How managing methane can make livestock part of a climate solution

Frank Mitloehner, Professor and Air Quality Specialist, UC Davis, Department of Animal Science
Director, CLEAR Center | fmmitloehner@ucdavis.edu

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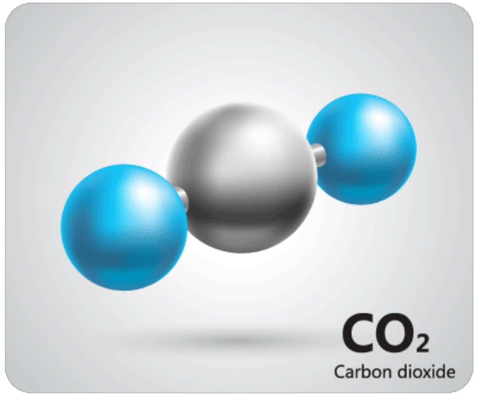
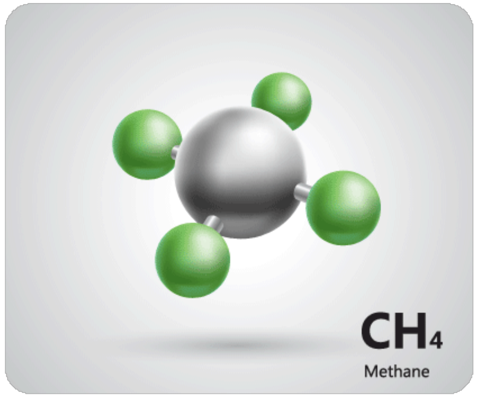
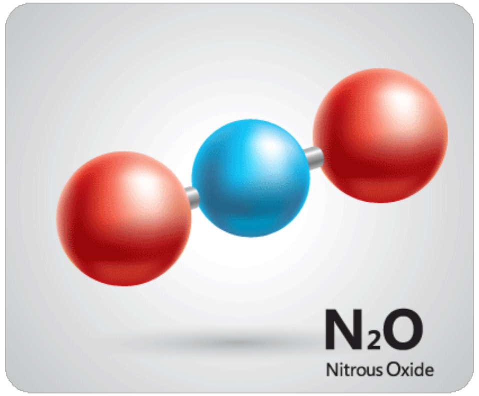


Global Warming Potential (GWP_{100}) of Main Greenhouse Gases



Carbon Dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous Oxide (N_2O)	265



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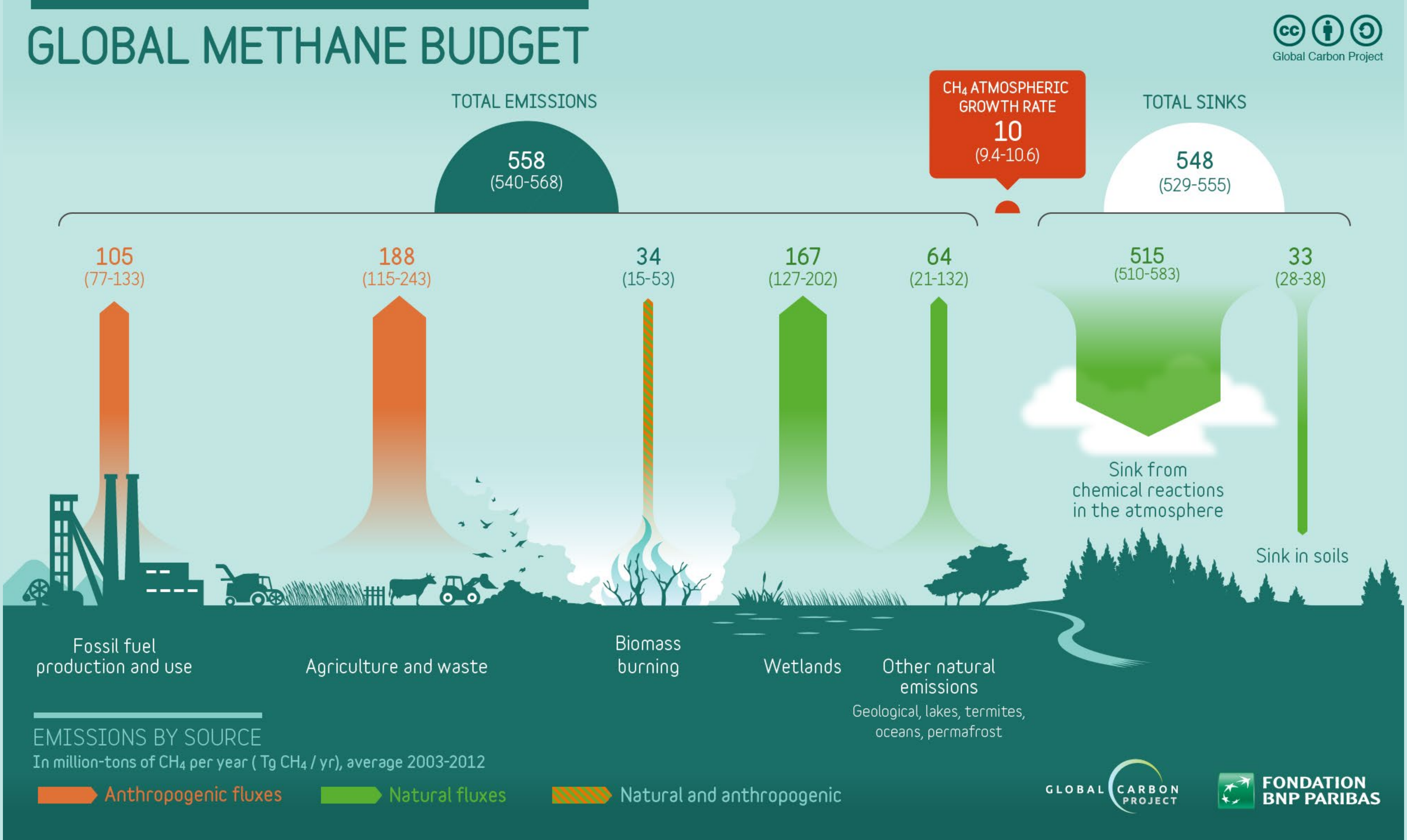
GLOBAL METHANE BUDGET
Global Carbon Project
TOTAL EMISSIONS
558
(540-568)
CH_4 ATMOSPHERIC GROWTH RATE
10
(9.4-10.6)
TOTAL SINKS
548
(529-555)
105
(77-133)
188
(115-243)
34
(15-53)
167
(127-202)
64
(21-132)
515
(510-583)
33
(28-38)
Sink from chemical reactions in the atmosphere
Sink in soils
Fossil fuel production and use
Agriculture and waste
Biomass burning
Wetlands
Other natural emissions
Geological, lakes, termites, oceans, permafrost
EMISSIONS BY SOURCE
In million-tons of CH_4 per year (Tg CH_4 / yr), average 2003-2012
Anthropogenic fluxes
Natural fluxes
Natural and anthropogenic
GLOBAL CARBON PROJECT
FONDATION BNP PARIBAS

