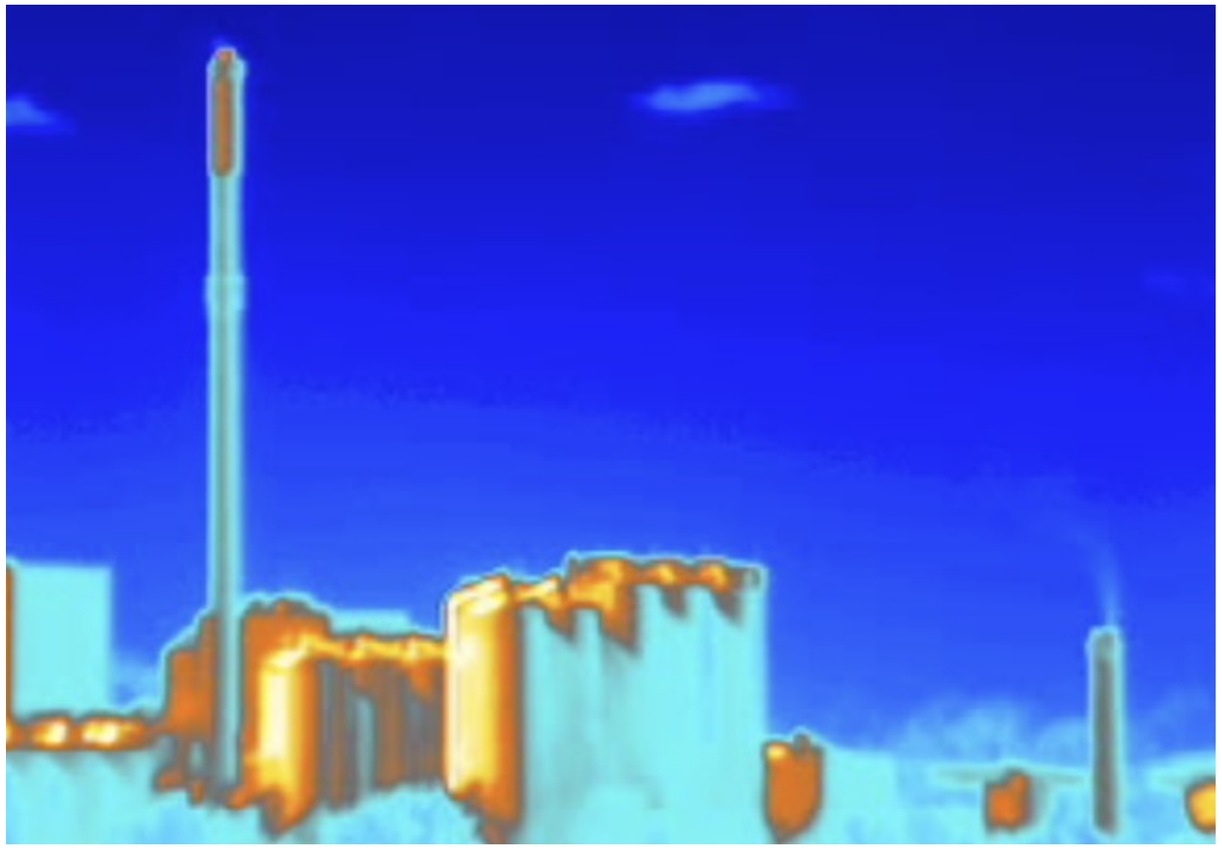
Arla's Arinco production facility lies 950 metres away from the Nature Energy Videbæk biogas plant.[H] When Nature Energy Videbæk first opened in 2019, with reports that the plant would provide Arinco with its energy needs through a pipeline directly connecting the facilities.[21] In 2024, Arla opened a new biogas storage unit for Arinco and two more facilities.[22]

As the Arinco facility is so close to the Videbæk plant, we incorporated an impromptu inspection of the site into our research. On 14 May at around 11:10, we visited the Arinco facility for approximately 20 minutes. During that time, the OGI camera captured methane being released from an unidentified chimney. However, our distance from the facility meant it was not possible to measure the concentration of the release at this time.[I]

H The Arinco plant produces milk powder and related products and is 100% owned by Arla Foods amba. See www.arlafoodsingredients.com/about/contact/locations/arinco

I As the visit to Arinco was additional to our investigation of the Videbæk biogas plant, we did not have a clear picture of the production process or whether venting was necessary. We were also too far away to use the gas trace analyser to measure the concentration of methane being expelled.

