Assignment 4

Reducing methane emissions alone will not keep warming to 1.5 degrees Celsius - a discussion at the Global Methane Pledge

Abstract

The Global Methane Pledge (GMP), proposed by the US and the EU at COP26 to reduce methane emissions, has now been signed by 111 countries worldwide with a view to meeting the commitment to control global warming to 1.5 °C. This paper corrects for methane emissions in the four Shared Socioeconomic Pathway (SSP) scenarios using sectoral methane emissions data from the Global Methane Initiative (GMI) and the reduction targets in the pledges, combined with the sectoral methane reduction potential from the literature. It is estimated that up to about three quarters of anthropogenic methane emissions could be eliminated. However, such mitigation measures lack a significant long-term contribution to reducing global temperature warming. And reaching the pledges alone will not limit warming to 1.5 °C, and will only eliminate close to 0.2 °C of warming by 2050 under the high emissions scenario. To achieve the desired effects of the pledges, other global efforts will be needed to underpin them.

1. Introduction

Atmospheric methane is the largest non-CO2 anthropogenic greenhouse gas contributor to warming, and has increased significantly in recent years. The 156% increase in methane concentrations since 1750 is much higher than the natural millennial change over the last 800,000 years (IPCC, 2021). A comparative study by Jackson et al. (2020) indicates a 10-13% increase in average atmospheric methane levels relative to the period 2000-2006. Much of this increase is attributable to increased methane emissions from human activities such as agriculture (livestock production, rice cultivation), fossil fuel extraction and use, waste and biomass disposal, and changes in natural methane fluxes caused by anthropogenic climate change (Ciais et al., 2013). Although not one of the most significant CO2 emitting sectors, agriculture is the largest single source of anthropogenic global methane emissions (Reisinger et al., 2021). 37% of anthropogenic methane emissions in 2020 are from agriculture, of which more than 80% are from livestock systems, including enteric fermentation and manure management from ruminants such as cattle and sheep (GMI, 2022). Of these, enteric fermentation accounts for approximately 90% and is the largest source of anthropogenic methane emissions globally (GMI, 2022).

Methane has been estimated to have a low atmospheric lifetime (12.4 years) relative to CO2 (100-300 years) and N2O (121 years) (Blasing, 2016) and is considered a 'short-term climate forcing' (GMI, 2022). Although methane accounts for only 20% of global GHG emissions and has a relatively short residence time (GMI, 2022), it has a much higher capacity to absorb heat per unit of methane in the atmosphere than CO2. The global warming potential of methane is 28 times higher than that of CO2 on a 100-year time scale, without climate feedbacks, and up to 80 times higher on a 20-year scale (Myhre et al., 2013). The net result of these properties of methane is that one third of the contribution to global warming of anthropogenic greenhouse gases is provided by methane (GMI, 2022). In addition, methane is largely responsible for the formation of ground-level ozone, a harmful air pollutant (UNEP, 2021).

It could be argued that an overall reduction in anthropogenic methane emissions would be a 'shortcut' to global cooling if only its own effect on global warming were considered. The reality is less than ideal. Although the Paris Agreement has required significant reductions in methane emissions from agriculture (Rogelj et al., 2018), and more than 100 countries have included agricultural emission reductions in their National Autonomous Contribution (NDCs) (Richards, 2019). But to date, most of the NDCs actually lack details and implemented policies to drive real industry-wide reductions in agricultural methane emissions (Henderson et al., 2020; Leahy et al., 2020). The Global Methane Pledge (GMP), proposed by the US and EU at COP26, has now been signed by 111 countries worldwide with a commitment to reduce methane emissions by 30% by 2030 (GMP, 2021). Whether this will be a reprise of the NDC or a translation into real action is not yet known, but the interesting point is that according to the World Bank, 45 countries have already implemented or plan to implement realistic price-based policies to reduce CO2 emissions from fossil fuels by 2021 (World Bank, 2021). The purpose of this research paper is not to systematically discuss the lack of global ambition to reduce methane emissions, the implementation of policies needs to be adapted to the combined realities of the country. For example, a request for climate mitigation in some developing countries even with international assistance that are predominantly agricultural would be detrimental to social equity and exacerbate food insecurity (Hasegawa et al., 2018). Developed countries such as the UK and Australia, on the other hand, have been able to lead the way, with net-zero emissions commitments that include commitments to reduce methane emissions from livestock in addition to CO2 emissions (Climate Change Committee, 2020; BBC, 2021). This paper argues that a fundamental recognition of the importance of methane reductions in addition to CO2 reductions should be reaffirmed, but that their effectiveness should not be deliberately magnified.

