Livestock's Path to Climate Neutrality

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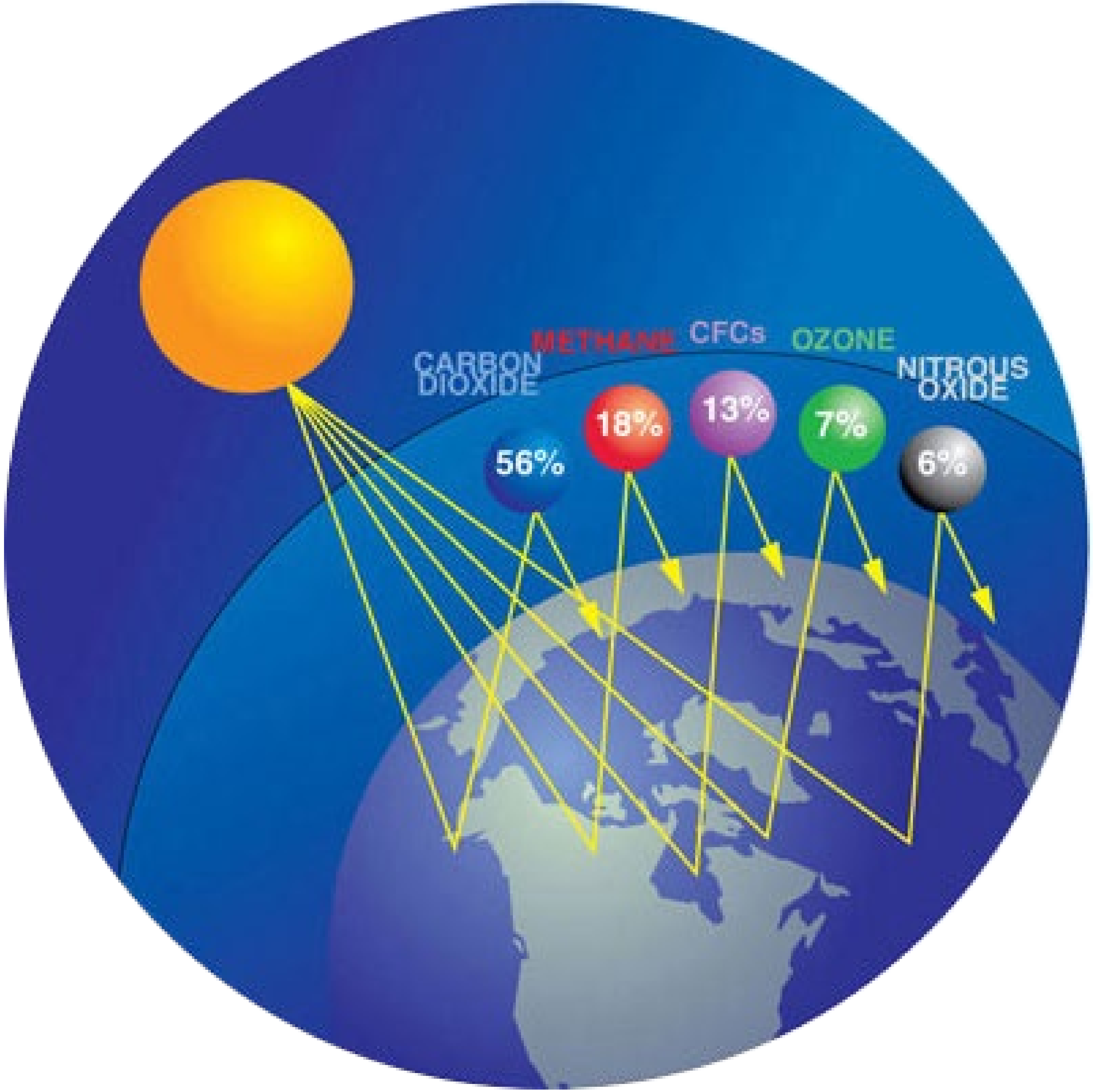

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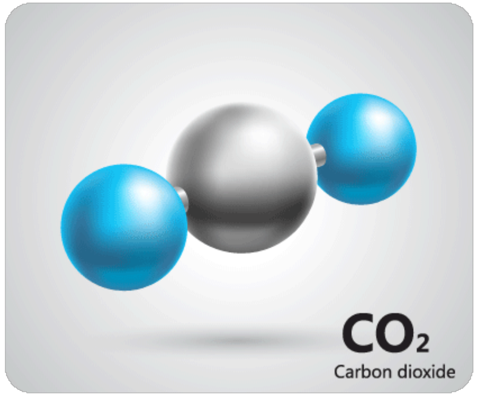
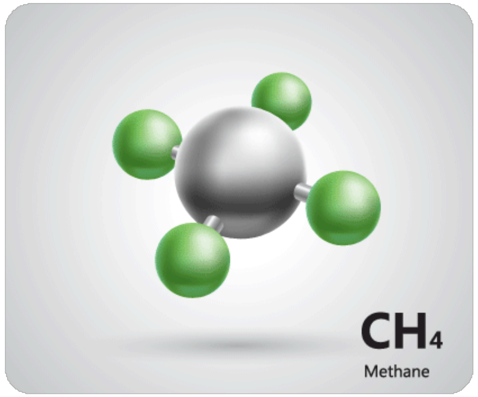
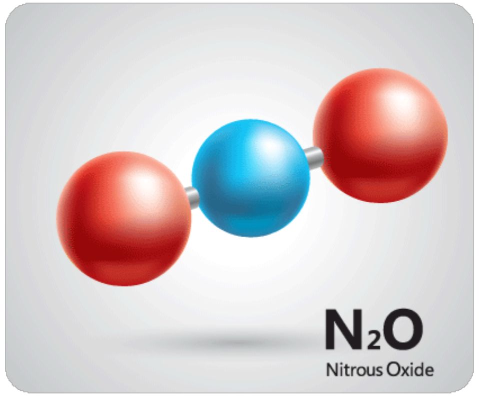
Global Warming Potential (GWP$_{100}$) of Main Greenhouse Gases







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

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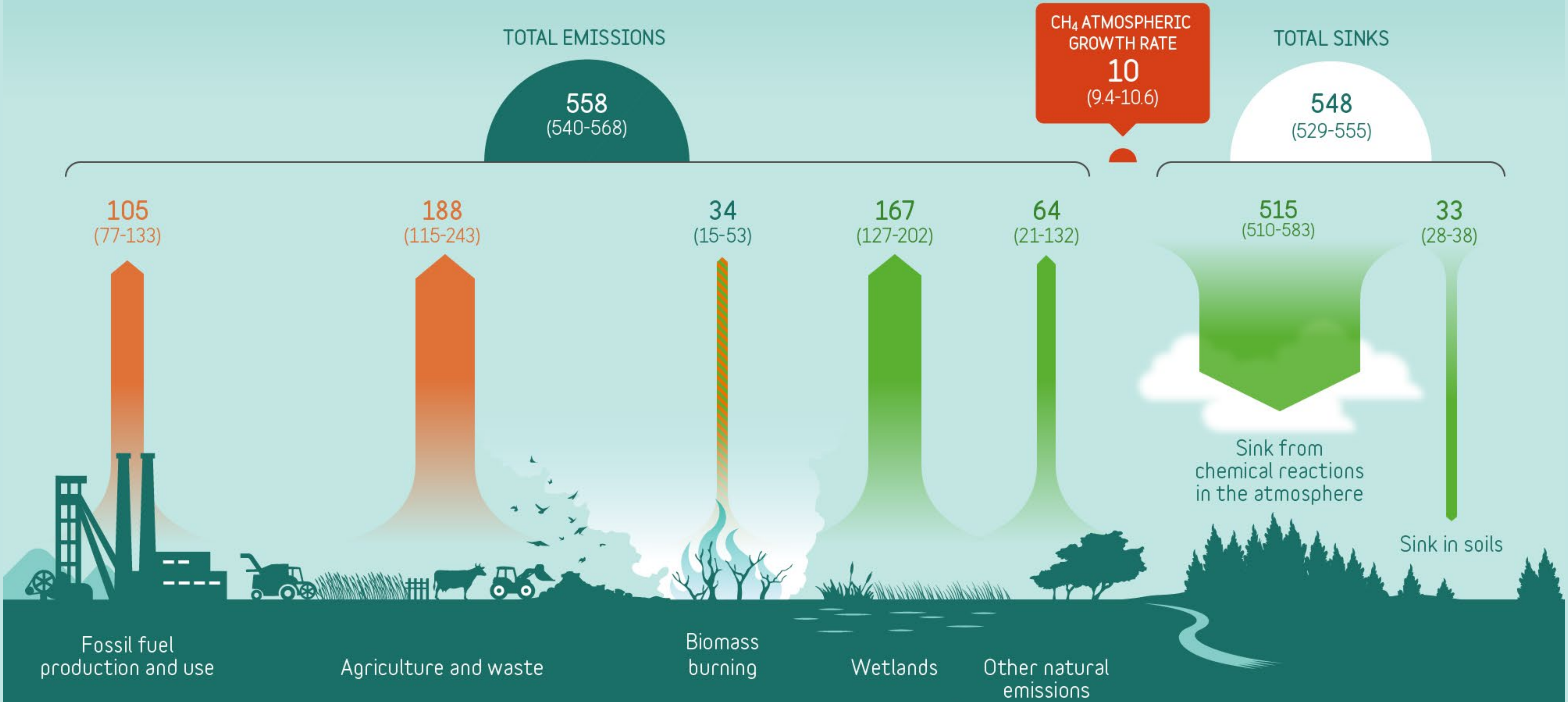
GLOBAL METHANE BUDGET



