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Grantham Institute

Evidence submission

House of Lords Environment and Climate Change Committee methane inquiry

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Contents

Key points

International commitments

- Methane emission reductions are essential and integral to meeting the climate goals of the Paris Agreement.
- Estimates of the remaining carbon budget depend on implied stringent methane emission reductions.
- Failure to implement these stringent reductions in methane emissions, results in an exhaustion of the remaining carbon budget and puts the achievement of the Paris Agreement climate goal out of reach.

Data, measurement and monitoring

- Landfill sites as well as anaerobic digestion and composting facilities have been identified as significant contributors to methane leakage, highlighting the need for improved management and containment strategies in these areas.
- The UK National atmospheric Emissions Inventory (NAEI) may be underestimating the proportion of methane emissions arising from the incomplete combustion of biomass and leakages in the natural gas supply chain.
- GWP* is a useful tool which provides a more direct link between emissions and their warming impact when working at a global scale. However, there may be significant unintended consequences of using GWP* for country-level analysis or when applying it to policy frameworks that were developed using GWP100.
- Interpreting the Paris Agreement net zero goal using GWP* rather than GWP100 leads to higher long-term temperature increases.
- Calculating country-level emissions using GWP* could undermine long-term efforts to reduce carbon dioxide by generating additional carbon credits in the short-term.
- Calculating country-level emissions using GWP* could also unfairly benefit those with historically high methane emissions and penalise those with low historic emissions.

Waste and waste management

- Given the complexity of accurately quantifying methane emissions and the diversity of emission sources within the waste sector, enhanced monitoring, reporting and verification mechanisms would help to achieve emission reduction ambitions in this sector. This includes continued innovation in methane detection and quantification technologies.
- Continued innovation and investment in methane capture technologies is necessary to address the emissions from existing and future landfills.

International commitments

1) What role could methane emissions reduction play in meeting the UK's domestic and international climate change targets?

Paris-aligned methane emission reductions

Methane emission reductions are essential to achieve the international climate goal of the Paris Agreement: to hold global warming well below 2°C while pursuing to limit it to 1.5°C relative to preindustrial levels. This insight was highlighted in initial studies looking at pathways aligned with keeping warming well-below 2°C or to 1.5°C[1],[2] and has been subsequently confirmed by the authoritative scientific assessments of Paris-aligned emissions pathways the IPCC in 2018[3] and 2022[4].

Based on the latest available evidence, we show that pathways limiting warming to 1.5°C tend to require a 50% reduction in methane emission between 2020 and 2050. While in theory less ambitious reductions of methane emissions could be compensated by stronger reductions in carbon dioxide (CO_2), the implications in practice do not allow for much leeway. Ambitious methane emission reduction is part and parcel of integrated, rational and cost-effective responses to meeting the international climate goal of the Paris Agreement3,4, and therefore these deep methane reductions are also used when estimating the remaining carbon budget for limiting warming to, for example, 1.5°C. The remaining carbon budget consistent with a specific level of global warming represents the total amount of CO_2 that can still be emitted while keeping warming below the specified level of warming.

The IPCC remaining carbon budget estimate for limiting warming to 1.5°C[5] assumes that methane is reduced by about 50% between 2020 and 2050, while the remaining carbon budget for limiting warming to a weaker 1.7°C of global warming assumes that methane is reduced by about a 45% over the same period.[6]

A failure to reduce methane emissions at all by 2050 would already condemn the world to failing to deliver on the 1.5°C warming target, even without considering any additional warming caused by CO_2. For a weaker temperature target like a 50% chance of 1.7°C warming, a failure to implement the consistent methane emission reductions and keeping them about constant to 2020 levels would reduce the amount of CO_2 that we could still release by more than a half making it technically impossible to stay below this warming level.

Because of the deep methane emissions reductions that are already assumed in the estimation of remaining carbon budgets, this means that very little additional emissions space can be created by deep methane emissions reduction, but a lot of it can be lost if countries including the UK fail to deliver on the technically feasible methane reductions aligned with achieving the climate goal of the Paris Agreement.

