Does methane matter?
Policy implications for landfill gas

Climate change mitigation policy to date has been mainly concerned with reducing emissions of carbon dioxide (CO_2). However, recent research has drawn attention to the importance of methane (CH_4) emissions and this has started a debate[1] about whether there should be more active policies, particularly in the landfill gas sector, to reduce emissions of this greenhouse gas.

1. Methane contributes to climate change

Greenhouse gases contribute to global warming by absorbing infra-red radiation and trapping it within the atmosphere. Factors such as the length of time a gas lingers in the atmosphere (its atmospheric lifetime[2]), the overall concentration of a gas, and its radiative properties will affect its contribution to radiative forcing.[3]

The positive radiative forcing from greenhouse gases is slightly offset by the cooling effect of aerosols. Given that burning fossil fuels is the primary source of both CO_2 and aerosols, causing their effects to counteract each other to some extent, it has been argued that non-CO_2 gases, including methane, could have been responsible for much of the warming observed since 1850.[4] The combined direct and indirect effects of methane between 1750-2000 are estimated to be about 50% of that of CO_2.[5]

Policy Implication:

Mitigation policies must continue to focus on reducing emissions of CO_2, which "undoubtedly remains the single most important contributor to greenhouse gas radiative forcing"[6], but there should also be more policies targeted at reducing other greenhouse gases, and in particular methane, the effect of which we may have previously underestimated.

2. The impact of methane on the climate changes over time

Since different gases make different contributions to the greenhouse effect, policymakers have tried to devise a single "currency" in order to compare them with one another. The most widely-used measure is Global Warming Potential (GWP), which has been adopted by the IPCC[7] among others. It converts the radiative effect of any gas to equivalent tonnes of CO_2 over a given timescale (Figure 1). However, in recent years this approach has been widely criticised.

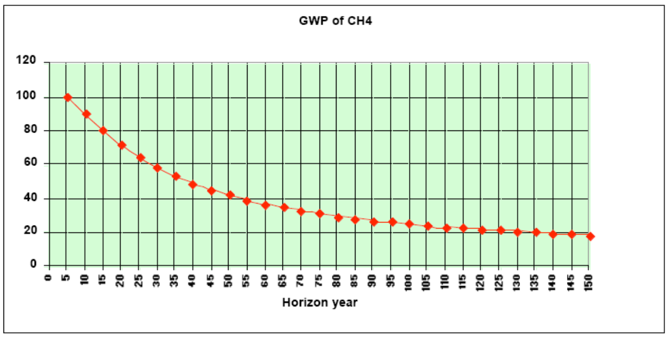
Figure 1: Illustration of Global Warming Potential

GWP usually uses an "arbitrary"[8] 100-year time span, so emissions tomorrow are given the same weighting as emissions at the end of the century. This creates a bias towards longer-lived gases, such as CO_2, and can result in methane, with an atmospheric lifetime of only 12 years, being undervalued in the short term. Table 1 is an extract from the IPCC report that shows the different GWP values for methane at 20-year, 100-year and 500-year intervals, but as Figure 2 shows, by the time the 20-year time interval is reached, the GWP of methane has already decreased by 25% of its initial value.

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	Radiative Efficiency ($W\ m^{-2}\ ppb^{-1}$)	Global Warming Potential for Given Time Horizon			
				SAR‡ (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below[a]	[b]1.4×10^{-5}	1	1	1	1
Methane[c]	CH_4	12[c]	3.7×10^{-4}	21	72	25	7.6

Table 1: Lifetime, radiative efficiencies and GWP, excerpt from IPCC report[9]

Figure 2: The global warming potential of methane over time[10]



However, GWP can be a useful way to compare methane and CO_2 if it is used to consider how the impact of methane varies over time, rather than to provide a constant value.

An alternative metric to GWP is the Global Temperature Change Potential (GTP)[11]. This approach is arguably more relevant for policy-making because it considers the effect of greenhouse gases on temperature rather than radiative forcing. Similar to GWP, timescale is also crucial in this model, as it investigates the relative values of methane and CO_2 over time in relation to a fixed temperature target. GTP finds that methane becomes more valuable as the temperature target approaches, because it is a short-lived gas and therefore mitigation has a more immediate effect on temperature. In other words, when faced with an impending temperature target, reducing methane emissions is a strategic way to take quick and effective action to prevent exceeding the target.

Therefore GWP and GTP compliment each other in enabling us to understand how to compare methane and CO_2:

- **The value of methane varies over time due to its short atmospheric lifetime.**
- **Mitigating methane emissions has the greatest impact in the short-term.**
- **Reducing methane is much more effective than CO_2 as a temperature target approaches.**

In the context of emissions and temperature targets that we will reach in the next few decades, the potential short-term impact of methane is crucial. Figure 3 demonstrates the importance of acting quickly since reducing emissions from 2013 could keep temperatures to a maximum of 1.5°C above pre-industrial levels.

Figure 4 also shows the benefits of early methane reduction. Achieving a 30% reduction in methane by 2020 as opposed to 2030 causes a $1Wm^{-2}$ additional reduction in radiative forcing, as well as being more effective when compared to reducing CO_2 emissions by 40%. However, Figure 4 also demonstrates that in the long-term CO_2 makes a greater contribution to climate change, which is why it is important to continue acting to reduce CO_2 emissions. Beyond 2030, the CO_2 curve steepens and over time the radiative forcing from CO_2 continually increases compared to methane.

