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Reducing methane emissions—the "easy" way to keep 1.5 alive?

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An Editorial on the Frontiers in Science Lead Article
The methane imperative

Key points

- Action taken so far to reduce carbon dioxide (CO_2) emissions has not been sufficient to keep the world on a path to stay within 1.5°C, or even 2.0°C, of warming—a stronger focus on reducing methane emissions could help us meet climate goals.
- Addressing the methane issue alone will not be enough—to successfully reduce global warming, action on methane emissions needs to be integrated with mitigation strategies that address CO_2 emissions.
- Multiple, cost-effective methane abatement options exist, but government action is needed to enforce the necessary reduction in methane emissions across different sectors.

Introduction

According to a 2024 survey by *The Guardian* (1), a large majority of the lead authors of the sixth Intergovernmental Panel on Climate Change (IPCC) assessment report are becoming increasingly skeptical that the aspirational goals of the Paris Agreement remain achievable, at least without substantial temperature overshoot. Only 6% of the respondents believed that remaining below 1.5°C is still possible while almost 80% anticipated at least 2.5°C of global warming. The consequences of such continued warming are likely to be dire, first and foremost for the most vulnerable populations. However, the effects will spread throughout the global economy and may pose major threats to international security and stability. Moreover, climate change mitigation strategies such as carbon dioxide (CO_2) removal remain unscalable at present, solar radiation management is unproven and may have undesirable side effects (2), and nature-based solutions have been criticized, with academics, civil society groups, and non-governmental organizations suggesting they are not properly defined and do not substantially address climate change (3). So, what are our options? Can anything be done to significantly reduce emissions and put us onto a desirable climate trajectory? That question is the main focus of the *Frontiers in Science* lead article, “The methane imperative” by Shindell et al. (4).

The most significant individual contributor to the global warming observed over the last 150 years is the steady increase in CO_2 concentrations largely driven by human activities, in particular by fossil fuel consumption. Action taken thus far to reduce CO_2 emissions has not been sufficient to keep the world on a path to stay within 1.5°C, or even 2.0°C, of warming (5). As CO_2 is chemically stable, once in the atmosphere it essentially remains there forever. Therefore, postponing decisions on CO_2 reductions not only delays addressing the problem of climate change but also exacerbates the problem with each additional ton of CO_2 emitted. This is well-known, but the forces pushing back against significant reductions in CO_2 emissions are strong. According to recent reports in *The Guardian* (6) and from the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28) (7): “fossil fuel lobbyists … were increasingly hampering the [United Nation’s] annual COP climate talks”. Moreover, economic prosperity—and even the basic livelihood of a large fraction of the human population—depend directly on fossil fuel consumption to meet basic energy demands, making CO_2 emissions very difficult to reduce.

The second most important anthropogenic greenhouse gas is methane (CH_4). Methane absorbs infrared radiation far more effectively than CO_2 and, even though its concentrations are significantly lower, methane accounts for 19% of the radiative forcing due to all long-lived greenhouse gases since preindustrial times (8). As methane has an atmospheric lifetime of only approximately 10 years, reducing its emissions will reduce its atmospheric concentrations and its contribution to radiative forcing far more quickly than the corresponding effects of reducing CO_2 emissions. However, this relatively short lifetime also means that methane emissions abatement is not an alternative to addressing the problem of anthropogenic CO_2 emissions; it may, however, buy us a little time while we tackle the more difficult problems regarding CO_2. Shindell et al. (4) explore whether significant methane emission reductions would be economically and politically less burdensome in the short term than the equivalent CO_2 reductions.

The authors present a comprehensive overview of what is currently known about methane emissions, the climate impact of methane, and the potential effectiveness and cost-efficiency of various methane emission mitigation strategies. Atmospheric background methane concentrations have been increasing since observations started. After a plateau from 1999 to 2006, concentrations started increasing again in 2007, rising particularly sharply in 2021 and 2022. This increase exceeds the current climate scenarios that allow us to meet the Paris Agreement temperature goals, including models that permit us to temporarily exceed the 1.5°C temperature limit. The authors argue that methane emissions have drawn too little attention from policymakers and decision-makers and that addressing this issue is the most efficient way—possibly the *only* viable way—to limit long-term overshoots. The reason why methane and other non-CO_2 greenhouse gases may not have always attracted sufficient attention is that, for the sake of simplifying the reporting and monitoring of progress, the radiative forcing due to greenhouse gases has been widely expressed in terms of CO_2 equivalents. This allows for a convenient lumping together of greenhouse-gas-related effects but can mask the differences between gases that have different warming potentials, lifetimes, sources, and sinks. Looking at CO_2 equivalents only can therefore lead to a certain blindness toward the actual mitigation options. Shindell et al. (4) address this imbalance by putting forward three “imperatives” to reduce methane emissions that they believe must be urgently addressed to limit global warming to below 1.5°C.

The imperative to reverse the current increase in methane emissions

The first imperative—to reverse current methane emission growth—is the most straightforward and probably the least controversial. The authors evaluate recent and projected trends in methane emissions in the context of different climate scenarios, finding that methane emissions have risen rapidly in the 2020s, far beyond what existing models had predicted and what would be required to meet the Paris Agreement goals. The overall imperative to immediately reverse this methane growth therefore has unquestionable merit. However, there are inconsistencies and significant simplifications in the arguments presented in support of this imperative, which largely center on the uncertainty around the sources and magnitude of this methane growth.