Details can be found in:

Rogelj, J., & Lamboll, R. D. (2024). Substantial reductions in non-CO2 greenhouse gas emissions reductions implied by IPCC estimates of the remaining carbon budget. Communications Earth & Environment 2024 5:1, 5(1), 1–5. https://doi.org/10.1038/s43247-023-01168-8

2) What is your assessment of the Global Methane Pledge: is the UK on track to meet it? If not, how could this be accelerated?

The UK was instrumental in launching the global methane pledge at COP26 in Glasgow, so it would be nationally embarrassing for this to fail. This global methane pledge calls for a global 30% reduction in methane emissions by 2030 from the 2020 level. This global methane emission reduction ambition is consistent with pathways that limit warming to 1.5°C and would set the UK up for a 50% or larger reduction by 2050.

The UK very successfully reduced emissions from industrial sources during the last few decades, and its per-capita territorial methane emissions are now below the global average. However, emissions from agricultural sources have declined by much less. Agriculture now makes up half of the UK's methane emissions, and digestion from cows and sheep makes up most of this half. Managing and controlling agricultural emissions is likely required to meet the 30% overall reduction of the pledge.[7]

The UK, as a world-leading financial hub, also has the capacity to incentivise investment in methane-reducing technologies such as renewable energy that displace fossil fuel use, and to reduce the finance available for methane-generating activities. Although these would not count towards national targets, the methane pledge is applied globally, incentivising this collaborative approach over simply offshoring emissions by cutting industrial or agricultural output

Data, measurement and monitoring

9) What progress is being made on methane monitoring and data collection in the UK using technologies such as satellite data and drones?

The UK is taking a big leap forward in tracking and measuring methane emissions, using cutting-edge technology like satellites and drones. A program launched by the Satellite Applications Catapult, GHGSat, and the UK Space Agency is providing UK organizations with detailed data on methane emissions from satellites. This program aims to fill the gap in how the UK uses and understands this data. Running from 2023 to 2025, this initiative will allow for more precise measurement of methane emissions across various sectors, from farms and landfill sites to oil and gas production. This will ultimately help them identify and reduce these harmful greenhouse gases.

So far, we have one study which validates satellite emissions with ground-based measurements from an active gas leak in Cheltenham, UK.[8] We can use satellite technology in future studies especially after MethaneSAT (a recently-launched American-New Zealand Earth observation satellite) data is available. However, it is important to highlight that monitoring UK's methane emissions using satellite data presents challenges, particularly due to the country's frequent cloudy weather, which can hinder the ability to get clear and effective observations from satellites.[9]

There are some studies recently published based on drones and aircrafts across the North Sea Region and landfill.[10] Those technologies should also be used in other methane sources such as cow barns, biogas plants, wastewater treatment plant in the future studies.

10) Are there significant methane leakages in the UK, and if so where do they usually occur?

Yes, significant methane emissions have been identified from natural gas pipelines in London and Birmingham. Research conducted by Royal Holloway University of London has collected data on these emissions, indicating that pipelines in London have higher leakage rates compared to those in cities like Groningen in the Netherlands.

The details of city measurements across other cities can be found in that peer-reviewed article:

> Vogel, F., Ars, S., Wunch, D., Lavoie, J., Gillespie, L., Maazallahi, H., Röckmann, T., Nęcki, J., Bartyzel, J., Jagoda, P. and Lowry, D., 2024. Ground-Based Mobile Measurements to Track Urban Methane Emissions from Natural Gas in 12 Cities across Eight Countries. Environmental Science & Technology.
> https://pubs.acs.org/doi/epdf/10.1021/acs.est.3c03160

Methane emissions are also found on oil and gas platforms in the North Sea. Measurements revealed methane concentrations significantly above background levels downwind of these platforms, suggesting that all observed platforms leaked methane during normal operation. These findings are critical as they highlight that a considerable amount of methane leakage has not been included in UK emission inventories.[11]