GWP*- A new way to characterize short-lived greenhouse gases

- GWP100 overestimates methane's warming impact of constant herds by a factor of 4, and overlooks it's ability to induce cooling when CH_4 emissions are reduced.

- GWP* is a new metric out of the University of Oxford that assesses how an emission of a short-lived greenhouse gas affects temperature.

- GWP* accounts for methane's short lifespan, including its atmospheric removal.

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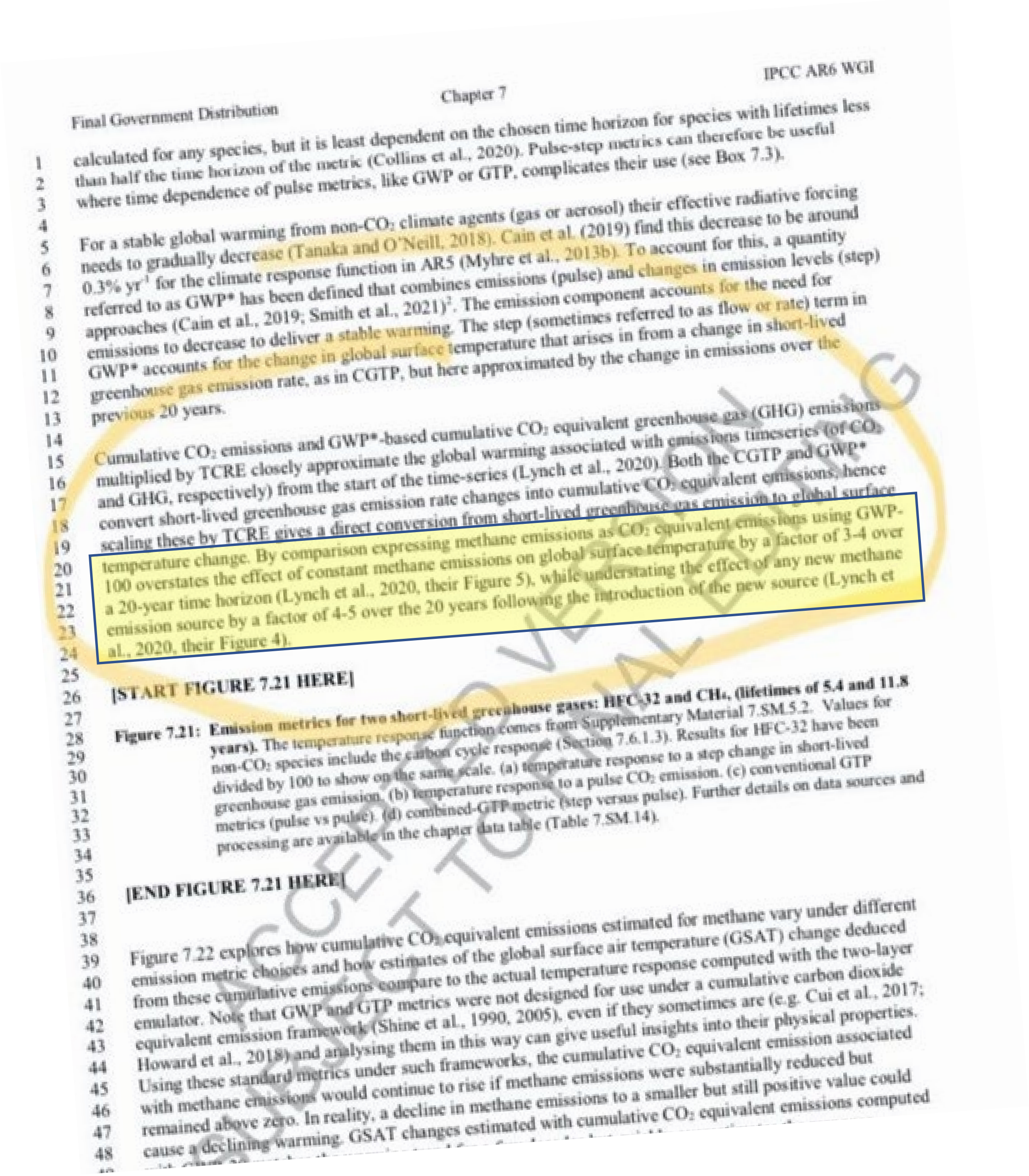


