

FORMATION AND IMPACT OF ENTERIC METHANE

■ Authors: Ashley Schilling-Hazlett¹, Kim Stackhouse-Lawson¹, Sara Place¹, Juan Vargas¹, Anna Shadbolt¹

What is methane?

TO CREATE animal agriculture practices that benefit climate action, it is important to understand greenhouse gases (GHGs) of primary interest. The three main GHGs emitted from agriculture production are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Each one of these gases has a different potential to trap heat and atmospheric lifetime which makes comparing GHGs important. The most commonly used metric is the 100-year global warming potential (GWP), which compares GHGs to the GWP of carbon dioxide over a 100-year time frame (GWP100). Using the GWP100 metric, a value of 1 is assigned for carbon dioxide, 27 for methane, and 273 for nitrous oxide (IPCC, 2021). Practically, this means 1 pound of methane is equivalent to 27 pounds of carbon dioxide. In terms of atmospheric lifetime, one molecule of methane generally remains in the atmosphere for approximately 12 years before oxidizing into carbon dioxide and water vapor. Despite being a more potent GHG than carbon dioxide, methane is relatively short-lived in the atmosphere, making methane emissions mitigation an attractive near-term climate action.

How is methane produced?

IN ANIMAL AGRICULTURE, methane is produced via two processes (Figure 1). The first process is from microorganisms utilizing fermentation by-products in the gut of ruminants such as cattle, sheep, and goats. In the rumen, the classification of microorganisms that convert primarily carbon dioxide and hydrogen, produced as by-products of feed fermentation, into methane are called *methanogens*. This process generates what is referred to as *enteric methane*. After enteric methane is formed in the rumen, it is emitted to the atmosphere primarily through eructation, which releases methane from the animal's nose and mouth. In general, ruminants will produce more enteric methane when consuming high forage or high fiber diets (e.g., grass or hay-based diets) as compared to lower forage, grain-based diets (Beauchemin et al., 2020). Another way methane is produced in animal agriculture is through *anaerobic* (without exposure to oxygen) *manure decomposition*. The methane produced can be managed for producing other forms of energy at anaerobic methane treatment facilities.

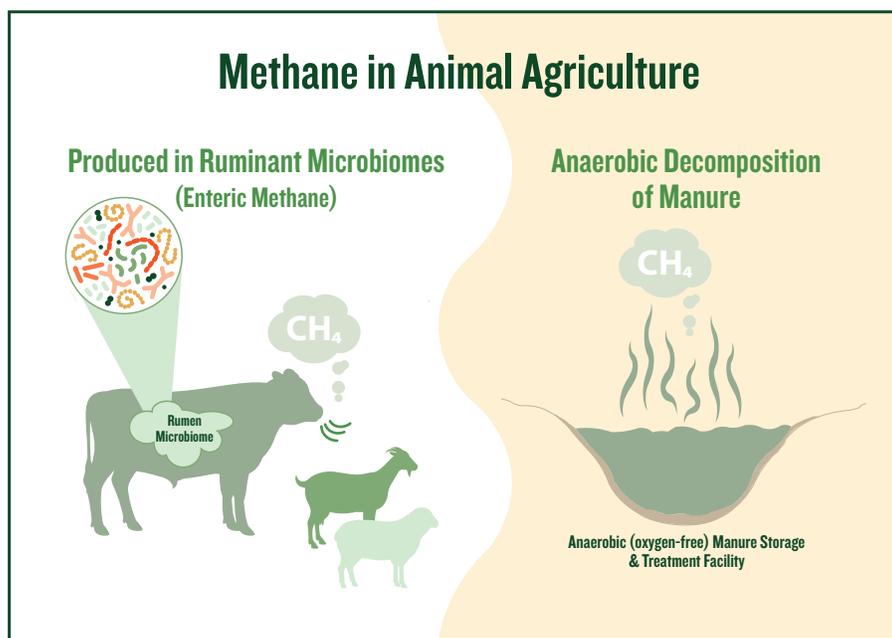


Figure 1. Overview of sources of methane from animal agriculture.