Our recent mobile surveys have revealed that methane emissions are not limited to traditional sources; they extend to a wide range of activities associated with waste management and agriculture. Specifically, anaerobic digestion facilities and landfills have been identified as significant contributors to methane leakage, highlighting the need for improved management and containment strategies in these areas. Additionally, wastewater and water treatment plants, along with composting facilities, have been recognised for their methane. Our peer-reviewed studies are published as: [12]

> Bakkaloglu, S., Lowry, D., Fisher, R.E., France, J.L., Brunner, D., Chen, H. and Nisbet, E.G., 2021a . Quantification of methane emissions from UK biogas plants. Waste Management, 124, pp.82-93. https://www.sciencedirect.com/science/article/pii/S0956053X21000167

> Bakkaloglu, S., Lowry, D., Fisher, R.E., France, J.L. and Nisbet, E.G., 2021b. Carbon isotopic characterisation and oxidation of UK landfill methane emissions by atmospheric

measurements. Waste management, 132, pp.162-175. https://www.sciencedirect.com/science/article/pii/S0956053X21003809#b0155

A recent study[13] has highlighted a concerning trend in methane emissions, pointing to an increase in overall levels while also noting a decrease in the isotopic signature (δ13C). This change in isotopic composition suggests a growing influence of thermogenic and pyrogenic sources, such as fossil fuels and incomplete combustion of biomass on the total methane emissions. This finding implies that the National Atmospheric Emissions Inventory (NAEI) might be underestimating the proportion of methane emissions originating from these sources. The implications of this study stress the need for a reassessment of the sources contributing to methane emissions, ensuring more accurate modelling and policy development to address the environmental impact of these emissions effectively.

11) What are the advantages and disadvantages of available metrics used to report and compare methane emissions including GWP100 and GWP*?

GWP100 and GWP*

The GWP100 metric is used to allow a comparison of the climate impact of different greenhouse gases over a 100-year period. It considers both the potency and lifetime of each gas and describes how much warming it would cause[14] over 100 years relative to the same amount of carbon dioxide. It allows methane emissions to be expressed in units of CO2-equivalence.

A downside of any metric is that if used incorrectly it might result in misleading messages.

For example, it would be incorrect to use CO2-equivalent emissions based on the GWP100 to project how global temperatures might respond to cumulative CO2-equivalent emissions. This is because GWP100 averages out the impact of shorter-lived greenhouse gases over 100 years rather than expressing the shorter-lived but more intense heating that would occur in reality, and because the temperature impact of shorter-lived greenhouse gases is more directly related to its annual emissions than to its total cumulative emissions over time.[15]

GWP* was designed so that cumulative emissions of both long-lived and short-lived greenhouse gases expressed in CO2-equivalence are more closely proportional to the resulting global warming. GWP*-weighted greenhouse gas emissions are also referred to as CO2-warming-equivalent emissions.[16]

Switching to GWP* in existing frameworks could undermine policy goals and ambition

Great care needs to be taken when applying new concepts (such as GWP*) to a pre-existing climate policy context that has been developed on the basis of other metrics (such as GWP100). There is a risk that it might create inconsistencies or loopholes in policy or could even unintentionally undermine targets.

We have conducted a study exploring the differences between interpreting the Paris Agreement goals in a metric like GWP* versus the standard GWP100 (which is traditionally used in assessment reports of the IPCC and mandated for reporting of aggregated greenhouse gas emissions by the United Nations Framework Convention on Climate Change, UNFCCC). We found that using GWP* could undermine the integrity of the Agreement's mitigation target altogether.

