

Dairy Cares Comments on June 8, 2021 Public Workshop to Commence Development of the 2022 Scoping Plan Update to Achieve Carbon Neutrality by 2045

July 9, 2021

Dairy Cares appreciates the opportunity to provide the following, preliminary comments on the 2022 Scoping Plan. Dairy Cares represents the California dairy sector, including over 1,200 family dairy farms, leading cooperatives, and major dairy processors.¹ Dairy Cares appreciates the opportunity to work with CARB and other State agencies toward achievement of the State's overall climate goals as well as efforts to reduce methane under the Short-Lived Climate Pollutant (SLCP) Plan. These comments focus on the important role dairy methane reduction efforts and SLCPs play in the overall strategy to reduce all GHG emissions.

California family dairy farms are leading change and making significant progress in reducing GHG emissions. Producing a glass of milk from a California dairy cow generates 45% less GHG emissions today than it did 50 years ago.² Significant advancements in farming efficiency, feed crop yields, veterinary care, sustainable food practices, and animal nutrition have helped reduce the environmental footprint of individual cows. More can and is being done to lower the climate footprint even further. California dairy farm families are working closely with the California Department of Food and Agriculture (CDFA) and CARB to further reduce the State's methane emission inventory. As detailed below, these efforts are making tremendous progress and are providing substantial climate, economic, social, public health, and environmental benefits to the State and to local communities.

As these efforts continue, it is important to improve our understanding of how methane contributes to climate impacts and the tremendous mitigation opportunity that further reductions in dairy sector emissions can provide as CARB seeks to reduce warming. In addition to discussing the benefits of methane reduction opportunities from dairies, these comments also provide an academic report recently released by the UC Davis CLEAR Center (see Appendix 1). The report is titled, *Methane Cow and Climate Change: California Dairy's path to Climate Neutrality*. Dairy Cares respectfully requests inclusion of this report in the administrative record for the 2022 Scoping Plan.

¹ More information on Dairy Cares, including various community and environmental sustainability efforts is available at: <https://www.dairycares.com>

² Naranjo, A., Johnson, A., Rossow, H., & Kebreab, E. (2020). Greenhouse gas, water, and land footprint per unit of production of the California dairy industry over 50 years. *Journal of Dairy Science*. 103, 3760-3.

The Role of SLCPs in the 2022 Scoping Plan

The short-term climate benefits of reducing SLCPs, including methane, are well documented. SLCP reductions account for about one-third of the cumulative GHG emissions reductions the State is relying on to achieve the statewide 2030 GHG emissions target established under SB 32.³ SLCP reductions are also necessary to achieve the State's mid-century carbon neutrality goal.⁴

Short-Lived Climate Pollutants, including methane, are powerful climate gases but have a relatively short atmospheric lifetime. In the case of methane, that lifetime is approximately 10-12 years. As a result, methane reductions achieved now have a short-term beneficial impact on climate change.

Accordingly, leading climate scientists and NGOs are now recognizing that moderate reductions in methane emissions can quickly stabilize the climate pollutant's powerful impact and further reductions can offset the far more persistent warming impacts of carbon dioxide, which accumulate in the atmosphere for hundreds of years.

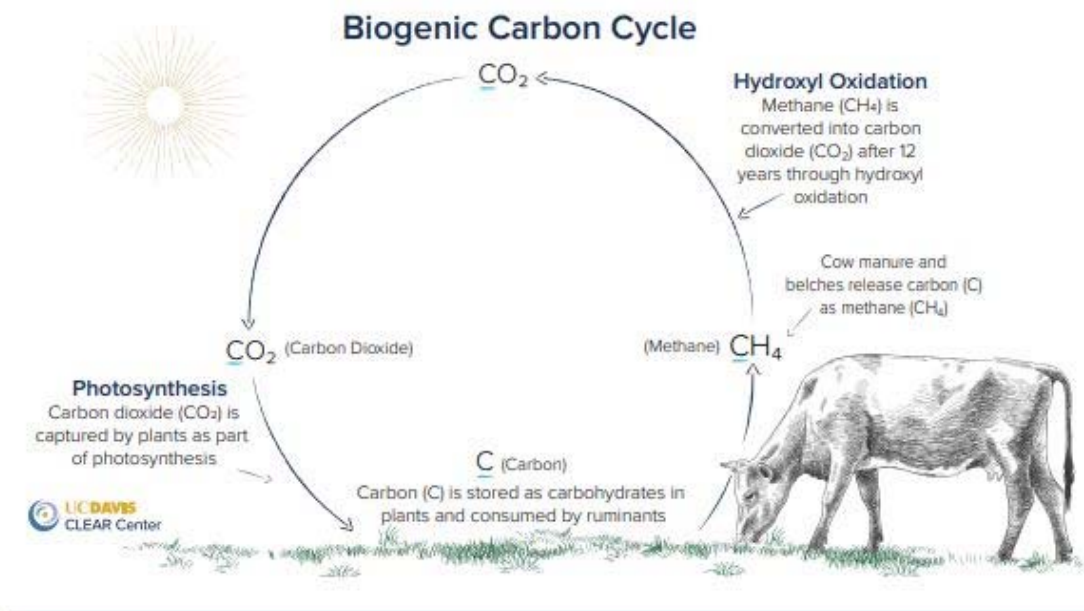
It is also important to differentiate fossil methane and biogenic methane. Fossil methane, such as natural gas, is carbon that has been locked in the ground for millions of years and is extracted and combusted for use in homes and businesses. The burning of fossil methane directly transfers carbon that was stored in the ground (geologic carbon) into the atmosphere as carbon dioxide (CO₂). That carbon continues to accumulate and persist in the environment, contributing to climate change for hundreds of years, driving climate warming.