calculated for any species, but it is least dependent on the chosen time horizon for species with lifetimes less than half the time horizon of the metric (Collins et al., 2020). Pulse-step metrics can therefore be useful where time dependence of pulse metrics, like GWP or GTP, complicates their use (see Box 7.3).

For a stable global warming from non-CO_2 climate agents (gas or aerosol) their effective radiative forcing needs to gradually decrease (Tanaka and O'Neill, 2018). Cain et al. (2019) find this decrease to be around 0.3% yr^{-1} for the climate response function in AR5 (Myhre et al., 2013b). To account for this, a quantity referred to as GWP* has been defined that combines emissions (pulse) and changes in emission levels (step) approaches (Cain et al., 2019; Smith et al., 2021)[2]. The emission component accounts for the need for emissions to decrease to deliver a stable warming. The step (sometimes referred to as flow or rate) term in GWP* accounts for the change in global surface temperature that arises in from a change in short-lived greenhouse gas emission rate, as in CGTP, but here approximated by the change in emissions over the previous 20 years.

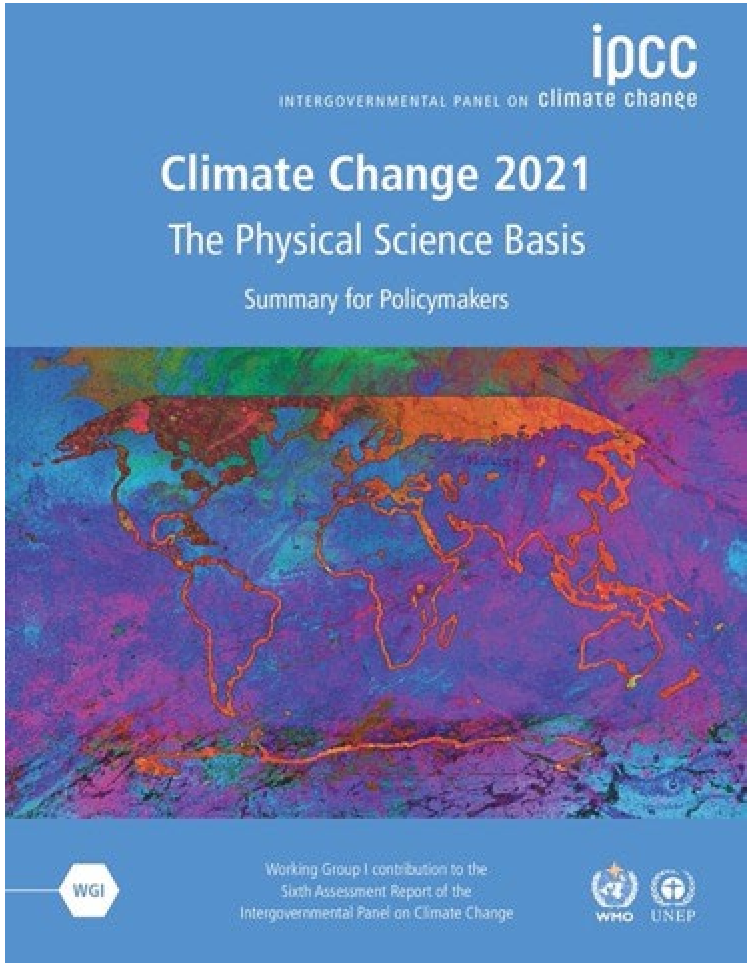
Cumulative CO_2 emissions and GWP*-based cumulative CO_2 equivalent greenhouse gas (GHG) emissions multiplied by TCRE closely approximate the global warming associated with emissions timeseries (of CO_2 and GHG, respectively) from the start of the time-series (Lynch et al., 2020). Both the CGTP and GWP* convert short-lived greenhouse gas emission rate changes into cumulative CO_2 equivalent emissions, hence scaling these by TCRE gives a direct conversion from short-lived greenhouse gas emission to global surface temperature change. By comparison expressing methane emissions as CO_2 equivalent emissions using GWP-100 overstates the effect of constant methane emissions on global surface temperature by a factor of 3-4 over a 20-year time horizon (Lynch et al., 2020, their Figure 5), while understating the effect of any new methane emission source by a factor of 4-5 over the 20 years following the introduction of the new source (Lynch et al., 2020, their Figure 4).

