California's Climate Transformation: The Path to Climate Neutral Dairy

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Rethinking Methane: Dairy's Path to Climate Neutrality

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Last name pronounced: ‘*Mit*-ler-nah’

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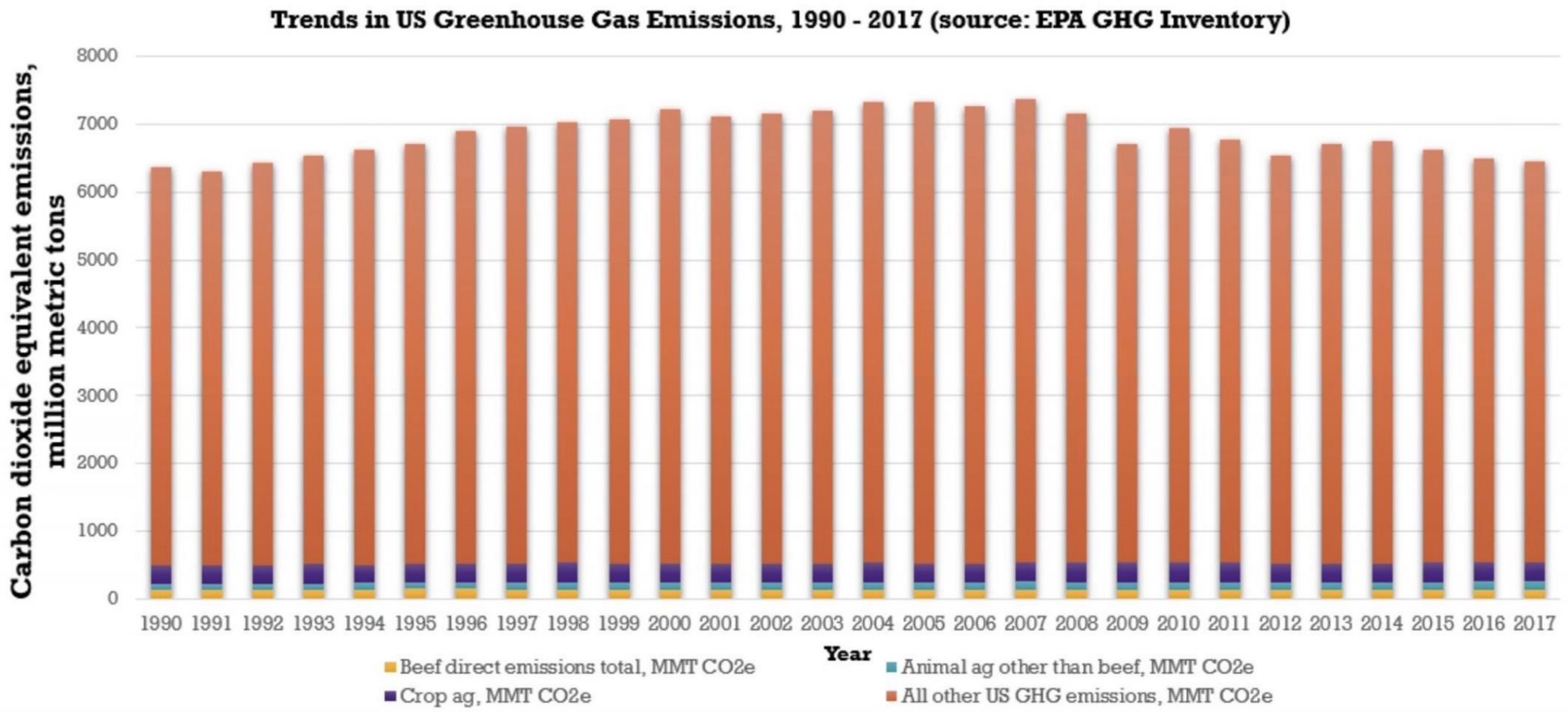
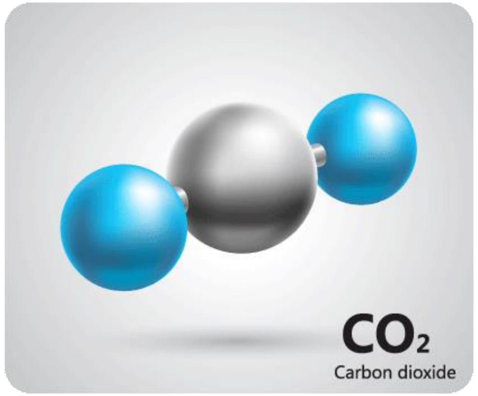
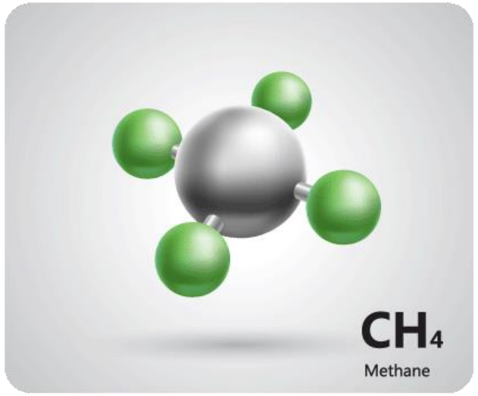


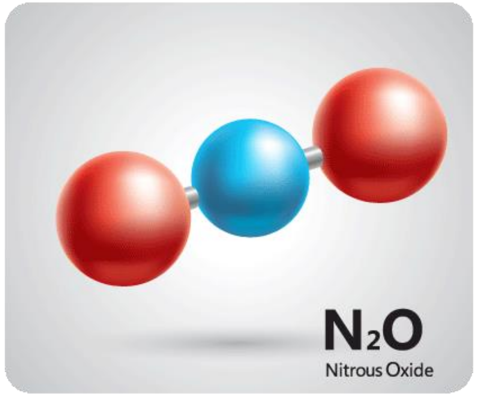
Why we need to rethink methane

You can see in the graph, U.S. beef (yellow) and animal agriculture (teal) have been roughly **stable** since 1990. Those emissions are primarily methane and make up a small portion of total U.S. emissions. According to the EPA, animal agriculture is 4% of direct U.S. emissions.

Methane is short-lived, warming for 12 years before it is naturally removed. If emissions are **stable** for 12 years, what is being emitted roughly equals what is naturally destroyed. That balance means no additional warming.







