Researchers invent 'methane cleaner' that could become a permanent fixture in cattle and pig barns

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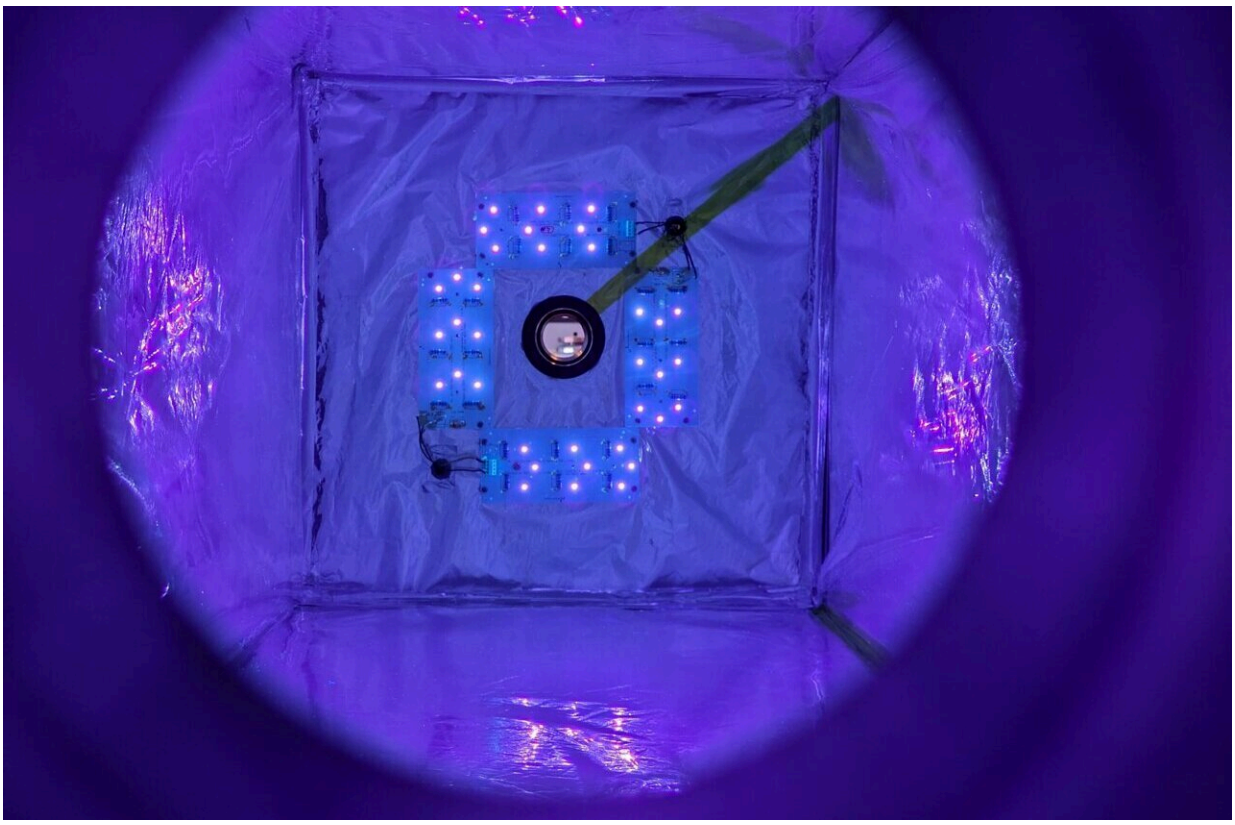


A look inside the MEPS reactor (Methane Eradication Photochemical System), where chlorine atoms are formed by UV light and react with methane gas. Credit: Morten Krogsbøll.

In a new study, researchers from the University of Copenhagen have used light and chlorine to eradicate low-concentration methane from air. The result gets us closer to being able to remove greenhouse gases from livestock housing, biogas production plants and wastewater treatment plants to benefit the climate. The work is published in the journal *Environmental Research Letters*.

The Intergovernmental Panel on Climate Change (IPCC) has determined that reducing methane gas emissions will immediately reduce the rise in global temperatures. The gas is up to 85 times more potent a greenhouse gas than CO_2, and more than half of it is emitted by human sources, with cattle and fossil fuel production accounting for the largest share.

A unique new method developed by a research team at the University of Copenhagen's Department of Chemistry and spin-out company Ambient Carbon has succeeded in removing methane from air.

