Including and quantifying methane mitigation in NDCs is key to a better climate outcome

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Context

Nationally Determined Contributions (NDCs)—national pledges to reduce emissions made every 5 years—are central to the Paris Agreement and have been an important focus of national and international efforts to address climate change. The updated NDCs for 2035 to be submitted to the United Nations early in 2025 are a critical opportunity to accelerate progress.

Nations are allowed great flexibility in how NDCs are defined. This has been crucial for ensuring broad participation in the Paris Agreement; however, it creates risk of suboptimal outcomes if NDCs are not suitably comprehensive or ambitious. Arguably, the most consequential of these risks involve the treatment of methane in NDCs.

First, when NDCs and longer-term goals (such as net zero) include reductions only in CO_2, this can lead to sizable unaddressed emissions of other gasses, and substantial associated warming. For example, China's most recent NDC set a target only for CO_2 emissions,[1] placing no limits on the nation's considerable emissions of methane and other non-CO_2 gasses – China's annual methane emissions of 64 Mt CH_4 (equivalent to 1.9 Gt CO_2e-100)[2,3] are similar to the overall annual GHG emissions of Russia.[4] Recognizing the risk of unaddressed emissions, the United Nations' Global Stocktake encourages the inclusion of all greenhouse gasses (GHGs) in NDCs,[5] and the US and China agreed in the Sunnylands Statement to include all GHGs in their next NDCs.[6]

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[1] Climate Action Tracker. https://climateactiontracker.org/countries/china/targets/
[2] Jones, et al. 2024. "National Contributions to Climate Change Due to Historical Emissions of Carbon Dioxide, Methane and Nitrous Oxide". Scientific Data. Zenodo. https://doi.org/10.5281/zenodo.10839859.
[3] Khanna, et al. 2024. An assessment of China's methane mitigation potential and costs and uncertainties through 2060. *Nat Commun* 15, 9694. https://doi.org/10.1038/s41467-024-54038-y
[4] https://www.wri.org/insights/4-charts-explain-greenhouse-gas-emissions-countries-and-sectors
[5] United Nations Framework COnvention on Climate Change, https://unfccc.int/topics/global-stocktake/about-the-global-stocktake/outcome-of-the-first-global-stocktake
[6] https://www.state.gov/sunnylands-statement-on-enhancing-cooperation-to-address-the-climate-crisis/

This risk was also a motivation for initiating the Global Methane Pledge (GMP),[7] a collective effort to reduce global methane emissions launched at COP26.

Second, the widely used CO_2e-100 metric tends to undervalue the near-term climate benefit of mitigating short-lived pollutants.[8] For methane, which has an atmospheric lifetime of about a decade, and accounts for around 30% of current observed warming,[9] this translates to an underestimate of the climate benefits of methane mitigation. Because of this, adding a specific methane contribution to an NDC defined in terms of CO_2e-100 might motivate stronger methane mitigation.

Finally, an NDC or other mitigation goal defined in terms of any single metric combining all greenhouse gasses together, such as CO_2e-100, does not provide enough information to reliably project future warming and associated societal impacts.[10] NDCs and longer-term goals that specify methane mitigation contributions to overarching emission reduction targets therefore allow for more reliable assessment of future warming impacts, and strong methane action in particular can also lead to significantly less near-term and long-term warming than scenarios with the same CO_2e-100 but weaker methane mitigation.