[START FIGURE 7.21 HERE]

Figure 7.21: Emission metrics for two short-lived greenhouse gases: HFC-32 and CH_4, (lifetimes of 5.4 and 11.8 years). The temperature response function comes from Supplementary Material 7.SM.5.2. Values for non-CO_2 species include the carbon cycle response (Section 7.6.1.3). Results for HFC-32 have been divided by 100 to show on the same scale. (a) temperature response to a step change in short-lived greenhouse gas emission. (b) temperature response to a pulse CO_2 emission. (c) conventional GTP metrics (pulse vs pulse). (d) combined-GTP metric (step versus pulse). Further details on data sources and processing are available in the chapter data table (Table 7.SM.14).

[END FIGURE 7.21 HERE]

Figure 7.22 explores how cumulative CO_2 equivalent emissions estimated for methane vary under different emission metric choices and how estimates of the global surface air temperature (GSAT) change deduced from these cumulative emissions compare to the actual temperature response computed with the two-layer emulator. Note that GWP and GTP metrics were not designed for use under a cumulative carbon dioxide equivalent emission framework (Shine et al., 1990, 2005), even if they sometimes are (e.g. Cui et al., 2017; Howard et al., 2018) and analysing them in this way can give useful insights into their physical properties. Using these standard metrics under such frameworks, the cumulative CO_2 equivalent emission associated with methane emissions would continue to rise if methane emissions were substantially reduced but remained above zero. In reality, a decline in methane emissions to a smaller but still positive value could cause a declining warming. GSAT changes estimated with cumulative CO_2 equivalent emissions computed



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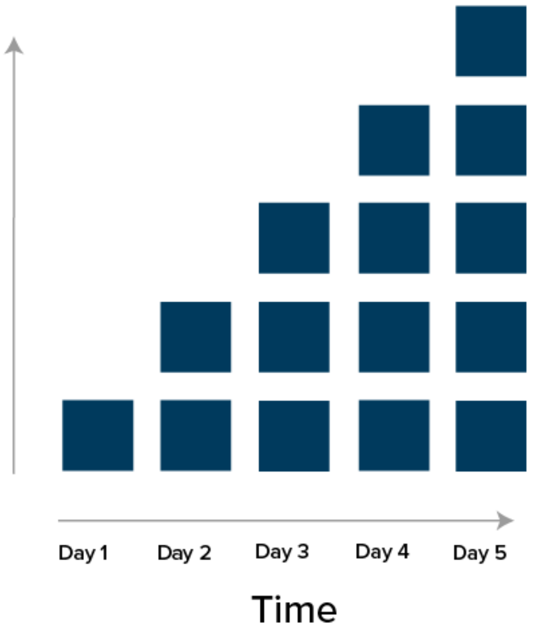
■ = Pulse of CO_2

Stock Gas
Carbon dioxide (CO_2)

Atmospheric Concentration

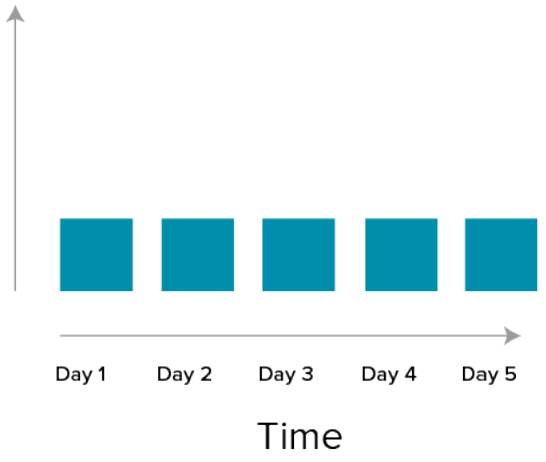


Stock gases will accumulate over time, because they stay in the environment.

■ = Pulse of CH_4

Flow Gas
Methane (CH_4)

Atmospheric Concentration



Flow gases will stay stagnent, as they are destroyed at the same rate of emission.