Methane being released through a chimney at Arla's Arinco processing plant



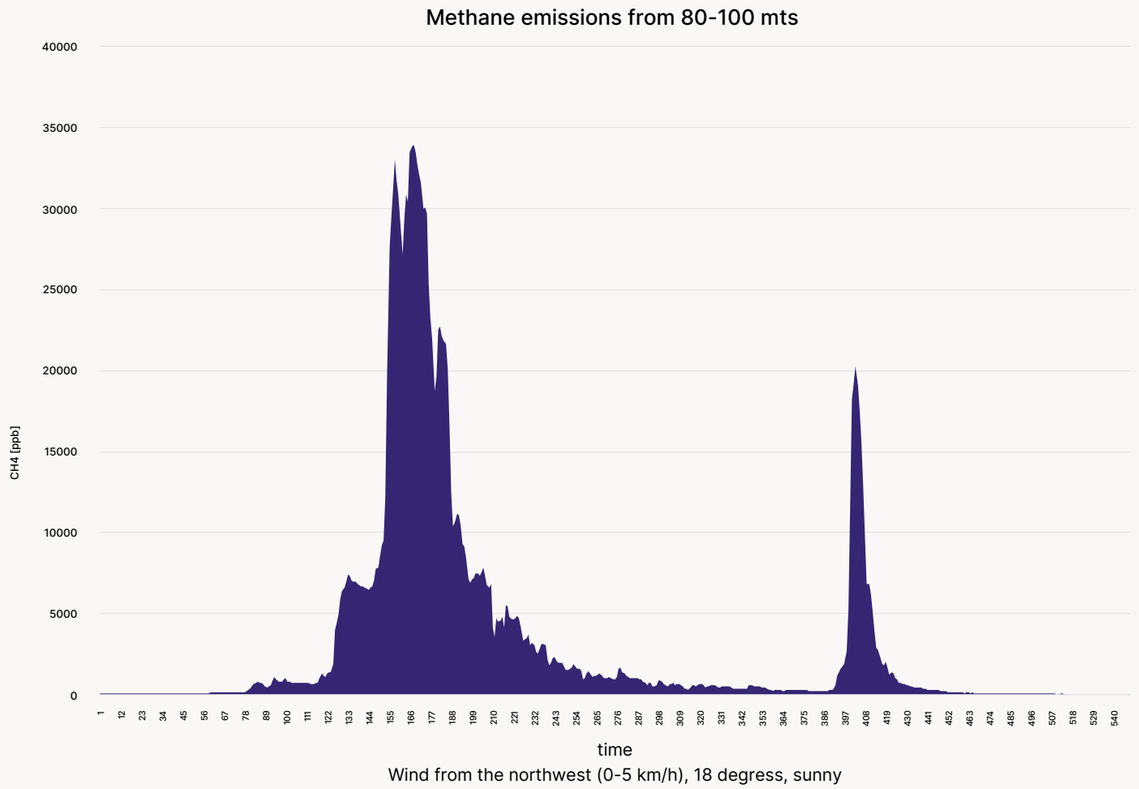
Wider view of Arla's Arinco's processing plant showing two chimneys, the one on the right releasing methane.