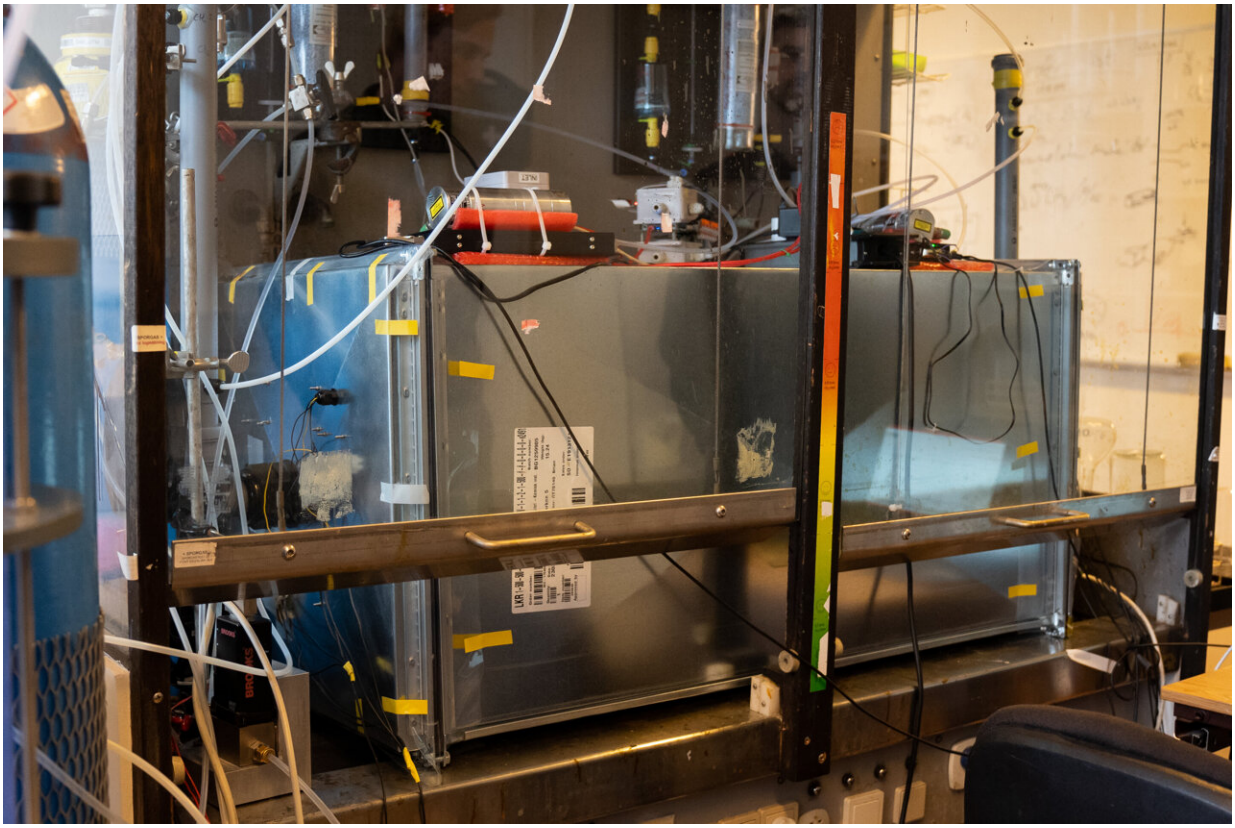
"A large part of our methane emissions comes from millions of low-concentration point sources like cattle and pig barns. In practice, methane from these sources has been impossible to concentrate into higher levels or remove. But our new result proves that it is possible using the reaction chamber that we've have built," says Matthew Stanley Johnson, the UCPH atmospheric chemistry professor who led the study.

Earlier, Johnson presented the research results at COP 28 in Dubai via an online connection and in Washington D.C. at the National Academy of Sciences, which advises the US government on science and technology.

Reactor cleans methane from air

Methane can be burnt off from air if its concentration exceeds 4%. But most human-caused emissions are below 0.1% and therefore unable to

be burned.



The researchers built a reaction chamber and devised a method that simulates and greatly accelerates methane's natural degradation process. Credit: Michael Skov Jensen, SCIENCE/KU

To remove methane from air, the researchers built a reaction chamber that, to the uninitiated, looks like an elongated metal box with heaps of hoses and measuring instruments. Inside the box, a chain reaction of chemical compounds takes place, which ends up breaking down the methane and removing a large portion of the gas from air.

"In the scientific study, we've proven that our reaction chamber can

eliminate 58% of methane from air. And, since submitting the study, we have improved our results in the laboratory so that the reaction chamber is now at 88%," says Matthew Stanley Johnson.