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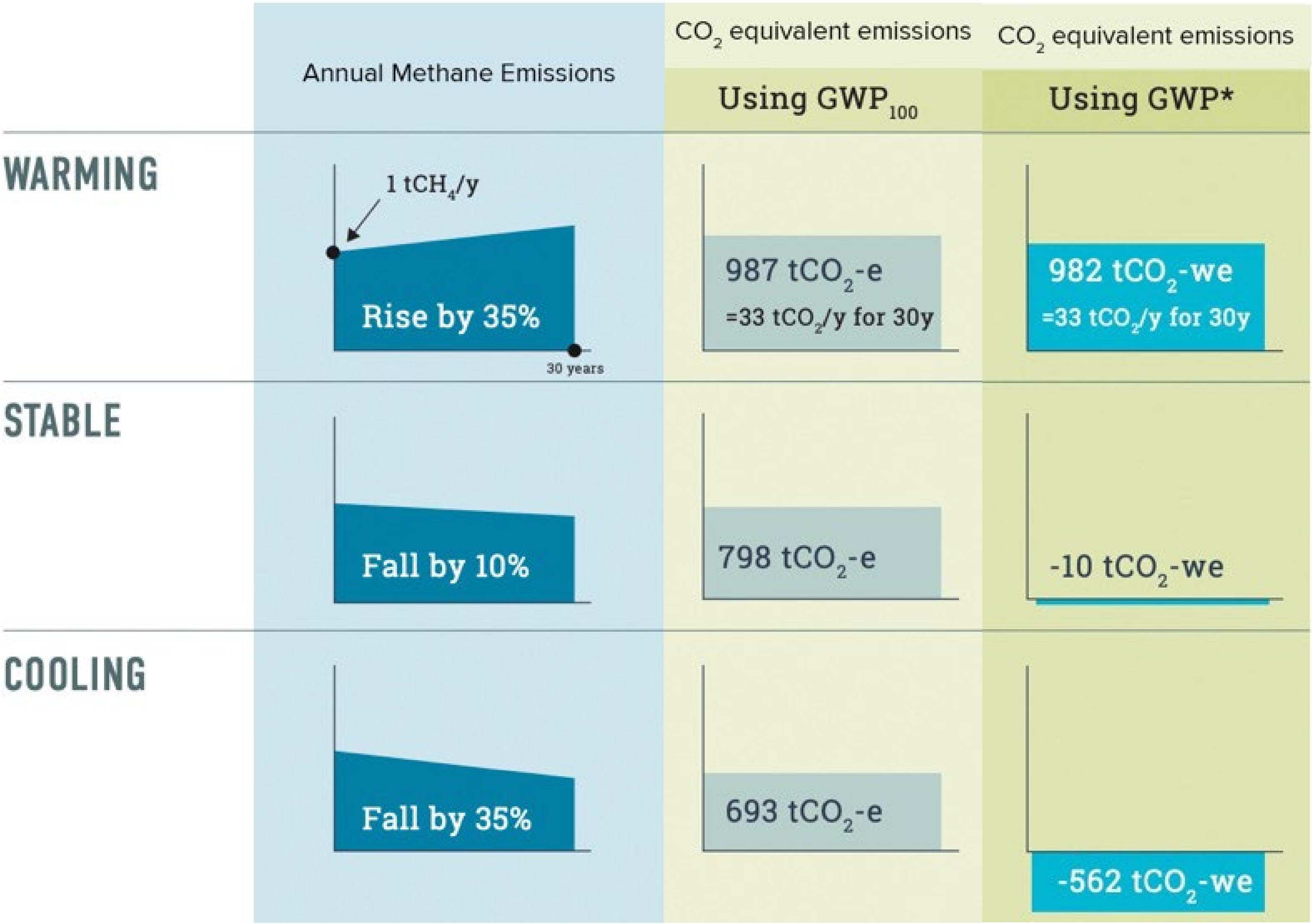
Based on research by Myles R. Allen, Keith P. Shine, Jan S. Fuglestvedt, Richard J. Millar, Michelle Cain, David J. Frame & Adrian H. Macey.
Read more here: https://rdcu.be/b1t7S



Cain, M., Allen, M. & Lynch, J. *Oxford Martin Programme on Climate Pollutants* (2019). Read more at: https://www.oxfordmartin.ox.ac.uk/downloads/academic/201908_ClimatePollutants.pdf.

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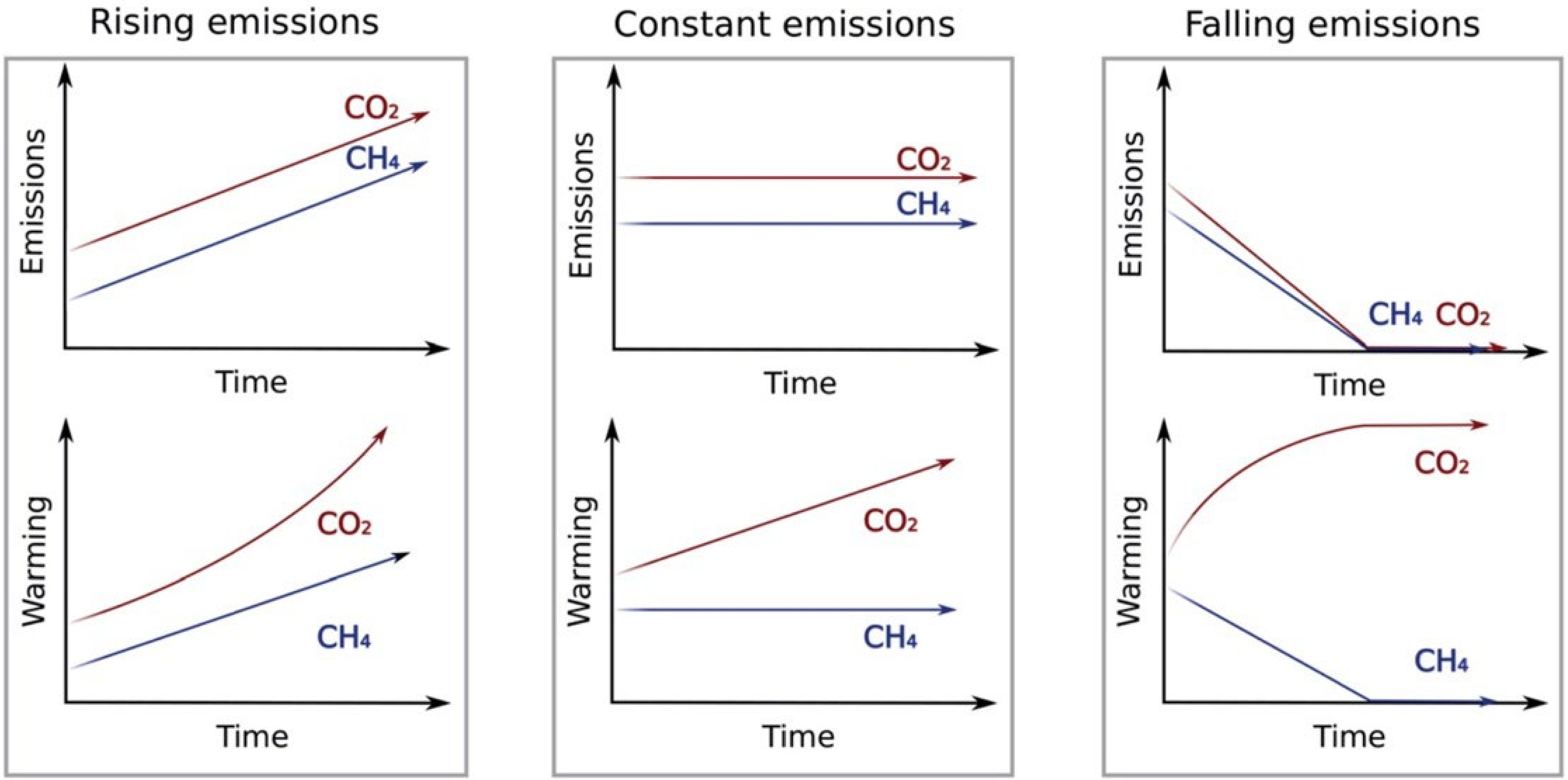

