



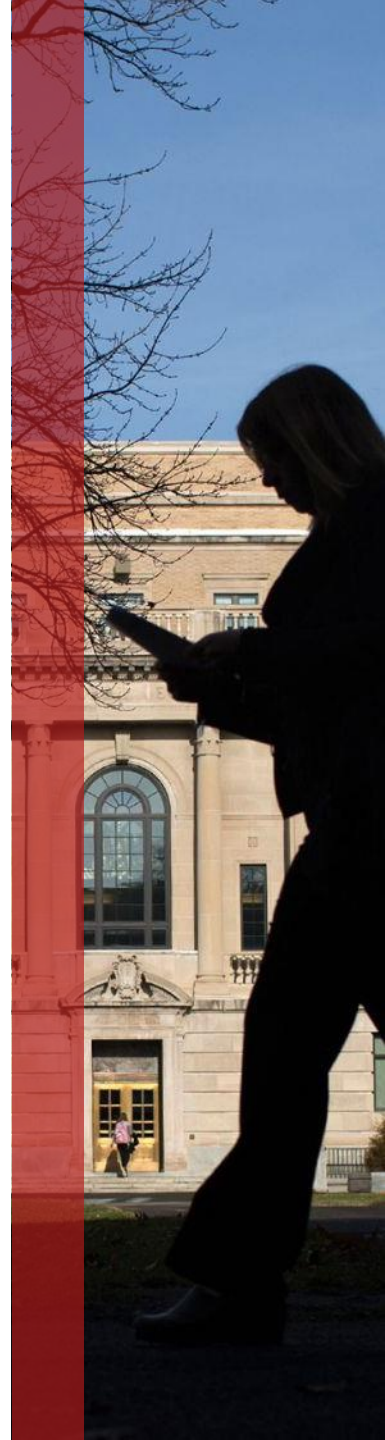
Dyson
Cornell
SC Johnson College of Business

Cornell **CALS**
College of Agriculture and Life Sciences

Framing the Green House Gas and Carbon Market Situation for the US Dairy Industry