Biogenic methane from cows is part of a natural carbon cycle, where after about 10-12 years it is removed from the atmosphere (short-lived) and does not continue to contribute to warming. As part of photosynthesis, plants capture CO₂ from the atmosphere, absorbing the carbon and releasing oxygen. That carbon is converted into carbohydrates in the plant, which are then consumed by cows, digested, and released from the cows as methane (CH₄). After about 12 years in the atmosphere, that methane is oxidized and converted into CO₂ – the same molecules that were consumed by cows in the form of plants. The biogenic carbon cycle returns the carbon that was originally utilized by the plant to the atmosphere, contributing no net gain of CO₂.⁵ The biogenic carbon cycle of dairy methane is depicted in the following diagram, provided by the UC Davis CLEAR Center:

³ CARB Draft Analysis of Progress toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target, (June 2021), available at: <https://ww2.arb.ca.gov/sites/default/files/2021-06/draft-2030-dairy-livestock-ch4-analysis.pdf>

⁴ *Id.*, p. 3.

⁵ *Methane Cow and Climate Change: California Dairy's Path to Climate Neutrality*, p. 5, appendix.



As part of the biogenic carbon cycle, the carbon originally utilized by the plant is returned to the atmosphere, contributing no net gain of CO_2 . Diagram provided by the UC Davis CLEAR Center

CO_2 produced by the combustion of fossil fuels is fundamentally different. CO_2 makes up the overwhelming majority of GHG emitted in California and is far more damaging than methane due to its long atmospheric lifetime and its continued accumulation in the environment, adding to continued warming. For these reasons, carbon dioxide, not methane, is the true “super-pollutant” affecting climate change. This improved understanding of how short-lived versus long-lived emissions affect climate differently is critical as CARB seeks to address further global warming. Limiting climate change requires that we bring emissions of CO_2 and other long-lived GHGs down to net-zero. For methane, however, it is possible to have steady ongoing emissions that do not result in additional warming.⁶

The short-lived atmospheric lifetime associated with methane reductions can result in a relatively quick drop in atmospheric concentration. As a result, reducing methane emission rates presents an important mitigation opportunity which can reverse some of the warming the planet has already experienced.⁷ The value of these mitigation opportunities should be analyzed and included in the 2022 Scoping Plan.

Dairy Methane Reduction Efforts

California’s dairy sector is already contributing less methane (and as a result, less global warming impact) than it was in 2008 because the state is home to fewer dairy cows today than in 2008. Put simply, more methane from the California dairy sector is currently leaving the atmosphere each year than is being produced and added.

⁶ Frame, D., Macey, A.H., & Allen, M. (2018). *Why methane should be treated differently compared to long-lived greenhouse gases. The Conversation.*

⁷ Lynch, J. (2019). *Agricultural methane and its role as a greenhouse gas.* Food Climate Research Network, University of Oxford.

Equally important, the dairy sector is on a path toward achieving the target of reducing methane emissions 40% below 2013 levels by 2030, already projected to accomplish more than half the reductions needed. CARB staff recently published an Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target.⁸ This analysis documents the dairy sector’s progress from modifications to manure management systems—primarily using anaerobic digesters—and additional reductions through decreases in animal populations. These efforts will need to continue over the remainder of this decade to help achieve the State’s SLCP targets.

CARB’s analysis also documents the “insufficient availability of public funds” as a leading market barrier for manure management project expansion in the dairy sector. The SLCP plan recommended a minimum funding amount of at least \$100 million per year for five years as necessary to accelerate project development by offsetting capital costs and economic risks for manure management methane emissions reduction projects. To date, just \$268 million has been provided, an insufficient amount to achieve the 2030 target. The FY 2019-2020 California Climate Investments allocation of \$34 million was considerably lower than the \$99 million available in FY 2017-2018 and FY 2018-2019, falling \$66 million short of annual funding needs. The proposed FY 2020-2021 allocation of \$20 million did not materialize due to budget cuts. The FY 2021-2022 proposed allocation of \$60 million has not been finalized. Finally, as the CARB analysis points out, “while dairy digesters offer significant and cost-effective methane reductions, without large scale public incentives, the rate of adoption would likely decrease greatly.” Additional funding for dairy manure methane efforts must be provided if the State is to meet the dairy and livestock sector methane reduction goals established by SB 1383.

Efforts to reduce enteric emissions through genetic selection, diet modification, and feed additives are also being pursued, and are critical to achieving livestock methane reduction goals. Extensive research and product development is being undertaken to make feed additives commercially available, and Dairy Cares agrees with CARB that conducting additional research on emerging enteric emission reduction strategies is warranted. Dairy Cares is also pursuing development of a voluntary enteric emissions protocol to monetize reductions and incentivize usage. SB 1383 requires a voluntary incentive-based strategy for enteric emissions reductions, and Dairy Cares looks forward to development of a CARB approved Compliance Offset Protocol.⁹

Proven Environmental and Community Benefits of Methane Reduction Projects

Dairy digester and other livestock methane reduction efforts also provide well-documented direct and indirect benefits to the State and to local communities. Despite these benefits, digester projects and other emission reduction efforts have faced opposition by various environmental justice advocates such as the Disadvantaged Communities Advisory Group and other parties

⁸ Available at: <https://ww2.arb.ca.gov/sites/default/files/2021-06/draft-2030-dairy-livestock-ch4-analysis.pdf>

⁹ Health & Saf. Code § 39730.7(f).

before the CPUC and other State agencies.¹⁰ While Dairy Cares does not agree with the opposition of these groups to methane reduction efforts, we do appreciate CARB's responsibility to evaluate the impacts and benefits of various climate strategies on front-line communities and ensure that the record of the 2022 Scoping Plan appropriately reflects the overall significant benefits of dairy methane reduction efforts.

Three recent reports from CARB and CDFA document the significant environmental, climate, social, and economic benefits of dairy digesters and dairy methane reduction efforts. These benefits include significant direct and indirect benefits to local disadvantaged communities and priority populations.

1. California Climate Investments - 2021 Annual Report

- Documents that the dairy digester program is responsible for achieving **29% of all GHG reductions** from all programs invested in by the State with just 2.1% of total funds implemented.
- Identifies the dairy digester program as the State's **most cost-effective program**, at just \$9 per ton of reduction.
- Reports that **66%** of funds expended on dairy digesters **benefit priority populations**.