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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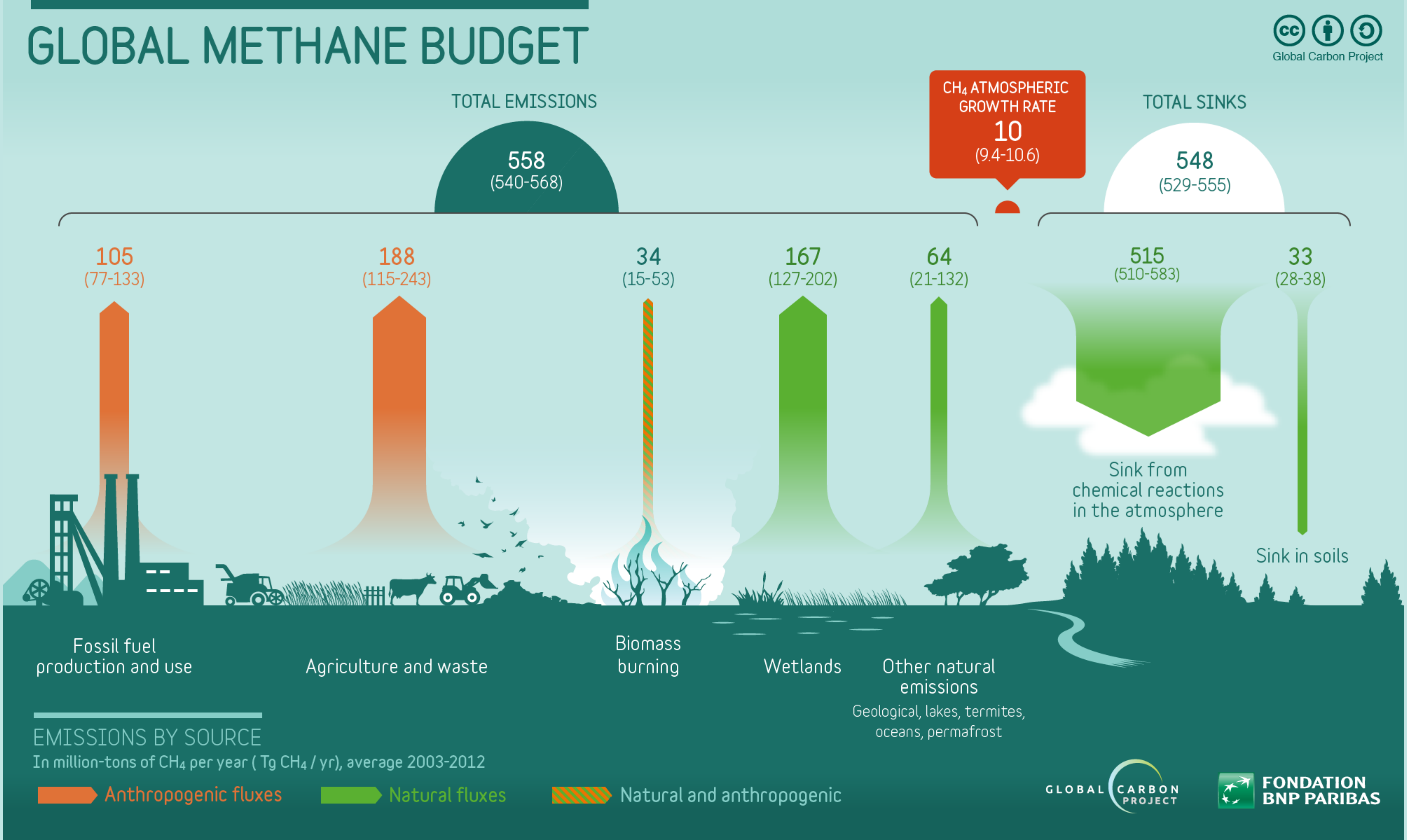
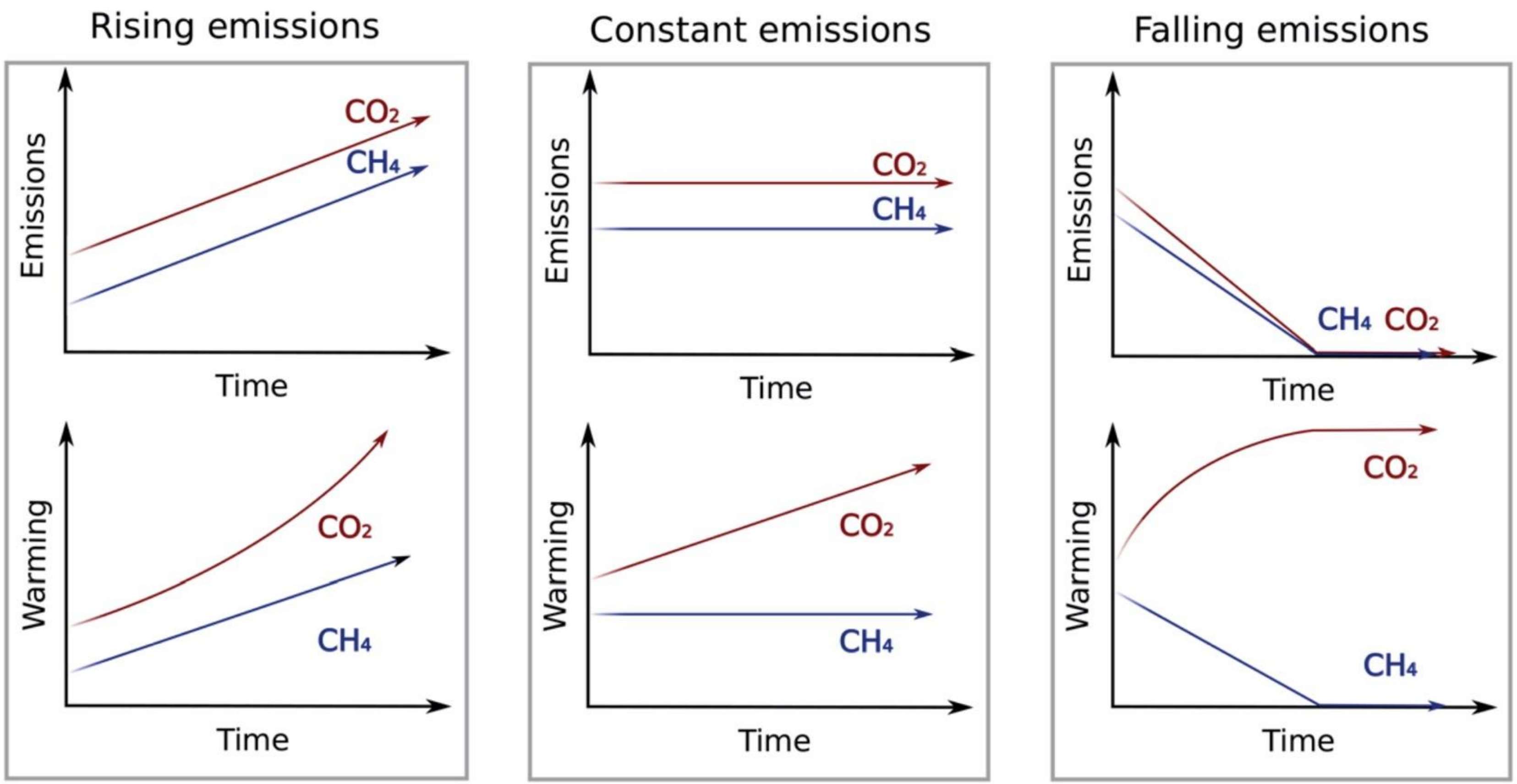


GLOBAL METHANE BUDGET
Global Carbon Project
TOTAL EMISSIONS
558
(540-568)
CH4 ATMOSPHERIC GROWTH RATE
10
(9.4-10.6)
TOTAL SINKS
548
(529-555)
105
(77-133)
188
(115-243)
34
(15-53)
167
(127-202)
64
(21-132)
515
(510-583)
33
(28-38)
Sink from chemical reactions in the atmosphere
Sink in soils
Fossil fuel production and use
Agriculture and waste
Biomass burning
Wetlands
Other natural emissions
Geological, lakes, termites, oceans, permafrost
EMISSIONS BY SOURCE
In million-tons of CH4 per year (Tg CH4 / yr), average 2003-2012
Anthropogenic fluxes
Natural fluxes
Natural and anthropogenic
GLOBAL CARBON PROJECT
FONDATION BNP PARIBAS

It's all about warming

How we currently measure methane doesn't factor in the natural removal of methane, and overestimates methane's warming impact by a factor of 3-4 according to the latest IPCC Report. Read that page here: bit.ly/ipcc_ch7.

In the graph, you can see that methane warms very differently than carbon dioxide, so why do we measure methane like it is CO2?



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*

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Reducing methane from manure

- Dairy digesters are a cost-effective way of reducing methane from manure.
- Dairy digesters have reduced 30% of the greenhouse gasses mitigated in the California Climate Investment Initiative with less than 2% of state funding.