TOTAL EMISSIONS

558
(540-568)

CH_4 ATMOSPHERIC GROWTH RATE
10
(9.4-10.6)

TOTAL SINKS

548
(529-555)

105
(77-133)
Fossil fuel production and use

188
(115-243)
Agriculture and waste

34
(15-53)
Biomass burning

167
(127-202)
Wetlands

64
(21-132)
Other natural emissions
Geological, lakes, termites, oceans, permafrost

515
(510-583)
Sink from chemical reactions in the atmosphere

33
(28-38)
Sink in soils

EMISSIONS BY SOURCE

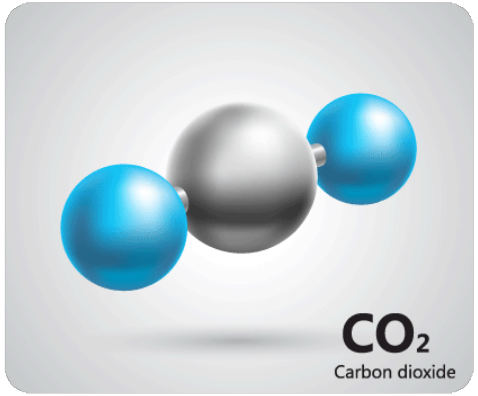
In million-tons of CH_4 per year (Tg CH_4 / yr), average 2003-2012

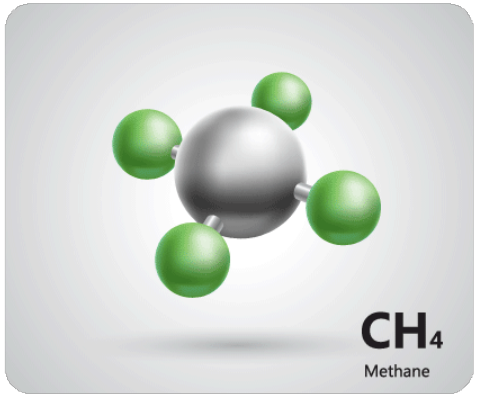
🟧 Anthropogenic fluxes 🟩 Natural fluxes ▨ Natural and anthropogenic

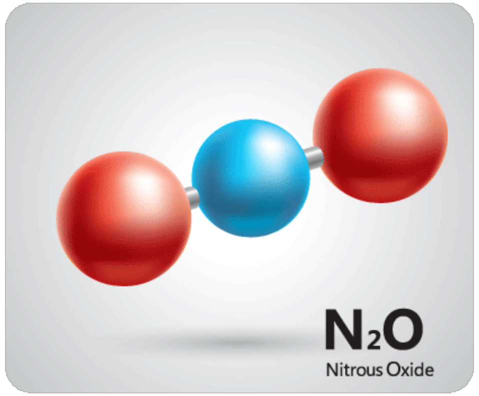
GLOBAL CARBON PROJECT
FONDATION BNP PARIBAS

Half-Life of Main Greenhouse Gases in Years

Carbon Dioxide (CO_2)	1,000
Methane (CH_4)	12
Nitrous Oxide (N_2O)	110







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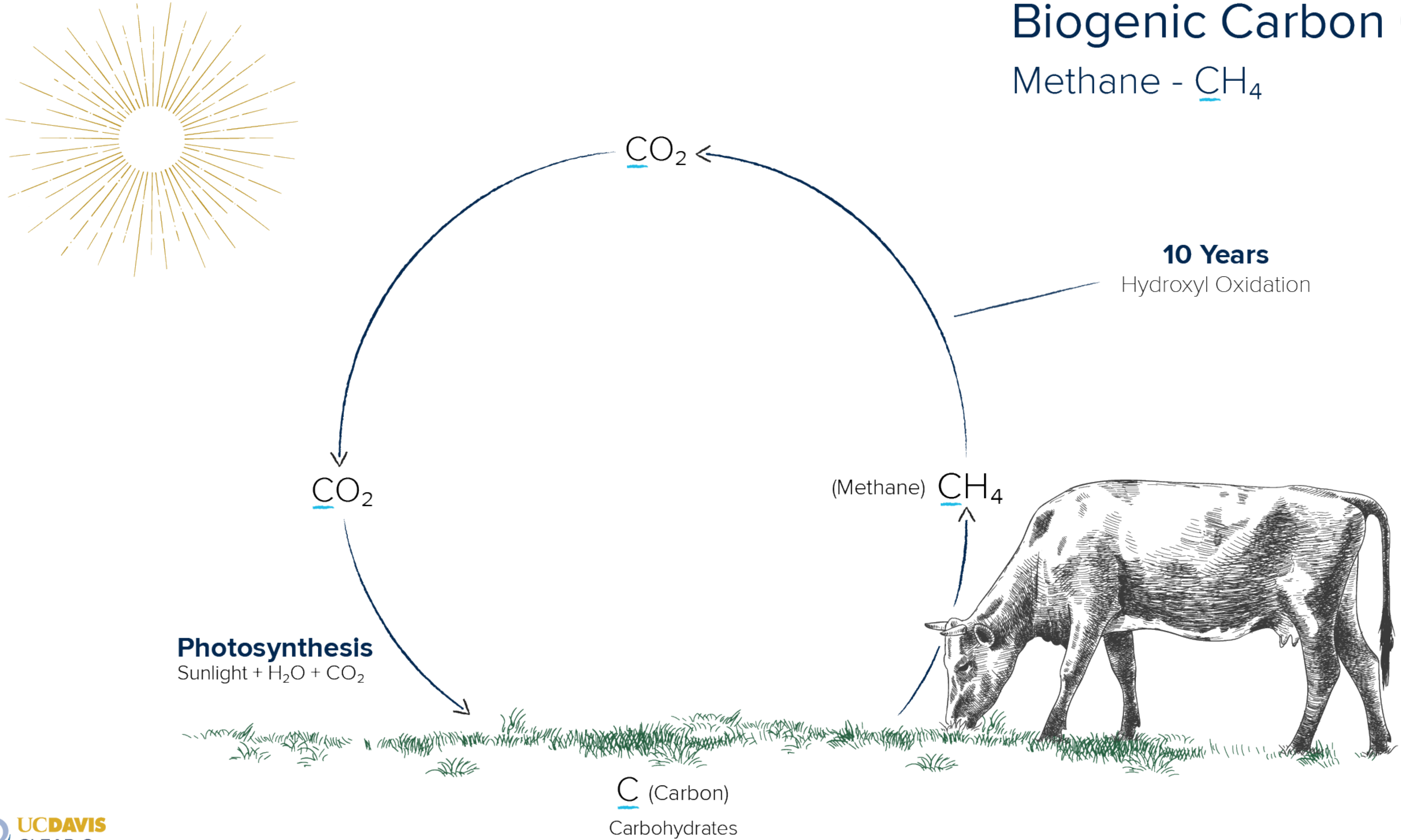
Biogenic Carbon Cycle