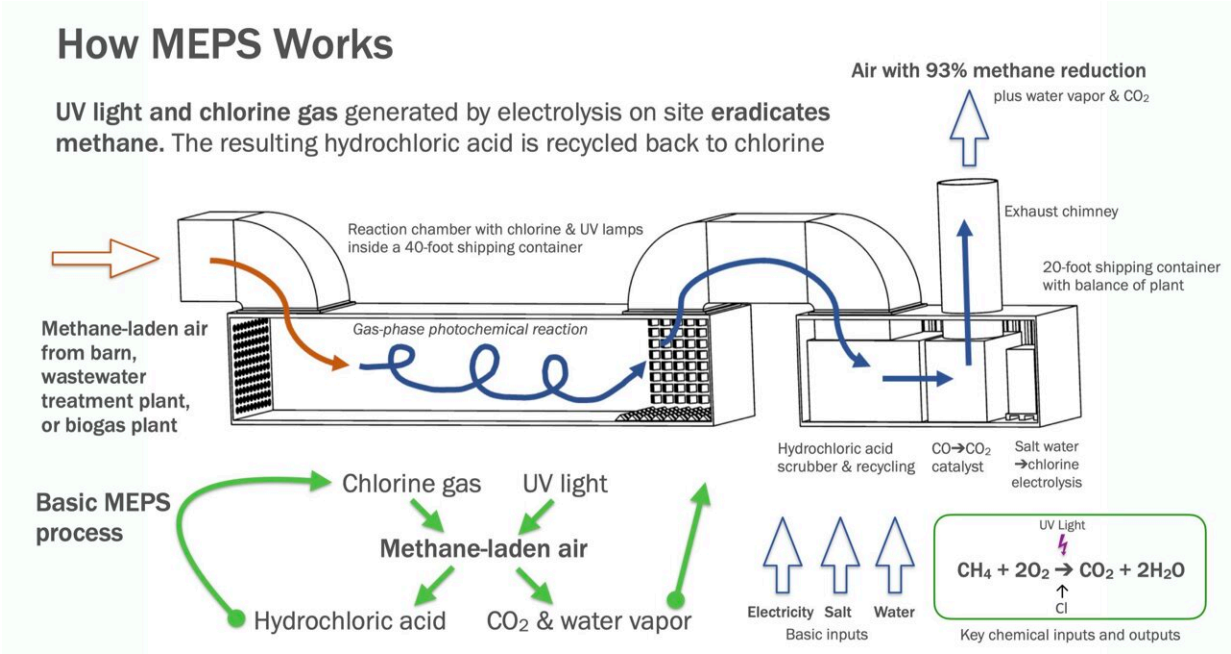
Chlorine is key to the discovery. Using chlorine and the energy from light, researchers can remove methane from air much more efficiently than the way it happens in the atmosphere, where the process typically takes 10–12 years.

"Methane decomposes at a snail's pace because the gas isn't especially happy about reacting with other things in the atmosphere. However, we've discovered that, with the help of light and chlorine, we can trigger a reaction and break down the methane roughly 100 million times faster than in nature," explains Johnson.

Up next: Livestock stalls, wastewater treatment plants and biogas plants

A 40ft shipping container will soon arrive at the Department of Chemistry. When it does, it will become a larger prototype of the reaction chamber that the researchers built in the laboratory. It will be a "methane cleaner" which, in principle, will be able to be connected to the ventilation system in a livestock barn.

"Today's livestock farms are high-tech facilities where ammonia is already removed from air. As such, removing methane through existing air purification systems is an obvious solution," explains Professor Johnson.



How MEPS work. UV light and chlorine gas by electrolysis eradicates methane on site. Credit: Matthew Stanley Johnson, Department of Chemistry, University of Copenhagen.

The same applies to biogas and wastewater treatment plants, which are some of the largest human-made sources of methane emissions in Denmark after cattle production.