The aim of this study is to investigate the different effects that anthropogenic methane emission reductions can have on global temperature change. Based on the above background, this study assumes a set of scenarios using data obtained from the literature. In the context of global governments and politicians prioritising the reduction of anthropogenic methane emissions, leading to the adoption of the highest reduction potential for methane emissions under all SSPs in 2030, compared to the effect of reaching the GMP commitment to complete methane reductions (GMI, 2022; GMP, 2022).

The subsequent sections of the paper are structured as follows: the next section describes the future climate change scenarios constructed under the assumptions and the findings in comparison with the original scenarios. The third section is the discussion, exploring the possible recommendations of this study for environmental policy, and the directions in which research can be extended based on this study. The final section provides a description of the use of the model.

2. Results

To address the question posed by this study: how far would reducing the now more neglected methane emissions in the SSP alone affect the original scenario? Future climate change scenarios were constructed using the Finite Amplitude Impulse Response (FaIR) simple climate model and analysed.

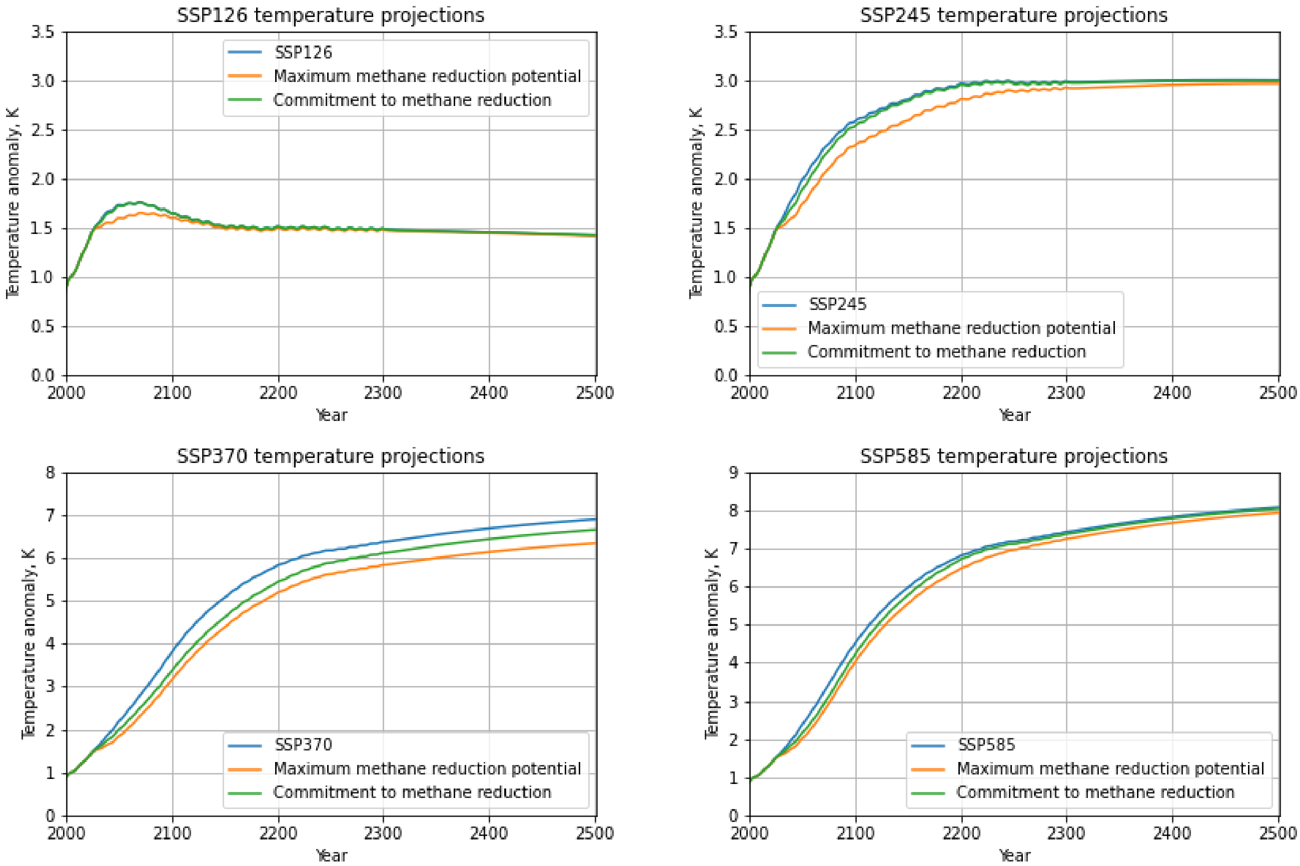

Figure 1. Comparison of global temperature changes in different SSPs in two methane abatement contexts.

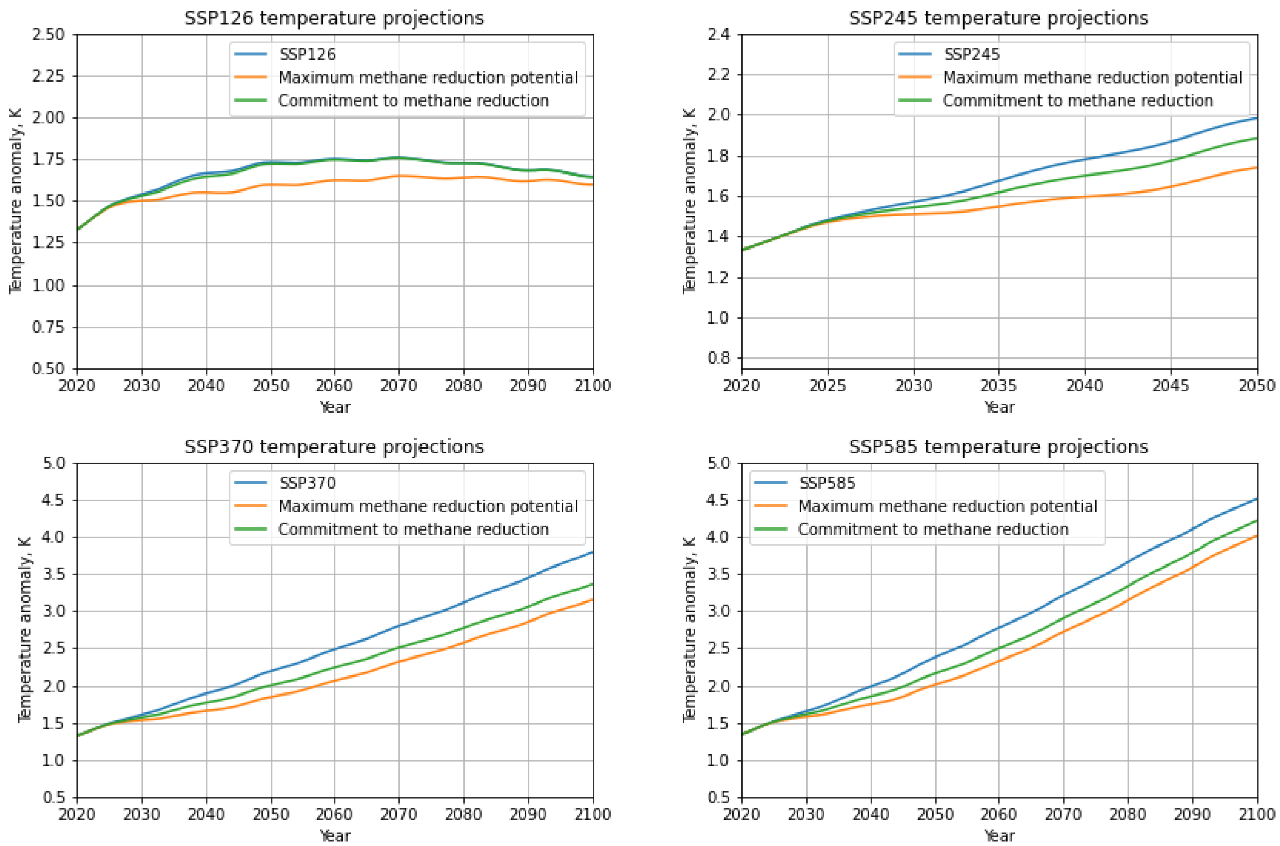

Figure 2. Short-term temperature change comparison.