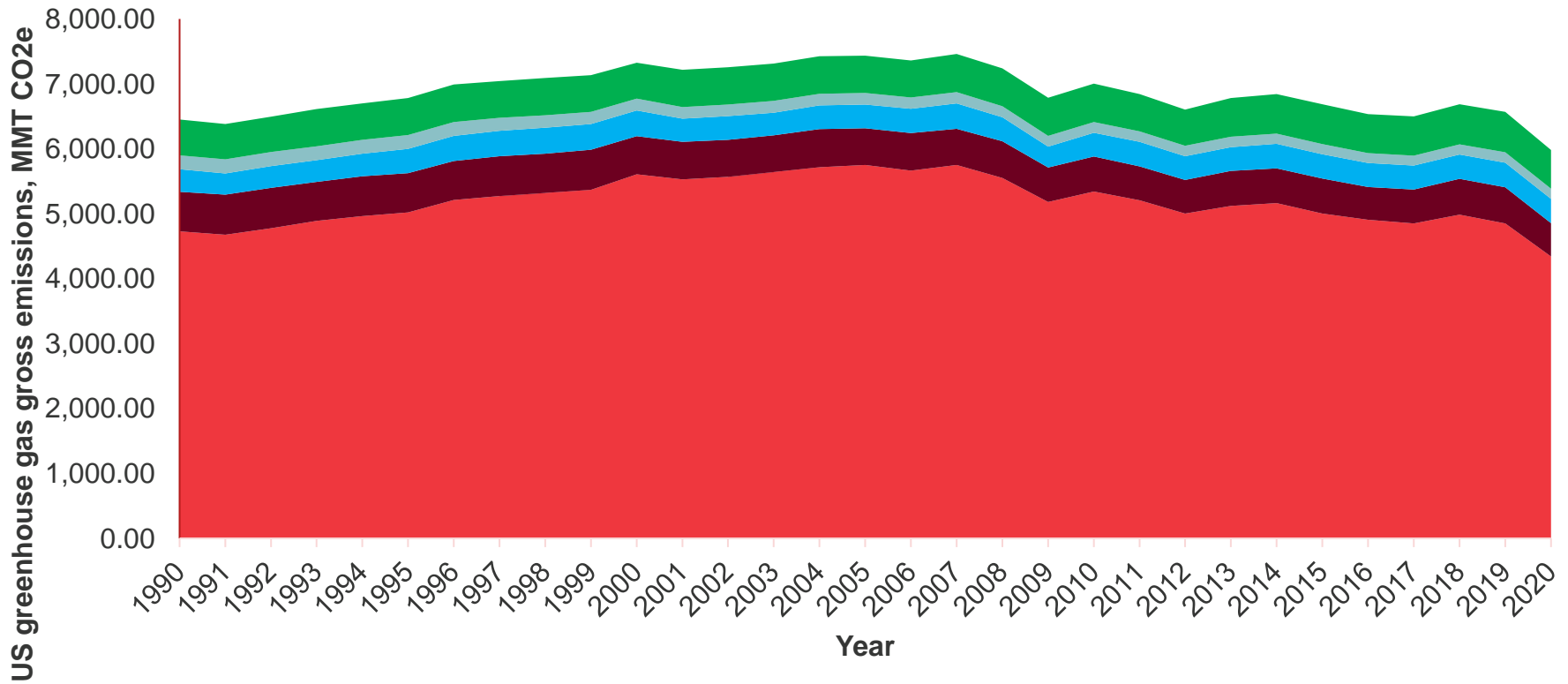
10/24/23

Christopher A. Wolf, Professor



Trends in US GHG emissions, 1990 – 2020

Change since 1990: fossil combustion -8%*, waste -27%, agriculture +8%



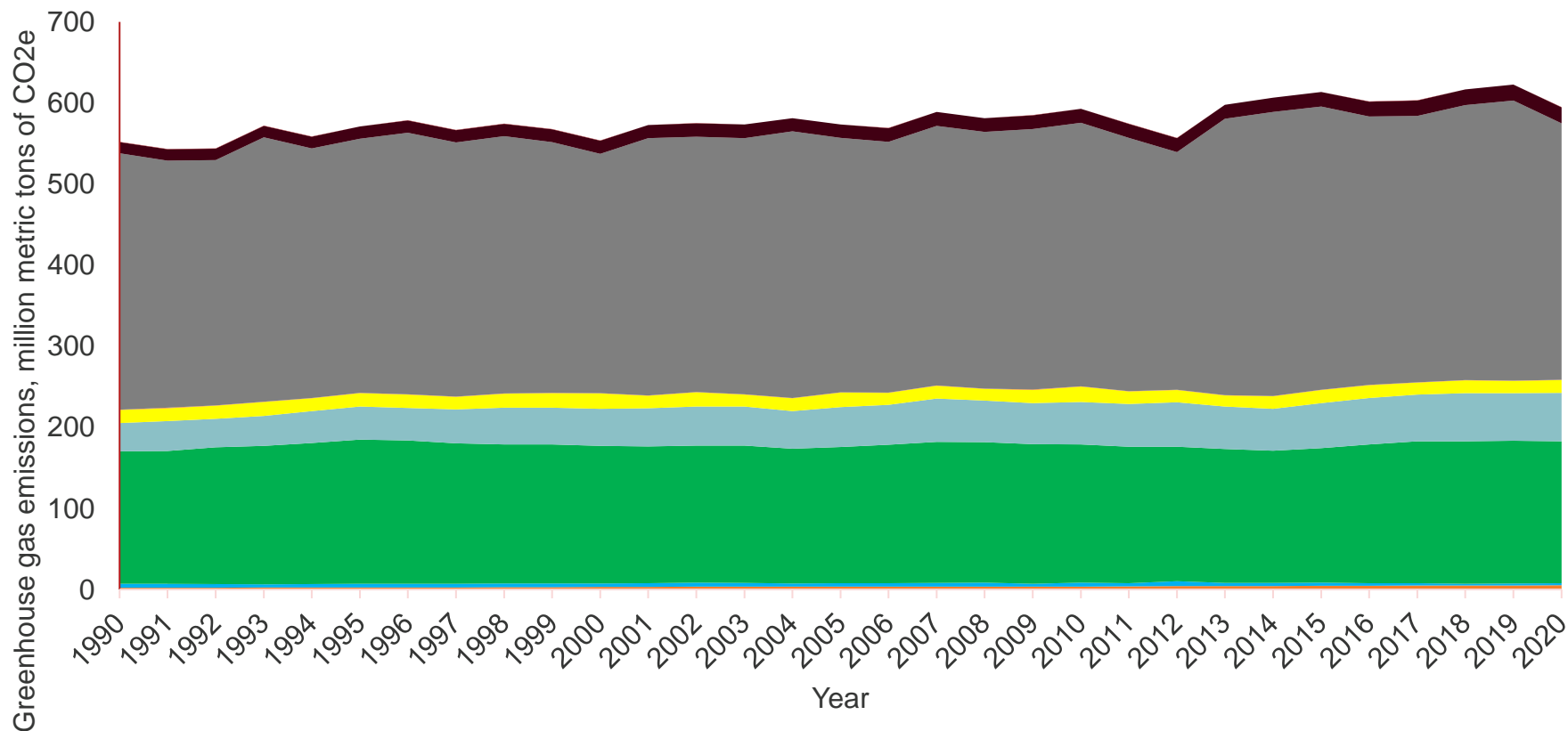
- Agriculture
- Waste
- Industrial processes
- Non-CO2 combustion gases and other energy emissions
- Fossil fuel combustion CO2

EPA (2022) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. U.S. Environmental Protection Agency, EPA 430-R-22-003. <https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissionsand-sinks-1990-2020>.

*2020 combustion CO₂ emissions were 509 MMT lower than 2019, mostly due to the pandemic

Trends in US agriculture GHG emissions, 1990 to 2020

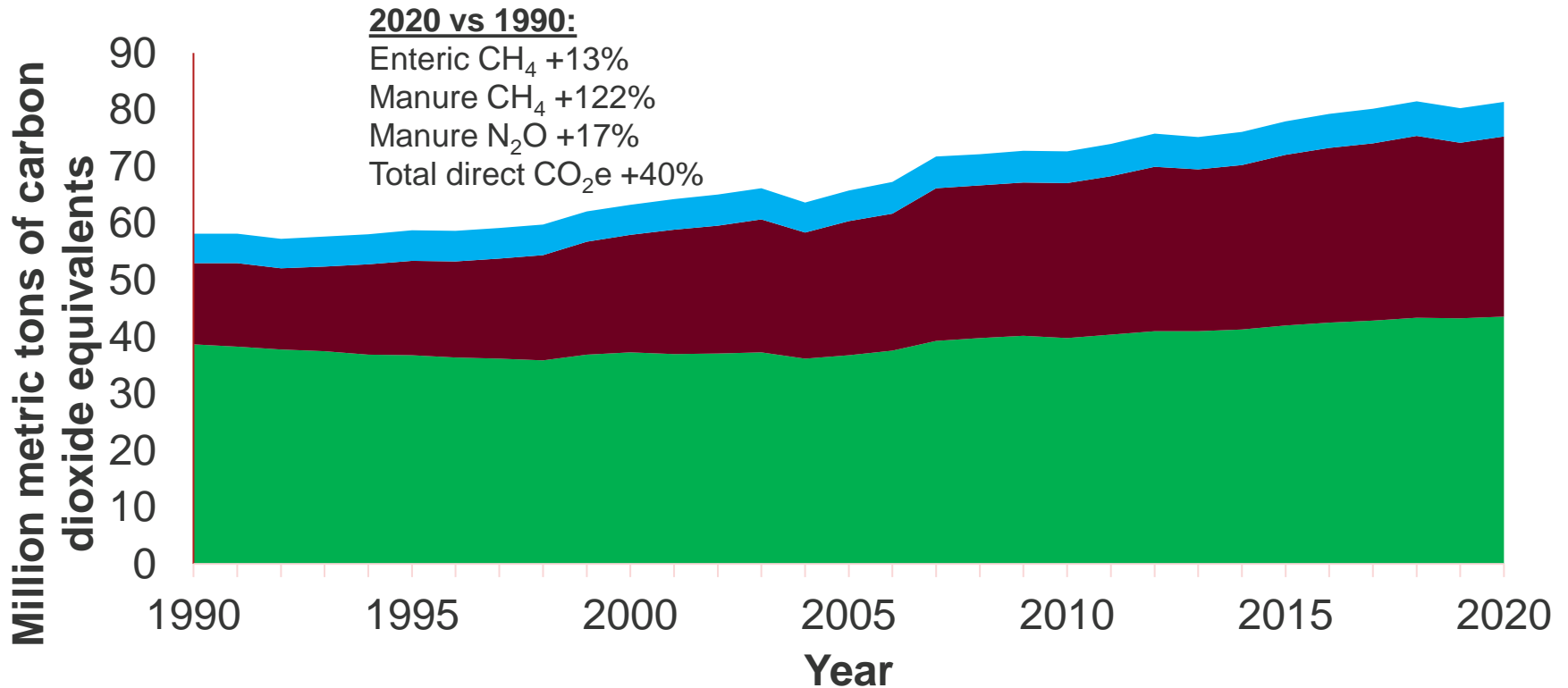
Top 3 emissions category increases since 1990:
 Urea CO₂ +121%, Manure CH₄ +71%, Manure N₂O +42%



