



Rethinking Methane: The Path to Climate Neutrality

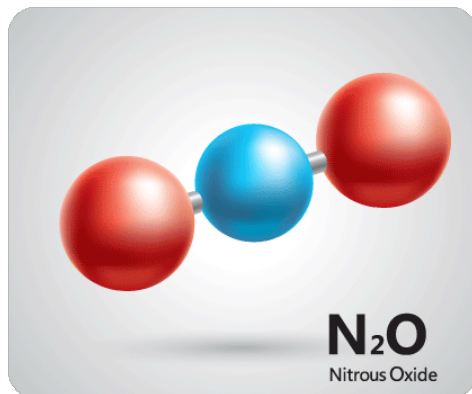
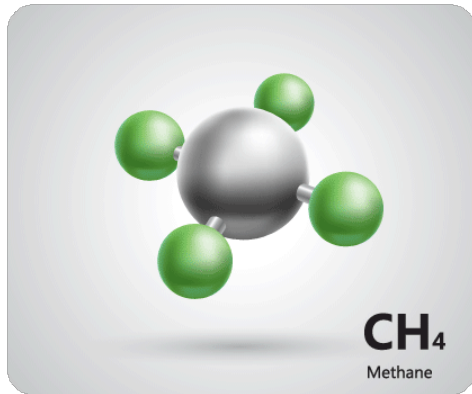
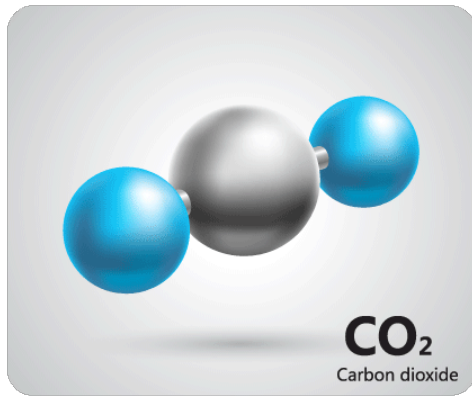
Frank Mitloehner, Ph.D.
Professor & Air Quality Specialist
Department of Animal Science
fmmitloehner@ucdavis.edu







Global Warming Potential (GWP₁₀₀) of Main Greenhouse Gases



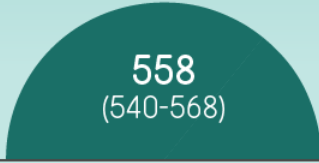
Carbon Dioxide (CO₂) 1

Methane (CH₄) 28

Nitrous Oxide (N₂O) 265

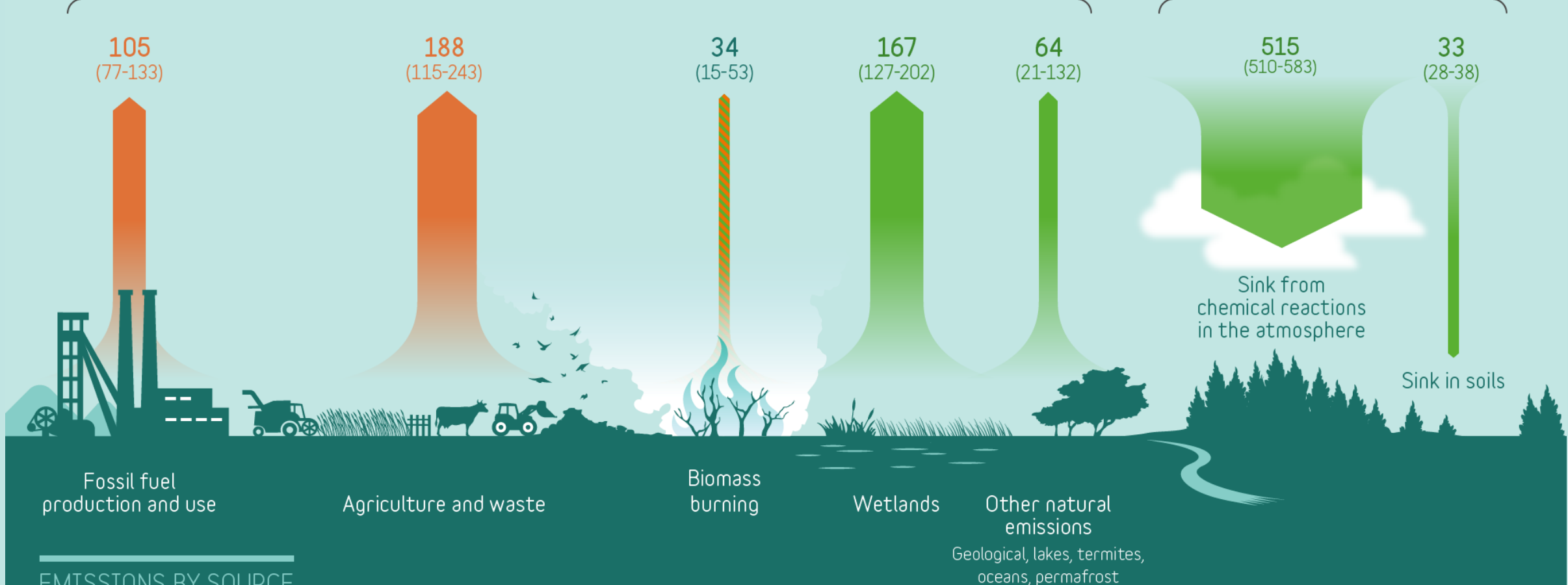
GLOBAL METHANE BUDGET

TOTAL EMISSIONS



CH₄ ATMOSPHERIC GROWTH RATE
10
(9.4-10.6)