Results

We illustrate these points using simulations of four idealized, illustrative scenarios performed with a reduced-complexity climate model.[11] These scenarios are based on the SSP3-7.0 scenario,[12] one of the "regional rivalry" family of scenarios. SSP3-7.0 involves high emissions generally, including high emissions of non-CO_2 pollutants.[13] Departing from SSP3-7.0 in 2030, three of our four scenarios involve a 50% reduction relative to 2015 in all-gas GHG emissions by 2040, and net-zero all-gas emissions in 2060 and beyond, as measured by CO_2e-100. These three scenarios differ in terms of how much mitigation is accomplished via methane vs CO_2, as described in more detail

[7] https://www.globalmethanepledge.org/

[8] Cohen-Shields et al. 2023. Distortion of sectoral roles in climate change threatens climate goals. Front. Clim., 5, p. 1163557. https://doi.org/10.3389/fclim.2023.1163557

[9] IPCC AR6 WGI SPM 2021 https://www.ipcc.ch/report/ar6/wg1/chapter/summary-for-policymakers/#figure-spm-2

[10] Miller J. S., et al., 2024. Beyond the single-basket mindset: A multi-gas approach to better constrain overshoot in near term warming, Environ. Res. Lett. *19*(9), 094011. http://iopscience.iop.org/article/10.1088/1748-9326/ad6461.

[11] https://magicc.org/

[12] In all the scenarios we consider, emissions of pollutants other than methane and CO_2 follow SSP3-7.0 scenario in all years.

[13] https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change/

below. Comparing them therefore illustrates both the potential of aggressive methane mitigation to limit both near- and long-term warming, as well as the ambiguity of expressing mitigation goals only in terms of CO_2e-100, without specifying contributions from individual gasses. We also show a “CO_2-only action” scenario in which only CO_2 emissions reach net-zero, and methane emissions increase following the trajectory in the SSP3-7.0 scenario. Comparing this “CO_2-only target” scenario to the others reveals that including non-CO_2 GHGs in mitigation targets results in less warming at both 2050 and 2100.

The four scenarios we consider are

(1) a “no methane action” scenario, in which all reductions in CO_2e-100 come in the form of reduced CO_2 emissions, and emissions of methane and other non-CO_2 gasses continue to increase as in the SSP3-7.0. This scenario achieves net-zero overall emissions, as measured via CO_2e-100, through strongly net-negative CO_2 emissions.

(2) a “weak methane action” scenario, in which the GMP goal of a 30% reduction in human methane emissions below the 2020 level is achieved not as desired in 2030, but in 2040. After 2040, human methane emissions are constant. Relative to the no methane mitigation scenario, this scenario requires less CO_2 removal to achieve net-zero overall emissions (as measured using CO_2e-100). This scenario has the same overall emissions, measured by CO_2e-100, as the “no methane action” scenario.

(3) a “strong methane action” scenario in which the GMP goal is realized, and human methane emissions continue to drop after 2030, decreasing roughly 80% by 2100. This scenario has the same overall emissions, as measured by CO_2e-100, as the “no methane action” and “weak methane action” scenarios. Stronger methane mitigation means that this scenario requires less CO_2 mitigation and less CO_2 removal than the “no methane action” and “weak methane action” scenarios.

(4) A “CO_2-only action” scenario in which CO_2 emissions are reduced 50% relative to 2015 by 2040, reach net zero by 2060, and remain at net zero through 2100. This scenario assumes no methane action, and methane emissions continue to rise following the trajectory in the SSP3-7.0 scenario. This scenario has higher all-gas emissions (as measured by CO_2e-100) than the other scenarios considered here.

In order to isolate and illustrate the effects of varying CO_2 and methane emissions, all our idealized scenarios assume the same emissions for all other pollutants. As a result, our results do not reflect any correlations between emissions of CO_2 or methane and emissions of other pollutants (in particular, the relationship between fossil fuel CO_2

emissions and sulfate pollution). We note below how this may affect the interpretation of our results.