- Urea Fertilization
- Enteric Fermentation
- Rice Cultivation
- Agricultural Soil Management
- N₂O - Field Burning of Agricultural Residues
- Liming
- CH₄ - Manure Management
- CH₄ - Field Burning of Agricultural Residues
- N₂O - Manure Management

EPA (2022) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. U.S. Environmental Protection Agency, EPA 430-R-22-003. <https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissionsand-sinks-1990-2020>.

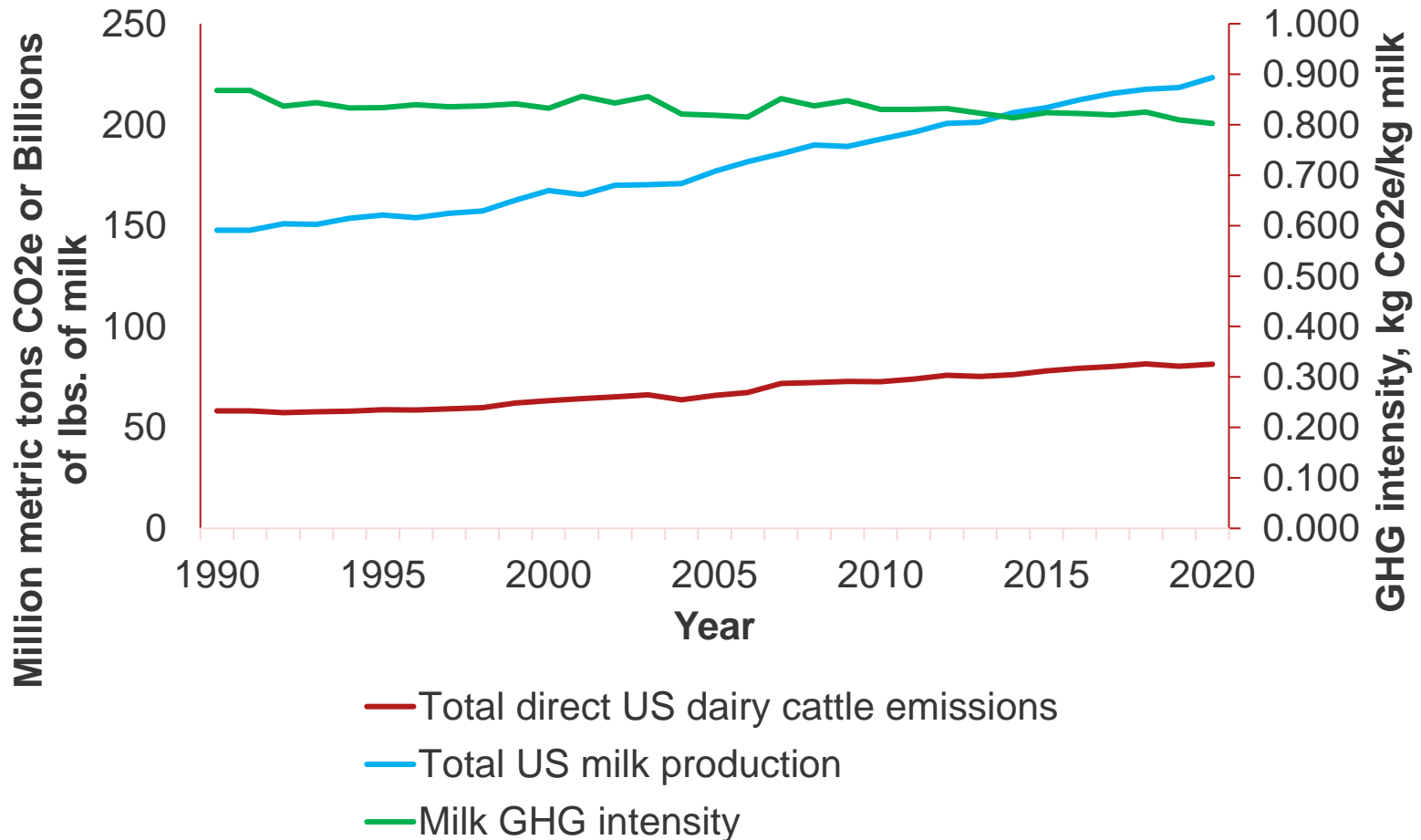
Trends in direct GHG emissions from US dairy cattle



- Dairy cattle enteric methane
- Dairy cattle manure methane
- Dairy cattle manure nitrous oxide