We provide a short summary of this work here, but the full study has been peer-reviewed and published as:

> Schleussner, C.F., Nauels, A., Schaeffer, M., Hare, W. and Rogelj, J., 2019. Inconsistencies when applying novel metrics for emissions accounting to the Paris agreement. Environmental Research Letters, 14(12), p.124055. (available at: https://iopscience.iop.org/article/10.1088/1748-9326/ab56e7/meta)

Our study compared the difference between interpreting the Paris Agreement goal of achieving net zero greenhouse gas emissions in the second half of this century using the GWP* metric and the GWP100 metric.[17]

Our assessment found that when calculated using the GWP* metric, achieving net-zero greenhouse gas emissions in 2050 leads to peak warming of around 1.8°C whereas when calculated using the GWP100 metric that is traditional used in the UNFCCC, achieving net-zero greenhouse gas emissions around the same date limits peak warming to close to 1.5°C. The Paris Agreement seeks to pursue 'efforts to limit the temperature increase to 1.5°C above pre-industrial levels' so we can see that applying the new GWP* metric to the preexisting context of the UNFCCC Paris Agreement could result in inconsistencies between different clauses of the Agreement (because achieving GWP* net zero would not limit temperature increase to 1.5°C).

Achieving net zero greenhouse gas emissions using the traditional GWP100 metric also differs in climate ambition from achieving net zero greenhouse gas emissions using GWP*. Achieving net zero greenhouse gas emissions as defined by GWP100 results in a peak and gradual decline in global warming, consistent with the Paris Agreement aim of limiting warming well below 2°C while pursuing to limit it to 1.5°C. If net zero greenhouse gas emissions are calculated by using GWP* this would result in a flatlining of global warming, but not a decline.[18] Achieving net zero greenhouse gas emissions by using GWP* therefore represents a lower global climate ambition.

Adopting GWP* could undermine efforts to reduce carbon dioxide

The differing lifetime of different greenhouse gases leads to different impacts on temperature when emissions are reduced. Carbon dioxide stays in the atmosphere for a long time; it takes thousands of years for levels to decline. This means that if we were to stop emissions, we would expect temperatures to plateau and stop rising (in the same way that when the flow of water into a bathtub is turned off, the water level will stop rising and remain constant). For short-lived gases like methane, however, when emissions stop, the level in the atmosphere will reduce (like turning off the tap to a leaky bathtub – the water level will go down as the water leaks out).

GWP* is designed to better reflect the near-term impacts of greenhouse gases but one consequence of this is that declining emissions of methane translate to the equivalent of negative carbon dioxide levels (under GWP100 it would translate only to reduced carbon dioxide equivalent levels). If countries or industries were to calculate their emissions using GWP*, those who were reducing their methane emissions could generate additional carbon dioxide allowances either for themselves or to a market mechanism, as a reward for their historically high methane emissions. Even though in the short-term we might not notice the difference (in terms of temperature rise) it would seriously undermine efforts to limit long-term temperature rise by slowing efforts to cut carbon dioxide. The reality is that we need to reduce emissions of both methane and carbon dioxide as quickly as possible for meeting the climate goal of the Paris Agreement.3,4

Using GWP* could create unintentional unfairness if applied at the country level

The GWP* metric is more complex than GWP100, but part of the calculation involves a comparison between emissions of short-lived greenhouse gases today relative to historical emissions (typically 20 years ago).

When applied at the global level, the GWP* metric is particularly useful to gain a more direct link between emissions and their warming impact. However, when applied at the national level there can be unintended consequences.

The comparison with historical emissions results in an unfair advantage to countries with high historical emissions of methane; if they were to keep emissions constant, this would equate to net zero methane emissions under GWP* and if they reduced emissions this would generate negative equivalent carbon dioxide emissions. In contrast, countries with low historical emissions (for example developing countries) who increased their methane emissions would be penalised more strongly under a GWP* regime. This could lead to questions of fairness and equity in relation the distribution of emissions reduction effort between different countries, which are explicitly highlighted as a key concern in the Paris Agreement text.