Methane - CH_4



CO_2

10 Years
Hydroxyl Oxidation

CO_2

(Methane) CH_4

Photosynthesis
Sunlight + H_2O + CO_2

C (Carbon)
Carbohydrates

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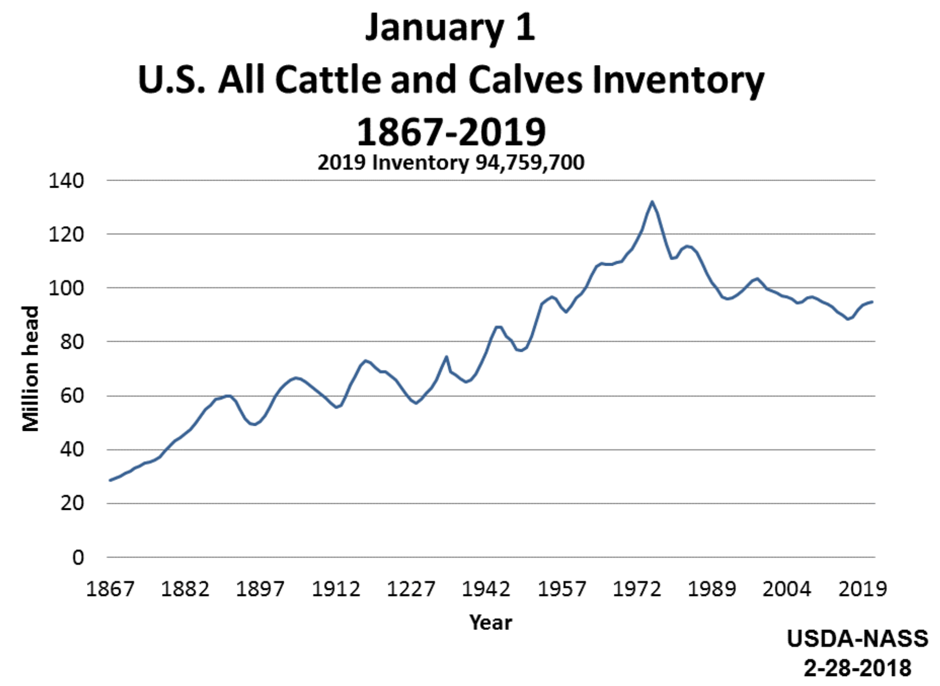
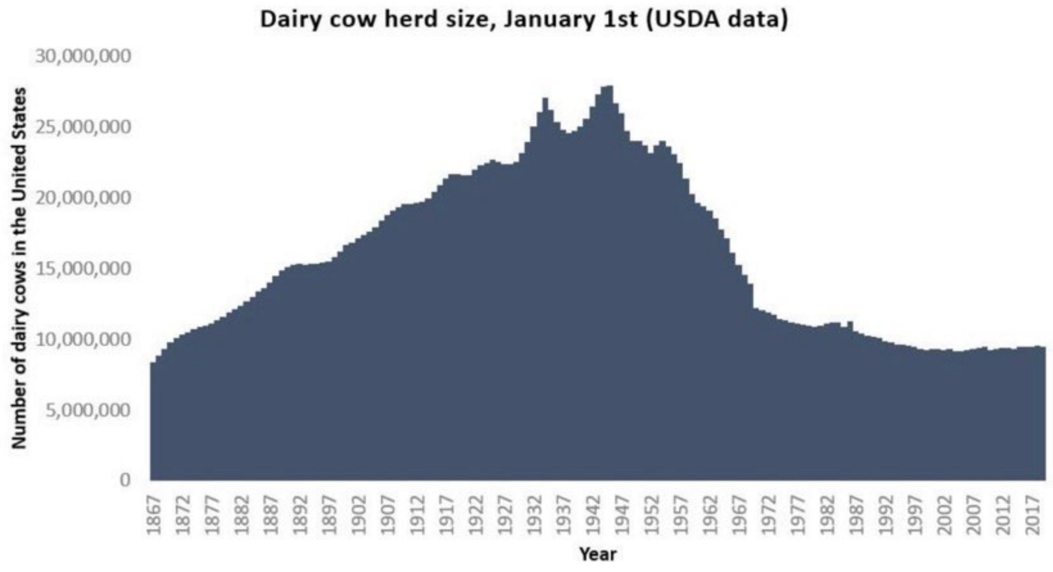
If herd sizes stay roughly stable for 20 years, then so does methane and therefore related warming



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

USDA-NASS
2-28-2018



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

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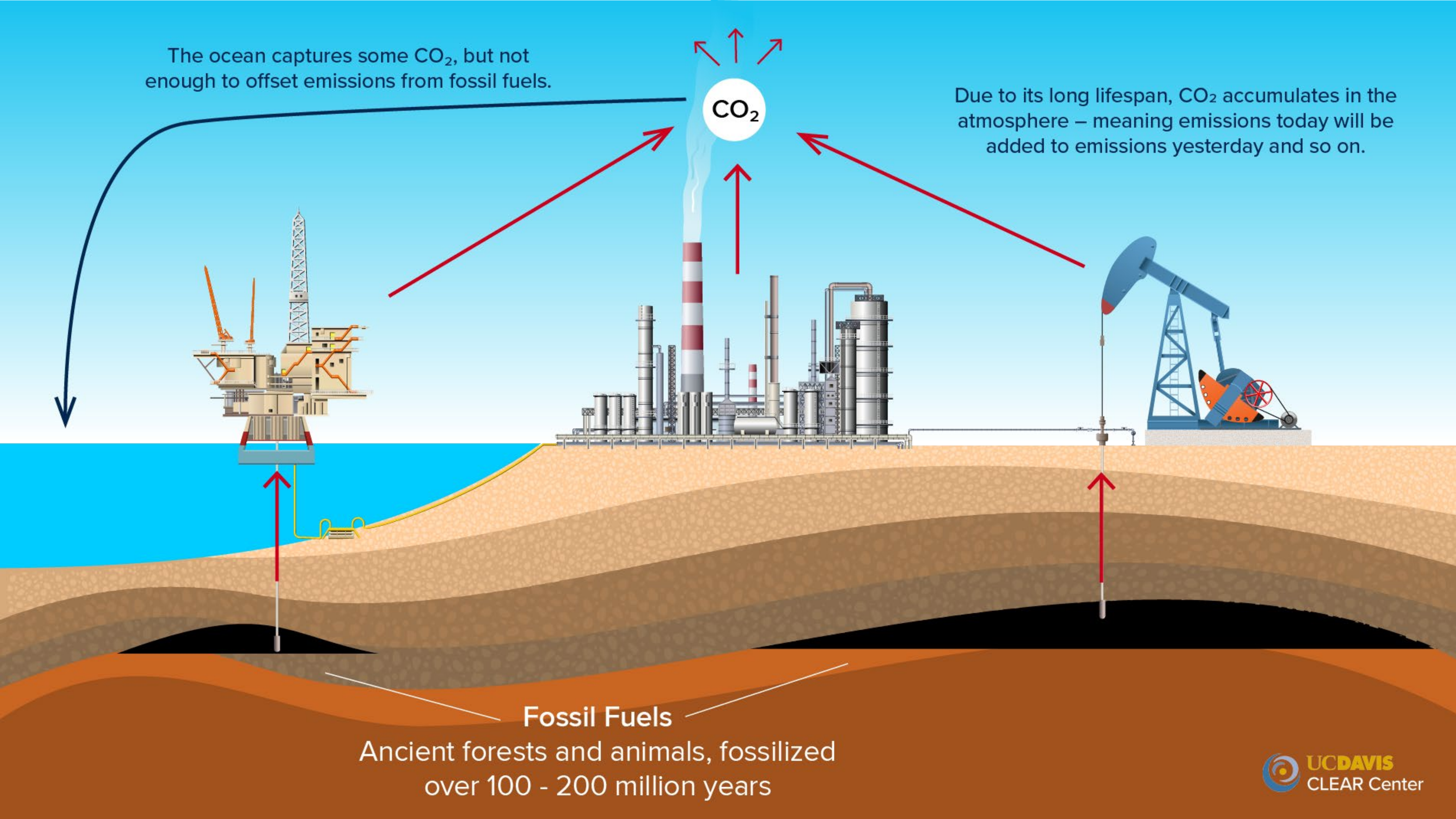

The ocean captures some CO_2, but not enough to offset emissions from fossil fuels.