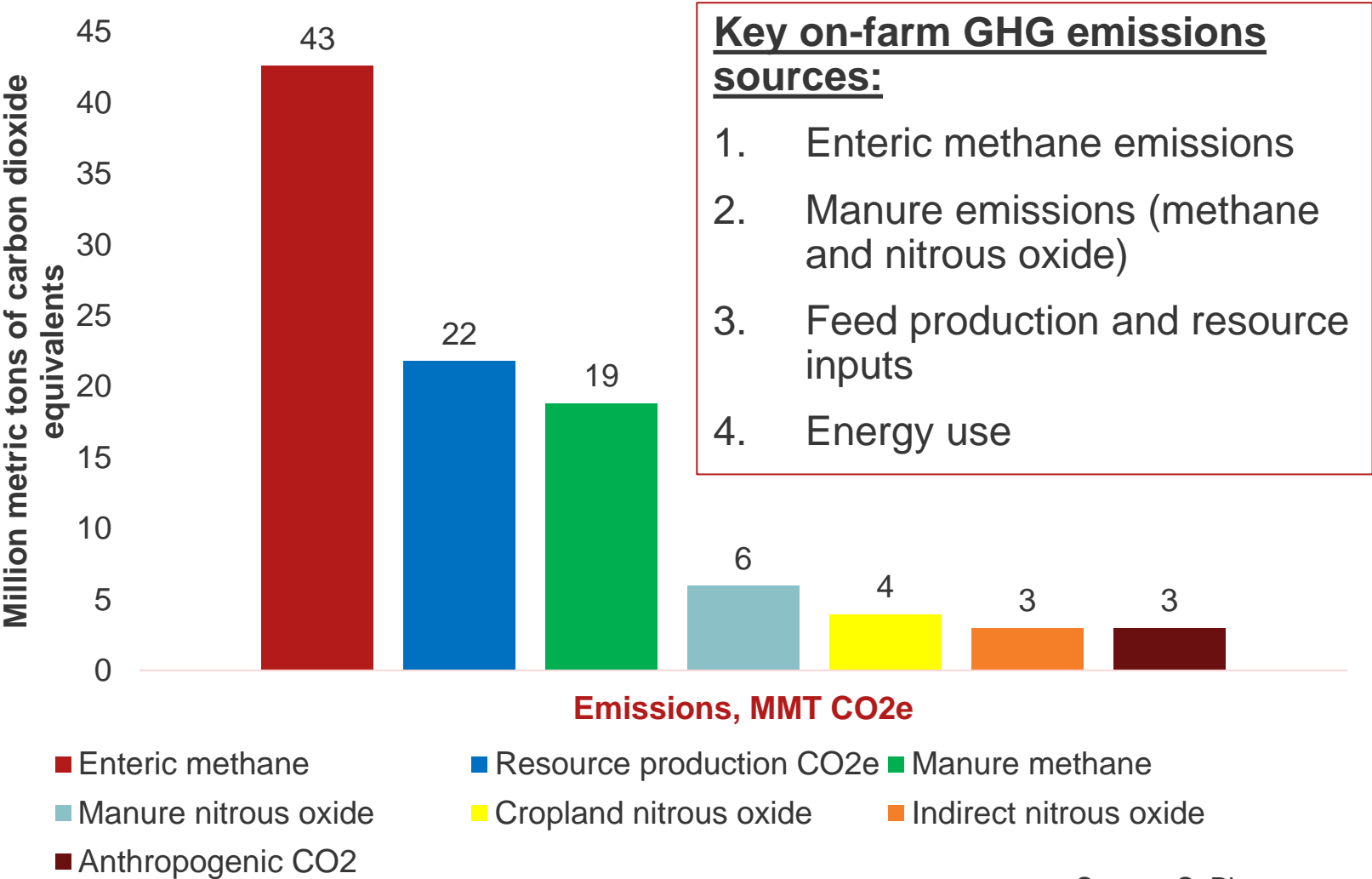
EPA (2022) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. U.S. Environmental Protection Agency, EPA 430-R-22-003. <https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissionsand-sinks-1990-2020>.

Direct GHG emissions have increased 40%, milk production has increased 51%, GHG intensity is down 7% since 1990



Source: S. Place

Dairy cattle production GHG emissions: ~1.6% of US GHG emissions



Source: S. Place

¹Rotz et al., 2021. Environmental assessment of United States dairy farms. J Cleaner Prod. <https://doi.org/10.1016/j.jclepro.2021.128153>