TOTAL SINKS



EMISSIONS BY SOURCE

In million-tons of CH₄ per year (Tg CH₄ / yr), average 2003-2012

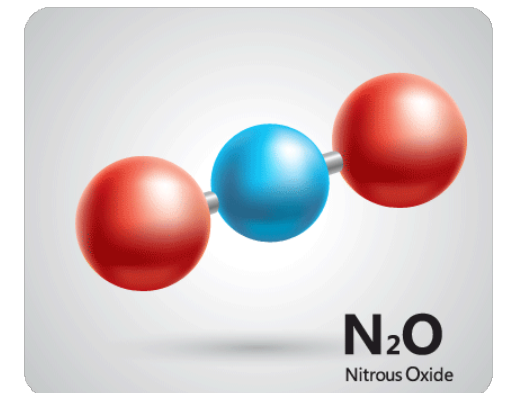
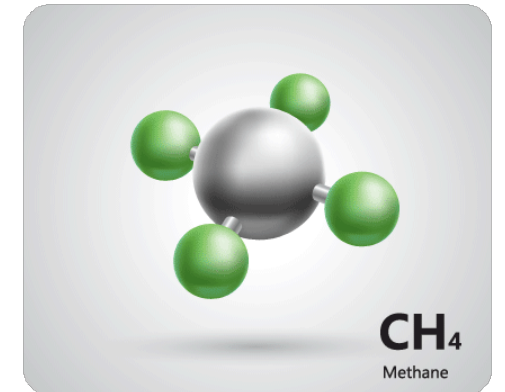
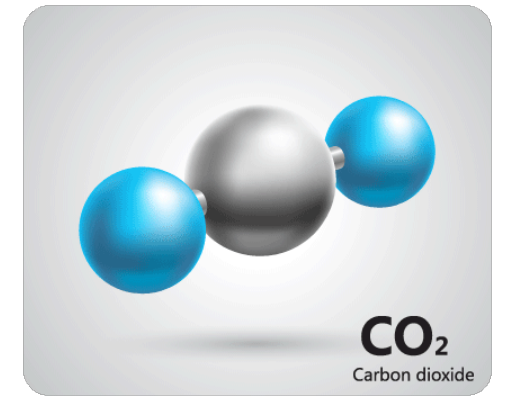
Anthropogenic fluxes Natural fluxes Natural and anthropogenic

Half-Life of Main Greenhouse Gases in Years

Carbon Dioxide (CO₂) 1,000

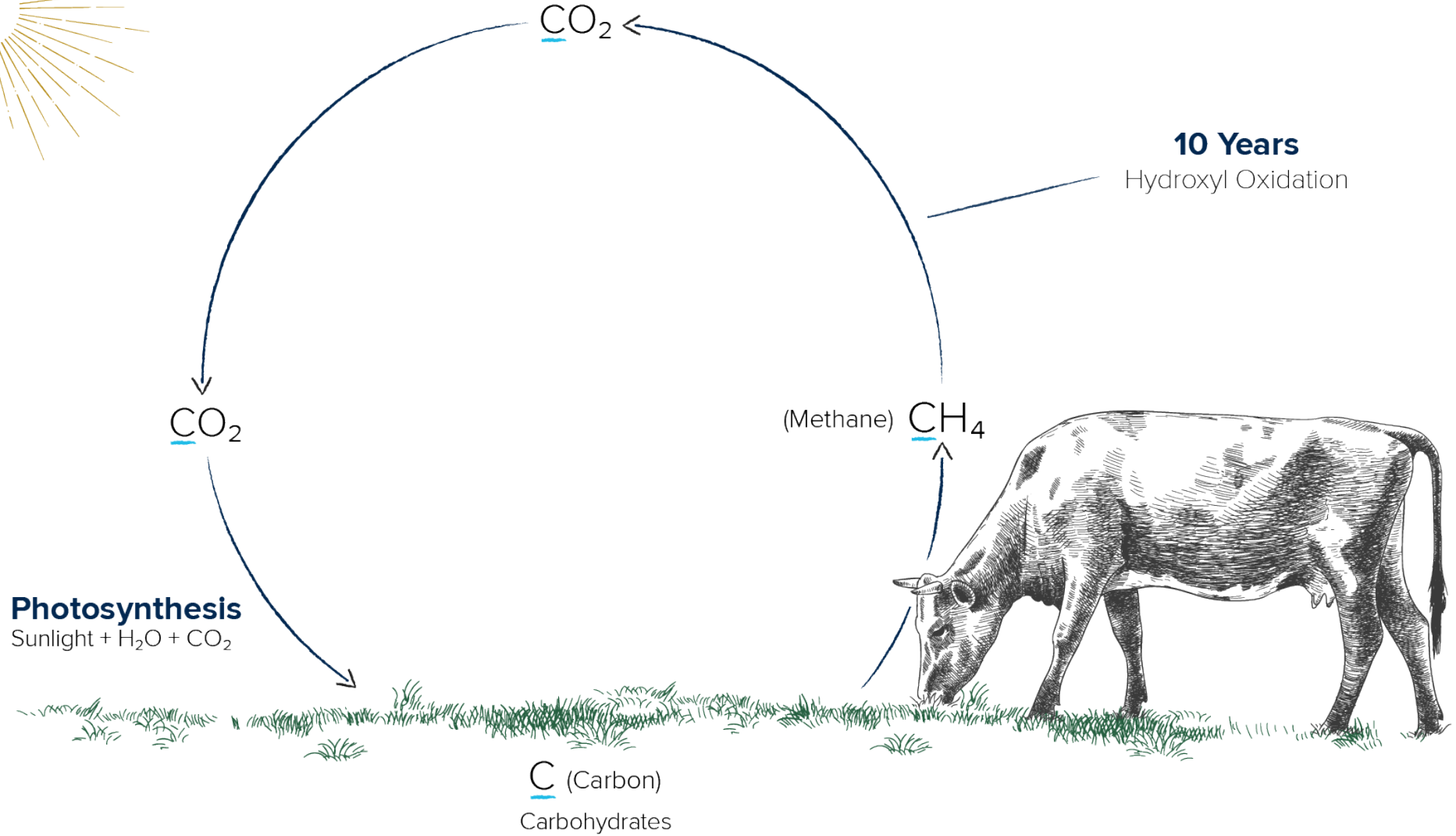
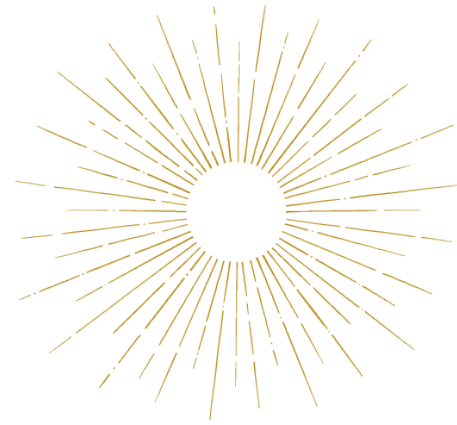
Methane (CH₄) 10