Due to its long lifespan, CO_2 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

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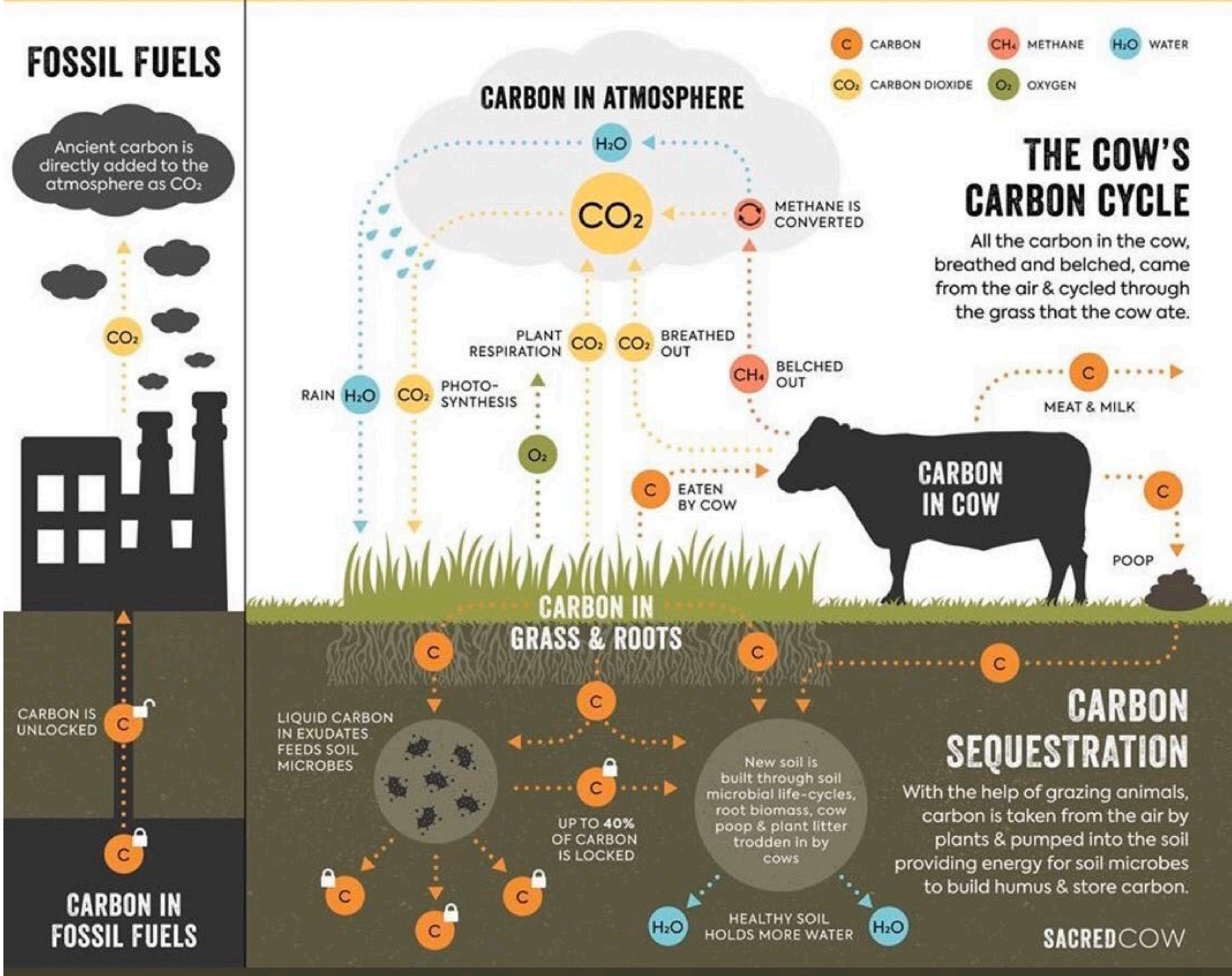
Fossil vs. Biogenic Carbon



Ancient carbon is directly added to the atmosphere as CO_2

THE COW'S CARBON CYCLE

All the carbon in the cow, breathed and belched, came from the air & cycled through the grass that the cow ate.

New soil is built through soil microbial life-cycles, root biomass, cow poop & plant litter trodden in by cows

CARBON SEQUESTRATION

With the help of grazing animals, carbon is taken from the air by plants & pumped into the soil providing energy for soil microbes to build humus & store carbon.

Via:
@sustainabledish
sacredcow.info

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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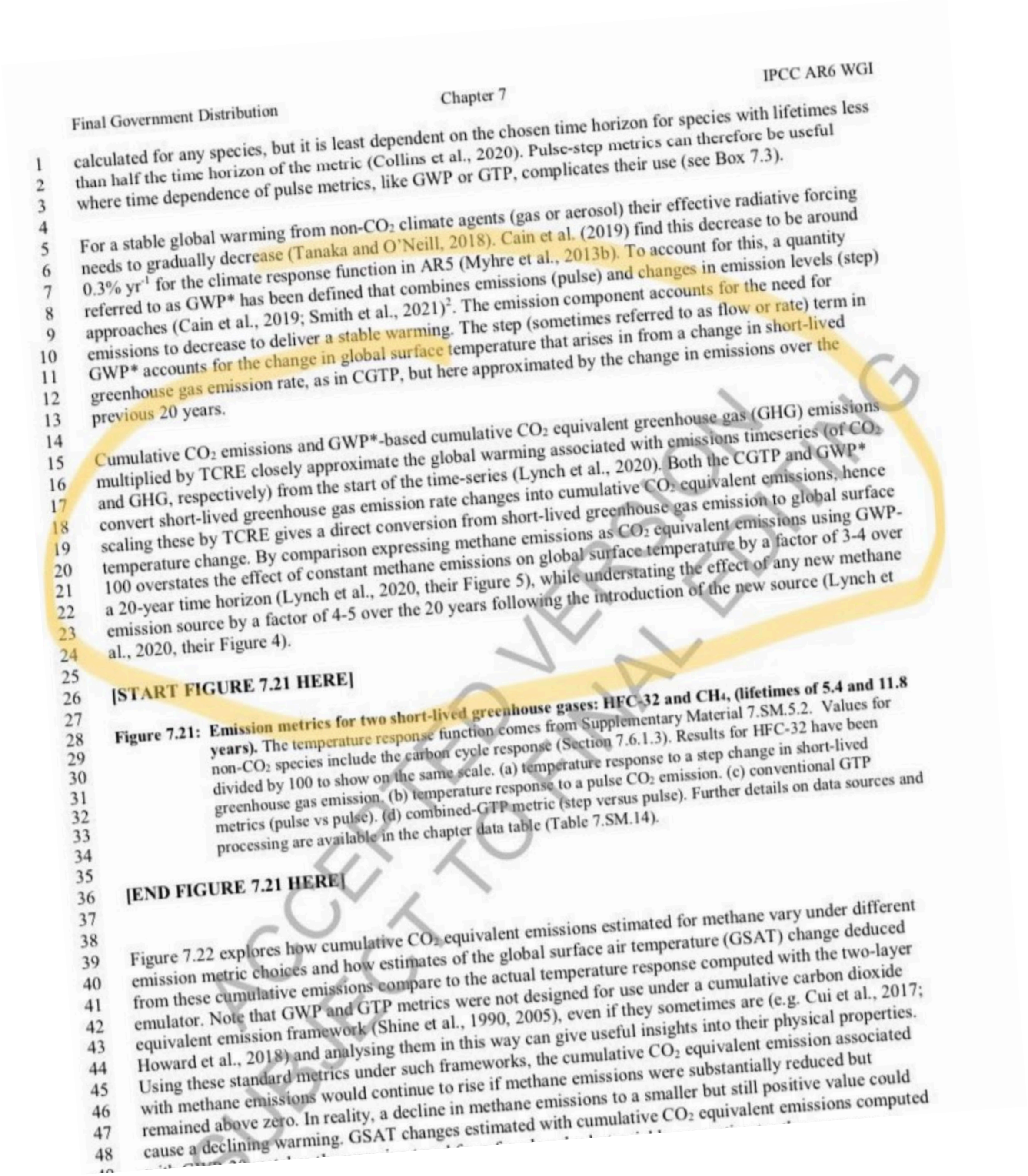


calculated for any species, but it is least dependent on the chosen time horizon for species with lifetimes less than half the time horizon of the metric (Collins et al., 2020). Pulse-step metrics can therefore be useful where time dependence of pulse metrics, like GWP or GTP, complicates their use (see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