For a more detailed explanation of this issue, please see our peer-reviewed paper:

> Rogelj, J. and Schleussner, C.F., 2019. Unintentional unfairness when applying new greenhouse gas emissions metrics at country level. Environmental Research Letters, 14(11), p.114039. (available at: https://iopscience.iop.org/article/10.1088/1748-9326/ab4928/meta)

As well as this comment:

> Cain, M., Shine, K., Frame, D., Lynch, J., Macey, A., Pierrehumbert, R. and Allen, M., 2021. Comment on 'Unintentional unfairness when applying new greenhouse gas emissions metrics at country level.' Environmental Research Letters 16, 068001 (available at https://iopscience.iop.org/article/10.1088/1748-9326/ac02eb)

and our reply:

Rogelj, J., and Schleussner, C.-F., 2021. Reply to Comment on `Unintentional unfairness when applying new greenhouse gas emissions metrics at country level.' Environmental Research Letters 16, 068002. (available at: https://doi.org/10.1088/1748-9326/ac02ec)

Waste and waste management

21) What further progress could be made in the waste and waste management sector on reducing methane emissions? Are there interventions and/or technologies that could bring emissions down?

The reduction of methane emissions in the waste and waste management sector in the UK can be advanced through several interventions and technologies, as highlighted by recent research:

1. Identification and Quantification of Methane Emissions: Effective emission reduction can be achieved by properly quantifying sources and verifying mitigation efforts. Waste streams such as biogas plants have distinct chemical markers (methane isotopic signatures) that can help identify and quantify emissions from different feedstock of the biogas production process. This approach was used to map methane emissions from waste sources in the UK using laser-based mobile surveys and isotopic characterisation, indicating variations in methane emissions from wastewater treatment plants, biogas plants, and active and closed landfill sites.

2. Methane Emissions from Biogas Plants: Monitoring and minimising methane losses from biogas plants is critical for reducing their contribution to global warming and ensuring the sustainability of renewable energy production. Our studies suggest that methane emission rates from biogas plants vary significantly, indicating the importance of managing emissions from these sources.[19]

Improving the efficiency of anaerobic digestion processes can significantly reduce methane leaks. This can be achieved through improved monitoring and control systems, leak detection, and repair practices. Upgrading facilities with modern, more airtight and controlled digesters can also help minimize emissions. Closed digestate storage with vapor recovery units can be implemented. Additionally, the feedstock storage unit should be covered and frequently monitored to detect any leakages. Designing the biomethane and biogas supply chain to avoid pressure relief valves venting directly to the atmosphere would further help mitigate methane emissions. For more detail see our published study:

Bakkaloglu, S., Cooper, J. and Hawkes, A., 2022a. Methane emissions along biomethane and biogas supply chains are underestimated. One Earth, 5(6), pp.724-736. https://www.cell.com/one-earth/pdf/S2590-3322(22)00267-6.pdf

3. Landfill management approaches: It has been reported that diverting biodegradable waste from landfills to anaerobic digestion (AD) is a wise strategy to reduce methane emissions, even though methane emissions can also occur from AD facilities. However, eliminating organic waste deposition in landfills will not terminate methane emissions instantly, as older landfill sites continue to mature. A gradual decrease in emissions from closed sites can be expected. For more detail, see our published study:

> Bakkaloglu, S., Cooper, J. and Hawkes, A., 2022b. Life cycle environmental impact assessment of methane emissions from the biowaste management strategy of the United Kingdom: Towards net zero emissions. Journal of Cleaner Production, 376, p.134229. https://www.sciencedirect.com/science/article/pii/S095965262203801X

Methane is emitted from landfills into the atmosphere in several ways: directly from uncovered operational areas, through the top layer of cover soil, through cracks or fissures in soil caps and leaking boreholes, and via leaks or vents around gas collection systems, as well as leakage from gas wells and combined heat and power (CHP) engine units. Closed landfill sites with gas extraction systems emit less methane compared to active sites where methane is not collected. Additionally, vegetable soil coverage helps to mitigate methane emissions, with a significantly higher methane oxidation rate observed in topsoil covered sites than in actively disposed landfill sites:

> Bakkaloglu, S., Lowry, D., Fisher, R.E., France, J.L. and Nisbet, E.G., 2021b. Carbon isotopic characterisation and oxidation of UK landfill methane emissions by atmospheric measurements. Waste management, 132, pp.162-175. https://www.sciencedirect.com/science/article/pii/S0956053X21003809#b0155