Nitrous Oxide (N₂O) 110



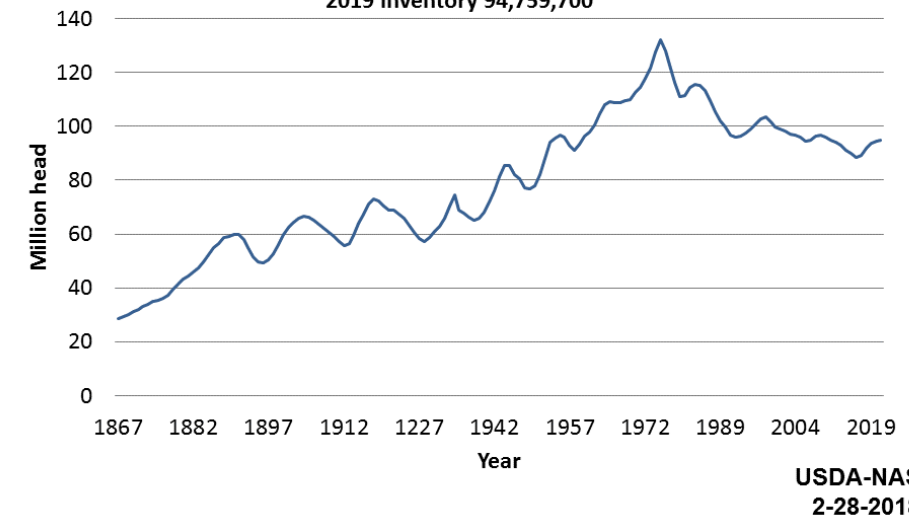
Biogenic Carbon Cycle

Methane - CH_4

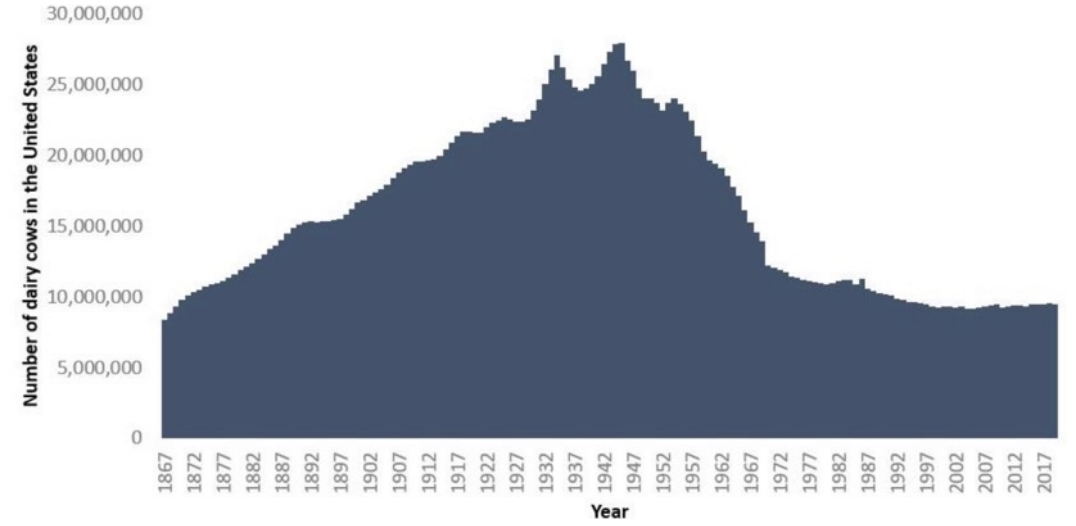


If herd sizes do not increase for 10 years, then additional methane is not added to the atmosphere.