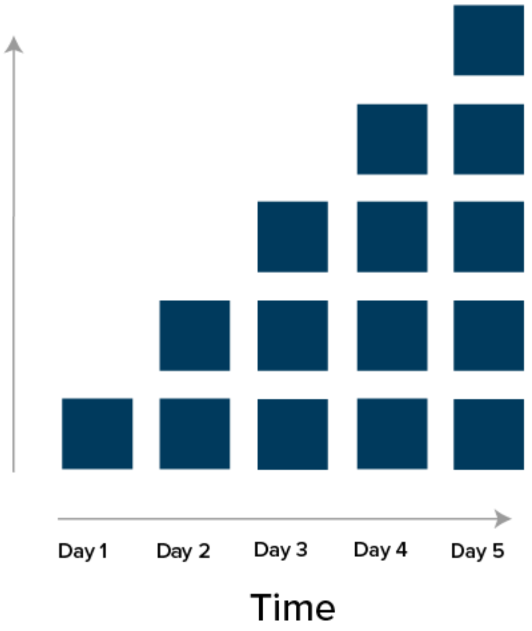
[END FIGURE 7.21 HERE]

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

■ = Pulse of CO_2

Stock Gas

Carbon dioxide (CO_2)

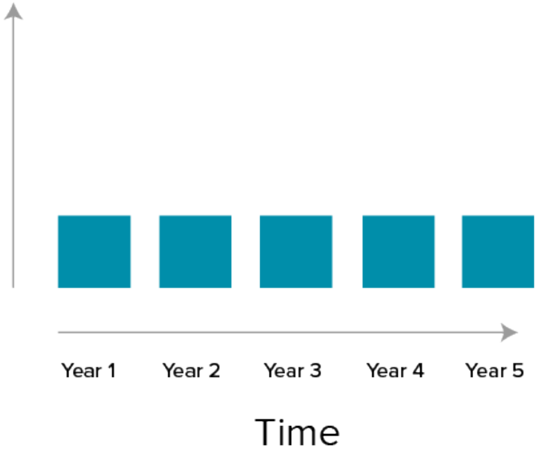


Stock gases will accumulate over time, because they stay in the environment.

■ = Pulse of CH_4

Flow Gas

Methane (CH_4)



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

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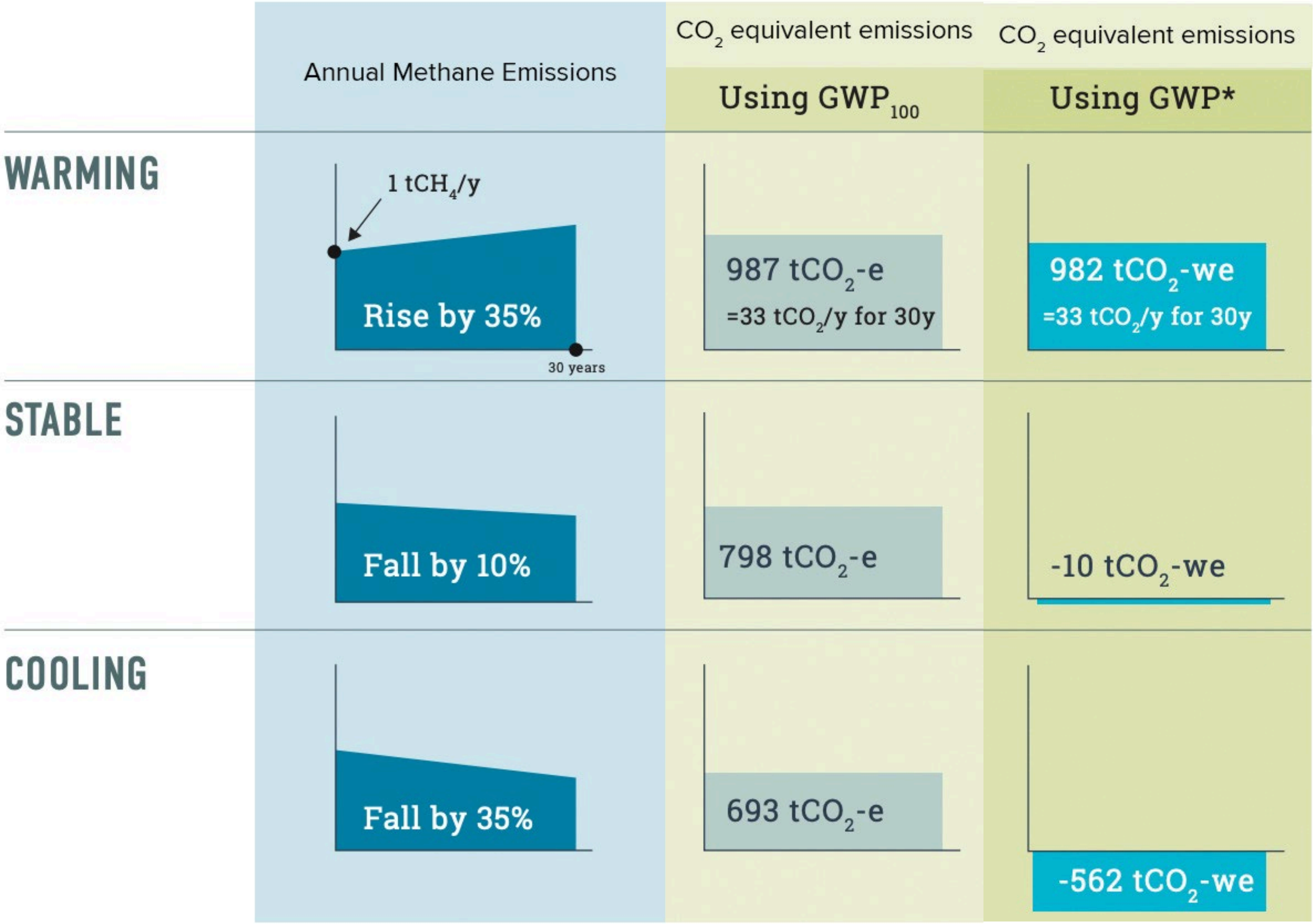
Based on research by Myles R. Allen, Keith P. Shine, Jan S. Fuglestvedt, Richard J. Millar, Michelle Cain, David J. Frame & Adrian H. Macey.
Read more here: https://rdcu.be/b1t7S



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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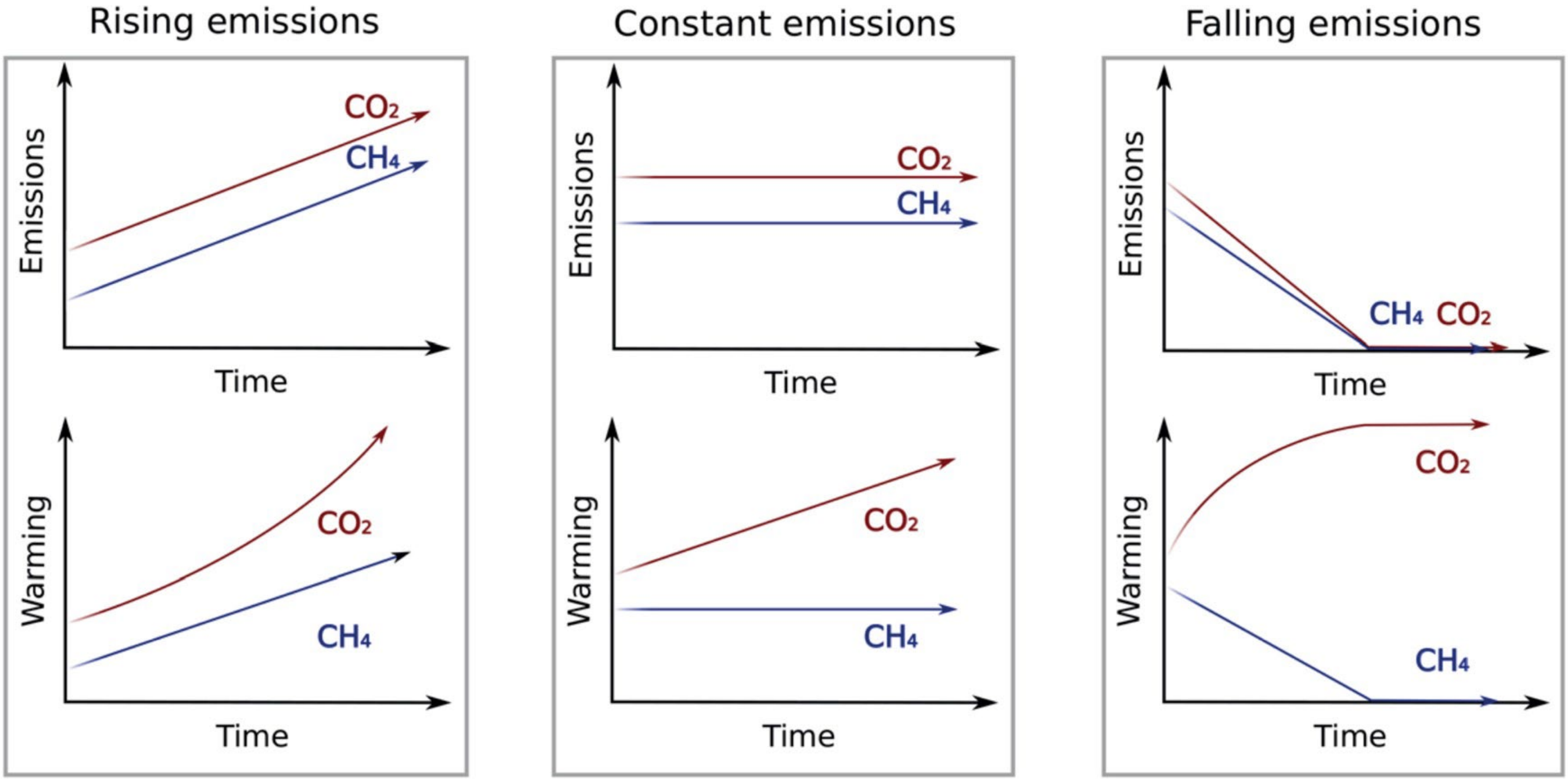