The authors note the lack of consensus about the main causes of the recent dramatic concentration growth rates, highlighting the considerable uncertainty about the magnitudes of the various potential methane sources and the role of sinks. They lean toward fossil fuel exploitation and livestock as the primary sources, with wetlands emissions, thawing permafrost, and slowing methane removal rates among the other potential explanations. The extreme methane concentration increase in 2021 and 2022 occurred during an extended La Niña period, and this context of interannual variability needs to be considered when interpreting the methane growth rates. Given the sensitivity of any bacterial methane sources to water availability and surface temperature, the emissions from rice paddies, landfills, and wetlands would be indistinguishable, and none of them can *a priori* be eliminated as potential sources of the dramatic increase observed in 2021 and 2022. Our inability to attribute methane growth rates to specific sources is in part caused by the insufficient density of ground-based observing systems in the parts of the world where these bacterial sources of methane are located, primarily in the tropics. Addressing spatial and temporal gaps in the observing system is one of the main objectives of the Global Greenhouse Gas Watch approved by the 19th World Meteorological Congress in 2023 (9). Putting methane concentration changes in the context of scenario development also makes a comparison with the output of integrated assessment models (IAMs) questionable; IAMs are not full Earth system models, thus they would not reproduce the interannual changes in natural emissions, nor would they modulate emission factors for anthropogenic emissions in response to climate change. These caveats notwithstanding, focusing on rapidly reducing anthropogenic methane emissions will be important in achieving the desired climate goals.

The imperative to align CO_2 and methane emission reduction strategies

The second imperative defined by Shindell et al. (4) is the need to align CO_2 and methane emission reduction strategies. It is reasonable to assume that integrated mitigation policies are beneficial as they allow countries to optimize mitigation action within the national context via appropriate tradeoffs. Given that a large fraction of CO_2 emissions and a significant fraction of methane emissions are associated with the energy sector, an integrated approach is in line with this imperative and with establishing joint emission reduction targets. The authors also argue that a strong link between CO_2 and methane mitigation actions may exist through the conversion of pastureland to forest, which would eliminate an important source of methane and at the same time increase CO_2 uptake. This may be an attractive option on paper, but care should be exercised when invoking IAM results as the main piece of supporting evidence since the correlation between the two impacts is trivial: if pastureland is converted to new forest, the assumed reduced emissions from the former will be strongly correlated with the assumed increased uptake by the latter. This is simply due to the limited availability of land and the way the two land use types are traded off against each other. IAMs are not complete Earth system models, and they cannot simulate whether afforestation would actually work in practice, even if the necessary political willingness existed. As Shindell et al. (4) point out, it is far from given that the afforestation of existing pastureland and the required dietary changes will be acceptable in all countries. Arguments related to dietary shifts will also need to be put in the context of social justice, both for the raising of livestock and for agriculture in general. The agricultural production and consumption of the products often take place in different parts of the world, and major changes in demand may have negative impacts on already weak economies and the livelihoods of their populations.

The imperative to optimize methane abatement strategies

The third imperative goes to the heart of what can be done to reduce methane emissions and what the main obstacles to implementing the abatement strategies are. Shindell et al. (4) thoroughly review existing abatement options, as well as their impacts and costs, by sector and by country. They find that while the sector-specific emission estimates are reasonably robust, the estimates for their abatement potential tend to have very large uncertainties. Two main sources are cited: the United States Environmental Protection Agency (EPA) and the International Energy Agency (IEA). The differences reported in the respective estimates are very large for some of the abatement options—in some cases arguably too large to be useful as policy instruments at this time. Work to narrow down these uncertainties is urgently needed. There are also some uncertainties regarding abatement costs, although to a lesser extent.

Unlike CO_2, methane is a fuel and if captured in concentrated form can be used as such, leading in some cases to negative abatement costs due to the profit made by the energy produced. However, the fact that costs may be negative for certain abatement approaches does not necessarily mean that they would be implemented without government intervention. Even though the abatement may be profitable, capital is limited, and commercial entities may find other, even more profitable investments, which is particularly evident in the oil and gas sector. Shindell et al. (4) therefore argue for setting a price on methane emissions to help stimulate their abatement. This could be based on the social cost of methane emissions (SCM) for which a range of published estimates are available, some taking into account both the climate impact and the secondary negative impact on human health arising from the fact that methane is a precursor for ozone in the troposphere.

Conclusion

Shindell et al. (4) outline practical ways forward to reduce methane emissions in line with the Paris Agreement temperature goals and for the implementation of the Global Methane Pledge—a global agreement to take voluntary actions to reduce methane emissions by at least 30% from 2020 levels by 2030, launched at COP26. They argue convincingly that immediate methane emission reductions are necessary, feasible, and may, if combined with other mitigation actions that tackle CO_2 emissions, help significantly limit the risk of long-lasting overshoots of the Paris Agreement temperature goals. The abatement potential in some of the methane mitigation options seems compelling, but the uncertainty measured by the different assessments remains an issue, and there is an urgent need to reduce this. There are good arguments for governments to set a price on methane emissions, and this may be another area where methane differs significantly from CO_2. As many methane emissions are involuntary and mitigation options exist—some even being profitable—the political appetite for action may exceed that evident so far for CO_2. Addressing the methane issue alone will not be enough, but that should not be seen as an excuse for not doing so.

Statements

Author contributions

LR: Writing – original draft, Writing – review & editing. OT: Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of financial relationships that could be construed as a potential conflict of interest.

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