Farm Level Methane Mitigation

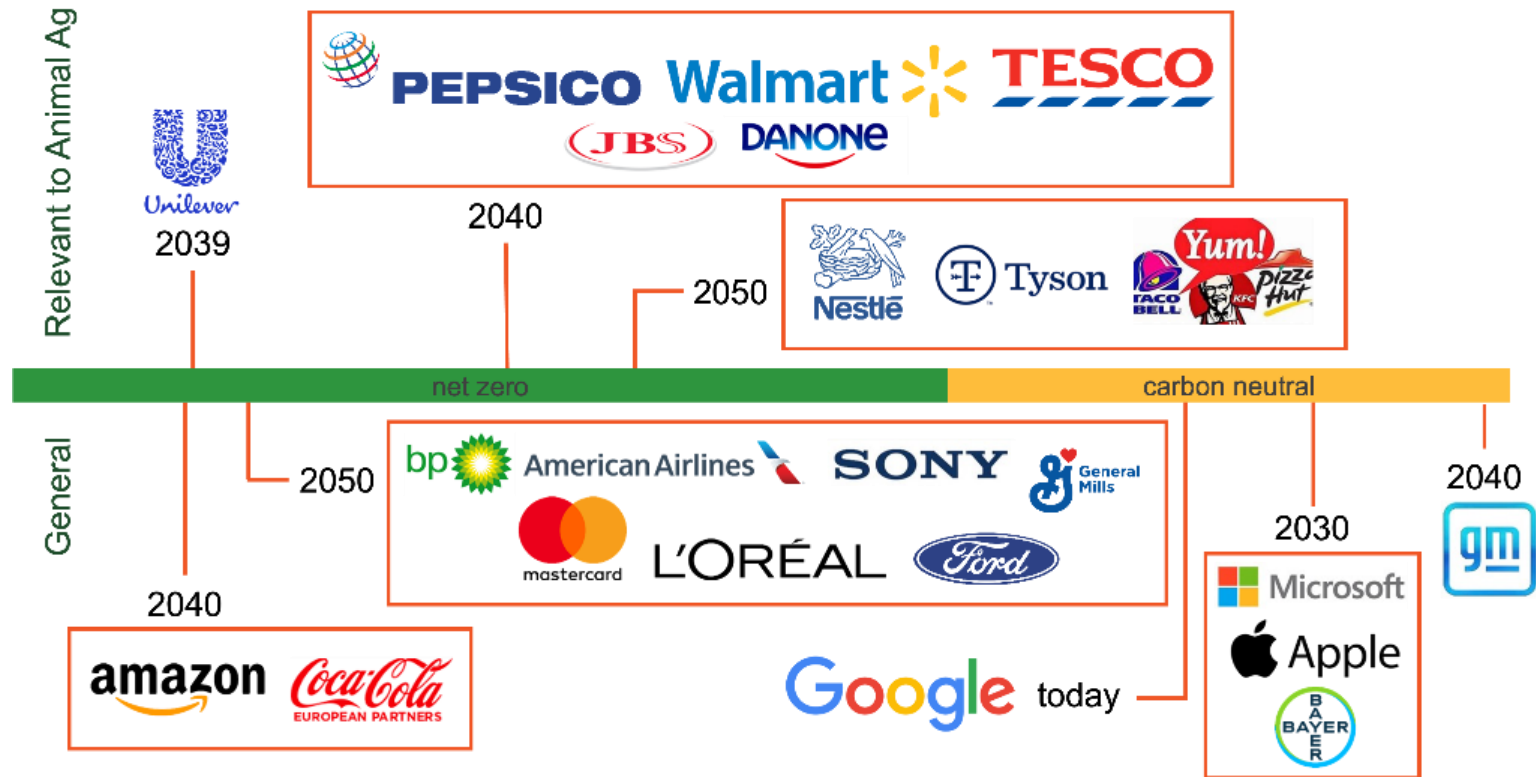
- Enteric
 - Feed ingredients/additives
 - Feed efficiency
 - Genetics

- Manure
 - Anaerobic digester
 - Scrape and dry
 - Pasture based system

Modes of change in production practices

- Regulation driven
 - California
 - Paris Accord
 - Subsidies, standards, taxes
- Market driven
 - Science Based Targets Initiative reports 68 food and ag companies have committed or set science based GHG reduction targets

Current Company Commitments



Source: S. Place

US Dairy industry stewardship goals

CLIMATE ACTION



- U.S. dairy cows generate the lowest greenhouse gas (GHG) emissions per gallon of milk in the world,⁴ and the dairy community is committed to continuous improvement for environmental stewardship. This includes a GHG reporting tool and improvement guidance available to all dairy farmers, guidelines and tools to credibly report GHG intensity and reductions for dairy processing, and a voluntary industry-wide goal of GHG neutral dairy production by 2050.