Implementing regulations based on measured methane emissions can significantly reduce emissions. For instance, using the methane collection index (MCI) to regulate landfills has shown potential for high methane capture rates. Proposed approaches involve annual measurement campaigns to quantify methane emissions and setting achievable but challenging MCI limits to trigger actions for reducing emissions from landfills.[20]

4. Wastewater treatment approaches: The wastewater sector can also emit significant methane emissions compared to what was previously thought. The UK National Atmospheric Emissions Inventory (NAEI) ranks it as the second-highest source of methane emissions, after landfills. To mitigate methane emissions in the wastewater sector, various recovery approaches and methane use options have been identified. Installing anaerobic sludge digestion, either as new constructions or by retrofitting existing systems, allows for the processing of wastewater biosolids into biogas. This biogas can be utilised on-site, reducing the need for fuels for electricity and thermal energy production. New centralised aerobic treatment facilities or covered lagoons, can replace less advanced treatment options, significantly reducing methane emissions. Simple degassing devices at the effluent discharge of anaerobic municipal reactors in warm climates can capture a significant portion of methane lost as dissolved gas, which can then be used beneficially. Optimising existing facilities through correct operation and maintenance is another strategy to reduce emissions without requiring new installations.[21]

22) Given the regulations already in place for methane reduction in the waste sector, why are emissions from the waste sector static over recent years? Are existing regulations monitored and enforced?

The static nature of methane emissions from the UK's waste sector in recent years, despite existing regulations, can be attributed to several factors. Firstly, it's worth noting that methane emissions from landfills have decreased significantly by 50% since 2010 (2021 data), largely due to the successful implementation of the Landfill Directive. This diversion of biodegradable waste away from landfills, driven by the Directive, resulted in fewer operational landfill sites and improved gas collection at these sites. However, even with improved capture, closed landfill sites can still emit methane, primarily through leaks from gas wells and CHP engine units. Abating these remaining emissions requires more effort, such as continuous monitoring, detection, and repair.

On the other hand, diverting biodegradables from landfills to AD and composting units brings its own challenges. The increase in methane emissions from composting facilities and the biomethane and biogas supply chain, including from AD processes (as noted in the NAEI data with a 49% increase in 2021 compared to 2010), highlights an emerging issue that warrants further investigation and action. This data suggests that while efforts to divert waste from landfills are effective in reducing emissions from those sources, they may inadvertently lead to increased emissions elsewhere in the waste management process. It's also important to note that the emission factors used by the NAEI underestimate methane emissions.[22] Methane emissions from anaerobic digestion and composting facilities are highly likely to be higher than those reported values based on the mobile measurement studies.[23]

The persistence of methane emissions from the waste sector in the UK, despite existing regulations, suggests a need for enhanced monitoring, reporting, and verification (MRV) mechanisms. These findings point to the complexity of accurately quantifying methane emissions, the diversity of emission sources within the waste sector, and the importance of adaptive regulatory frameworks that can respond to the nuanced challenges of methane emission reduction. Moreover, these studies highlight the necessity for continued innovation in methane detection and quantification technologies, as well as the importance of collaboration between regulators, industry stakeholders, and scientific researchers to effectively address methane emissions from the waste sector.

24) To what extent will improved methane captured at landfill sites, remain necessary to reduce methane emissions after this date?

Methane emissions from landfills can persist for decades after the cessation of waste deposition due to the long-term degradation of organic material. As such, enhancing methane capture not only addresses current emissions but also mitigates future emissions from existing waste. Also, captured methane can be used as a renewable energy source, offsetting the need for fossil fuels in electricity generation and heating. This not only reduces emissions but also contributes to energy security and diversification. Although waste diversion and recycling efforts are increasing, landfills are expected to remain a component of waste management systems for the foreseeable future. Continued innovation and investment in methane capture technologies is necessary to address the emissions from existing and future landfills.

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[14] Technically expressed as the amount of radiative forcing that it causes.

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