The results of the modelling in this paper are shown in Figure 1. In the SSP126 and SSP245 scenarios, lower methane emissions are able to smooth out the temperature changes during the process of reaching the climate steady state significantly. In SSP126, the short term warming due to the rapid decline in total GHG emissions is neutralised by the short term rapid cooling due to the maximum reduction in methane emissions, delaying and reducing the peak warming by approximately 0.1 °C. As a sustainable scenario on a green path, the impact of only a 30% reduction in methane emissions is minimal. It can be assumed that the original control commitments for methane emissions in this scenario are already being considered. In the SSP245 scenario, a maximum reduction in methane emissions would significantly slow the rate of global warming. Only in the SSP370 scenario would global warming be mitigated to a small extent, even if only the GMP commitment for methane emissions in 2030 is met. However, the maximum methane reduction under this scenario is not much more significant than a mere 30% reduction in emissions, but is still the most significant of the four scenarios. The SSP370 scenario originally pointed to a medium-high reference future of regional rivalry, a scenario with the highest methane and air pollution gas emissions (Meinshausen et al., 2020), global methane emission targets would not be the focus of policy under this scenario. The prominence of maximum methane emission reductions in this scenario can be attributed to this and can be considered as lacking in informativeness. SSP585 as the upper edge of the SSP scenario, a world with a high level of fossil fuel development is also unable to use reduced methane emissions as a 'silver bullet' to slow global warming. Given that the actual atmospheric lifetime of methane under the high emissions scenario is longer than the predicted original value (Meinshausen et al., 2020), the role of reducing methane emissions under the high emissions scenario is even more questionable.

In summary, a single reduction in methane emissions is unlikely to make a substantial and dramatic difference to the current SSP scenario in the long term. In the short term, reducing methane emissions alone also does not have the conditions to support policy ambition. All scenarios assumed do not meet the commitment to not exceed 1.5 °C of warming, and all scenarios achieve more than 1.5 °C of warming by 2030 (Figure 2). The GMP's initiative to "keep a 1.5°C future within reach" by reducing methane emissions(GMP, 2022) can be considered unrealistic in the context of the results of this study . Only in the context of high emissions can a reduction in methane emissions close to "0.2°C of warming" by 2050 be achieved (GMP, 2022). But it is still important to note that the short-term effects of reducing methane emissions can be significant, and that reducing anthropogenic methane emissions can contribute to controlling global warming as a complementary tool.

3. Discussion

The conclusions of this paper corroborate Balcombe et al.'s (2018) critique of global warming potential, the concept often referred to in studies supporting the importance of reducing methane emissions (Myhre et al., 2013; Harmsen et al., 2019; Reisinger et al., 2021; UNEP and CCAC, 2021; GMI, 2022). Comparing the effects of methane with those of CO2 in terms of global warming potential can lead to an overemphasis on the specificity of the short-term forcing of methane and a systematic underestimation of the long-term effects of CO2 (Balcombe et al., 2018). It is also due to the long-term nature of CO2 in the atmosphere that net CO2 emissions must be reduced to zero in order to stabilise temperatures (Reisinger et al., 2021), and this paper suggests that the highest priority for mitigation targets and efforts should still be focused on CO2 emissions. However, it is worth pointing out that since additional warming occurs when short-term cooling aerosol removal reaches zero emissions (Smith et al., 2019), the smoothing effect that lower methane emissions can have is also worth exploiting.

The amount of reduction in methane emissions is highly debated in practical politics (Meyer, 2021). In this study it was also found that methane emission reductions are worth finding a path that best matches the reduction with the cost. This best-fit path is often worth exploring because of regional and sectoral differences.