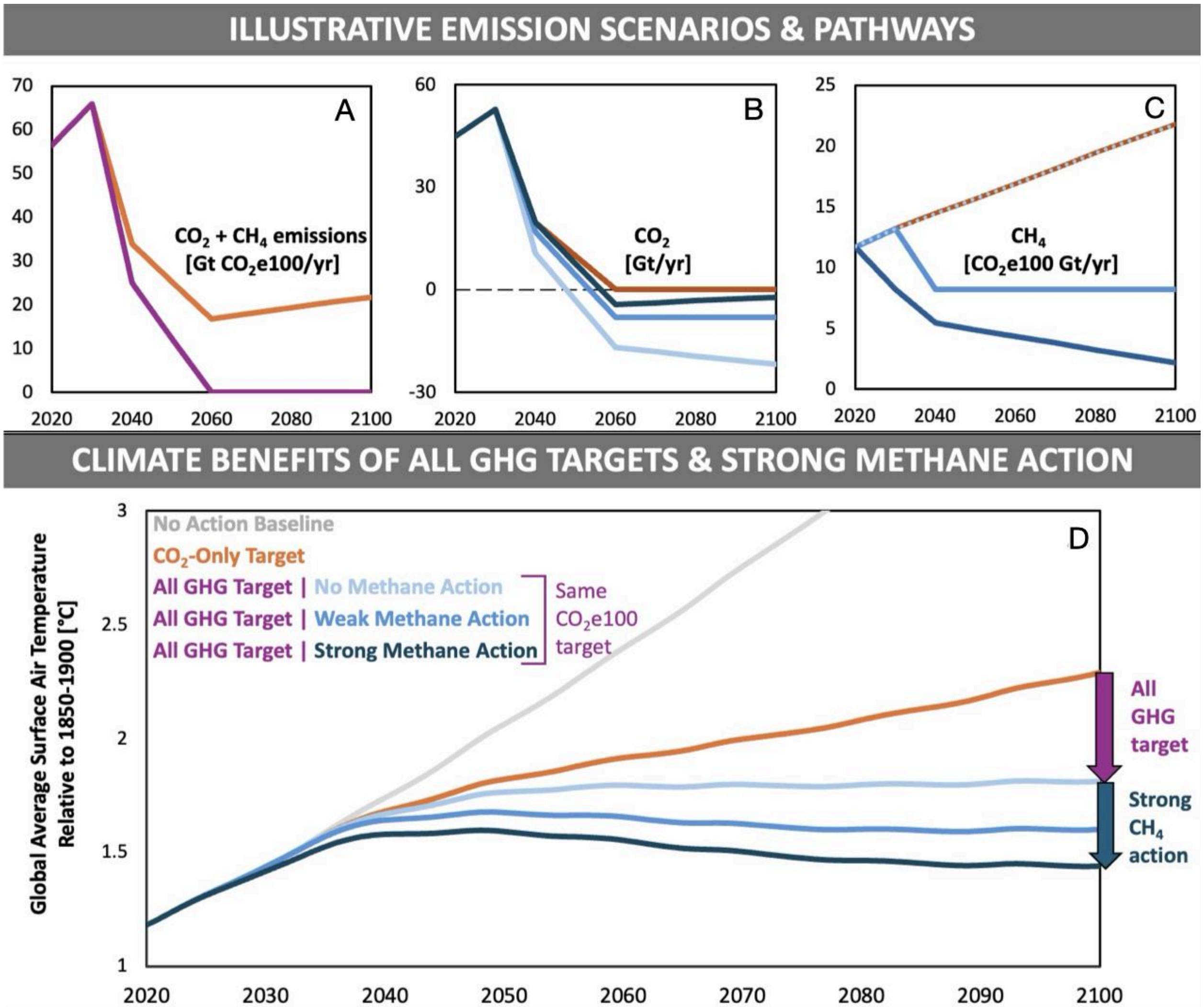

Figure: Idealized scenarios illustrating the effect of methane mitigation on near-term warming, the ambiguity of not specifying methane reductions in scenario definitions, and the greater risks associated with CO_2-only mitigation. Panel (A): Annual aggregate GHG emissions (expressed as CO_2e-100) in a mitigation scenario that reduces all-gas emissions 50% relative to 2015 by 2040 and reaches net zero by 2060 (purple line), and in a scenario in which CO_2 reaches net zero but methane emissions continue to rise following SSP3-7 trajectory (orange line). Panel (B): Annual net emissions of CO_2, in the no methane action scenario (light blue), weak methane action scenario (medium blue), strong methane action scenario (dark blue), and CO_2-only action scenario (orange). Panel (C): Annual emissions of methane, for the SSP3-7.0, CO_2-only action scenario, and no methane action scenario (orange and blue hash), the weak methane action scenario (light blue), the strong methane action scenario (dark blue). Panel (D)l: Simulated global temperatures, relative to preindustrial, for all scenarios.