January 1
U.S. All Cattle and Calves Inventory
1867-2019
2019 Inventory 94,759,700

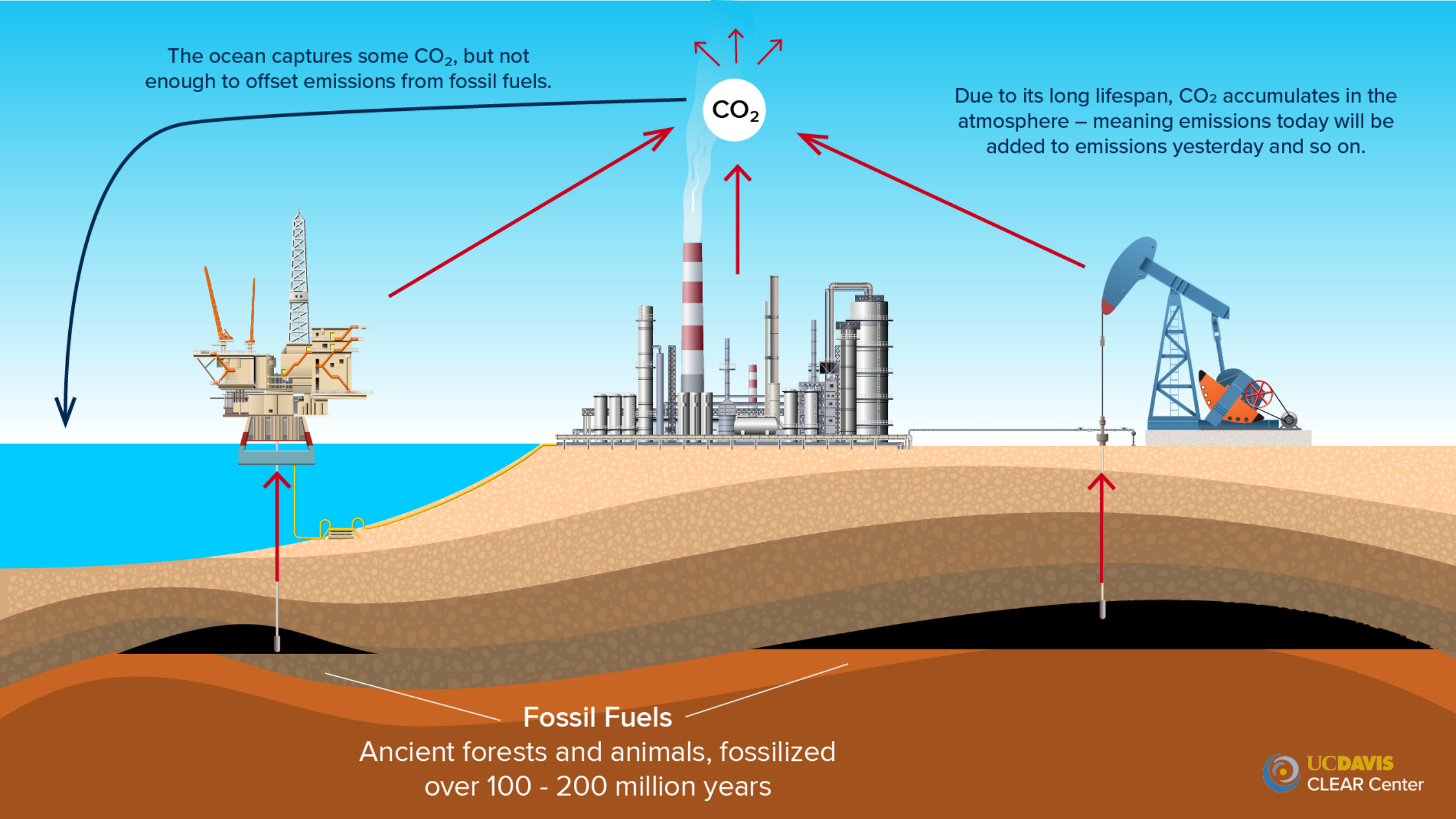


Dairy cow herd size, January 1st (USDA data)



The ocean captures some CO₂, but not enough to offset emissions from fossil fuels.

Due to its long lifespan, CO₂ accumulates in the atmosphere – meaning emissions today will be added to emissions yesterday and so on.

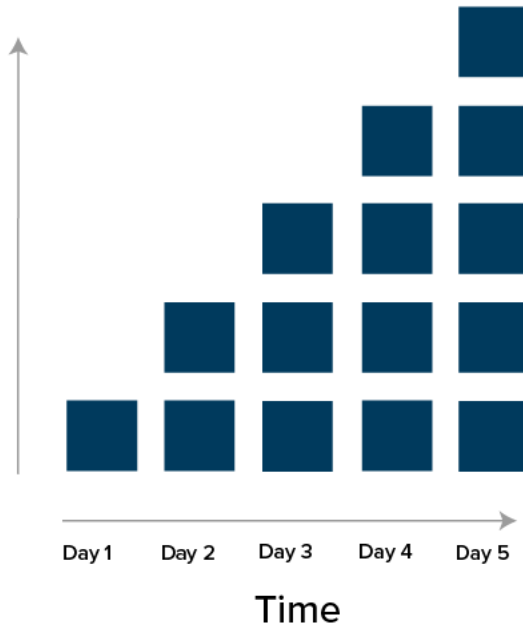


Fossil Fuels

Ancient forests and animals, fossilized
over 100 - 200 million years

■ = Pulse of CO₂

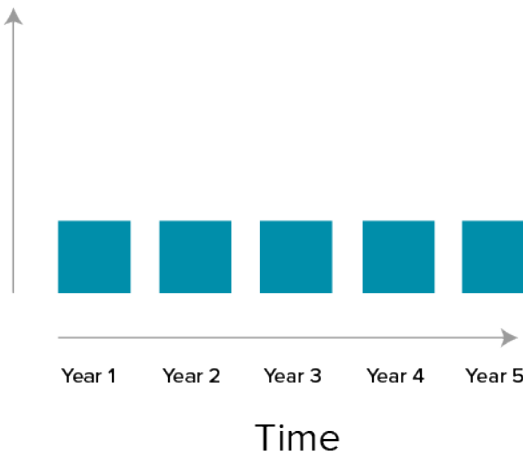
Stock
Gas
Carbon dioxide
(CO₂)
Atmospheric
Concentration



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

■ = Pulse of CH₄

Flow
Gas
Methane (CH₄)
Atmospheric
Concentration



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



Why methane should be treated differently compared to long-lived greenhouse gases

June 12, 2018 12:59am EDT

Livestock is a significant source of methane, a potent but short-lived greenhouse gas. from www.shutterstock.com, CC BY-SA

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New [research](#) provides a way out of a longstanding quandary in climate policy: how best to account for the warming effects of greenhouse gases that have different atmospheric lifetimes.