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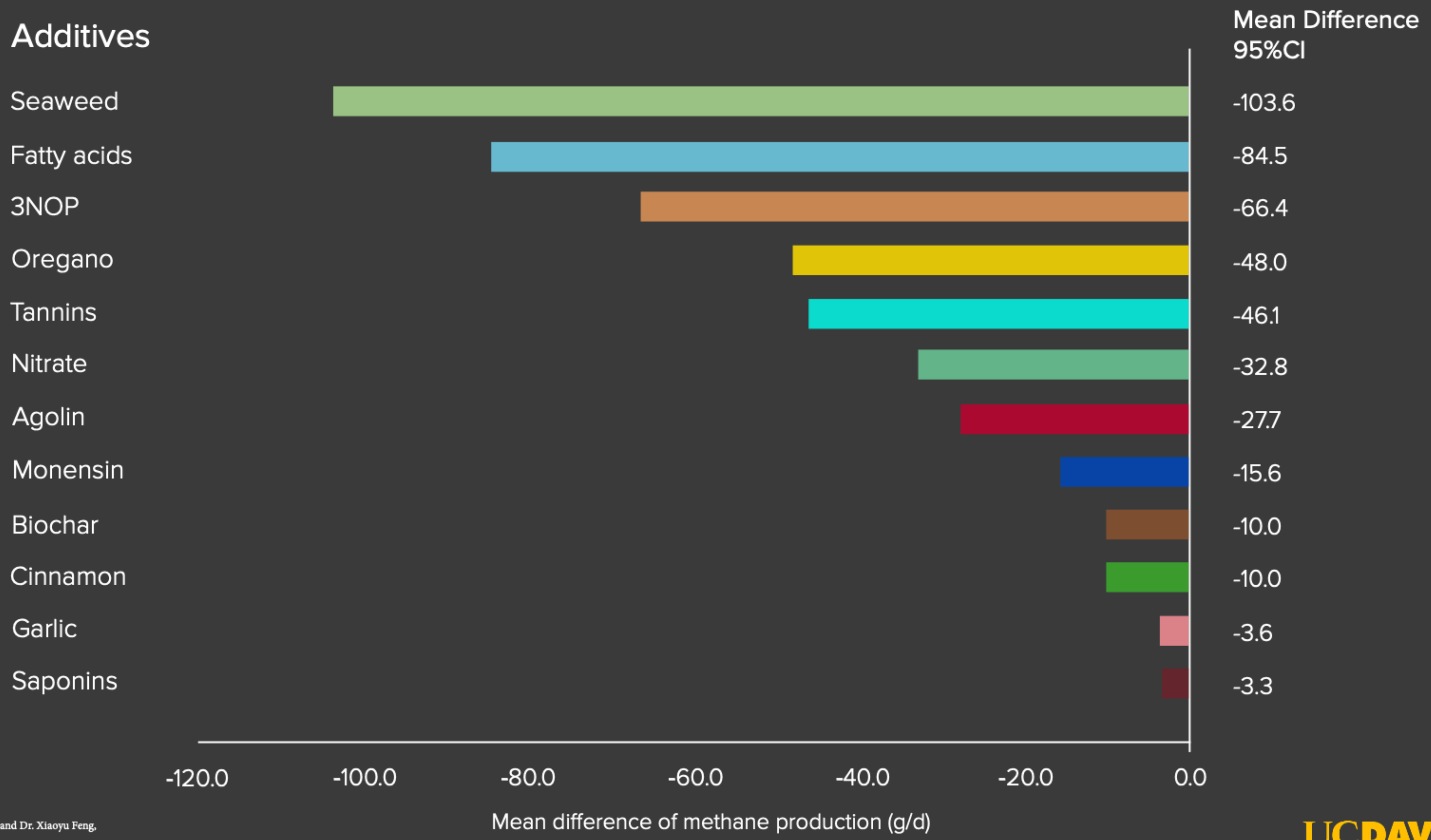
Livestock can be part of a climate solution

If we reduce methane emissions from livestock, we can pull carbon out of the atmosphere.

Only two sectors can do this, agriculture and forestry. Agriculture, and livestock specifically, is a climate solution we aren't talking enough about.

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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- Continued commitment to the incentive-based climate-smart solutions in California should lead to the **full 40 percent reduction, or 7.2MMTCO2e in dairy methane by 2030** sought by state regulators

- Milk production improvements and attrition in milk cow numbers in the state will play a significant and increasing role in methane reductions, contributing a **2.6 to 3.3 MMTCO2e reduction annually**

- Utilization of alternative and advanced manure management practices will reduce between **0.6 and 1.1 MMTCO2e in methane annually by 2030**

- Continued implementation of dairy manure digesters will deliver another approximately **4 MMTCO2e of reduction annually by 2030**

- Feed additives will provide additional dairy methane reductions, ranging from **250,000 MTCO2e annually to over 2 MMTCO2e**, depending on reduction efficiency and the ultimate rate of adoption by dairy farms in the state.

The methane reductions from programs and projects in place today, coupled with the implementation of a moderate feed additive strategy to reduce enteric emissions, is on track to reduce methane between 7.6 to 10.6 MMTCO2e by 2030, from the dairy sector alone.

Table 1. California Dairy Methane Reductions Projected to Exceed SB 1383 Requirements

Projected Dairy Sector Methane Reductions	
Reduction Type	**Expected Dairy Emission Reductions Through 2030 (MMTCO2e)**
Herd Reduction	2.61 – 3.3
Anaerobic Digestion	4.15
Alternative Manure Management Practices	0.6 - 1.1
Enteric Emission Reduction Strategies	0.25 – 2.04
Total	**7.61 – 10.59**

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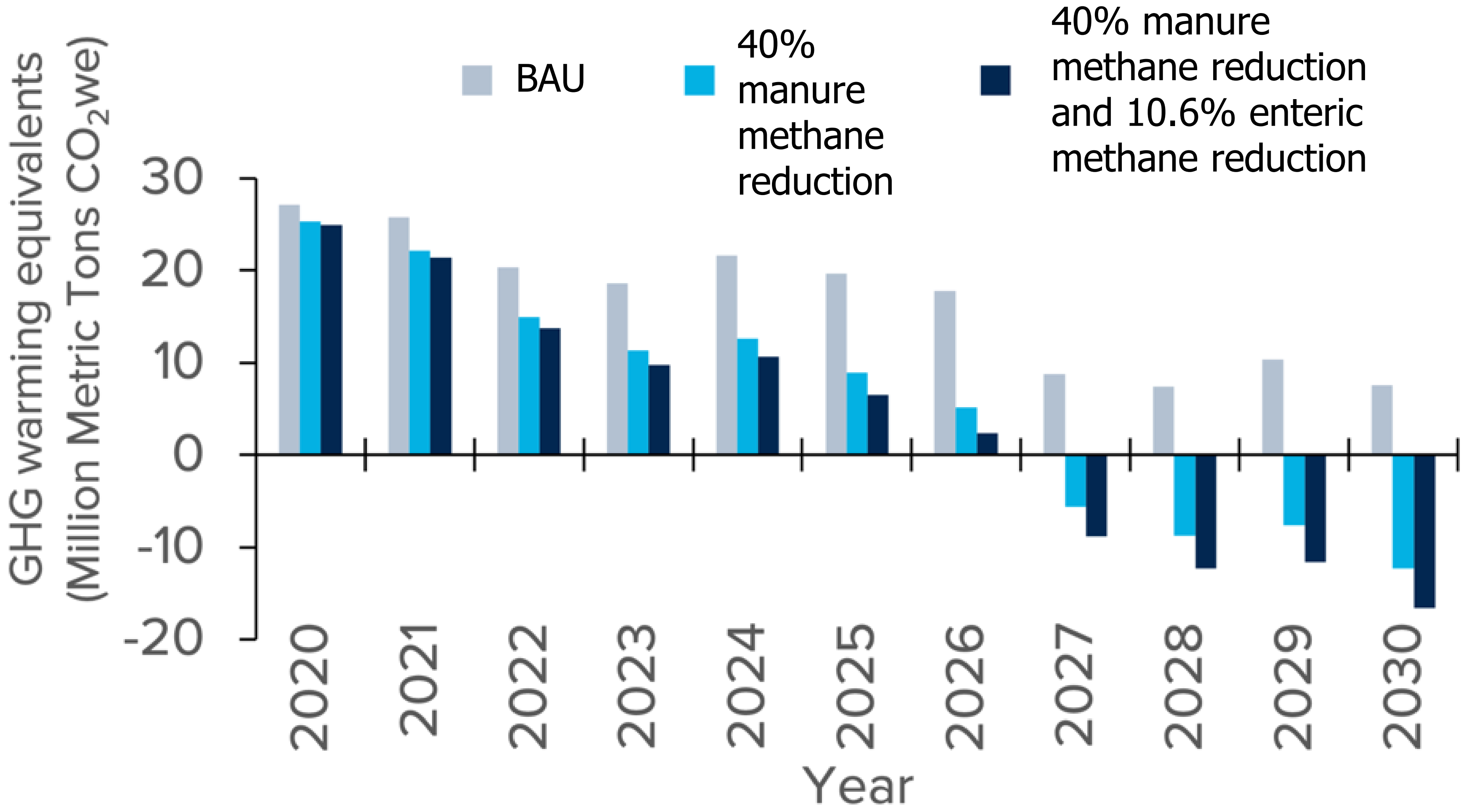
Potential pathways to climate neutrality for California dairy



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NEW PAPER

Meeting the Call: How California is Pioneering a Pathway to Significant Dairy Sector Methane Reduction

Use your cellphone camera to scan the QR code and take you to the article.

https://bit.ly/pathwayclear

Find the summary and paper online at clear.ucdavis.edu

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Thank you

clear.ucdavis.edu

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California's Climate Transformation: The Path to Climate Neutral Dairy