2. California Department of Food and Agriculture - Report of Funded (Dairy Digester Research and Development Program) Projects

- Estimates the cumulative reduction from the dairy digester program as 21.12 million metric tons MMTC0_{2e} over 10 years or 2.11 MMTC0_{2e} annually.
- Documents the environmental protection of water and air quality.
- Identifies significant air, water quality, and nuisance (odor) benefits provided to local communities.

3. California Air Resources Board Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target

- Documents the progress toward the targeted livestock sector methane reductions.
- Identifies the need for additional incentives and grant funding.
- Estimates the societal benefits of reducing methane emissions at up to \$2.46 billion.
- Confirms the 40% targeted reduction in dairy and livestock methane cannot be achieved without significant additional digester development.
- Recognizes that the voluntary, incentive-based approach has helped fund projects that provide additional environmental benefits, including improved air quality and water quality protection.

¹⁰ See for example, CPUC Application 19-02-015, Disadvantaged Communities Advisory Group December 2, 2020 Letter to California Public Utilities Commissioners; See also, CPUC OIR 13-02-008, Comments of Leadership Council for Justice and Accountability, Food & Water Watch, pp 4 -9 (June 30, 2021), available at: <https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M389/K957/389957229.PDF> .

In addition, a recent Global Methane Assessment¹¹ conducted by the United Nations Environment Programme emphasizes the need to further abate methane as a short-term hedge against the more damaging and long-term impacts of CO₂, the primary GHG causing global warming. The UN report recognizes the importance of improved farm management efficiency and productivity. It also specifically identifies livestock manure management, including treatment in biogas digesters and improvements in manure storage covering as critical targeted measures for the agriculture sector.¹² Notably, the target measures identified by the UN are fully consistent with CARB's own SCLP policies, including the important role of dairy methane reduction and utilization of dairy digesters.

Conclusion

The dairy and livestock sector is well-positioned to make additional progress toward achieving the target of reducing methane emissions 40% below 2013 levels by 2030. However, this can only be achieved with significant additional public funding and incentives to facilitate development of additional manure methane reduction projects as well as the development of cost-effective voluntary incentive-based enteric reduction opportunities. Maintaining the overall voluntary incentive-based approach for dairy methane reduction, as envisioned and mandated by SB 1383, will also be critical moving forward. Alternative regulatory-based approaches will fail to achieve the desired reductions, lead to methane emission leakage, and result in higher overall global methane emissions as production simply shifts to regions with higher emissions per gallon of milk produced.

Finally, Dairy Cares recommends CARB incorporate the role of SLCP reductions as a short-term hedge against long-term CO₂ impacts. The 2022 Scoping Plan should consider and address climate impacts of biogenic dairy methane emissions going forward. Rethinking methane's role in climate policy is important and the 2022 Scoping Plan is the appropriate venue for such analysis. Appropriate goals and policies should be identified and set for methane, recognizing its tremendous mitigation potential in the short-term.

¹¹ United Nations Environment Programme and Climate and Clean Air Coalition (2021). Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions.

<https://www.unep.org/resources/report/global-methane-assessment-benefits-and-costs-mitigating-methane-emissions>

¹² *Id.*, p. 16

APPENDIX 1

UC Davis CLEAR Center

Methane, Cows, and Climate Change: California Dairy's Path to
Climate Neutrality

September 2, 2020



Methane, Cows, and Climate Change:

California Dairy's
Path to Climate
Neutrality

CLEAR Center

1103 Meyer Hall
One Shields Ave
Davis, CA 95616
United States

Media Contact:

Joe Proudman
jproudman@ucdavis.edu
530-564-2734

Dr. Frank Mitloehner

Professor and Air Quality Specialist
Director, CLEAR Center
University of California, Davis

Dr. Ermias Kebreab

Professor and Sesnon Endowed Chair
Director, World Food Center
University of California, Davis

Michael Boccadoro

Executive Director
Dairy Cares

INTRODUCTION

Climate change is a global issue that requires comprehensive and far-reaching solutions across all economic and demographic jurisdictions. The Paris Climate Agreement, adopted in 2015, sets out a global framework to address harmful climate impacts by limiting additional global warming to well below 2 degrees Celsius (°C) (1.5 °C goal). The accord recognizes regional differences and the need for specific actions across all jurisdictions, including developed economies providing leadership and assistance to developing nations in their climate mitigation efforts.

California continues to lead the United States and world in implementing measures to achieve emissions reductions of greenhouse gases (GHGs) that advance climate change. Toward this end, California has established ambitious goals for reducing GHG emissions (Senate Bill 32) by 40 percent by 2030 and 80 percent by 2050. Senate Bill 1383 (2016) also established specific goals for reducing short-lived climate pollutants (SLCPs), such as methane, by 40 percent from 2013 levels. Ultimately, California is working toward a goal of “net-zero” carbon emissions by 2045 (Executive Order B-55-18).

The U.S. dairy industry recently announced efforts to address climate change, boldly aiming for carbon neutral or better (net zero climate impact) by 2050 (Innovation Center for U.S. Dairy, 2020). As part of these important efforts, California’s dairy farms are leading change and making significant progress in reducing the amount of GHG emissions released into the environment. Producing a glass of milk from a California dairy cow generates 45 percent less GHG emissions today than it did 50 years ago. This finding, recently published in the Journal of Dairy Science, comes from a life-cycle assessment of California dairy farms in 1964 and 2014, conducted by researchers at the University of California,



Davis (Naranjo et al., 2020). Significant advancements in farming efficiency, feed crop yields, veterinary care, sustainable feed practices, and animal nutrition have helped reduce the environmental footprint of individual cows. Building on these gains, more can be done to lower the climate footprint of milk production in the coming decade. California's dairy farmers are working closely with the California Department of Food and Agriculture (CDFA) and the California Air Resources Board (CARB) to further reduce dairy methane emissions. **As the efforts continue, it is also important to improve our understanding of how methane and other GHGs contribute to climate impacts, as we seek to limit warming.** Leading climate scientists are now recognizing that moderately reducing methane emissions can quickly stabilize the climate pollutant's powerful impact, and further reductions can actually offset the far more damaging impacts of carbon dioxide (CO₂), which accumulate in the atmosphere for hundreds of years.