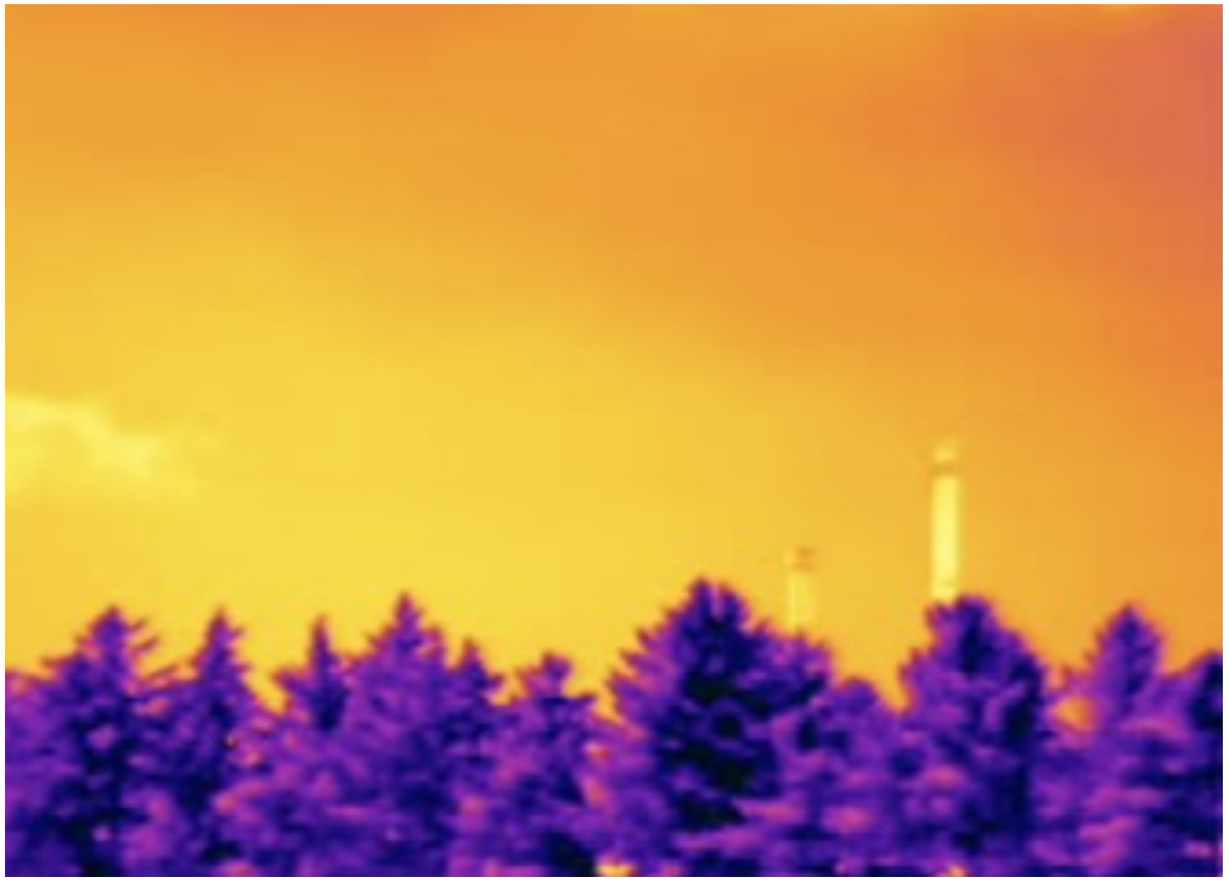
Tønder biogas plant

Figure 2: Close up of the peak detected during the inspection on 13 May

The Tønder biogas plant,145 km south of Videbæk, is one of the largest in Europe. It began partial operations in December 2022, with the whole facility scheduled for completion in 2025. It is owned by Copenhagen Infrastructure Partners' Advanced Bioenergy Fund, which claims it will be able to process more than 900,000 tonnes of organic matter a year and produce over 40 million normal cubic metres (Nm^3) of biomethane.[23]

While Arla is not directly involved in the project, it is likely that Arla farmers supply manure to the plant. An Arla board of representatives member, the dairy farmer Ingrid van den Hengel,[24] also sits on the board *of*





View of Tønder biogas plant chimneys without any methane release.