Ermias Kebreab
Professor and Associate Dean
University of California, Davis

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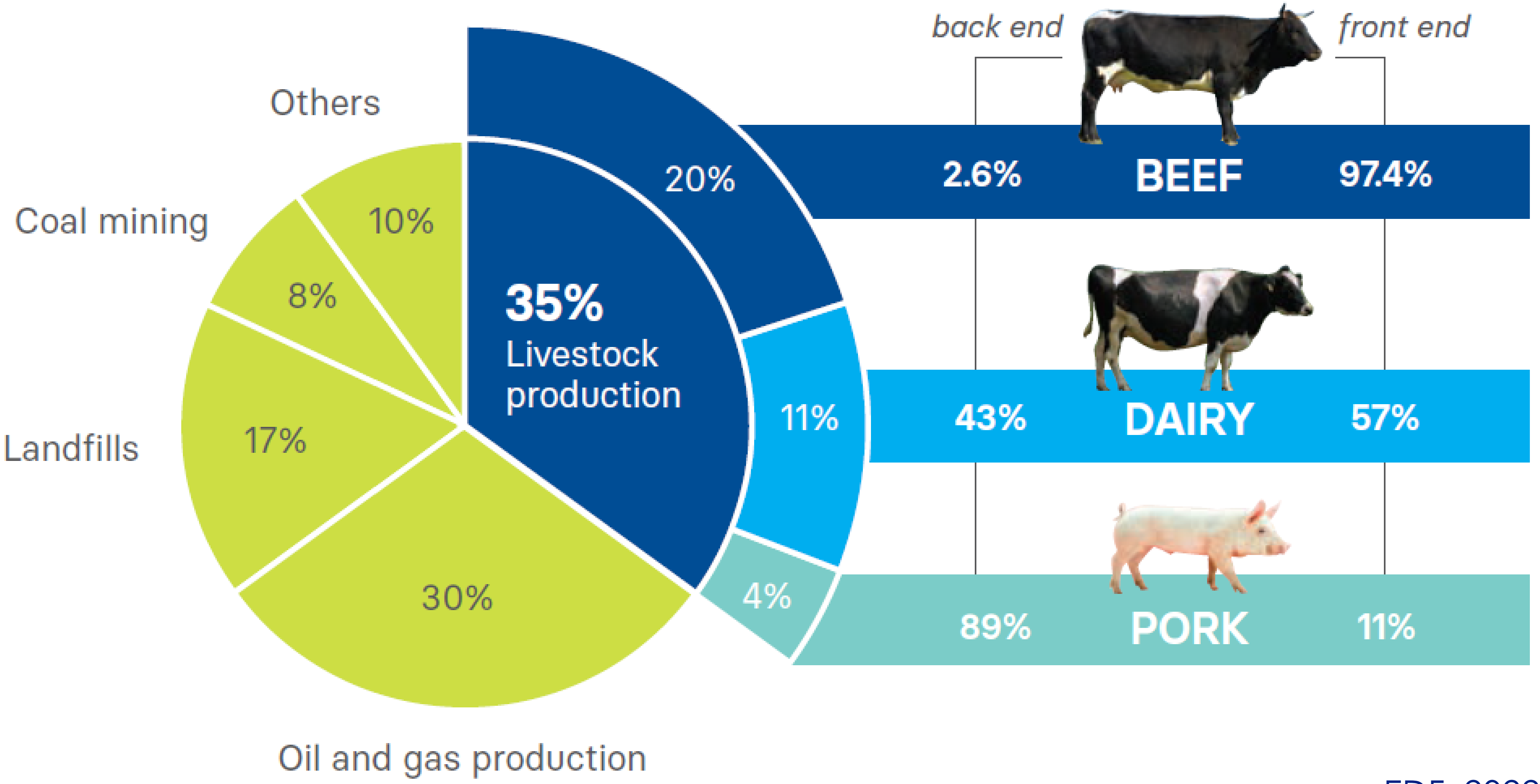
The U.S. Methane Breakdown



EDF, 2022

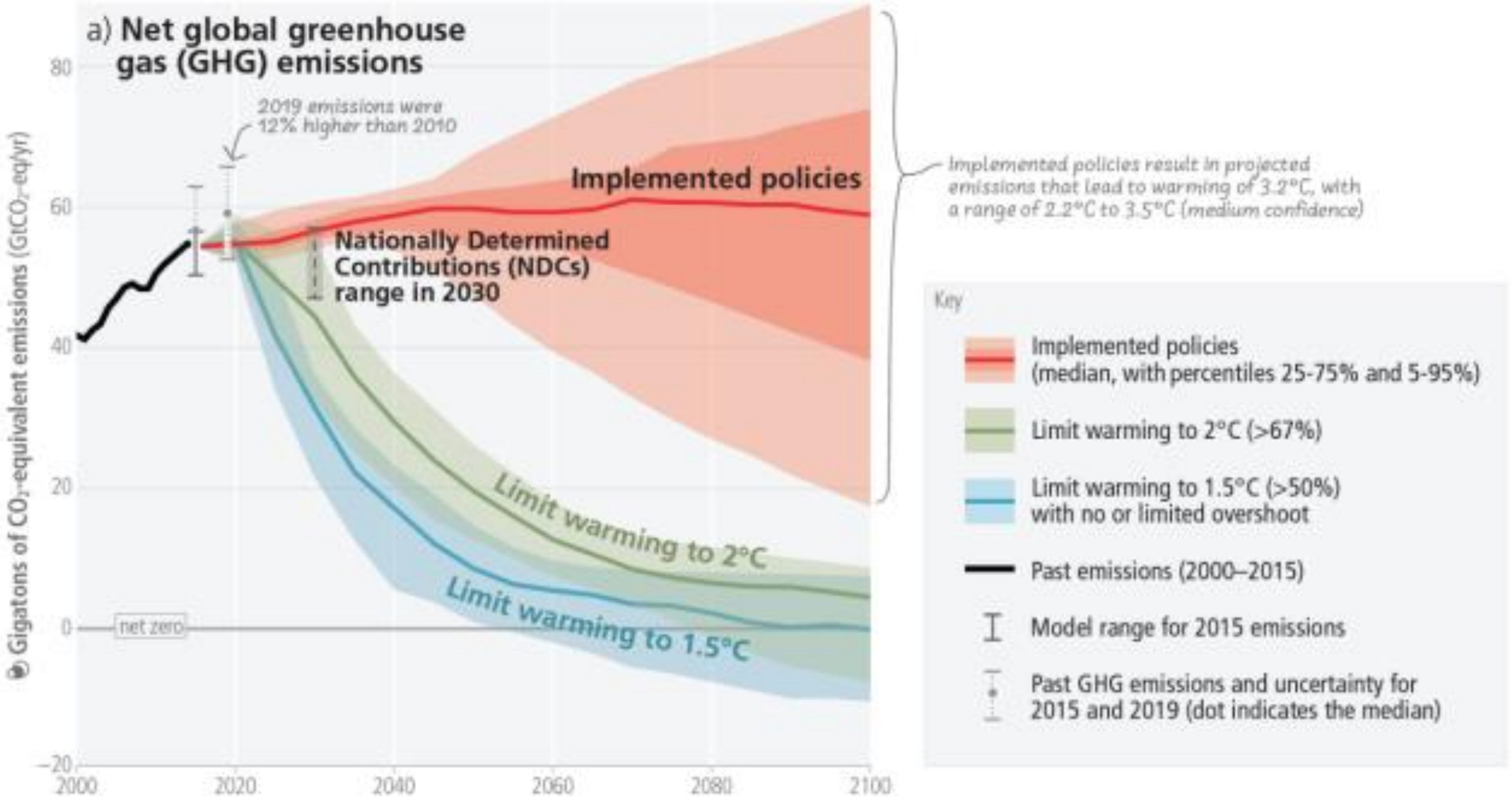
Methane Reduction Targets

- Reduce global methane emissions at least 30% from 2020 levels by 2030, which could eliminate over **0.2˚C warming** by 2050.

- Reduction in California methane emissions of 40% below 2013 levels by 2030.