Carbon dioxide is a long-lived greenhouse gas, whereas methane is comparatively short-lived. Long-lived "stock pollutants" remain in the atmosphere for centuries, increasing in concentration as long as their emissions continue and causing more and more warming. Short-lived "flow pollutants" disappear much more rapidly. As long as their emissions remain constant, their concentration and warming effect remain roughly constant as well.

Our research demonstrates a better way to reflect how different greenhouse gases affect global temperatures over time.

Cost of pollution

The difference between stock and flow pollutants is shown in the figure below. Flow pollutant emissions, for example of methane, do not persist. Emissions in period one, and the same emissions in period two, lead to a constant (or roughly constant) amount of the pollutant in the atmosphere (or river, lake, or sea).

With stock pollutants, such as carbon dioxide, concentrations of the pollutant accumulate as emissions continue.

Authors

Dave Frame
Professor of Climate Change, Te Herenga Waka — Victoria University of Wellington

Adrian Henry Macey
Senior Associate, Institute for Governance and Policy Studies; Adjunct Professor, New Zealand Climate Change Research Institute, Te Herenga Waka — Victoria University of Wellington

Myles Allen
Professor of Geosystem Science, Leader of ECI Climate Research Programme, University of Oxford

<https://theconversation.com/why-methane-should-be-treated-differently-compared-to-long-lived-greenhouse-gases-97845>

Cattle round-up before shipping on a West Texas ranch. Credit: Luc Novovitch / Alamy Stock Photo.

GUEST POSTS 7 June 2018 10:08

Guest post: A new way to assess 'global warming potential' of short-lived pollutants

CB DR MICHELLE CAIN
06.07.18

GUEST POSTS Guest post: A new way to assess 'global warming potential' of short-lived pollutants

Dr Michelle Cain in a science and policy research associate on the Oxford Martin School's

<https://www.carbonbrief.org/guest-post-a-new-way-to-assess-global-warming-potential-of-short-lived-pollutants>

ARTICLE OPEN Improved calculation of warming-equivalent emissions for short-lived climate pollutants

Michelle Cain^{1,2}, John Lynch³, Myles R. Allen^{1,3}, Jan S. Fuglestedt⁴, David J. Frame⁵ and Adrian H Macey^{6,7}

Anthropogenic global warming at a given time is largely determined by the cumulative total emissions (or stock) of long-lived climate pollutants (LLCPs), predominantly carbon dioxide (CO₂), and the emission rates (or flow) of short-lived climate pollutants (SLCPs) immediately prior to that time. Under the United Nations Framework Convention on Climate Change (UNFCCC), reporting of greenhouse gas emissions has been standardised in terms of CO₂-equivalent (CO₂-e) emissions using Global Warming Potentials (GWP) over 100-years, but the conventional usage of GWP does not adequately capture the different behaviours of LLCPs and SLCPs, or their impact on global mean surface temperature. An alternative usage of GWP, denoted GWP⁺, overcomes this problem by equating an increase in the emission rate of an SLCP with a one-off "pulse" emission of CO₂. We show that this approach, while an improvement on the conventional usage, slightly underestimates the impact of recent increases in SLCP emissions on current rates of warming because the climate does not respond instantaneously to radiative forcing. We resolve this with a modification of the GWP⁺ definition, which incorporates a term for each of the short-timescale and long-timescale climate responses to changes in radiative forcing. The amended version allows "CO₂-warming-equivalent" (CO₂-we) emissions to be calculated directly from reported emissions. Thus SLCPs can be incorporated directly into carbon budgets consistent with long-term temperature goals, because every unit of CO₂-we emitted generates approximately the same amount of warming, whether it is emitted as a SLCP or a LLCP. This is not the case for conventionally derived CO₂-e.

npj Climate and Atmospheric Science (2019)2:29 | <https://doi.org/10.1038/s41612-019-0086-4>

INTRODUCTION

Comprehensive climate policies must appraise a range of greenhouse gases and aerosols, which can differ significantly in their radiative efficiencies and atmospheric lifetimes, and hence the nature of their climate impacts¹. To reflect this, different climate pollutants are often expressed using a common emission metric. Emissions reporting under the United Nations Framework Convention on Climate Change (UNFCCC) now requires the use of 100-year Global Warming Potential (GWP₁₀₀) to account for all gases as carbon dioxide equivalent (CO₂-e) quantities. Despite its prevalence in the UNFCCC and national climate policies, GWP has received criticism,^{2–4} not least that it cannot be used to appraise temperature-related goals,⁵ and other equivalence metrics have been proposed.^{6–8} In deed, Shine⁹ notes that strong caveats were in place when GWP was introduced in the Intergovernmental Panel on Climate Change's First Assessment Report¹⁰: "It must be stressed that there is no universally accepted methodology for combining all the relevant factors into a single [metric]... A simple approach [i.e. the GWP] has been adopted here to illustrate the difficulties inherent in the concept." Working Group 1 of the Fifth Assessment Report, AR5, did not recommend any metric and emphasised that the choice of metric depends on the specific goal of the climate policy. In AR4, however, the GWPs were the recommended metric to compare the effects of long-lived greenhouse gases,¹¹ and AR5 values of GWP₁₀₀ have now been

adopted for emissions reporting (see the textual proposal from 12 December 2018 on the transparency framework for action and support referred to in Article 13 of the Paris Agreement: <https://unfccc.int/process/bodies/subsidiary-bodies/ad-hoc-working-group-on-the-paris-agreement/apa/information-on-apa-agenda-item-5>).