California dairies reduced emissions by 45% between 1964-2014.

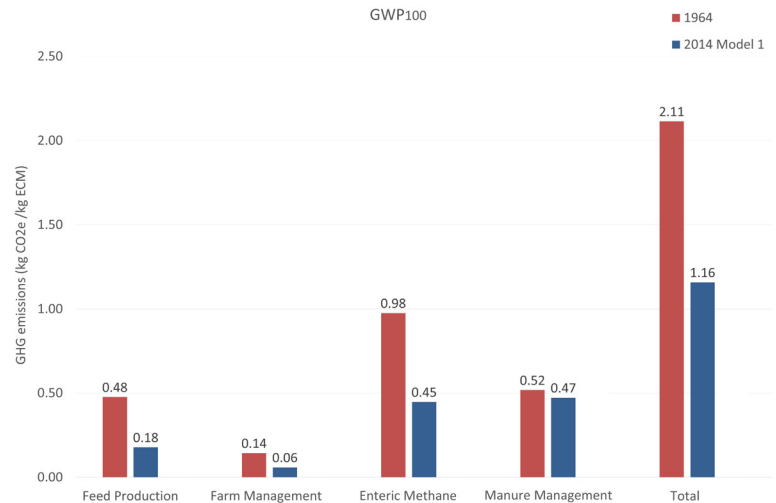


Figure 1. Comparison of global warming potential (GWP) in 1964 and 2014 by emission source for model 1 (using farm sampled diets). GHG = greenhouse gas; CO₂e = CO₂ equivalents. - Journal of Dairy Science, Naranjo et. al., 2020

California's Greenhouse Gas Emissions

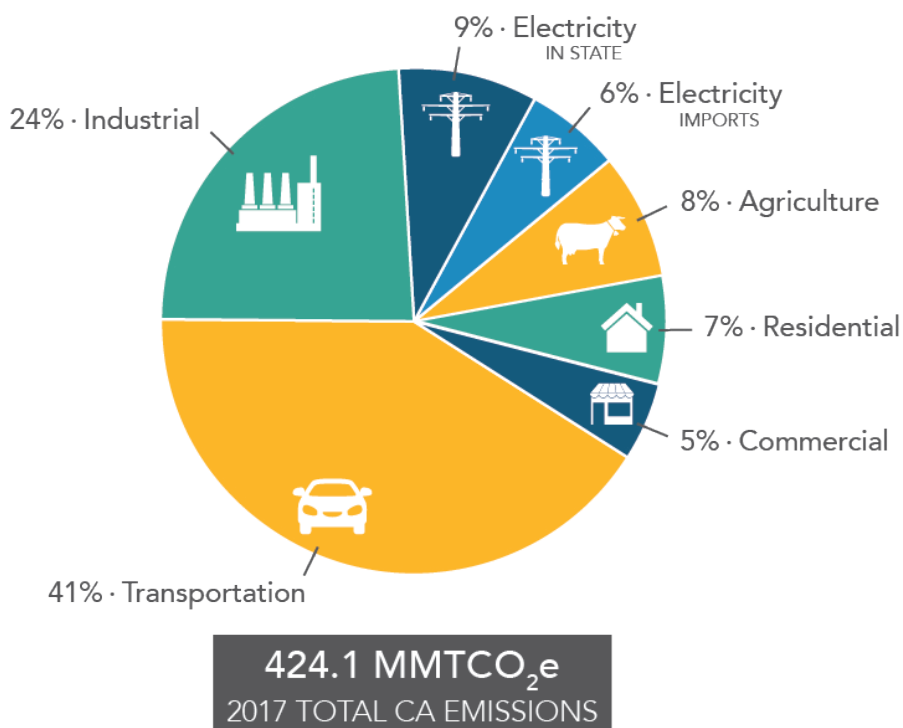


Figure 2. 2017 California greenhouse gas emissions by sector. Source: CARB.

California, the fifth largest economy in the world, is responsible for about 1 percent of all global GHG emissions. More than 80 percent of California's emissions come from the transportation (41 percent), industrial (23 percent) and electrical (16 percent) sectors. Even though California is the United States' largest agricultural producer—producing fruits, vegetables, nuts, livestock, and other commodities for much of the U.S. and world—the sector's GHG contribution is only 8 percent of the state's total. California's largest-in-the-nation dairy sector accounts for about half of the agricultural share, or 4 percent of the state's total GHG emissions. The U.S. dairy sector accounts for 2 percent of the nation's total GHG emissions.

While CO₂ is the primary GHG driving climate warming, methane (CH₄), nitrous oxide (N₂O), and refrigerants are also important GHGs in California. According to CARB, carbon dioxide accounts for about 83 percent of California's GHG inventory. In comparison, methane accounts for 9 percent, and N₂O accounts for about 3 percent. In addition to knowing how much of each gas is being emitted, understanding how each gas causes actual warming is most critical to fully understanding and addressing climate change. Recent work by leading climate scientists at the Oxford Martin School and Environmental Change Institute at Oxford University has shed light on important differences among these GHGs and their impact on climate change (Lynch, 2019).

Methane emissions are generated by a number of processes, both those resulting from human-related activity (anthropogenic) and natural (biogenic). Fossil-fuel methane (more commonly known as “natural gas”) results from the process of extracting coal or oil, or from leakage during the extraction, storage, or distribution of natural gas for homes and businesses. Fossil methane is largely converted to CO₂ when we burn natural gas in our homes, factories, buildings, and other businesses. Biogenic methane emissions are created by wetlands, rice cultivation, and ruminant livestock, as well as the waste sector, when microbes digest organic matter in our landfills and sewage treatment plants. Animal agriculture activity (all livestock) in California represents the largest source of biogenic methane emissions, accounting for roughly 55 percent of all human-related methane emissions in the state. California is the largest dairy state, producing roughly 18.5 percent of the nation's milk (USDA, 2019). The dairy livestock sector accounts for about 45 percent of all methane emitted in the state (CARB, 2015), primarily from two sources. Roughly half (55 percent) of dairy methane emissions come from manure management (storage, handling, and utilization), and the remaining 45 percent comes from enteric emissions.