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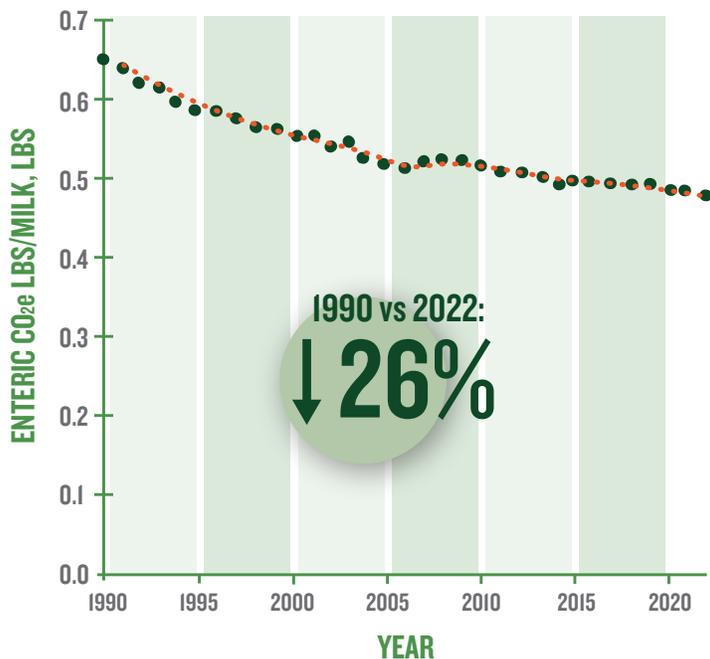
Why is enteric methane reduction important?

AGRICULTURE COMPRISED 9.4% of total US GHG emissions in 2022, of which approximately 33% were attributed to enteric methane (EPA, 2024a). When considering the state of Colorado in 2022, 12.5% of total GHG emissions in the state came from agriculture, of which approximately 41% were enteric methane (EPA, 2024b). The urgency to reduce methane emissions is catalyzed by the recognition of the rate at which emissions have increased over the last three decades. From 1990 to 2022, CH₄ from enteric fermentation has increased by 5.2% nationally, however, a 20.3% increase in enteric fermentation emissions has been observed in Colorado (EPA, 2024a,b). In part, these divergent trends can be explained by the growth in the number of dairy cattle in Colorado since 1990 (+170%) compared to a national trend of lower dairy cow inventories in recent years compared to 1990 (USDA NASS, 2025). While total emissions of enteric methane have not significantly declined since 1990 nationally, emissions per lb. of milk and beef (methane emissions

intensity or enteric methane footprint) have declined by 26% and 17%, respectively (**Figure 2**). While substantial, it is projected that a continued decline in methane emissions intensity will likely be insufficient to offset the continued increase in absolute (i.e. total) emissions (Beauchemin et al., 2020). Therefore, to support continued growth in animal agriculture industries, ensure a secure food supply, and reduce the impacts of climate-induced warming, enteric methane mitigation research and innovation are necessary. However, agriculture research funding has been and will continue to be a rate-limiting factor in measuring, reporting, and verifying enteric methane emissions mitigation strategies and reduction potential. Therefore, opportunities to increase funding of research to support climate action in animal agriculture will be paramount for future progress.

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U.S. DAIRY ENTERIC FOOTPRINT



U.S. BEEF ENTERIC FOOTPRINT

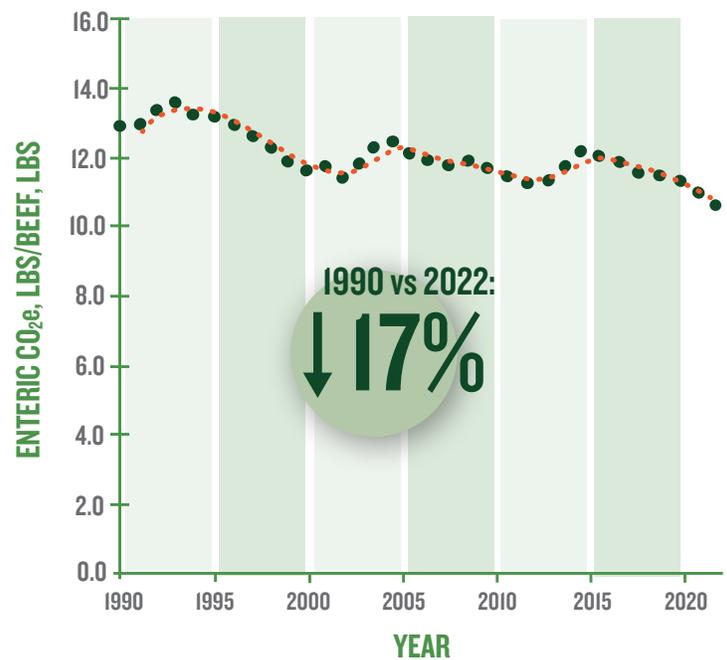


Figure 2. Trends in US enteric methane emissions per lb. of milk and per lb. of beef. Data from US EPA (2024a) and USDA-NASS (2025).