Global Methane Pledge

What Needs to Happen? IPCC



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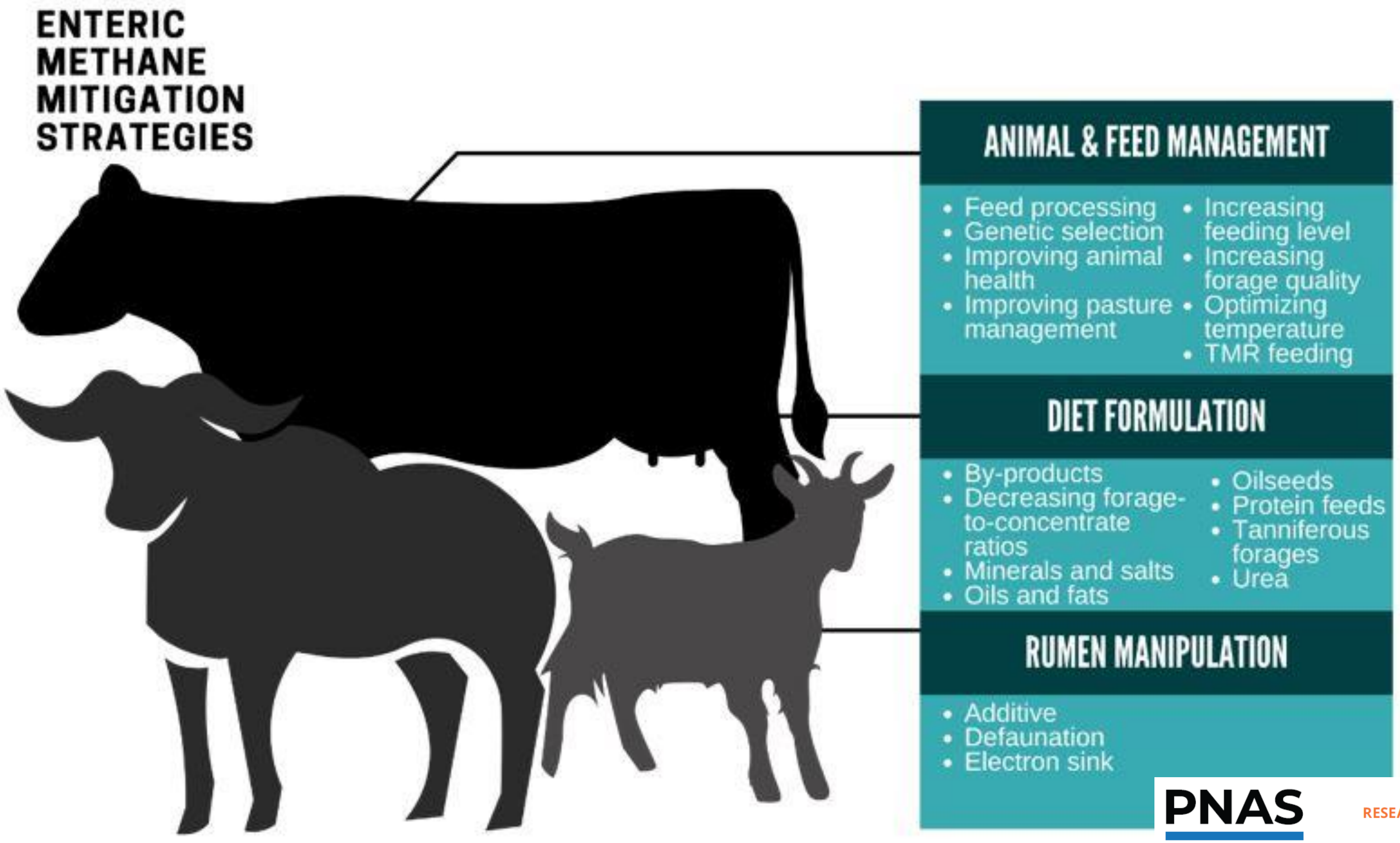
IPCC 2023

Methane Mitigation Strategies



PNAS RESEARCH ARTICLE | SUSTAINABILITY SCIENCE OPEN ACCESS

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

Claudia Arndt[a,1], Alexander N. Hristov[b], William J. Price[c], Shelby C. McClelland[d], Amalia M. Pelaez[b,e], Sergio F. Cueva[b], Joonpyo Oh[b], Jan Dijkstra[e], André Bannink[e], Ali R. Bayat[f], Les A. Crompton[g], Maguy A. Eugène[h], Dolapo Enahoro[a], Ermias Kebreab[i], Michael Kreuzer[j], Mark McGee[k], Cécile Martin[h], Charles J. Newbold[l], Christopher K. Reynolds[g], Angela Schwarm[m], Kevin J. Shingfield[f,2], Jolien B. Veneman[n], David R. Yáñez-Ruiz[o], and Zhongtang Yu[p]

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Methane Mitigation Strategies

A

Product-Based Reductions

	MITIGATION STRATEGY	POTENTIAL EMISSIONS REDUCTION		RELEVANT PRODUCTION SYSTEM
1	INCREASING FEEDING LEVEL	CH_4I_M CH_4I_G	-17% No Data	
2	DECREASING GRASS MATURITY	CH_4I_M CH_4I_G	-13% No Data	
3	DECREASING DIETARY FORAGE-TO-CONCENTRATE RATIO	CH_4I_M CH_4I_G	-9% -9%	

Absolute Reductions

	MITIGATION STRATEGY	POTENTIAL EMISSIONS REDUCTION				RELEVANT PRODUCTION SYSTEM
1	CH_4 INHIBITORS	CH_4I_M CH_4I_G	-32% No Data	Daily CH_4 CH_4Y	-35% -34%	
2	TANNIFEROUS FORAGES	CH_4I_M CH_4I_G	-18% No Data	Daily CH_4 CH_4Y	-12% -10%	
3	ELECTRON SINKS	CH_4I_M CH_4I_G	-13% -12%	Daily CH_4 CH_4Y	-17% -15%	
4	OILS & FATS	CH_4I_M CH_4I_G	-12% -22%	Daily CH_4 CH_4Y	-19% -15%	
5	OILSEEDS Lactating animals only	CH_4I_M CH_4I_G	-12% No Effect	Daily CH_4 CH_4Y	-20% -14%	

Production system — FEEDLOT & MIXED SYSTEMS — GRASSLAND SYSTEMS

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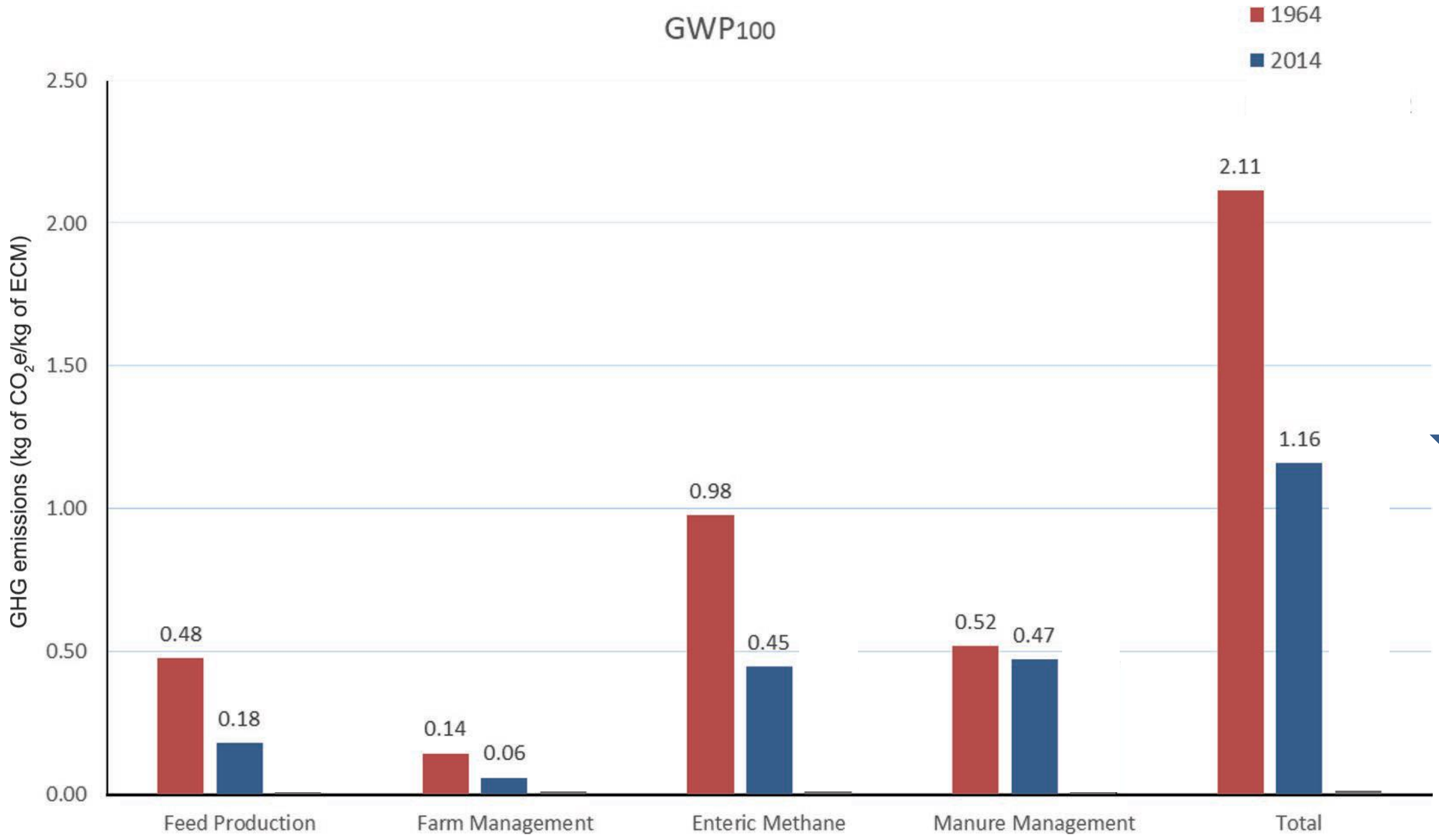
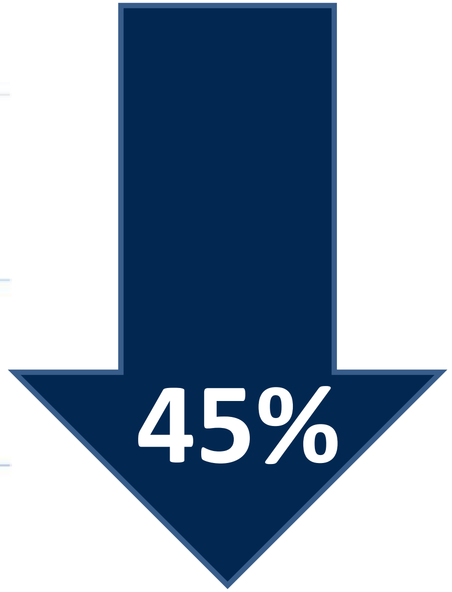
Arndt et al. 2022