In ruminant animals, methane is produced during manure decomposition as well as during enteric fermentation, where microbes decompose and ferment plant materials in the first compartment of their stomach, known as the rumen. This methane is expelled by the animal through belching.

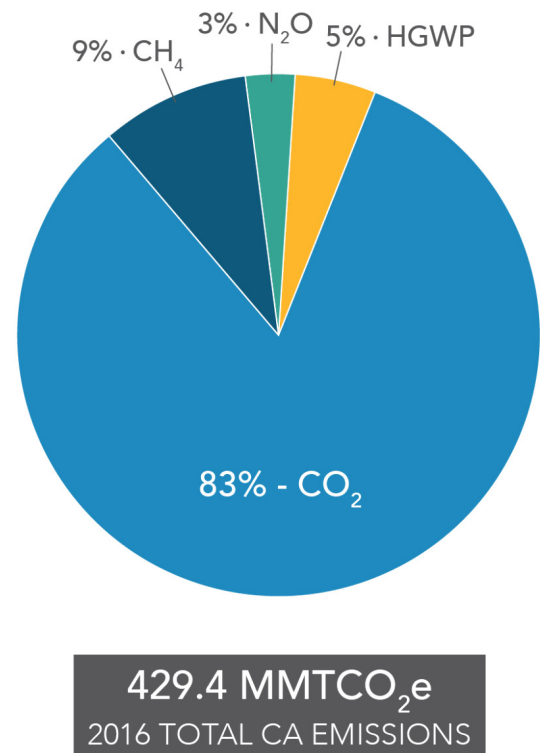


Figure 3. 2017 California greenhouse gas inventory. Source: CARB.

2013 Methane: 118 MMTCO₂e (20-yr GWP)

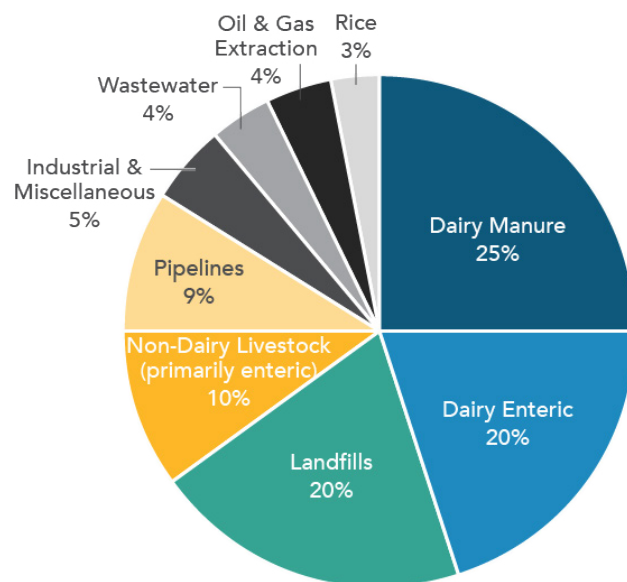


Figure 4. 2015 California methane inventory. Source: CARB.

FOSSIL METHANE VS. BIOGENIC METHANE

Fossil methane impacts the climate differently than biogenic methane. Fossil methane, such as natural gas, is carbon that has been locked up in the ground for millions of years and is extracted and combusted in homes and businesses. The burning of fossil methane directly transfers carbon that was stored in the ground (geologic carbon) into the atmosphere as CO_2 . That carbon continues to accumulate and persist in the environment, contributing to climate change for hundreds of years. **Bottom line: Fossil methane increases the total amount of carbon in the atmosphere, which drives warming.**

Biogenic methane from cows is part of a natural carbon cycle, where after about 12 years it is removed from the atmosphere. As part of photosynthesis, plants capture CO_2 from the atmosphere, absorbing the carbon and releasing oxygen. That carbon is converted into carbohydrates in the plant, which are then consumed by the cows, digested, and released from the cows as methane (CH_4). After about 12 years in the atmosphere, that methane is oxidized and converted into CO_2 . These carbon molecules are the same molecules that were consumed by cows in the form of plants. **As part of the biogenic carbon cycle, the carbon originally utilized by the plant is returned to the atmosphere, contributing no net gain of CO_2 .**