4. Methods

4.1.Methane emissions:

The starting point for the analysis in this study comes from research on methane emissions. the global methane assessment by UNEP and CCAC (2021), through a broad sectoral analysis of the reduction potential of various methane emitting sectors (UNEP and CCAC, 2021, pp95-107), concludes that if the full range of methane targeting measures available today are applied to 2030 anthropogenic methane emissions reduction potential of up to 45% by 2030. Although more than half of these measures have negative costs, the majority of the reduction potential can be achieved at low cost, particularly for waste, fossil fuel extraction and use (UNEP and CCAC, 2021). Harmsen et al. (2019) based on a multi-model comparative scenario analysis of several integrated assessment models, indicated that there is a consensus in the literature on the reduction potential of present-day anthropogenic methane emission sources, with the exception of ruminant emissions. Installing centralised aerobic wastewater treatment systems in all countries worldwide to achieve the same per capita emissions as in the OECD Europe could reduce methane emissions from the wastewater sector by 90% (US-EPA, 2013, Harmsen et al., 2019). Rice emission reductions due to the diverse complexity of its model, a policy of maximising additional measures in parallel with technological improvements is chosen based on the scenarios assumed in this study, using its plausible maximum reduction potential of 87% and a global minimum unavoidable emission reduction set at 10 Mt/year (Harmsen et al., 2019). The high maximum abatement potential of the fossil fuel sector with landfills/solid waste is the consensus of the existing literature and can typically be higher than 90% by 2100 (Harmsen et al., 2019). Manure collection and treatment in centralised or large-scale agriculture can achieve 75% of today's maximum methane emission potential (Harmsen et al., 2019). A recent study by Zubieta et al.(2021) summarises the literature on methane mitigation by looking at the underlying causes of methane production by ruminants and suggests that sound grazing practices can reduce methane emissions from ruminants by 55% while maintaining today's meat supply. The above data can be considered the high end of the literature and is consistent with the hypothesis of this paper. Combined with the GMI statistics on global methane emissions, the following table was produced for this study.

Sectors	Ratio to total emissions (%)	Ratio of maximum mitigation (%)	Final ratio in 2030 (compared to 2020)
Enteric Fermentation	27	55	12.15
Agriculture (Manure Management)	3	75	0.75
Rice Cultivation	7	87	7 (0.91*)
Coal Mining	9	90	0.9
Municipal Solid Waste	11	90	1.1
Oil & Gas	24	90	2.4
Wastewater	7	90	0.7
Other Anthropogenic Sources	5	0	5
Biomass	3	0	3
Stationary & Mobile Sources	4	0	4
Total	100		37

* It is important to note that since there is a minimum limit for rice emissions (10 Mt/yr) (Harmsen et al., 2019), the maximum formula for using the maximum potential to reduce methane emissions is calculated as

$$ECH_{4(2030)} = ECH_{4(2020)} \times 0.37 - (ECH_{4(2020)} \times 0.07 - ECH_{4(\min of\ rice)})$$

where $ECH_{4(2030)}$ and $ECH_{4(2020)}$ are the anthropogenic global methane emissions (in Mt/yr) in 2030 and 2020 respectively. *0.37* is the final combined mitigation correction factor for methane emissions in the above table when the value for rice emissions is held constant. 0.07 is the ratio of rice to total emissions in 2020. $ECH_{4(\min of\ rice)}$ is the minimum limit for methane emissions from rice. The final 2030 data obtained is the maximum control value for the final subsequent years, above which it is set.

4.2.Modelling climate response/climate models.

The FaIR model (version 1.6.4) was used in this study to assess future scenarios for the scenario setting. The FaIR model predicts temperature change by calculating atmospheric concentrations of GHG and total effective radiative forcing including aerosol precursor emissions, by calibrating the Earth system model to the temperature and carbon cycle (Smith et al., 2018). The model agrees exceptionally well with the RCP2.6 and RCP4.5 scenarios (Smith et al., 2018) and was used in the IPCC Sixth Assessment Report for projections of future emission scenarios and estimates of warming contributions (Forster et al., 2021). The effective radiative forcing values generated in the FaIR model also avoid the underestimation of methane forcing in AR5 (Etminan et al., 2016; Smith et al., 2019). making FaIR model predictions of temperature very relevant to this paper.

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