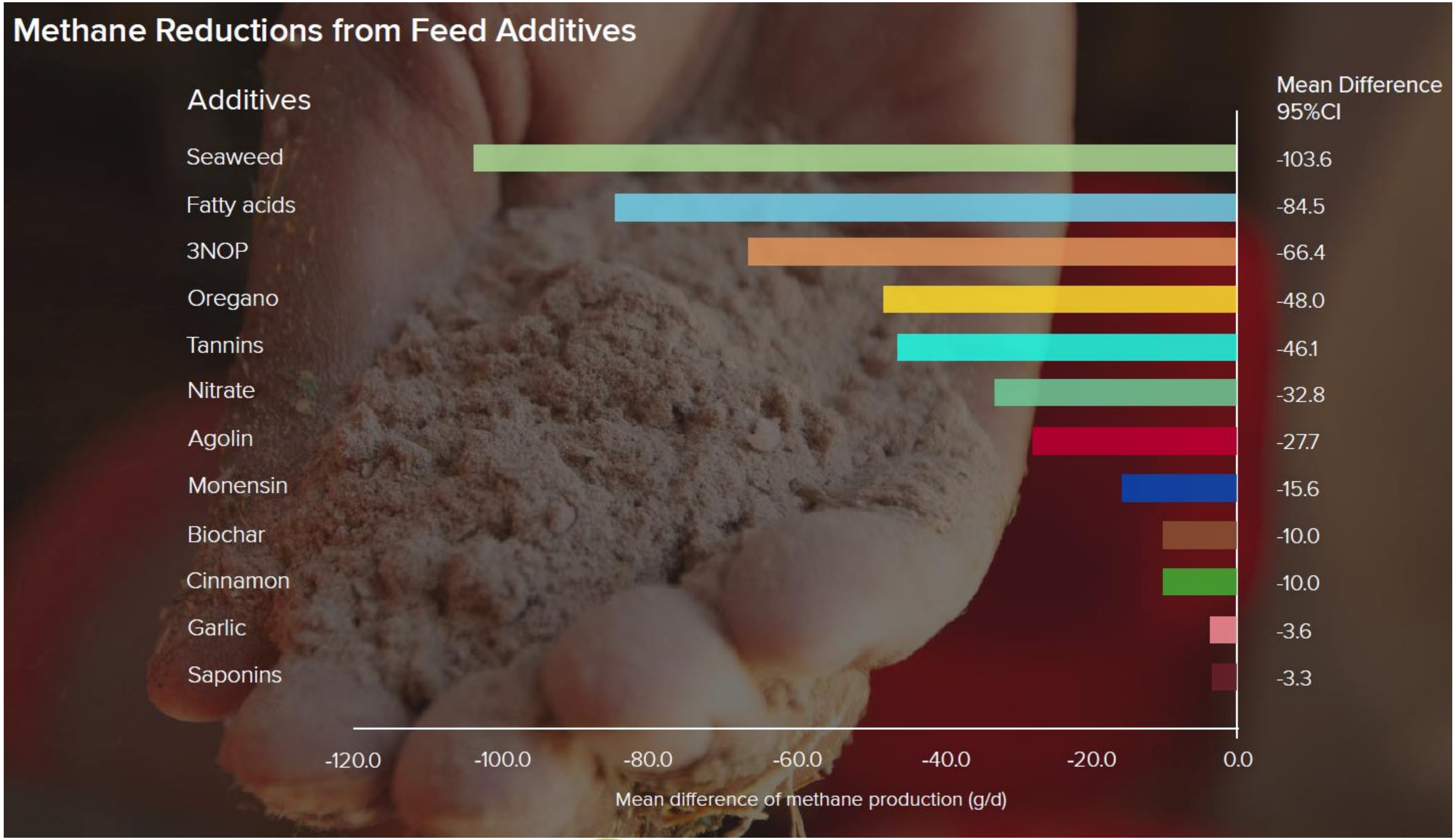
Product Based Solutions





Naranjo et al., 2020

Absolute Reduction - Feed Additives



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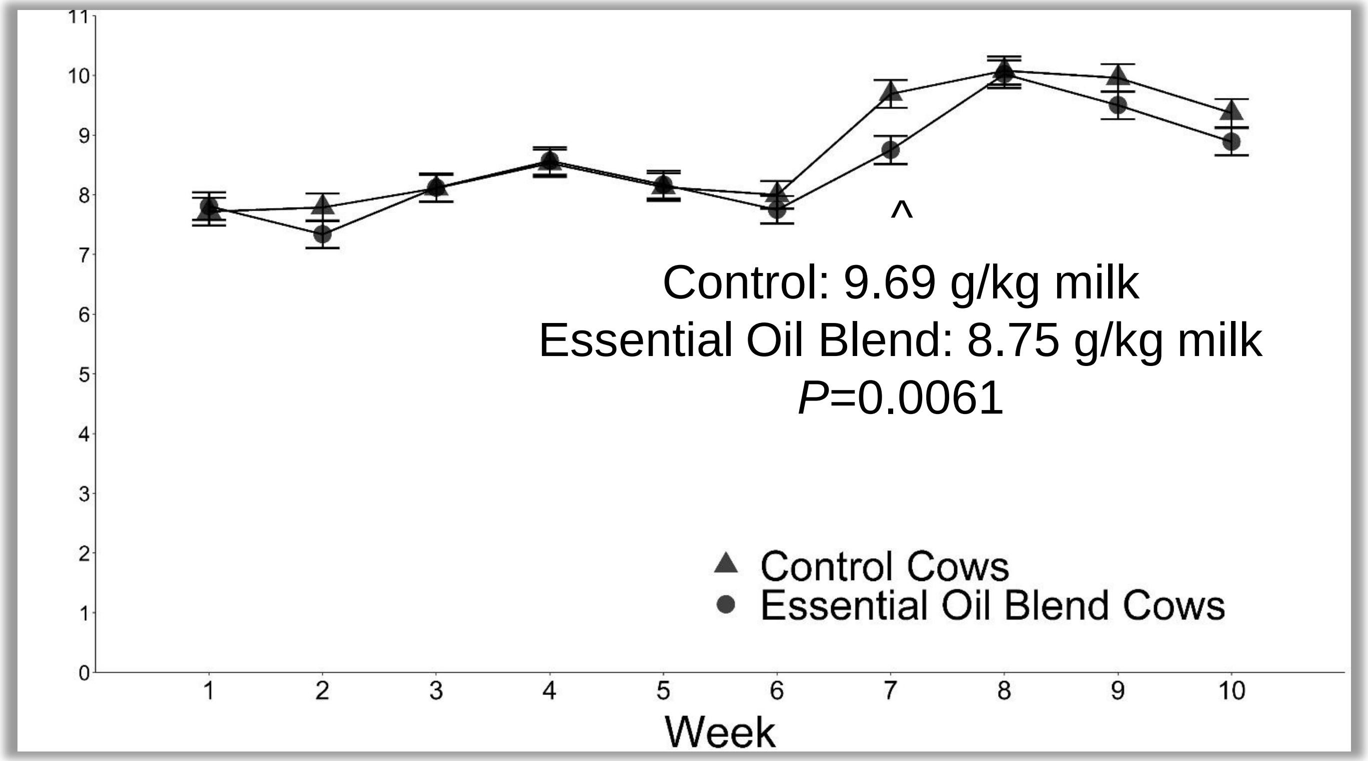
Honan et al. 2021