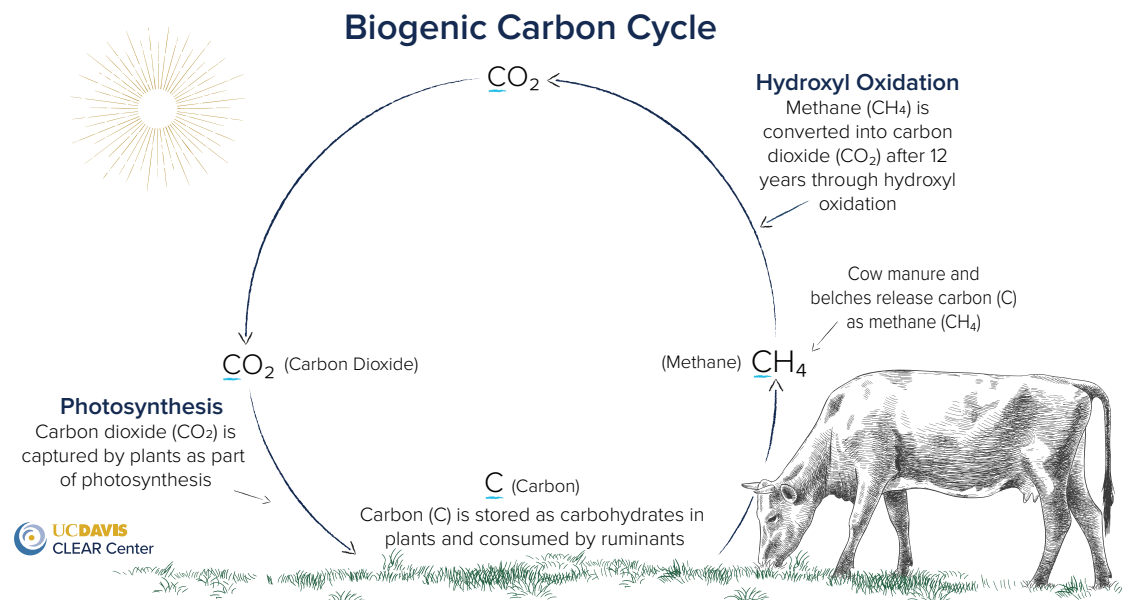
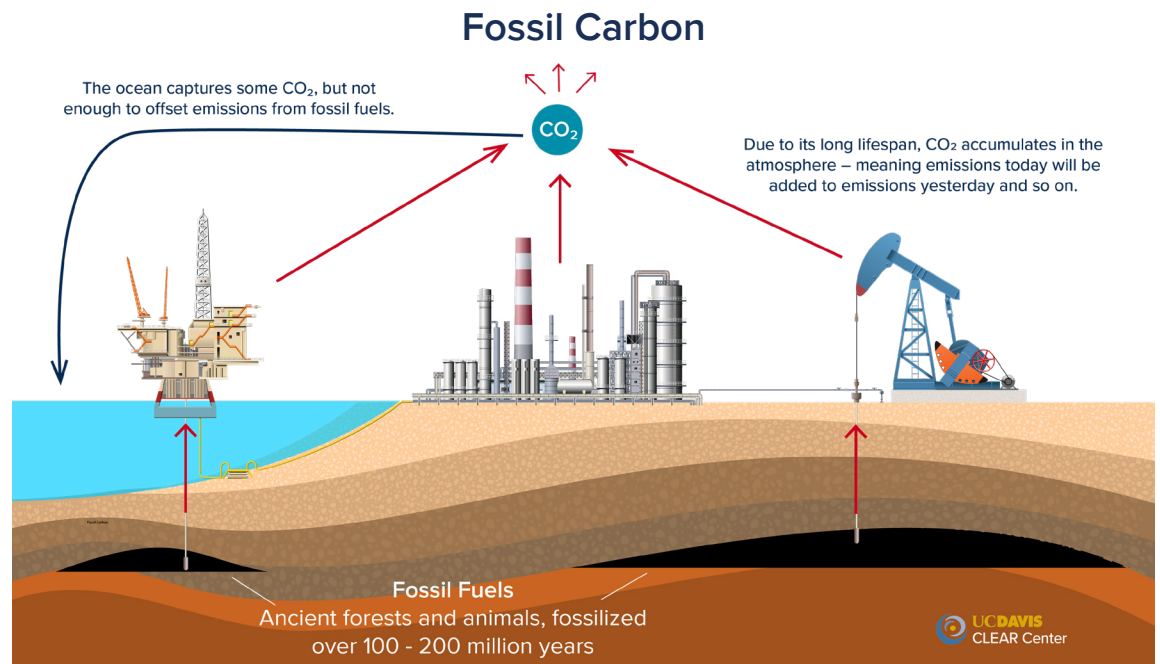


Figure 5. Top, the biogenic carbon cycle shows how carbon moves from the atmosphere to plants, and then to animals, and then back into the atmosphere. This process is further explained in the [CLEAR Center video "Rethinking Methane."](#)

Figure 6. Bottom, the burning of geologic carbon – including fossil methane – is a one-way process, resulting in CO_2 accumulating in the atmosphere.



Global Warming Potential of California's Primary Greenhouse Gases

Each GHG captures and retains heat at a unique rate, known as its global warming potential or GWP (as shown in Table 1 as GWP 100). For example, CH₄ has 28 times the warming potential of CO₂ over a 100-year period. Understanding how emissions impact global climate; however, requires consideration

of not just the potency, but also how long each type of GHG will last in the atmosphere (atmospheric lifetime).

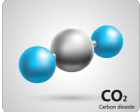

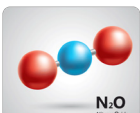
| Global Warming Potential (GWP ₁₀₀) of Main Greenhouse Gases | | AR4 | AR5 |
|-----------------------------------------------------------------------------------|-----------------------------------|-----|-----|
|  | Carbon Dioxide (CO ₂) | 1 | 1 |
|  | Methane (CH ₄) | 25 | 28 |
|  | Nitrous Oxide N ₂ O | 298 | 265 |

Table 1. This table is adapted from the IPCC Fourth Assessment Report (AR4), 2007 and the IPCC Fifth Assessment Report (AR5), 2014. Note, CARB uses AR4.

This is particularly important for methane, as it is a SLCP, with emissions breaking down after about 12 years (Farlie 2019; Lynch, 2019). In contrast, a significant proportion of CO₂ emissions are expected to persist in the atmosphere for hundreds of years, or even longer (Farlie, 2019; Lynch, 2019). As a result, **the treatment of all GHGs as CO₂ equivalent (CO₂e) using GWP—and failure**

to consider the atmospheric removal of SLCPs—misrepresents the impact of methane on future warming (Frame et al., 2018; Cain, 2018). Recognizing this shortcoming, leading climate scientists expanded on GWP and developed GWP* (GWP-Star), which quantifies a GHG's actual warming potential, instead of just its CO₂ equivalence, by factoring in how much more or less methane is being emitted from a source over a period of time. GWP* appropriately builds on the conventional GWP approach employed in typical reporting of GHG emissions (Lynch, 2019). GWP* recognizes the rate and degradation of methane emissions, in addition to the total amount of CO₂ and other long-lived gases emitted (Lynch, 2019; Cain, 2018; Frame et al., 2018).