Biomasse Leverandører Syd Vest (Biomass Suppliers South West), an association which collects biomass from its members to supply biogas plants.[25] At the association's 2022 founding meeting, board members declared they were "ready" to deliver slurry to the Tønder plant, once it was complete.[26] [J]

The inspection team visited the Tønder biogas plant on 13 and 14 May 2025. On the first day, we measured methane concentrations and made observations with the OGI camera from around 12:15 for approximately 30 minutes. We detected a peak methane concentration outside the plant of close to 35,000 ppb, more than 16 times higher than the baseline (2,075 ppb). On the second day, we used the OGI camera from around 14:45 for approximately 20 minutes but did not take measurements.

Despite the high levels of methane detected outside the site, the OGI camera did not detect leakage from the facility on either of the two inspection days. This means we could not confirm the biogas plant as the source of the elevated methane levels in this instance. It is possible that it emanated from biomass being unloaded in the area. The inspections at Tønder were shorter and more challenging than at Videbæk as access was more restricted.

The findings underscore the importance of using both instruments - the trace gas analyser and the OGI camera - as although we could not identify the source at this time, we were still able to detect high levels of methane in the atmosphere.

J At time of writing, there was no clear publicly available evidence of whether the cooperative is already supplying the Tønder plant.

Conclusion

By providing a recent snapshot of two biogas plants on different days, our findings support evidence that methane leakage from biogas production is a persistent and widespread problem in Denmark. This is particularly concerning as Denmark is renowned for its targets to reduce agricultural emissions.[27] Our results, in combination with the information received by Greenpeace Denmark, show that leaks are an ongoing concern at the Nature Energy Videbæk biogas plant. This raises questions about the effectiveness of existing regulations. Currently, an independent third-party audit is only required once a year, while self-monitoring by the industry appears to be inadequate.

Furthermore, methane leakage from biogas is not unique to Denmark. Over the last two years, DUH has been inspecting biogas plants in three European countries (including Denmark)[K] and has detected at least 20 leaks.[28][29] While there is existing EU regulation to reduce methane leaks from fossil fuel production, such as oil and gas plants,[L] the provisions do not currently extend to biogas production at the EU level.[30] As many countries and companies turn to biogas and biomethane as 'green' solutions to agricultural emissions and as an alternative to fossil gas, it is essential that gaps in current policies around leaks are recognised and addressed.

Denmark currently holds the EU Presidency, and with this, the opportunity to not only strengthen regulation at home, but across the EU.

K The countries are Denmark, Germany and Hungary. At present only the findings from Germany have been published.

L The Regulation came into effect following a major Clean Air Task Force report which documented more than 800 methane emission sources at oil and gas infrastructure between 2021 and 2023 across including storage tanks, unlit flares and other facilities in several EU countries. Clean Air Task Force (2023) It Happens Here Too: Methane Pollution in Europe's Oil and Gas Network. www.catf.us/resource/it-happens-here-too-methane-pollution-europes-oil-gas-network

Annex 1 - Instruments used

We used two industry-standard instruments for the investigation:

- **Measurements:** A portable measuring device from LI-COR, the LI-7810 CH4/CO2/H2O trace gas analyser. This provides methane measurements with an accuracy of 0.25 ppb (1[3] , with 5-second averaging) at 2000 ppb CH4 in dry air, with a drift of less than 1 ppb per 24 hours. It has an integrated power supply, so it can be used to take measurements in areas with no power supply. This model of trace gas analyser detects the concentration of methane (and other gases) in an area by absorbing air from the environment, analysing its contents and recording the data. The instrument measures the background concentration of methane before and after the identified source, and documents ambient temperature, wind strength and distance to the source. A trained technician from DUH operated the gas analyser.

- **Sources:** The OGI camera is an advanced thermal technology that can pinpoint sources of methane and document evidence of these emissions, along with additional parameters such as temperature, coordinates and time. We used an FLIR Gx320 OGI camera, fitted with a 6° narrow-angle lens to allow for long-range, high-precision detection of methane emissions. This camera is equipped with a cooled Indium Antimonide detector, in the 3.2–3.4 [3] m wavelength band, which is ideal for detecting methane and other volatile organic compounds. Methane can be powerfully captured in the mid-infrared range. Through the camera's spectral response filtering system, which matches the capture window range, methane plumes are visualised as dynamic, semi-transparent clouds against a thermally contrasting background. The FLIR camera was operated by a trained thermographer from AIRMO, a company specialising in methane monitoring, particularly within the framework of the EU Methane Regulation.