Figure 3: Temperature rise associated with various emissions scenarios of CO_2, CH_4 and N_2O[12]

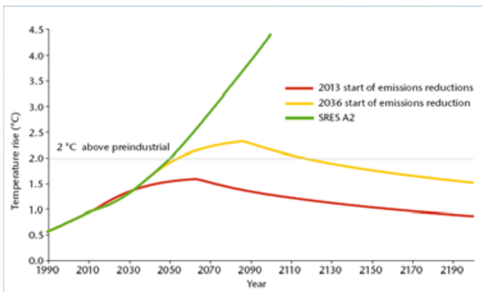
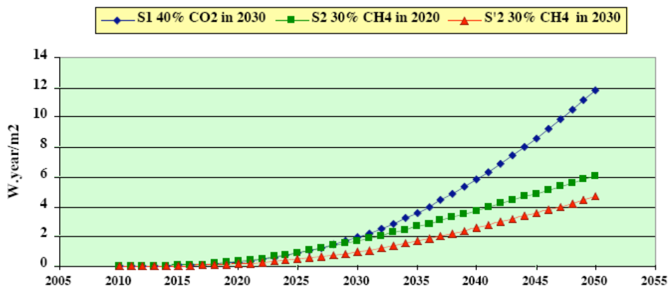


Figure 4: Comparison of climate impacts of reductions in CO_2 and CH_4[13]



Policy Implication:
Policymakers need to establish their priorities for mitigation to achieve a balance between meeting a short-term temperature target and long-term stabilisation. We are already committed to 0.25-0.75°C warming over the next century[14], but in order to minimise impacts after this time our emissions in the next decade are crucial; "the climate question will arise in a far shorter term than policy-makers generally imagine".[15] Implementing policies to reduce methane emissions from landfill sites is an effective way to meet these targets. However, resources should not be diverted to reducing landfill gas at the expense of CO2 mitigation, which will become more important in the long-term.

3. Current uncertainty makes methane more valuable

There are many uncertainties about how concentrations of greenhouse gases will change in the future and about climate sensitivity (the temperature change that will result from a doubling of CO_2). It has been said that "methane poses the biggest challenge to current understanding"[16] and so this raises the question about whether it is too much of a risk to develop policies to mitigate methane.

We can already be sure that methane is a key contributor to climate change (see Section 1) and that its effect is greatest in the short-term (see Section 2). If climate sensitivity is low, with a small temperature change resulting from a doubling of CO_2, there will be a gradual increase in temperature and therefore little benefit from the short-term effect of mitigating methane. However, as climate sensitivity increases, reducing methane emissions becomes more effective. Research[17] has found that as long as we expect to gain a better understanding in the future, methane is slightly more valuable than CO_2 when climate sensitivity is uncertain. This is because the benefits that could be gained from early action on methane if climate sensitivity is high are greater than the potential losses if sensitivity is lower than we currently expect.

Policy Implication:
Policies for mitigating methane in the landfill sector need to be implemented in the near future in order to be effective towards meeting targets over the next few decades. There is uncertainty about how the climate will respond to changing concentrations of methane and CO_2 but research indicates that we will benefit from early action to mitigate methane while we continue to improve our understanding.

4. Methane emissions reductions are achievable and cost-effective

While mitigating methane may be the key to meeting short-term targets, an important question that policy makers will need to ask is: are methane emissions reductions achievable? Research suggests that they are and that the greatest potential for reducing emissions in 2010 is in the energy and landfill gas sectors.[18]

Currently landfill gas emissions make up 20% of global methane emissions. A realistic estimate is that action to reduce releases of landfill gas could cut these emissions by 60-70% by 2020-2030, which corresponds to a 12-14% reduction in global methane emissions.[19] This is the pace and level of cuts required to put the world on a path to avoid dangerous climate change and shows how reducing methane emissions from landfill sites can make a significant contribution.

There is also an economic argument in support of reducing methane as well as CO_2 emissions in the short-term. Research using models to compare the costs of mitigating each gas finds that multi-gas strategies are more cost-effective (by 30-60%)[20] than focussing on only one gas. Cost reductions are greatest early on[21], with savings of up to 85% in 2010 and 25-35% in 2050 if multi-gas rather than CO_2-only mitigation policies are implemented.[22] However, in the long-term (beyond 2040), reductions in CO_2 become proportionally more cost-effective.

Policy Implication:
Mitigating methane from landfill sites in the short-term is economically viable as well as practically achievable. Together with the mitigation potential of methane over the next decade, this should encourage the development of policies to reduce landfill gas emissions. Multi-gas strategies are the most effective approach and in the long-term, CO_2 mitigation policies will become proportionally more significant[23] and cost-effective. Therefore policies to mitigate both CO_2 and methane should be developed in parallel.

References

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[2] Atmospheric lifetime is the length of time it takes for a pulse of gas to decrease to 37% of its initial concentration. CH_4 has an atmospheric lifetime of 12 years, but will remain in the atmosphere in very small concentrations for hundreds of years.

[3] Radiative forcing is the measure used to compare natural and anthropogenic drivers of climate change. The IPCC defines radiative forcing as the change in net (down minus up) radiation at the tropopause, allowing for temperatures in the stratosphere to return to equilibrium.

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