Our results, shown in the figure, illustrate three key messages:

(1) **NDCs and net zero goals that cover CO_2 only, without mitigating other climate pollutants, allow significant warming and therefore opens the door to higher levels of societal risks**. Net zero CO_2, together with continued high emissions of other pollutants, results in an end-of-century temperature greater than 2°C above preindustrial, and with an increasing trend. The CO_2-only action scenario is warmer than the others because it assumes no methane action and because it is the only scenario considered here in which CO_2 emissions never become net-negative.

(2) **Within the context of a given CO_2e-100 scenario, ambitious mitigation of methane reduces near-term and end-of-century warming significantly more than weak or no methane mitigation does.** Compared to no methane action, strong methane action results in almost 0.2°C less warming in 2050 and about 0.3°C less warming in 2100, even though the overall CO_2e-100 emissions pathway is identical. These differences are large enough to translate to measurably different societal risks. Moreover, our analysis tends to underestimate these differences because we do not consider that CO_2 mitigation unmasks warming from particulate pollution associated with fossil fuel use. One analysis that includes this effect shows double the climate benefits, with 0.4°C less warming in 2050 associated with greater methane ambition.[14]

(3) **Scenarios defined only in terms of CO_2e-100 reductions, do not allow reliable assessments of future societal risks.** Because scenarios which do not specify contributions from individual gasses are consistent with a wide range of temperature outcomes, these scenarios cannot be associated with well-defined expectations for climate-driven societal risks. Among the illustrative scenarios shown here, for example, only the "strong methane action" scenario results in limiting warming to 1.5°C by 2100. In different scenarios based on less overall ambition, the degree of methane mitigation could determine whether or not temperature outcomes are Paris-compliant.

Conclusion

NDCs are the heart of the Paris Agreement and represent nations' individual and collective contributions to address climate change. The Agreement was designed with no required minimum initial national pledge, and great flexibility in how NDCs are defined, in order to encourage widespread participation. That strategy is working—all but a few nations are part of the Paris process. Long-term success requires that NDCs be aggressive in terms of ambition and comprehensive in terms of gasses and sectors

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[14] Miller J. S., et al. 2024. Beyond the single-basket mindset: A multi-gas approach to better constrain overshoot in near term warming, Environ. Res. Lett. 19(9), 094011. http://iopscience.iop.org/article/10.1088/1748-9326/ad6461.

covered. We call upon nations to include all GHGs in the next NDCs and specify additional ambitious quantitative contributions from methane and other non-CO_2 gasses; this is a critically important opportunity to increase overall mitigation ambition,[15] to deliver reduced near-term warming, and to obtain important societal co-benefits. To help facilitate these steps, the United Nations Environment Programme's Climate and Clean Air Coalition offers guidance for including methane[16] and other non-CO_2 pollutants[17] in NDCs. Finally, we note that specific NDC contributions from methane mitigation can attract financial, technical, and capacity resources from climate and health financing sources, which can significantly offset mitigation costs.

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[15] Tanaka K., et al., 2024. Aligning long-term climate mitigation with enhanced methane action, arXiv: 2402.04749: http://arxiv.org/abs/2402.04749

[16] https://www.ccacoalition.org/resources/guidance-including-methane-ndcs

[17] https://www.ccacoalition.org/resources/including-non-co2-pollutants-nationally-determined-contributions-ndc-30