U.S. DAIRY STEWARDSHIP COMMITMENT



November 2021

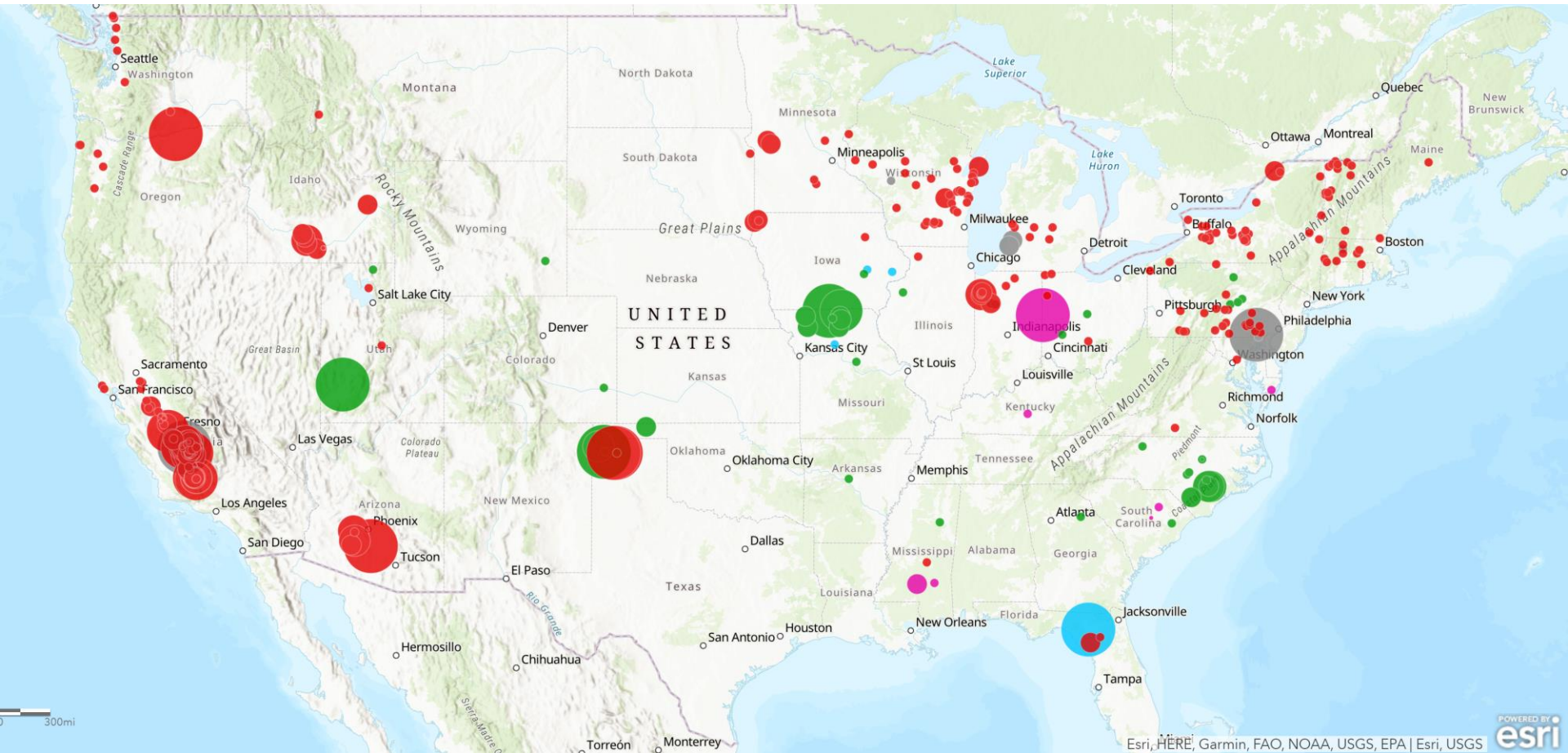


Source: <https://www.usdairy.com/getmedia/19e026e5-e281-4fa6-b577-cd6ecb342ac6/us-dairy-stewardship-commitment-2020.pdf?ext=.pdf>

Cost of Carbon Emissions

- Cost of Carbon = NPV \sum (damages)
 - Damages: crop loss, fires, heat waves, healthcare costs, flooding
 - Depends on discount rate EPA and Biden Admin use $r=0.02$
- Biden/Obama Admins \$51/ton
- Resources for the Future \$185/ton
- EPA \$190/ton