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What is the role of ruminants in enteric methane emissions?

NATIONALLY IN 2022, approximately 71% of enteric methane emissions came from beef cattle, with dairy cattle contributing an additional 25% (EPA, 2024a). A similar distribution for enteric methane emissions was observed in Colorado, with approximately 79% of enteric methane emissions in 2022 coming from beef cattle, with dairy cattle comprising an additional 17.4% (**Figure 3**; EPA, 2024b). Proposed enteric methane mitigation efforts have been broadly defined in three main categories; feed and animal management, diet formulation, and rumen manipulation (Arndt et al., 2022). Looking into the future, many opportunities exist to potentially reduce enteric methane emissions from ruminant species, which will be of the utmost importance to curb the rate of rising atmospheric GHG concentrations.

Colorado Greenhouse Gas Emissions from Enteric Fermentation by Animal Species

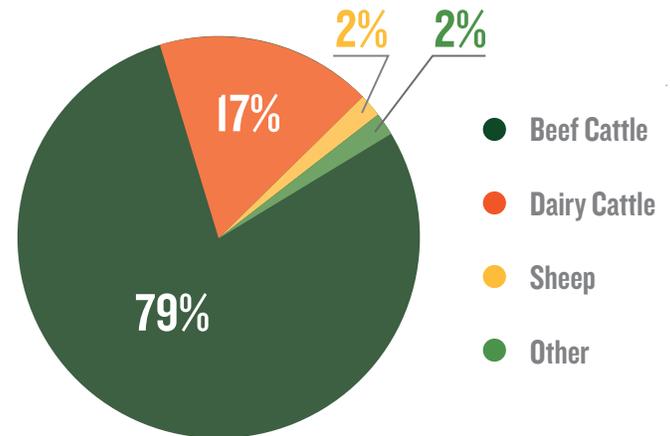


Figure 3. Breakdown of Colorado enteric methane emissions for 2022 (EPA, 2024a).

BOTTOM LINE: Enteric methane emissions are naturally produced as a part of the digestive processes in ruminant livestock (e.g., cattle, sheep, goats). Methane is a greenhouse gas, and enteric methane emissions represent 3.1% of US and 5.1% of Colorado greenhouse gas emissions. Methane emissions have declined per lb. of milk and beef in the US, but further reductions driven by evidence-based solutions can lower total methane emissions and decrease the climate impacts of ruminant agriculture.

References:

- Arndt, C., Hristov, A. N., Price, W. J., McClelland, S. C., Pelaez, A. M., Cueva, S. F., Oh, J., Dijkstra, A., Bannink, A., Bayat A. R., Crompton, L. A., Eugène, M. A., Enahoro, D., Kebreab, E., Kreuzer, M., McGee, M., Martin, C., Newbold, C. J., Reynolds, C. K., Schwarm, A., Shingfield, K. J., Veneman, J. B., Yáñez-Ruiz, D. R., & Yu, Z. (2022). Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5 C target by 2030 but not 2050. *Proceedings of the National Academy of Sciences*, 119(20), e2111294119. <https://doi.org/10.1073/pnas.2111294119>
- Beauchemin, K.A., Ungerfeld, E.M., Eckard, R.J., Wang, M. (2020). Review: Fifty years of research on rumen methanogenesis: lessons learned and future challenges for mitigation, *Animal*, 14(s2-s16). <https://doi.org/10.1017/S1751731119003100>.
- IPCC (2021). Chapter 4: Atmospheric Chemistry and Greenhouse Gases. Intergovernmental Panel on Climate Change, AR6. <https://www.ipcc.ch/report/ar3/wg1/chapter-4-atmospheric-chemistry-and-greenhouse-gases/>
- EPA (2024a). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022 U.S. Environmental Protection Agency, EPA 430R-24004. <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022>.
- EPA (2024b). Methodology Report: Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990 – 2022. Available at: <https://www.epa.gov/ghgemissions/methodology-report-inventory-us-greenhouse-gas-emissions-and-sinks-state-1990-2022>
- USDA-NASS (2025) Quick Stats. Available at: <https://quickstats.nass.usda.gov/results/90D1C82D-30CF-3796-8707-3E022D105106>

Affiliations and Acknowledgements:

¹AgNext | Department of Animal Sciences, Colorado State University, Fort Collins, CO

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