Oxford Martin, Climate Metrics for Ruminant Livestock, July 2018,
[*https://www.oxfordmartin.ox.ac.uk/downloads/reports/Climate-metrics-for-ruminant-livestock.pdf%C2%A0*](https://www.oxfordmartin.ox.ac.uk/downloads/reports/Climate-metrics-for-ruminant-livestock.pdf%C2%A0)

California dairies have reduced greenhouse gases by 2.3MMTCO2e – **30% of the sector's methane reduction goal.**

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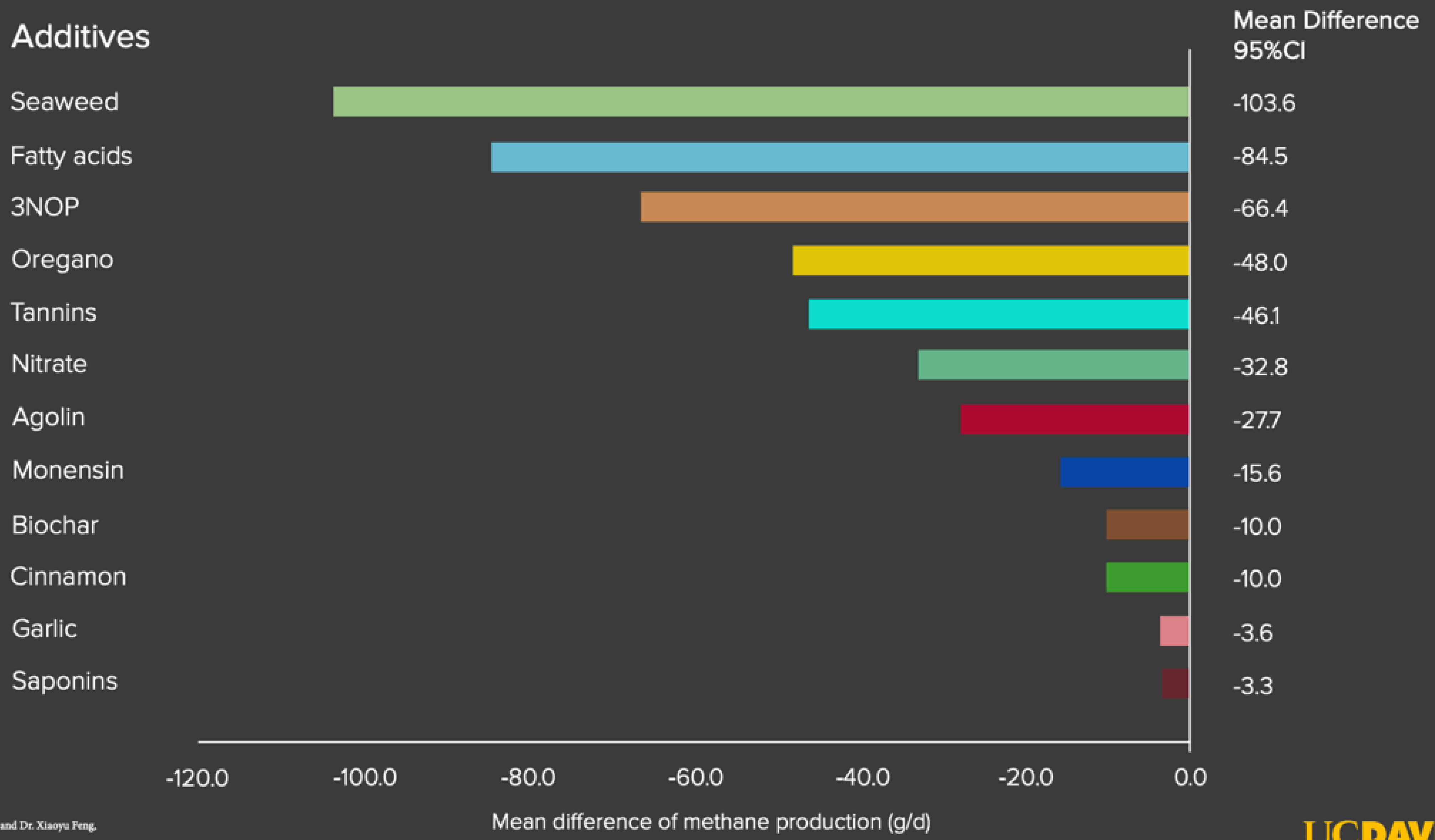
Methane Reductions from Feed Additives