Oxford Martin, Climate Metrics for Ruminant Livestock, July 2018,
https://www.oxfordmartin.ox.ac.uk/downloads/reports/Climate-metrics-for-ruminant-livestock.pdf%C2%A0

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California GHG trends

Since 2015 California dairies has reduced methane by

2.2 million metric tons CO2e annually.

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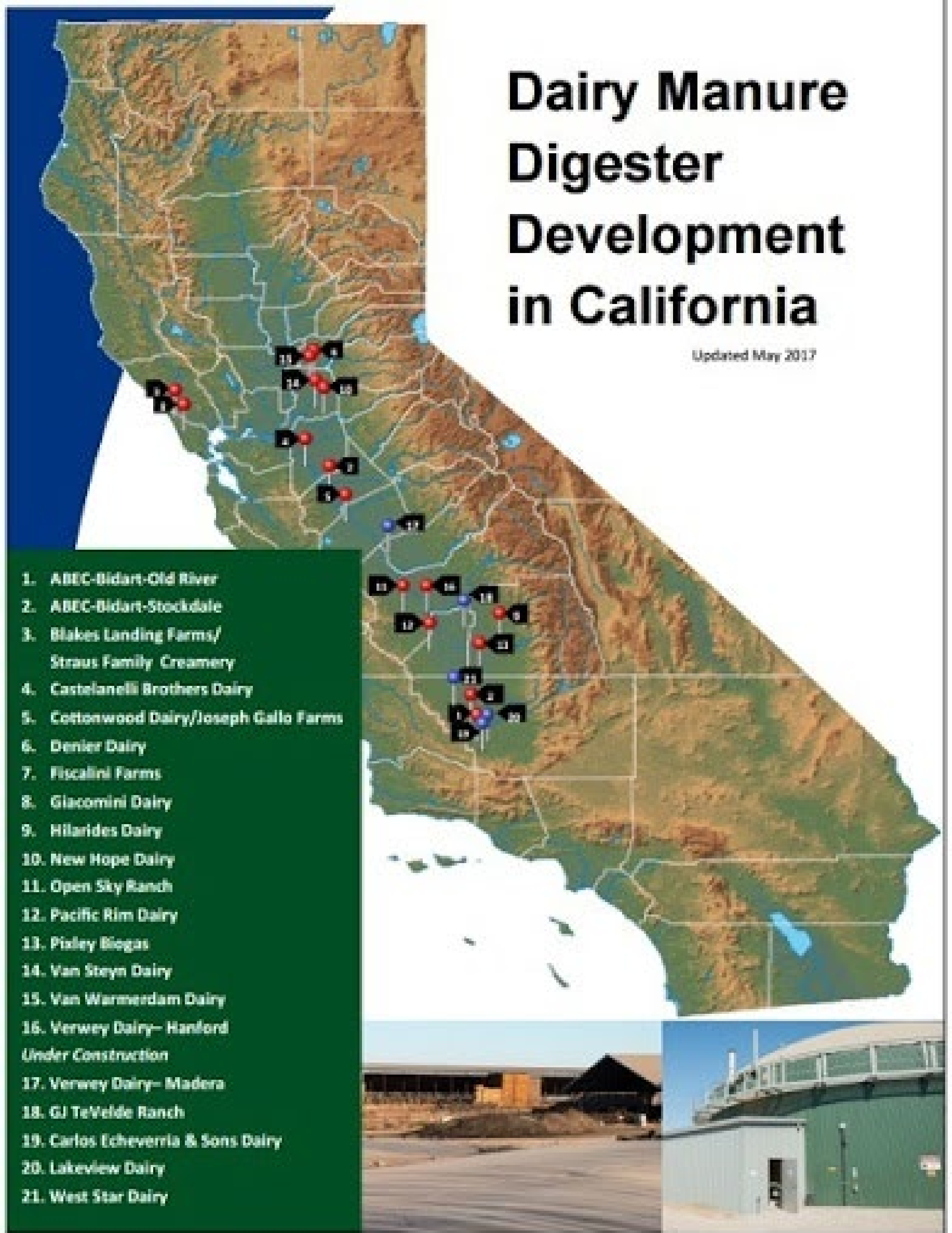

Dairy Manure Digester Development in California

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 the dairy industry’s methane emissions.

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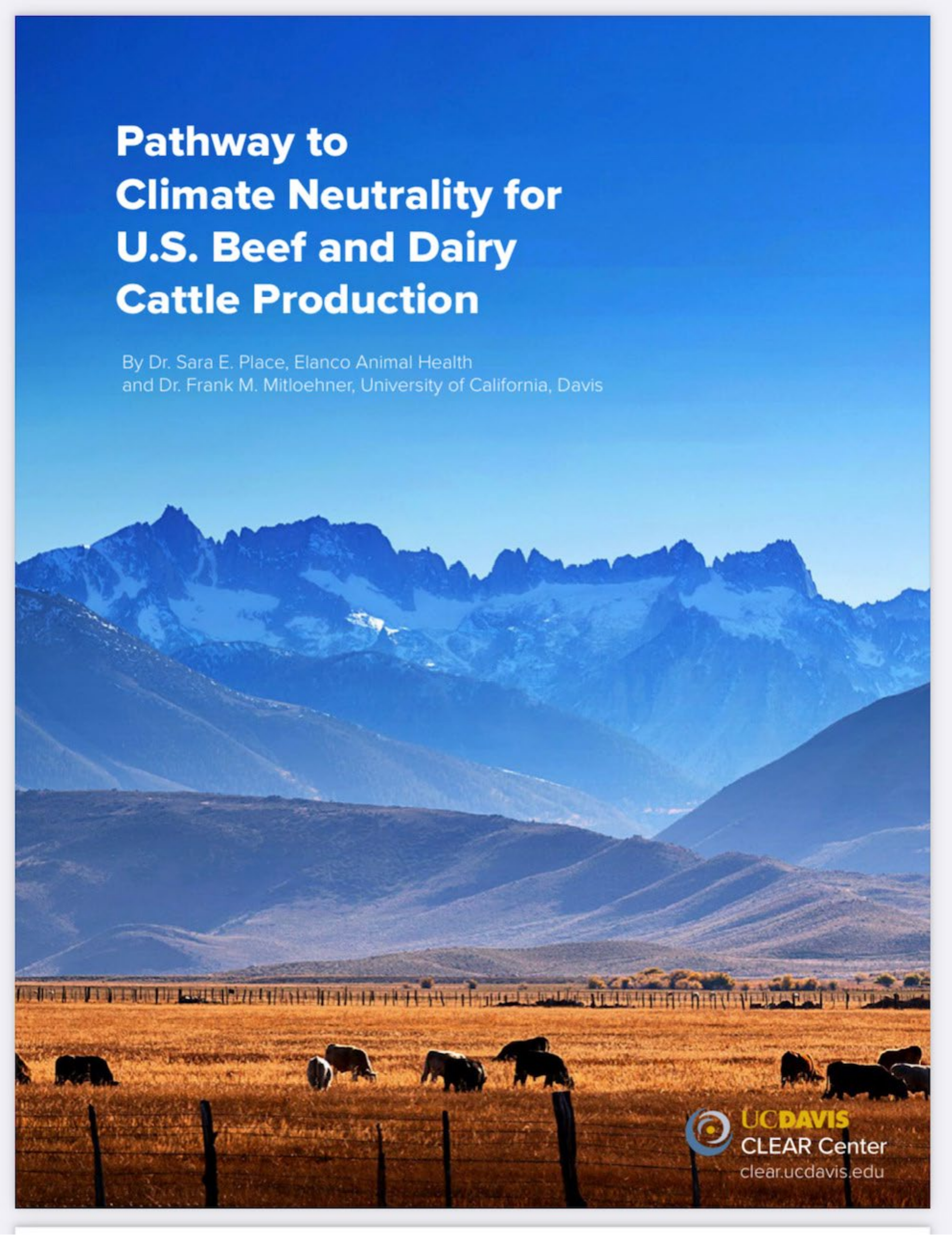