Climate Impact Potential/GWP* (GWP-Star)

Recognizing the important differences in how methane and carbon dioxide affect climate change is critical to quantifying their actual climate impacts. GWP* was developed to better and more completely account for the warming impacts of short- and long-lived gases and better link emissions to warming (Cain, 2018). GWP* is still based on GWP, but recognizes how different gases such as methane affect warming (Cain, 2018).

Because CO₂ emissions last in the atmosphere for so long, they can continue to impact warming for centuries to come. New emissions are added on top of those that were previously emitted, leading to increases in the total atmospheric stock or concentration of CO₂. As a result, when additional CO₂ is emitted, additional global warming occurs (Frame et al., 2018).

In contrast, methane emissions degrade in the atmosphere relatively quickly, after about 12 years, and do not act cumulatively over long periods of time. For a constant rate of methane emissions, one molecule in effect replaces a previously emitted molecule that has since broken down. This means that

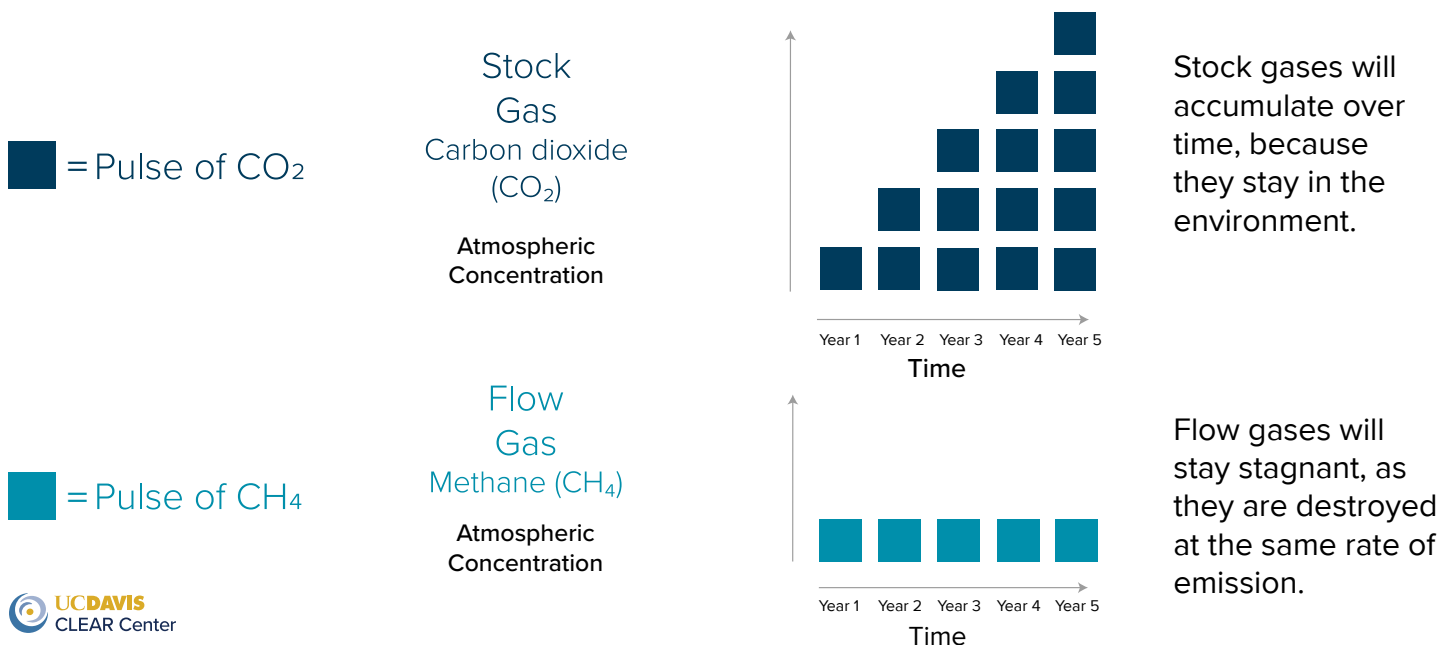
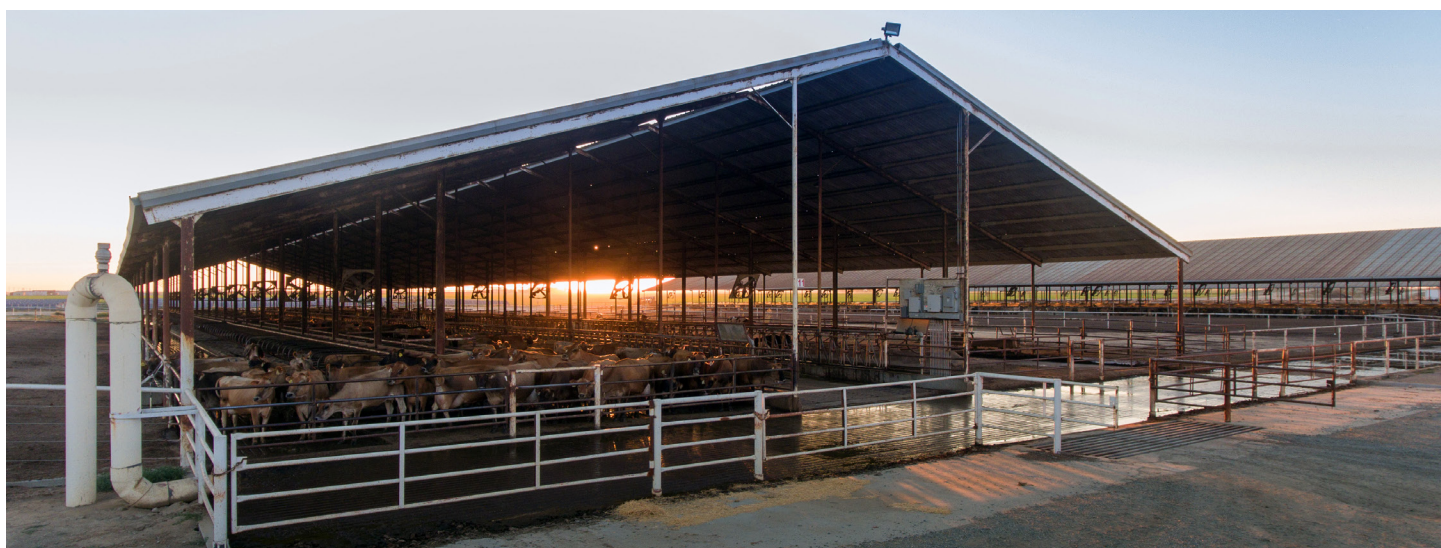