Annex 2 - Background on Arla and biogas

Arla, headquartered in Denmark, is a dairy industry giant. In February 2025, Changing Markets and Greenpeace Nordic released a report, *Dairytales*: *Arla's smokescreen for its lack of climate action*.[31] This included a focus on the company's heavy reliance on biogas as a solution to reducing its methane emissions. All the information below comes from this report, unless otherwise referenced.

Methane emissions

- Arla's estimated methane emissions are 13.4 MtCO2e (more than the reported agricultural methane emissions of the Netherlands, and more than twice those of Denmark) and represent 56% of its overall greenhouse gas emissions (24 MtCO2e). Enteric fermentation represents around 75% of its methane emissions, while manure management is around 25%.

- In its 2022 Climate Check report, the company stated: '*Making the most of manure is important for both climate and business profitability.*' Arla has also claimed to be *'turning manure into climate gold'*.[32]

- Arla's biogas activities fall into the following categories:
  - Production by Arla itself
  - Production on Arla's farms
  - Supplying manure to third-party plants, then receiving the leftover material (digestate) to be used as fertiliser (Nature Energy)
  - Use as a fuel in Arla's plants (Arinco) or transport.

- We estimated that the maximum potential savings for Arla from biogas, if all manure was collected and leaks weren't considered, would be a 15% reduction in emissions compared to the 2015 baseline. Looking at milk specifically, Arla has a stated ambition to reduce its overall greenhouse gas emissions by 30% per kilogram of milk produced. Yet, our calculations show that using biogas equates to just 2.6% emissions saving per kg, and this is before accounting for any losses from leakages or the wider life-cycle considerations of biogas feedstocks. Biogas alone will not come close to enabling Arla to deliver on its target.

Incentivising industrialisation

- The company states that 11% of its farmers have a biogas generator on their farm or deliver manure to an outside production system.[33]

- Arla promotes biogas production through its FarmAhead tool, which allows farmers to gain points for farm activities that support the company's sustainability agenda. A farmer can receive a premium of 0.03 euro cent/kg of milk delivered to Arla for each point. One category is manure handling, for which farmers can gain up to six points - with biogas providing four of these points. The system incentivises intensification and industrialisation, since a farmer can earn up to 0.12 euro cent per kilo for biogas, but only 0.06 euro cent for keeping cows on pasture.

- Arla has stated that 15% of the slurry from its farms was used for biogas in 2020, increasing to 17% for 2021. In Denmark, Arla claims that 30% of its farms send the manure to a third-party plant, and only 1% have their own biogas plant. In Sweden, Arla has the ambition to increase the number of farmers that feed their manure into biogas plants from 89 to 160 by 2030.

- The Nature Energy business model also appears to incentivise farmers to provide biomass (manure) by making them equity shareowners (5-10%).[34]

Claims

- At the opening of the Videbæk plant, Arla claimed it would help to achieve carbon-neutral production.[35] The company stated that it had created a *'fully closed loop'* by reducing its waste and need for fossil fuels, calling it *'revolutionary in helping fuel a greener future.'*

- The World Biogas Association has used Arla as an example of how biogas can help companies reduce their emissions. A 2020 article claims that Arla had reduced CO2 emissions at two plants, likely including Arinco, by more than a third: "*In 2019, CO2 emissions from the two plants totalled 105,000 tonnes. Without the use of biogas, they would have emitted 167,000 - a reduction of 62,000 tonnes. A similar saving is forecast for 2020, despite increased production.*"[36]

Financial incentives and subsidies

- Under Denmark's subsidy regime for biogas, the subsidies available for producing biogas from manure from Arla's farms in Denmark amount to:
  - 600 million DKK (€80 million) if all biogas is burned for electricity
  - An additional 140 million DKK (€20 million) if all biogas is upgraded to biomethane and injected into the gas grid.

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