Pathway to Climate Neutrality for U.S. Beef and Dairy Cattle Production

By Dr. Sara E. Place, Elanco Animal Health
and Dr. Frank M. Mitloehner, University of California, Davis

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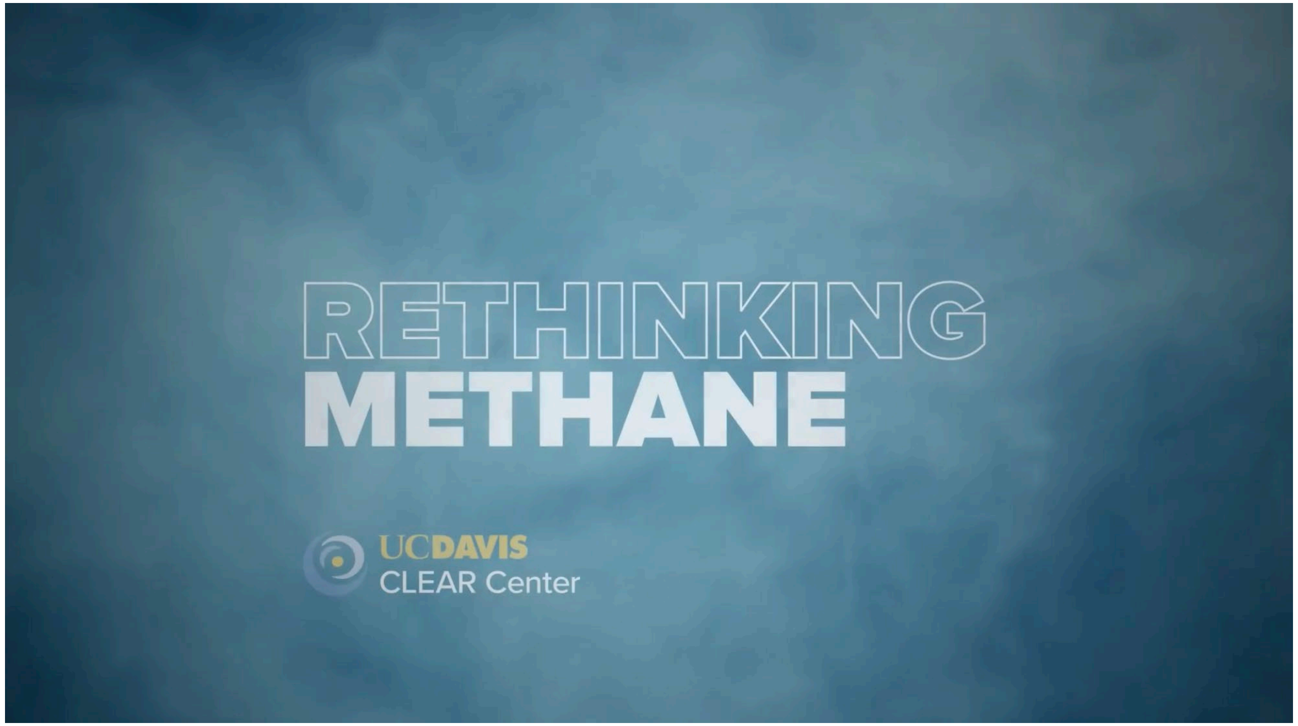

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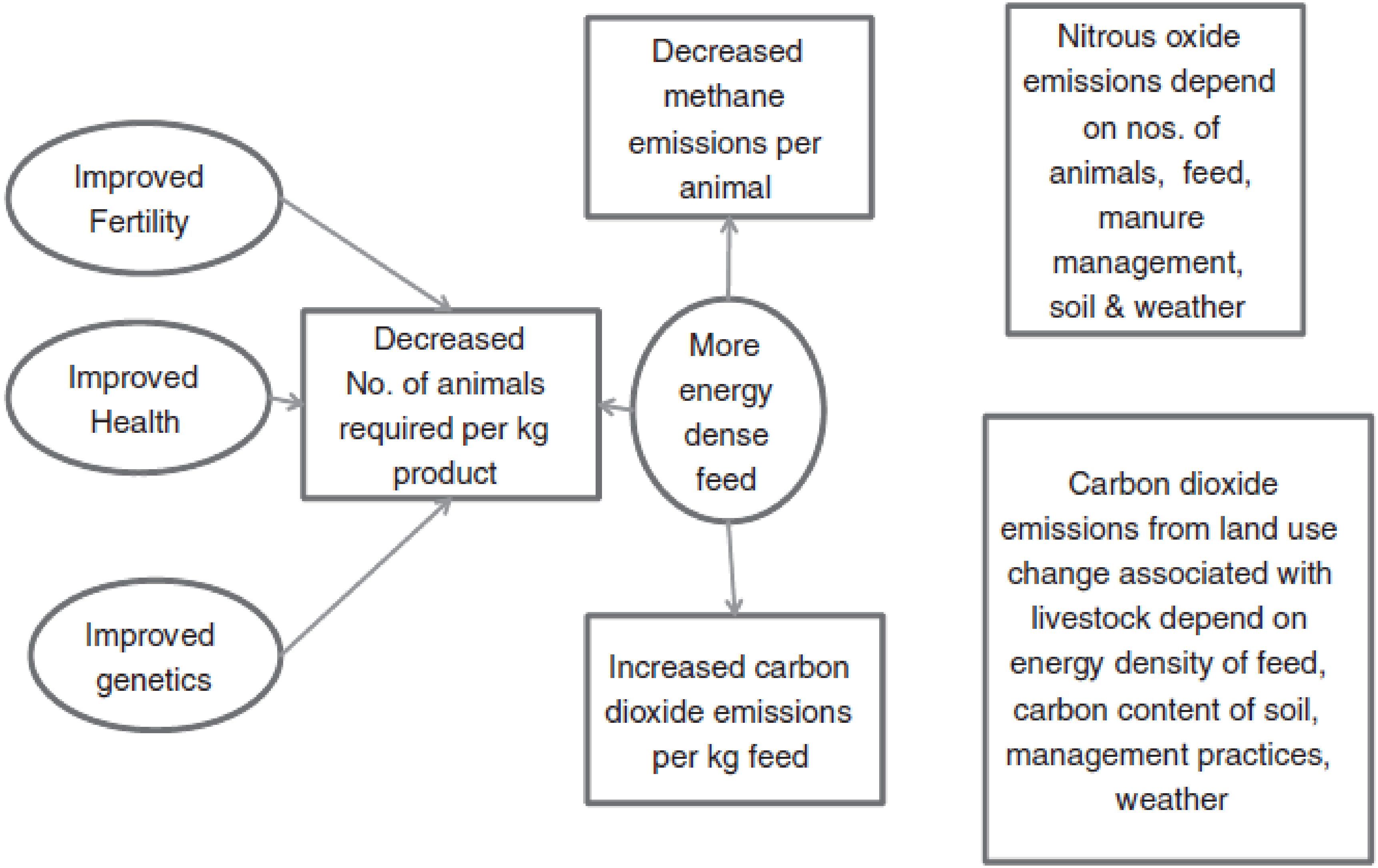
Mitigation: interventions to improve productivity and reduce emissions



Gill et al. (2010)

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US Beef Trends

- In 1970, the U.S. had 140 million head of beef.
- By comparison, today there are 90 million head.
- In both 1970 and 2010, 24 million tons of beef were produced.