EPA AgStar Digesters

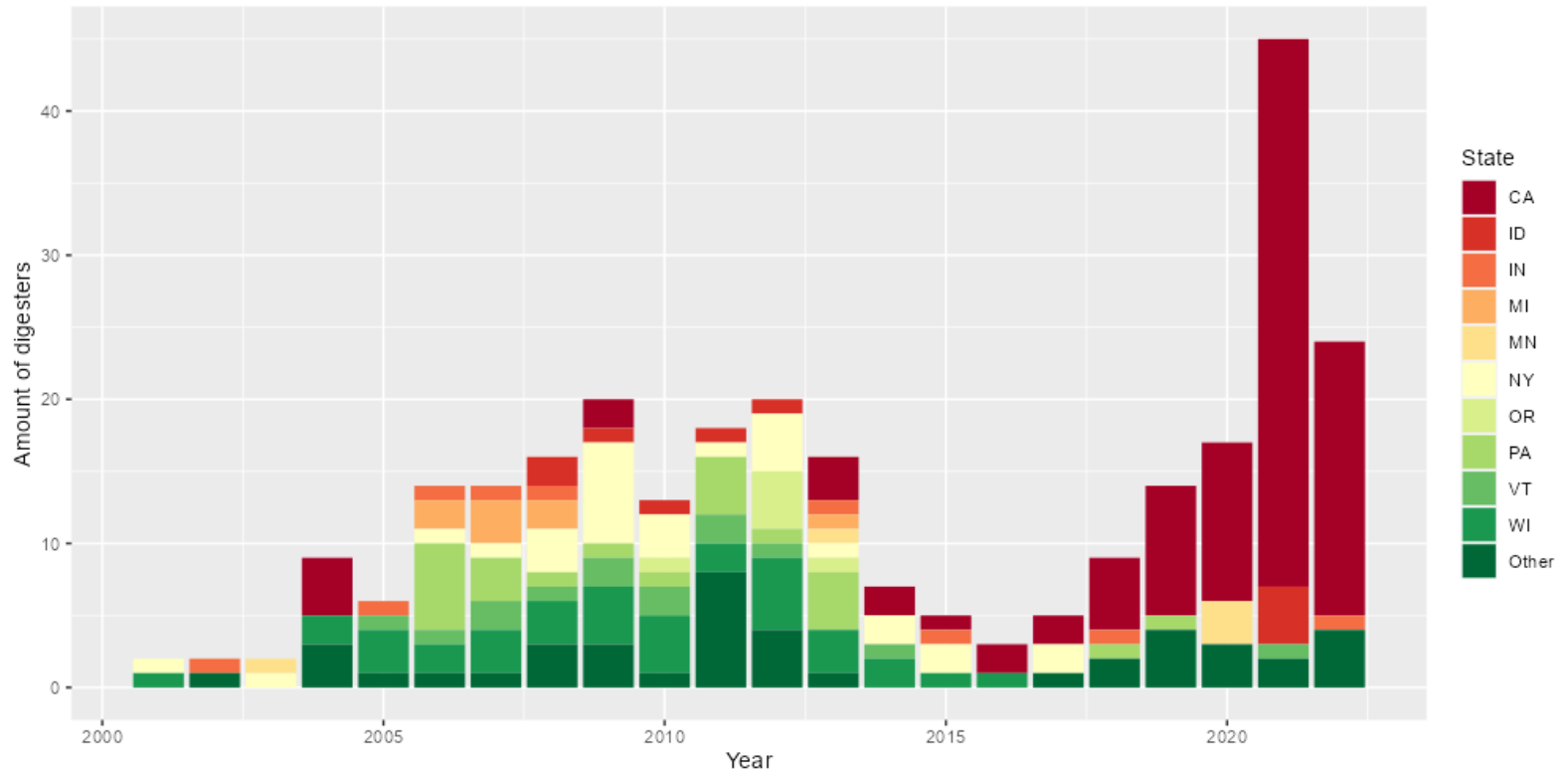


red = dairy; green = swine; purple = poultry; blue = cattle; gray = mixed use

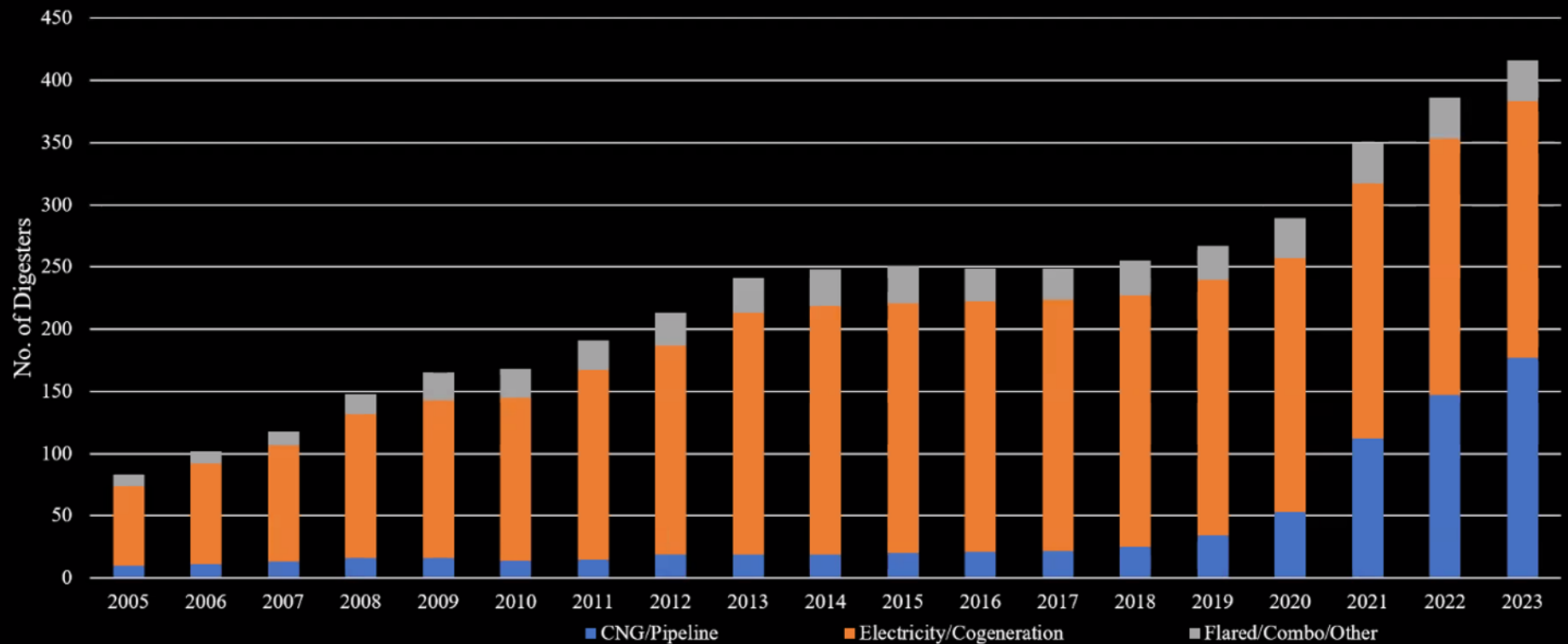


Amount of digesters by state and year

Adapted from Aaron Smith



Number of U.S. Manure-Based Anaerobic Digesters by Year by Energy Source



Source: EPA

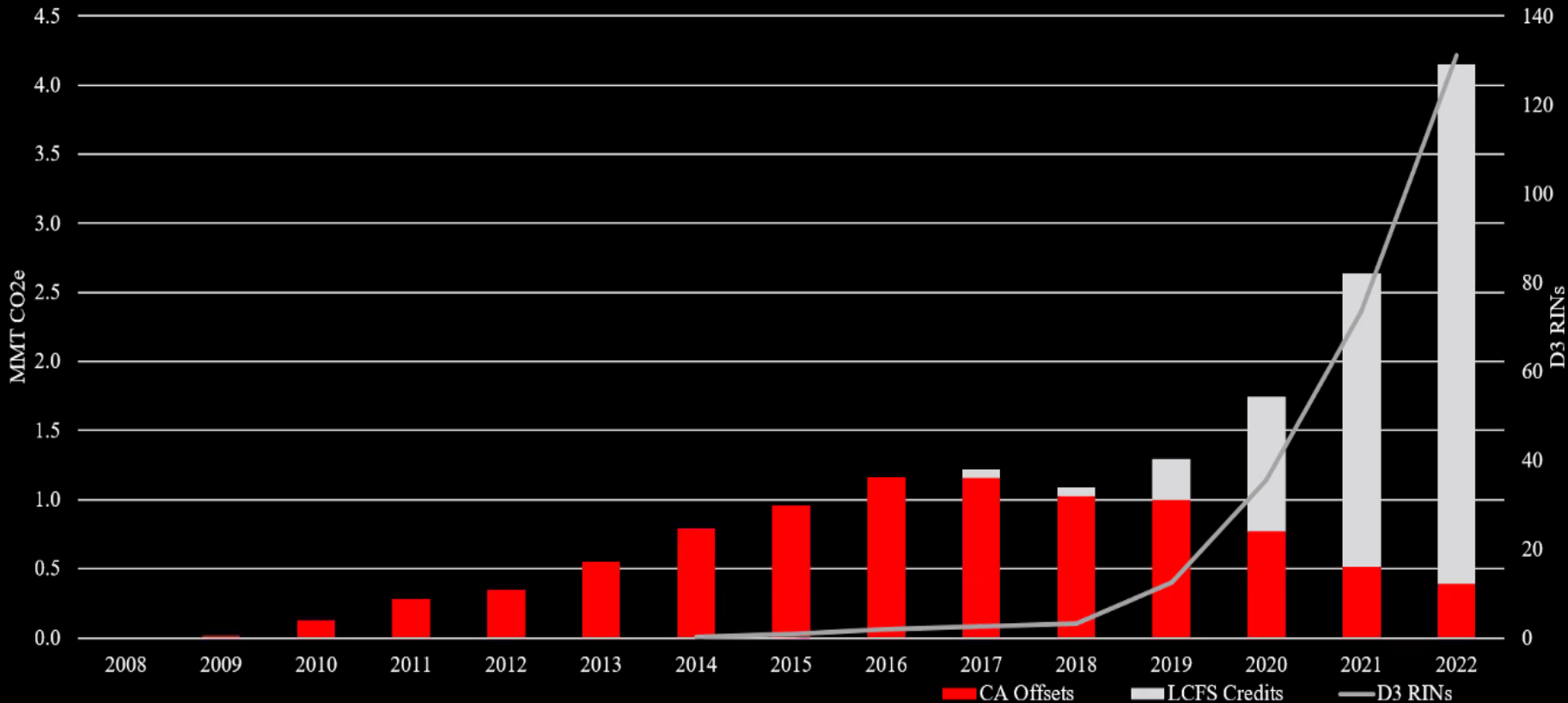
Revenue from Digesters

- Sales or value of electricity or RNG produced
- Carbon credits/offsets or Low Carbon Fuel Standard Credits in California
- Renewable identification numbers (RINs) are credits used for compliance, and are the “currency” of the RFS program.