Essential Oil Blend



Fouts et al. 2023

INNOVATION CENTER FOR U.S. DAIRY
HEALTHY PEOPLE • HEALTHY PRODUCTS • HEALTHY PLANET

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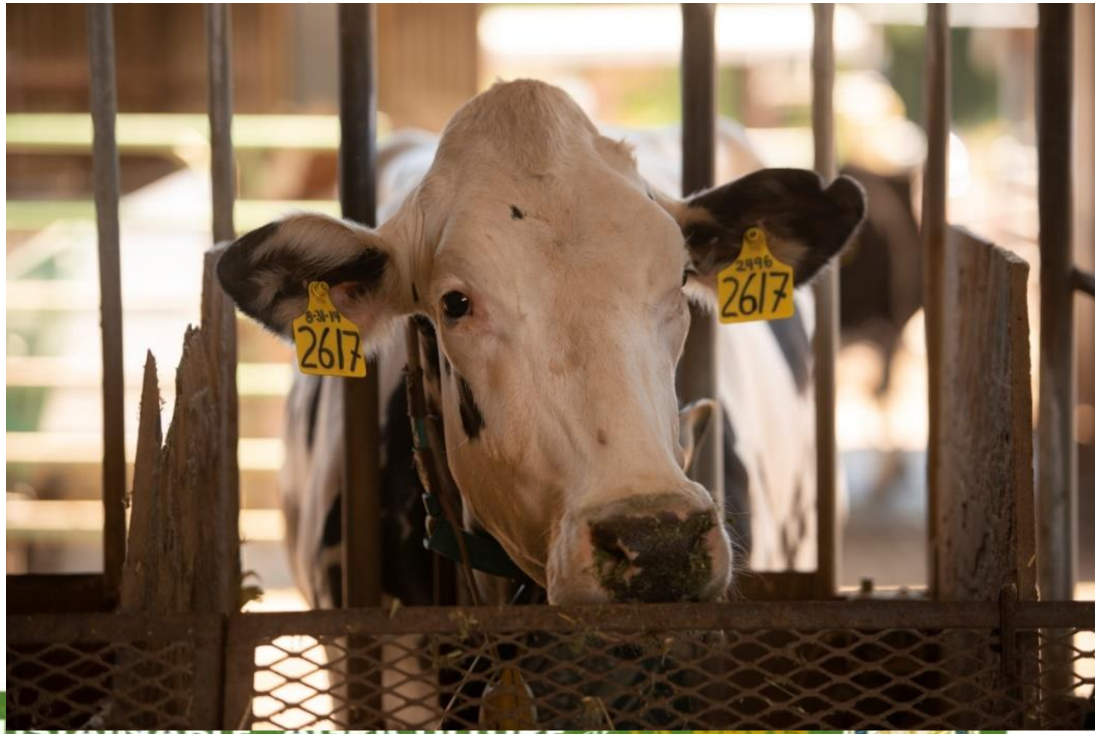
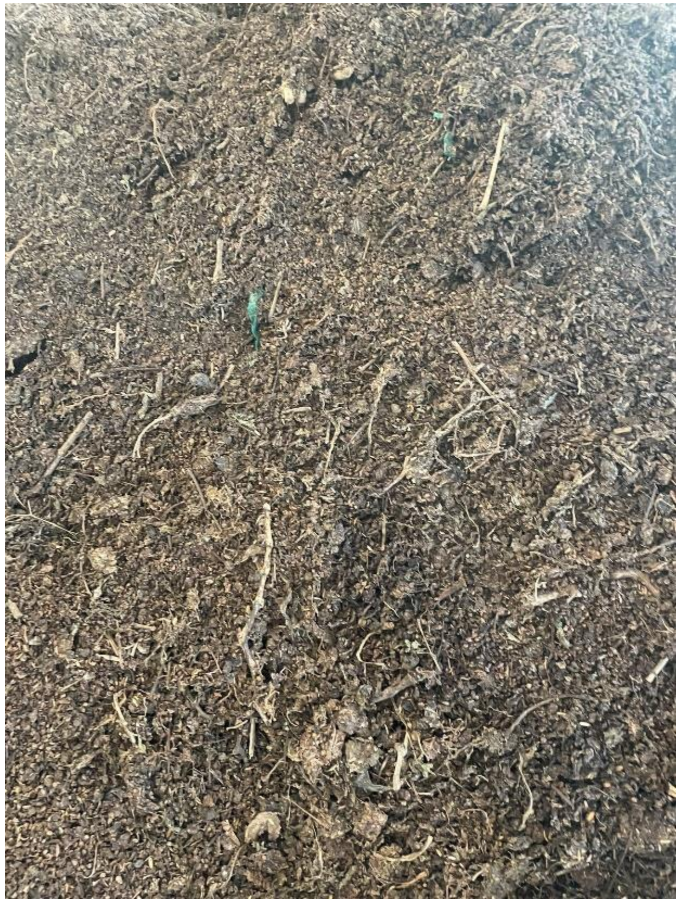
Plant Bioactive Compounds - Tannins

Variate	Diet [1]			SEM [2]
	CON	RGM	WGM	
Number of cows	11	10	10	-
Total DMI [5] (kg/d)	18.4	18.8	18.6	0.29
Methane emission (g/d)	383	326	326	12.9
Methane intensity (g/kg ECM [6])	13.3	12.8	12.5	0.47