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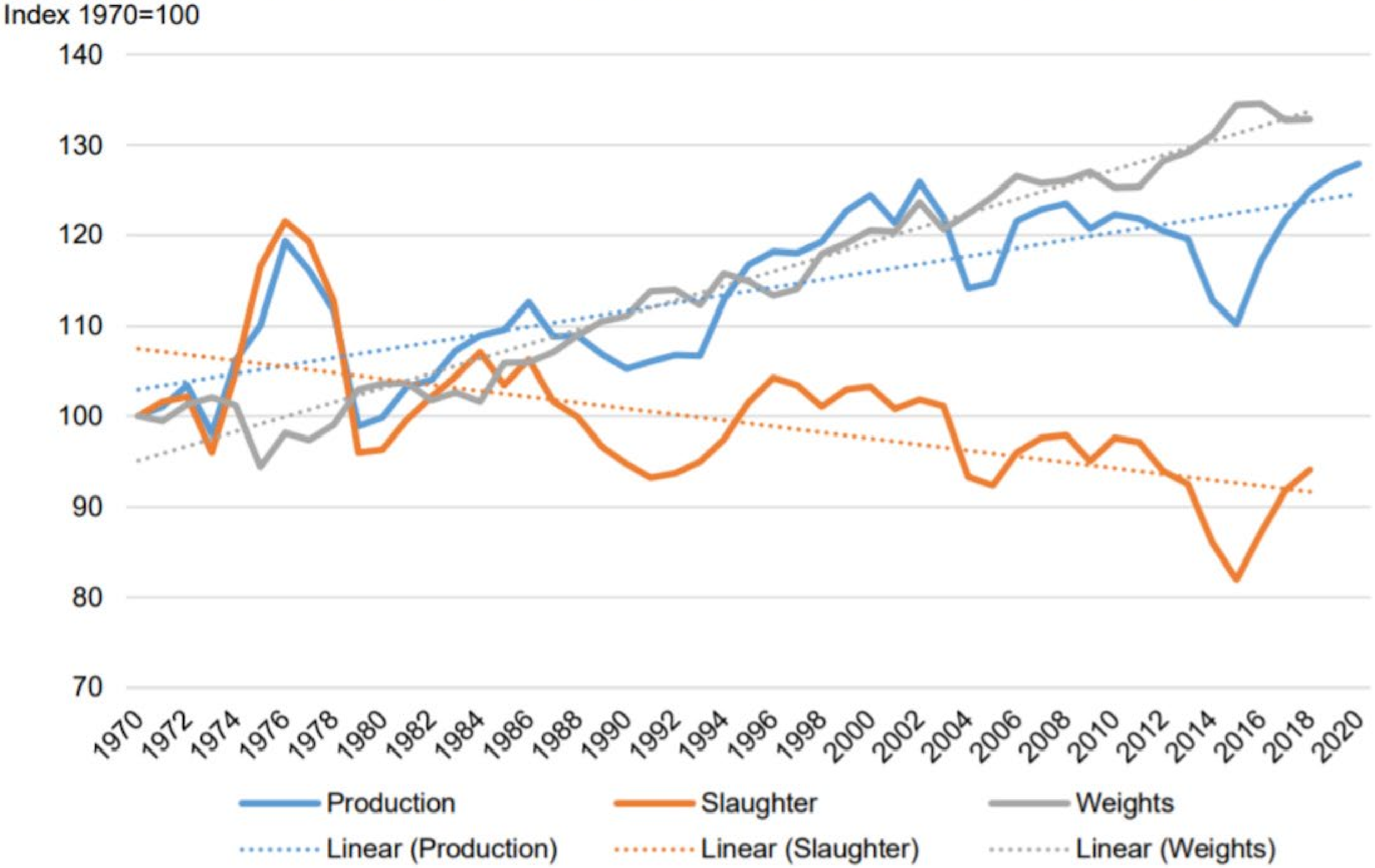
For over 50 years, cattle weights have propelled beef production as cattle slaughter decreased



Source: Calculations by USDA, Economic Research Service based on data from USDA, National Agricultural Statistics Service.

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US Dairy Trends

- In 1950, there were 25 million dairy cows in the U.S. Today there are 9 million.

- With 16 million fewer cows (1950 vs 2018), milk production nationally has increased 60 percent .

- The carbon footprint of a glass of milk is 2/3 smaller today than it was 70 years ago.

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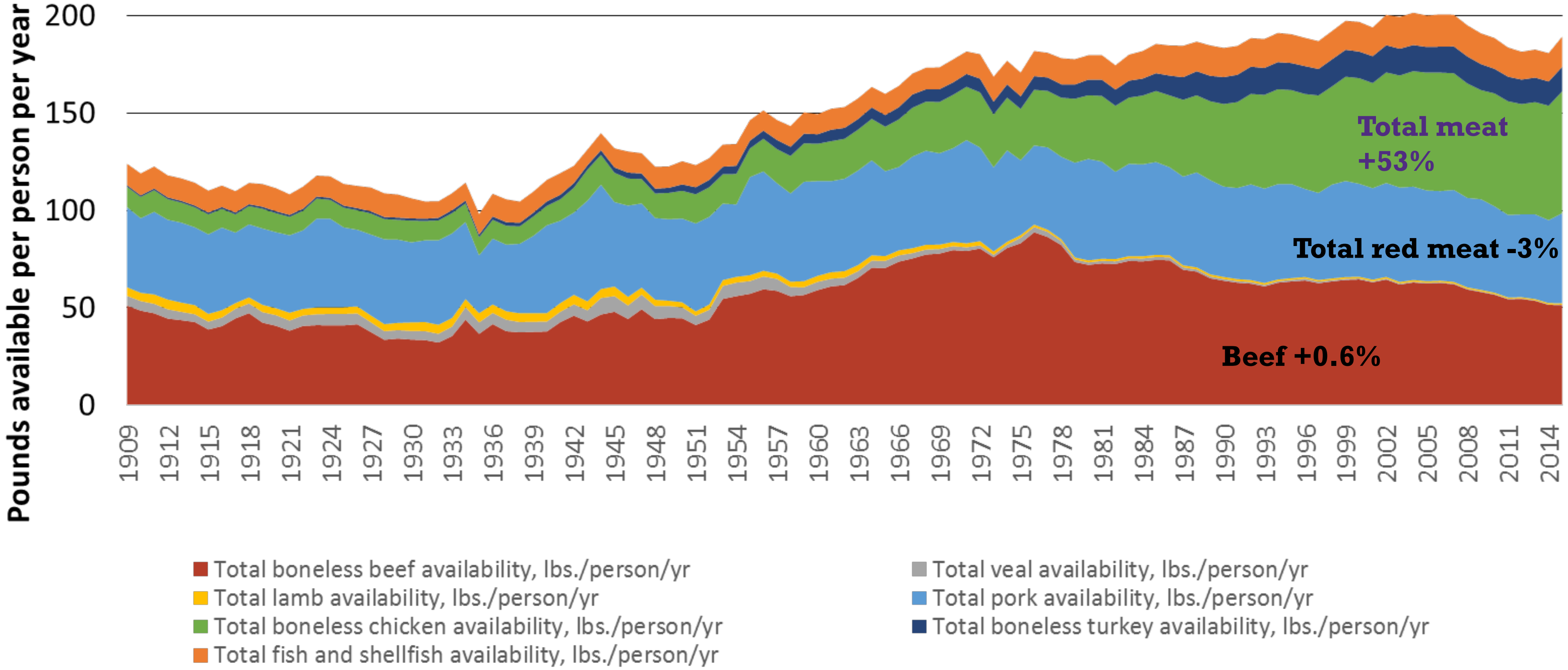
Americans eat the same amount of beef as 1909, but 500% more chicken



Source: USDA-ERS Food Availability Data System

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Can we eat our way out of climate change?

- Omnivore to vegan (peryr) = 0.8 tons CO2e (Wynes & Nicholas, 2017)
- One trans-Atlantic flight (per passenger) = 1.6 tons CO2e (Wynes & Nicholas, 2017)
- Meatless Monday (US) = 0.3% GHG reduction (Hall & White, 2017)
- Vegan US = 2.6% (Hall & White, 2017)

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PHOTOGRAPH BY ROBERT CLARK, NATIONAL GEOGRAPHIC

Global Waste:

1 out of 3 calories

40% of food in the U.S. is wasted

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Read my blog

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Thank you

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