Created based on the work of Dr. Ermias Kebreab and Dr. Xiaoyu Feng, University of California, Davis.
https://ww2.arb.ca.gov/sites/default/files/2020-12/17RD018.pdf

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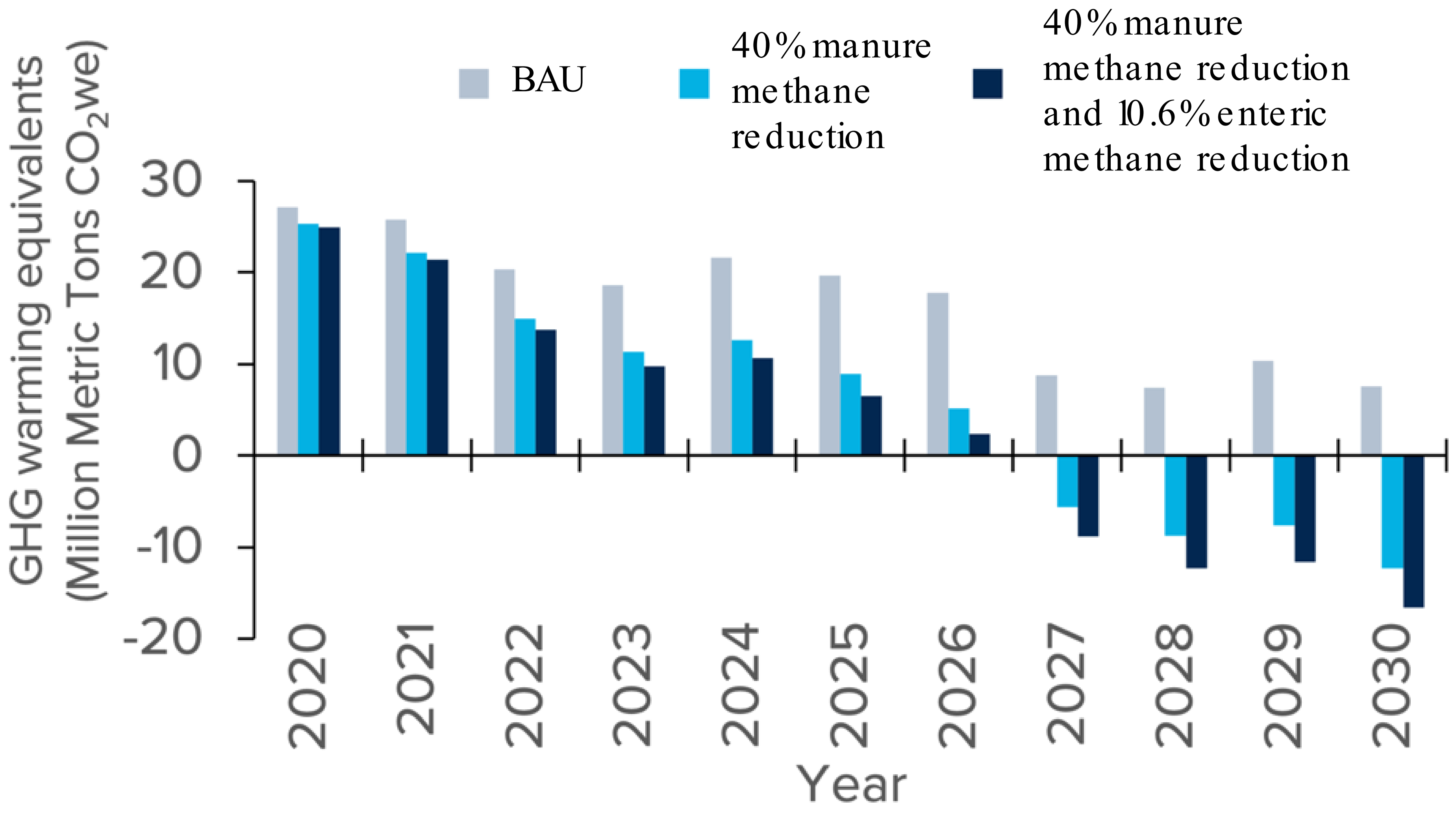
Potential pathways to climate neutrality for California dairy



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Symposium review: Defining a pathway to climate neutrality for US dairy cattle production*

S. E. Place,[1] C. J. McCabe,[2] and F. M. Mitloehner[2]†
[1]Elanco Animal Health, Greenfield, IN 46140
[2]Department of Animal Science, University of California–Davis, One Shields Ave., Davis 95616-8521