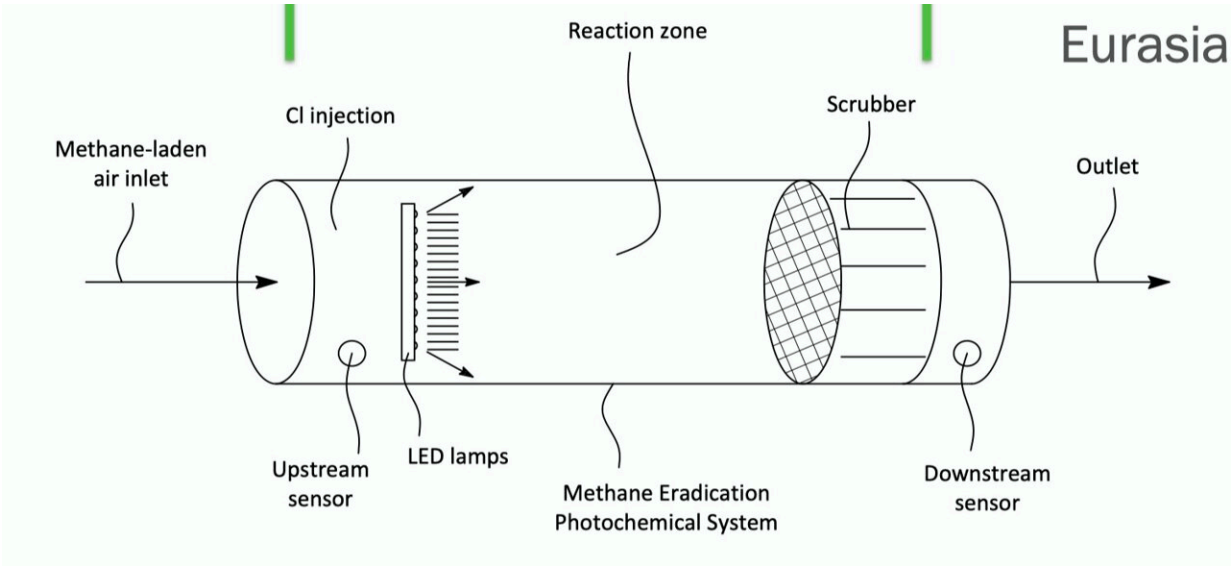
As a preliminary investigation for this study, the researchers traveled around the country measuring how much methane leaks from cattle stalls, wastewater treatment plants and biogas plants. In several places, the researchers were able to document that a large amount of methane leaks into the atmosphere from these plants.

"For example, Denmark is a pioneer when it comes to producing biogas. But if just a few percent of the methane from this process escapes, it counteracts any climate gains," concludes Johnson.

The research was conducted in collaboration between the University of Copenhagen, Aarhus University, Arla, Skov and the UCPH spin-out company Ambient Carbon, now headed by Professor Matthew Stanley Johnson. The company was started to develop MEPS (Methane Eradication Photochemical System) technology and make it available to society.

About the method

The researchers built a reaction chamber and devised a method that simulates and greatly accelerates methane's natural degradation process.



MEPS reactor. Credit: Matthew Stanley Johnson, Department of Chemistry, University of Copenhagen.

They dubbed the method the Methane Eradication Photochemical System (MEPS) and it degrades methane 100 million times faster than in

nature.

The method works by introducing chlorine molecules into a reaction chamber with methane gas. The researchers then shine UV light onto the chlorine molecules. The light's energy causes the molecules to split and form two chlorine atoms.

The chlorine atoms then steal a hydrogen atom from the methane, which then falls apart and decomposes. The chlorine product (hydrochloric acid) is captured and subsequently recycled in the chamber.

The methane turns into carbon dioxide (CO_2) and carbon monoxide (CO) and hydrogen (H_2) in the same way as the natural process does in the atmosphere.

More about methane (CH_4)

Methane can be burned off to remove it from air, but its concentration must be over 4%, 40,000 parts per million (ppm) to be flammable. As most human-caused emissions are below 0.1%, they cannot be burned.

The Intergovernmental Panel on Climate Change (IPCC) has determined that reducing methane gas emissions will immediately reduce the rise in global temperatures.

Methane is a greenhouse gas that is emitted naturally from, among other things, wetlands and from man-made sources such as food production, natural gas and sewage treatment plants.

Today, methane gas is responsible for a third of the greenhouse gases that affect the climate and cause global warming.

It takes methane 10–12 years to decompose naturally in the atmosphere,

where it is converted into carbon dioxide.

Over a 25-year period, methane is 85 times worse for the climate than CO_2. Over a 100-year period, methane is 30 times worse for the climate than CO_2.

The concentration of methane in the atmosphere has increased by 150% since the mid-1700s.

Methane alone has increased anthropogenic radiation exposure by 1.19 W/m^2, which is responsible for a 0.6°C increase in global average surface air temperature, according to the IPCC.

More information: Morten Krogsbøll et al, A high efficiency gas phase photoreactor for eradication of methane from low-concentration sources, *Environmental Research Letters* (2023). DOI: 10.1088/1748-9326/ad0e33

Provided by University of Copenhagen