The temperature response to emissions is ambiguous under GWP^{12,13} and this ambiguity is particularly relevant in the context of the Paris Agreement, given its stated aim of holding the increase in the global average temperature well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C. Beyond the reference to a balance of emissions by sources and removals by sinks well before the end of the century, neither the means by which this is to be achieved nor the metrics used to assess progress are explicitly stated.¹⁴ Tanaka and O'Neill¹⁵ demonstrate that net-zero aggregate CO₂-e emissions based on GWP₁₀₀ (which is often assumed to be the definition of the balance of sources and sinks described in the Paris Agreement) are not essential to limit warming to 1.5 °C. Wigley¹⁶ posits that the balance of sources and sinks in Article 4.1 of the Paris Agreement is scientifically inconsistent with the temperature goals in Article 2.1. These papers show how moving from the temperature goals articulated in the Paris Agreement to emissions targets and profiles is not something that is currently well-handled by conventional carbon accounting; they also show that the area

¹Environmental Change Institute, School of Geography and the Environment, University of Oxford, South Parks Road, Oxford OX1 3QY, UK; ²Oxford Martin School, University of Oxford, 34 Broad Street, Oxford OX1 3BD, UK; ³Atmospheric Oceanic and Planetary Physics, Department of Physics, University of Oxford, Parks Road, Oxford OX1 3PU, UK; ⁴Center for International Climate and Environmental Research (CICERO), PO Box 1129 Blindern, 0318 Oslo, Norway; ⁵New Zealand Climate Change Research Institute, Victoria University of Wellington, PO Box 600, Wellington, New Zealand; ⁶Institute for Governance and Policy Studies, Victoria University of Wellington, PO Box 600, Wellington, New Zealand and ⁷Institut d'Études Avancées de Nantes, 5, Allée Jacques Berquet, 44000 Nantes, France

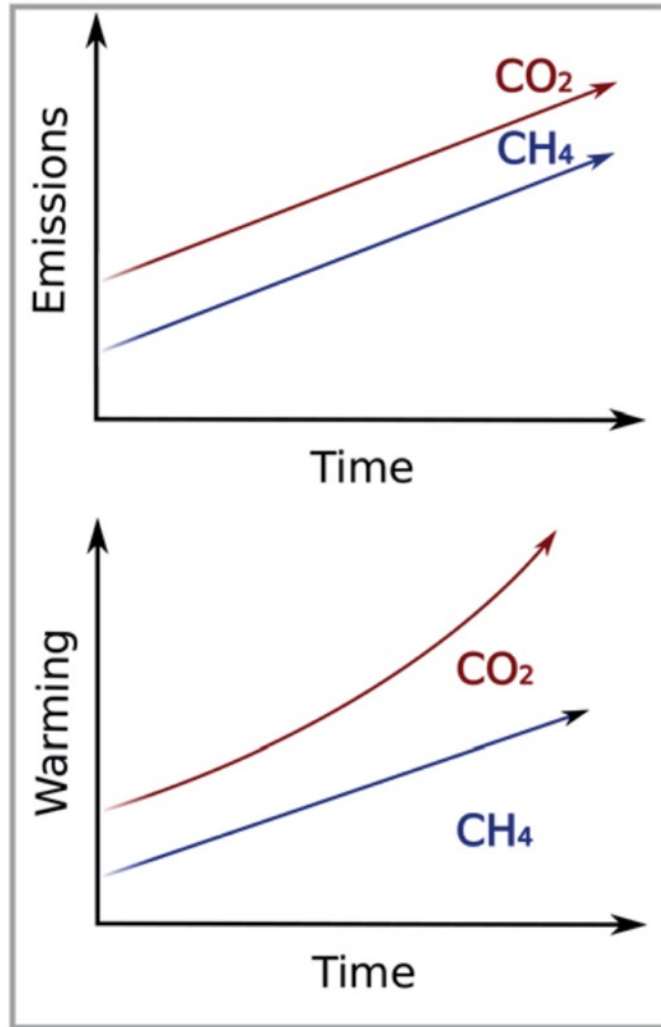
Correspondence: Michelle Cain (michelle.cain@oxfordmartin.ox.ac.uk)
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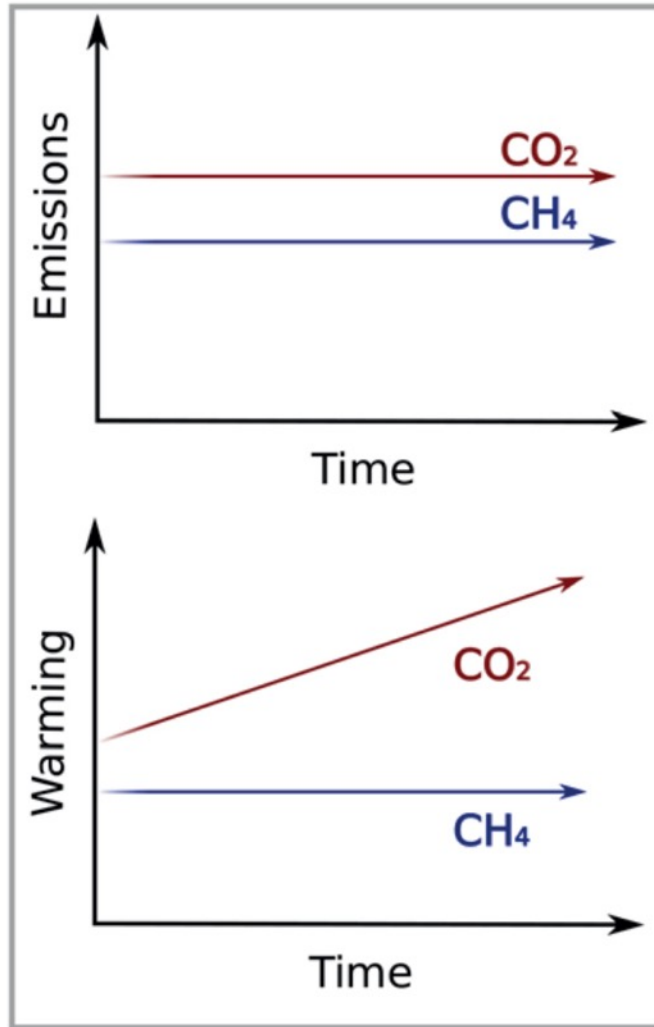
<https://www.nature.com/articles/s41612-019-0086-4.pdf>