California Air Resources Board Environmental Market Programs

- 1. Cap-and-Trade Program: issues offset credits to digester projects for avoided CH₄ emissions
- 2. Low Carbon Fuel Standard (LCFS), which provides biofuel credits to compressed natural gas (CNG)-producing digesters that reduce the carbon intensity of transportation fuels.
- CARB's LCFS credit formula provides digesters with credits for avoided CH₄ emissions. Thus, digesters cannot receive both offsets and LCFS credits from CARB for the same period.

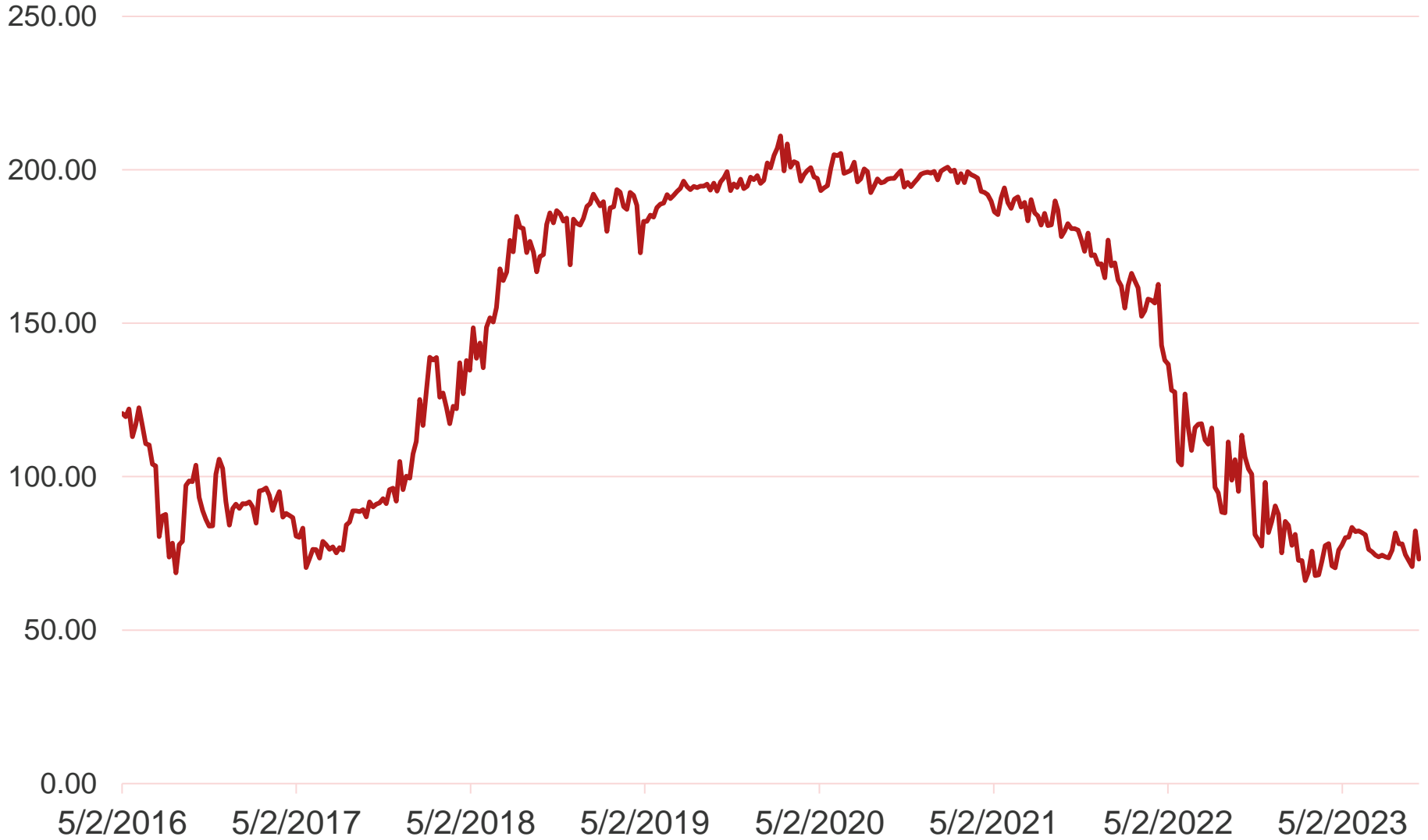
Digesters and Environmental Market Credits



Sources: CARB, EPA

\$/ton

Average LCFS Price



Carbon prices per metric ton of CO₂e (10/22/23)

| CarbonCredits.com Live Carbon Prices | Last | Change | YTD |
|--------------------------------------|---------|---------|----------|
| Compliance Markets | | | |
| European Union | €85.70 | - | +7.13 % |
| UK | £42.85 | - | -41.50 % |
| California | \$29.41 | - | +1.17 % |
| Australia (AUD) | \$31.25 | - | -7.54 % |
| New Zealand (NZD) | \$69.50 | - | -9.06 % |
| South Korea | \$29.00 | - | -26.25 % |
| China | \$11.38 | - | +41.30 % |
| Voluntary Markets | | | |
| Aviation Industry Offset | \$0.73 | -1.35 % | -80.99 % |
| Nature Based Offset | \$1.59 | - | -65.43 % |
| Tech Based Offset | \$0.82 | - | -28.07 % |

Take Home Messages

- Dairy cattle production in the United States is approximately **1.6% of US GHG emissions** in CO₂e
- Methane (both enteric and manure-sourced) is the most important GHG from dairy cattle production, **methane emissions from US dairy have increased in recent decades**
- Most of the revenue from digesters from government created environmental credits which creates policy risk and uncertain investment situation