ABSTRACT

The US dairy industry has made substantial gains in reducing the greenhouse gas emission intensity of a gallon of milk. At the same time, consumer and investor interest for improved environmental benefits or reduced environmental impact of food production continues to grow. Following a trend of increasing greenhouse gas emission commitments for businesses across sectors of the economy, the US dairy industry has committed to a goal of net zero greenhouse gas emissions by 2050. The Paris Climate Accord's goal is to reduce warming of the atmosphere to less than 1.5 to 2°C based on preindustrial levels, which is different from emission goals of historic climate agreements that focus on emission reduction targets. Most of the emissions that account for the greenhouse gas footprint of a gallon of milk are from the short-lived climate pollutant CH_4, which has a half-life of approximately 10 yr. The relatively new accounting system Global Warming Potential Star and the unit CO_2 warming equivalents gives the industry the appropriate metrics to quantify their current and projected warming impact on future emissions. Incorporating this metric into potential future emissions pathways can allow the industry to understand the magnitude of emissions reductions needed to no longer contribute additional warming. Deterministic modeling was performed across the dairy industry's emission areas of enteric fermentation, manure management, feed production, and other upstream emissions necessary for dairy production. By reducing farm-level absolute emissions by 23% based on current levels, there is the opportunity for the US dairy industry to realize climate neutrality within the next few decades.
Key words: net zero, climate neutrality, methane

INTRODUCTION

Human activities that release greenhouse gas (**GHG**) emissions have increased the concentrations of GHG, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), in the troposphere (Myrhe et al., 2013; Forster et al., 2021). Since preindustrial times, the concentrations of CO_2, CH_4, and N_2O have increased approximately 50, 150, and 22%, respectively (US EPA, 2021a). Dairy cattle production, defined as all activities from upstream inputs into feed production and animal management, contributes to the atmospheric increase of GHG emissions and the warming impacts associated with those increased GHG concentrations. These emissions include feed production N_2O emissions from soils, enteric CH_4, CH_4 and N_2O emissions from manure, and CO_2 emissions from the combustion of fossil fuels used in farming equipment.

In the United States, it is estimated that dairy cattle production is responsible for approximately 99 to 172 million metric tonnes of CO_2 equivalents (**CO_2e**), which represents approximately 1.9 to 2.5% of annual US GHG emissions (Thoma et al., 2013; Capper and Cady, 2020; Rotz et al., 2021; Uddin et al., 2022). The range in the estimated total GHG emissions from the US dairy cattle production are reflective of differences in modeling techniques, time periods assessed, system boundaries, and differences in the 100-yr global warming potentials (**GWP100**) used within the analysis.

The GWP100 of a GHG is a measure of how much energy the emissions of 1 ton of a gas will absorb over 100 yr, relative to the emissions of 1 ton of CO_2, which is the reference gas (US EPA, 2022). Over time, substantial changes have been made to the GWP100 values of CH_4, and as this gas is approximately 62% of the US dairy cattle production's total GHG emissions (Rotz et al., 2021), changes to the estimated warming impacts of CH_4 can significantly shift the total estimated contribution of the industry to US or global emissions inventories.

Recently, work has demonstrated that the GWP100 poorly links emissions to warming effects across a variety of emissions scenarios. Specifically, GWP100 over-

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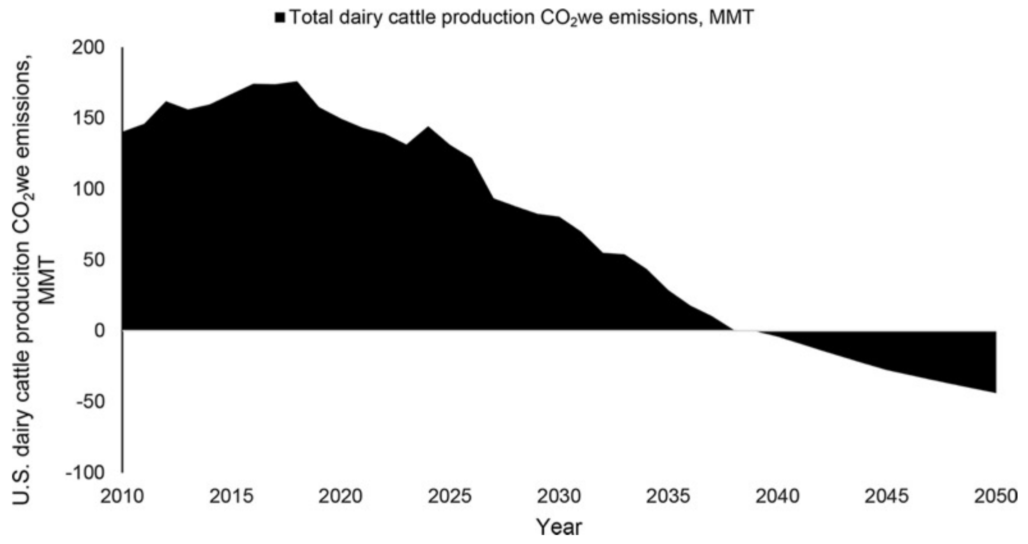
†Corresponding author: fmmitloehner@ucdavis.edu

The US Dairy Sector can Reach Climate Neutrality by 2041



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