	Annual Methane Emissions	CO ₂ equivalent emissions	
		Using GWP ₁₀₀	Using GWP*
WARMING	<p>1 tCH₄/y Rise by 35% 30 years</p>	<p>987 tCO₂-e =33 tCO₂/y for 30y</p>	<p>982 tCO₂-we =33 tCO₂/y for 30y</p>
STABLE	<p>Fall by 10%</p>	<p>798 tCO₂-e</p>	<p>-10 tCO₂-we</p>
COOLING	<p>Fall by 35%</p>	<p>693 tCO₂-e</p>	<p>-562 tCO₂-we</p>

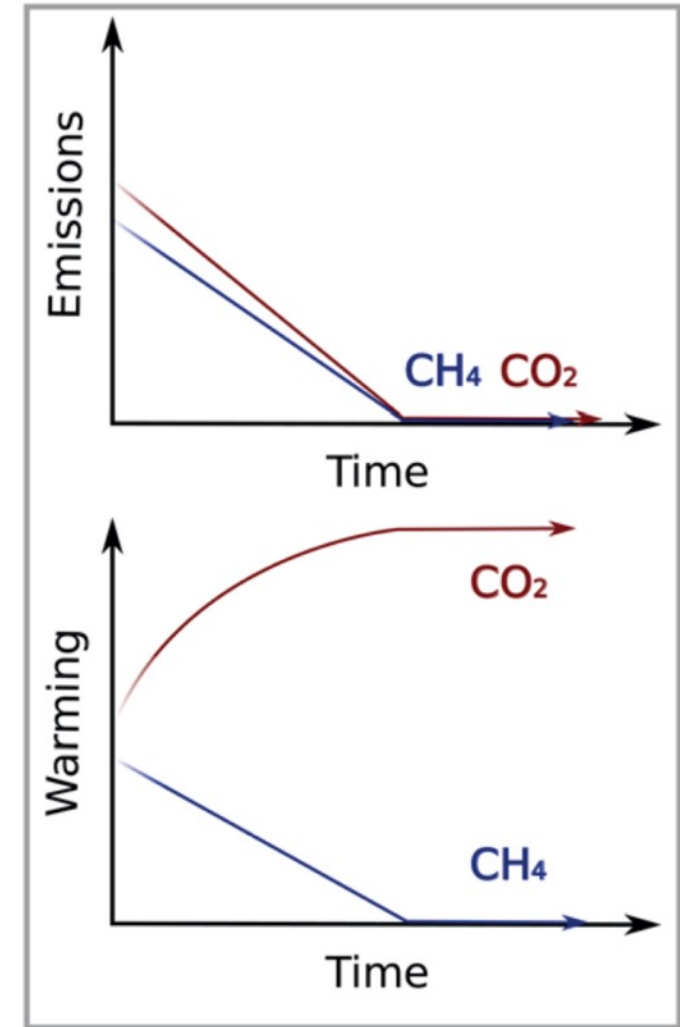
Rising emissions



Constant emissions



Falling emissions





How do we do it?