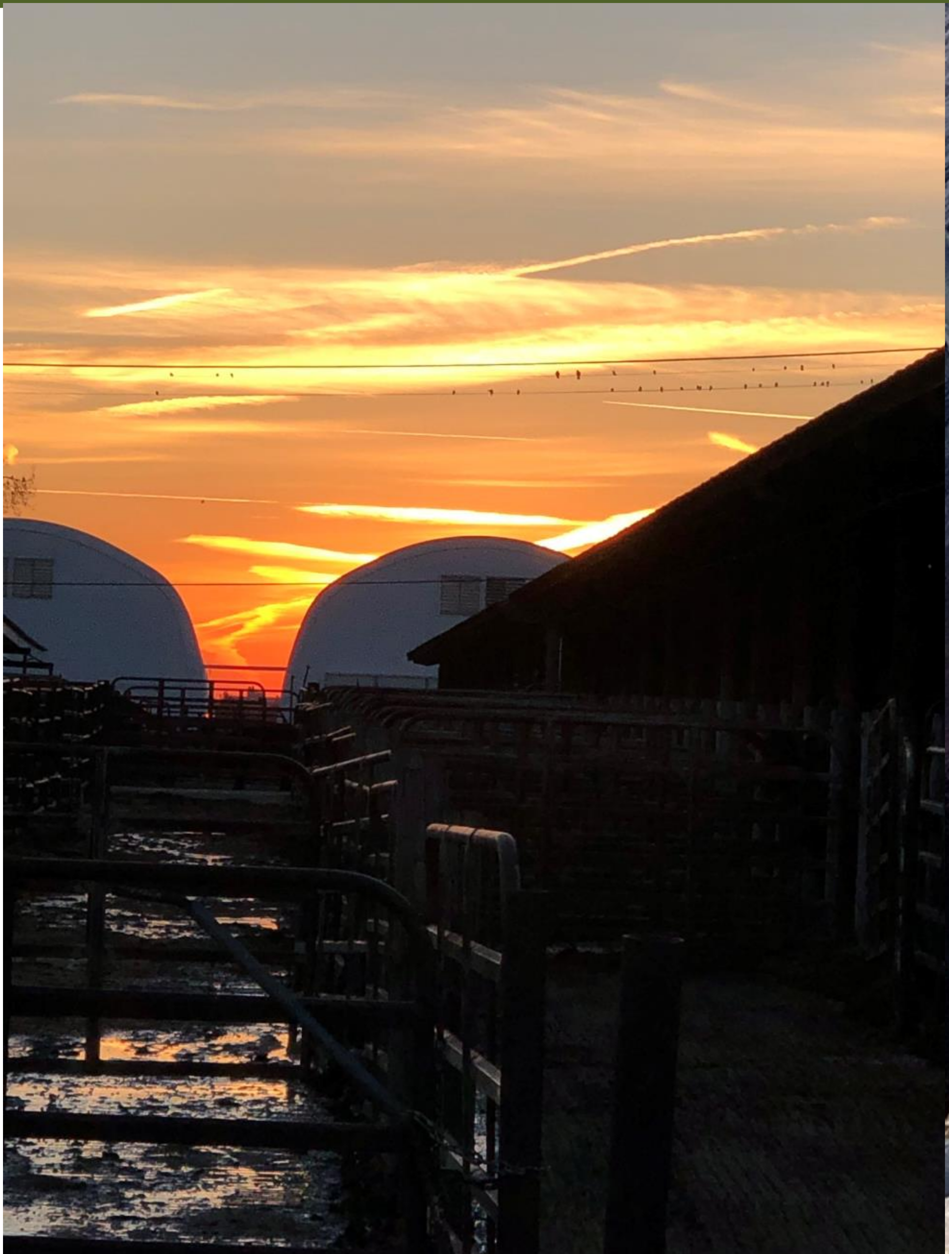


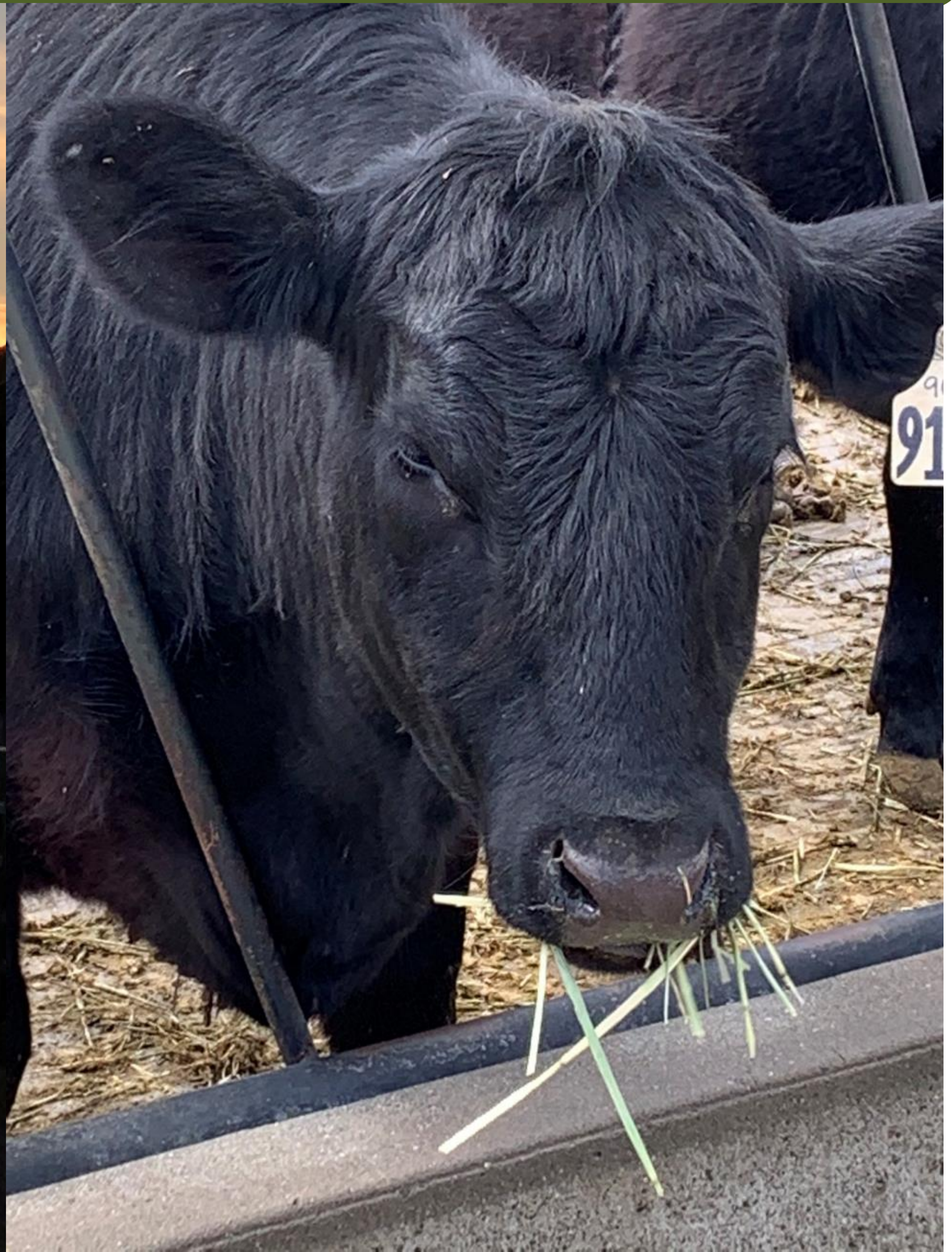
Moate et al. 2020

CALIFORNIA DAIRY RESEARCH FOUNDATION
Science for a Sustainable Future



Inhibitor – Rumin8





Rumin8

Future Direction – Microbial Genomics

Can CRISPR Cut Methane Emissions From Cow Guts?

TED Audacious Project Funds $70-Million UC Collaboration for Health, Climate

by Clémentine Sicard | April 17, 2023

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THE AUDACIOUS PROJECT

An initiative of TED

ABOUT NEWS GRANTEES APPLY IMPACT

Project Progress

In Progress

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ENGINEERING MICROBIOMES WITH CRISPR TO IMPROVE OUR CLIMATE AND HEALTH

Comprehensive Review

J. Dairy Sci. 105
https://doi.org/10.3168/jds.2022-22091

Invited review: Current enteric methane mitigation options

Karen A. Beauchemin,[1] Emilio M. Ungerfeld,[2*] Adibe L. Abdalla,[3] Clementina Alvarez,[4] Claudia Arndt,[5] Philippe Becquet,[6] Chaouki Benchaar,[7] Alexandre Berndt,[8] Rogerio M. Mauricio,[9] Tim A. McAllister,[1] Walter Oyhantçabal,[10] Saheed A. Salami,[11] Laurence Shalloo,[12] Yan Sun,[13] Juan Tricarico,[14] Aimable Uwizeye,[15] Camillo De Camillis,[15] Martial Bernoux,[16] Timothy Robinson,[15] and Ermias Kebreab[17]

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Environmental Animal Science

OXFORD

AMERICAN SOCIETY OF ANIMAL SCIENCE

Quantification of methane emitted by ruminants: a review of methods

Luis Orlindo Tedeschi,[†,1] Adibe Luiz Abdalla,[‡] Clementina Álvarez,[‖] Samuel Weniga Anuga,[$] Jacobo Arango,[¶] Karen A. Beauchemin,[§] Philippe Becquet,[††] Alexandre Berndt,[‡‡] Robert Burns,[‖‖] Camillo De Camillis,[§§] Julián Chará,[¶¶] Javier Martin Echazarreta,[$$] Mélynda Hassouna,[†††] David Kenny,[‡‡‡] Michael Mathot,[‖‖‖] Rogerio M. Mauricio,[$$$] Shelby C. McClelland,[§§,¶¶¶] Mutian Niu,[§§§] Alice Anyango Onyango,[††††,‡‡‡‡] Ranjan Parajuli,[‖‖‖‖] Luiz Gustavo Ribeiro Pereira,[$$$$] Agustin del Prado,[¶¶¶¶,§§§§] Maria Paz Tieri,[†††††] Aimable Uwizeye,[§§] and Ermias Kebreab[‡‡‡‡‡]

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