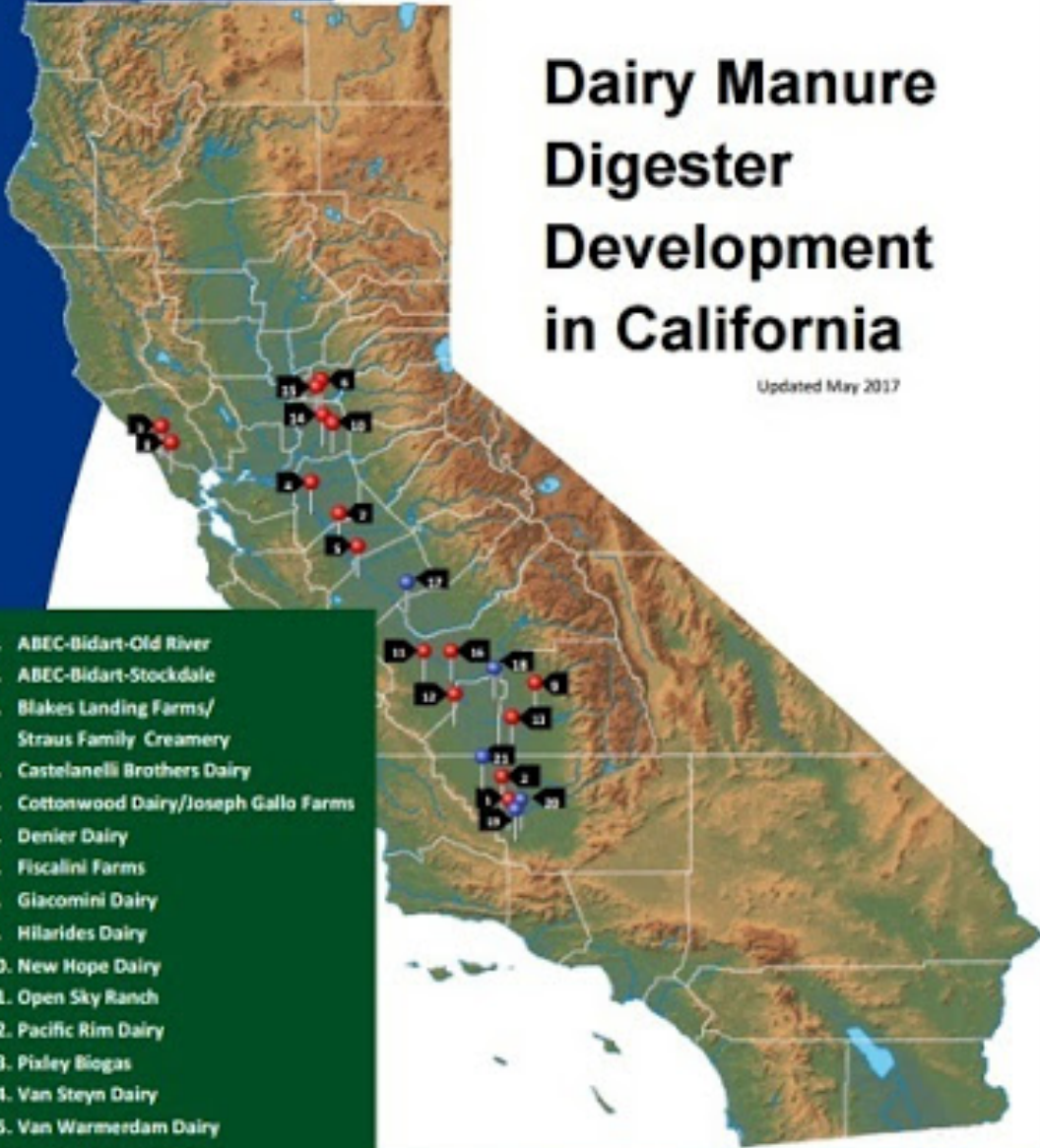


Since 2015
California
dairies have
reduced
greenhouse
gases by
**2.2 million
metric tons.**



Dairy Manure Digester Development in California

Updated May 2017



1. ABEC-Bidart-Old River
2. ABEC-Bidart-Stockdale
3. Blakes Landing Farms/
Straus Family Creamery
4. Castelanelli Brothers Dairy
5. Cottonwood Dairy/Joseph Gallo Farms
6. Denier Dairy
7. Fiscalini Farms
8. Giacomini Dairy
9. Hilarides Dairy
10. New Hope Dairy
11. Open Sky Ranch
12. Pacific Rim Dairy
13. Pixley Biogas
14. Van Steyn Dairy
15. Van Warmerdam Dairy
16. Verwey Dairy- Hanford
Under Construction
17. Verwey Dairy- Madera
18. GJ TeVelde Ranch
19. Carlos Echeverria & Sons Dairy
20. Lakeview Dairy
21. West Star Dairy

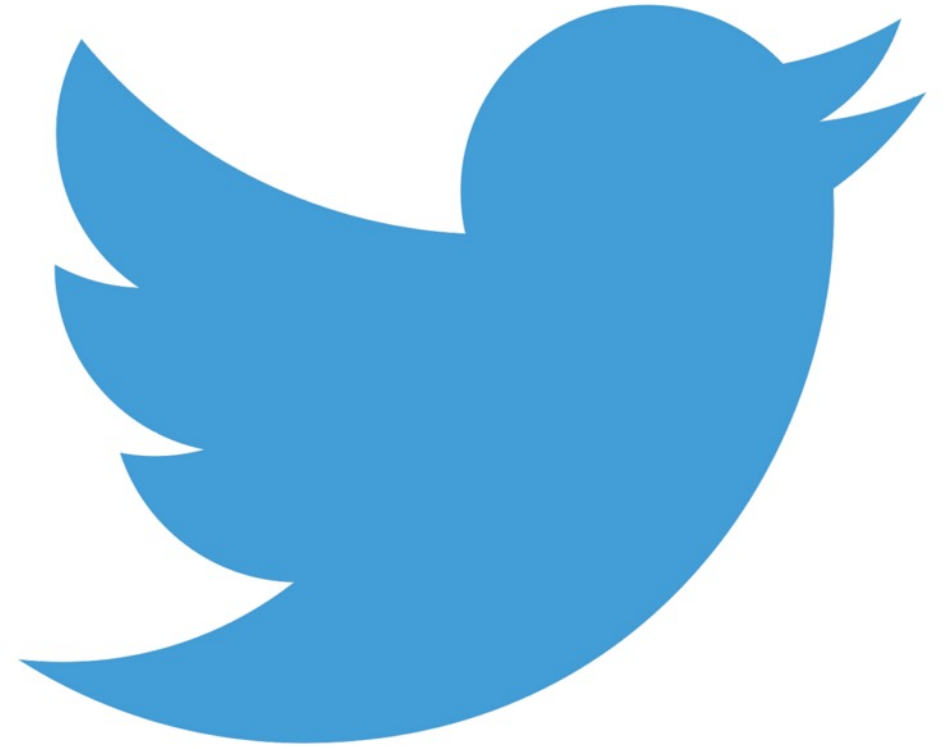


That's a **25 percent** reduction in GHG emissions.

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Thank you
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