Figure 7. Based on research by Myles R. Allen, Keith P. Shine, Jan S. Fuglestedt, Richard J. Millar, Michelle Cain, David J. Frame & Adrian H. Macey. Read more here: <https://rdcu.be/b1t7S>

for a steady rate of methane release—as emitted by a constant number of dairy cows, for example—the amount of methane in the atmosphere (concentration) stays at the same level and does not increase. As a result, when a steady amount of methane is emitted for more than 12 years, no additional global warming occurs (Frame et al., 2018).

This improved understanding of how short-lived versus long-lived emissions affect climate differently is critical to addressing further global warming. Limiting climate change requires that we bring emissions of CO_2 and other long-lived GHGs down to net-zero (Frame et al., 2018). For methane, however, it is possible to have steady ongoing emissions that do not result in additional warming (Frame et al., 2018).

This does not mean that methane can or should be ignored. Increasing methane emissions would result in significant warming. Because of its short-lived atmospheric lifetime, reducing methane emissions can lead to a drop in atmospheric concentration relatively quickly. **So, reducing methane emission rates presents an important mitigation opportunity, which could reverse some of the warming the planet has already experienced (Lynch, 2019). Put simply, a reduction in methane emissions has climate cooling effects (Cain, 2018).**



Climate-Neutral Dairy: Achievable in California's Near Future

Understanding how methane impacts global warming is critical to understanding the role of dairy production as a contributor to climate change. California's dairy sector is an excellent case in point. It is no longer growing and expanding production. The number of milk cows raised in the state reached a peak in 2008, around the same time that California passed its first climate policy (2006). Since then, the number of cows has declined by a little more than 7 percent (CDFA, 2017). Total milk production has also decreased in recent years. As a result, the amount of methane in the atmosphere contributed by California milk production is less today than in 2008, as more methane is being removed from the atmosphere each year through its natural breakdown process (biogenic methane cycle) than is created by fewer dairy cows.

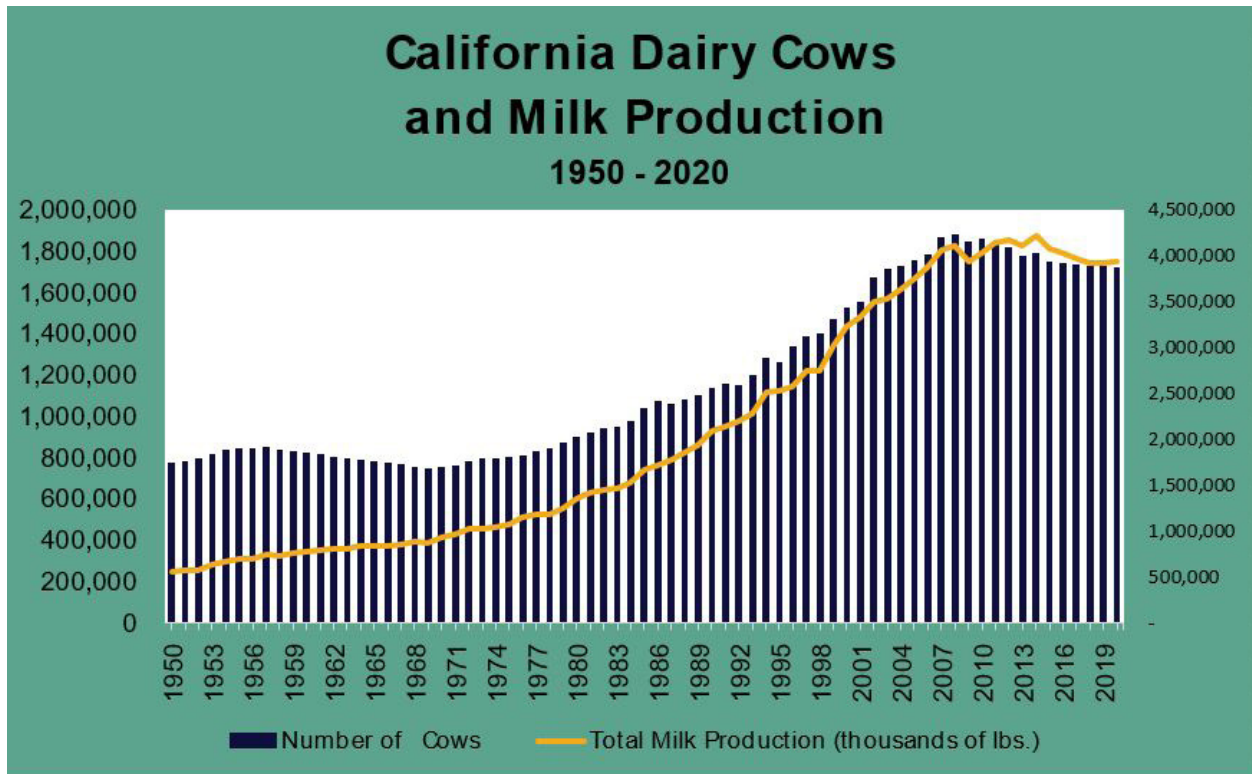


Figure 8. Number of California Dairy Cows and Volume of Milk Production: Sources: CDFA Dairy Marketing, Milk Pooling, and Milk and Dairy Foods Safety Branches; USDA Milk Production Report

California dairy farms are also taking important, voluntary steps to further reduce methane from farms by installing anaerobic digesters designed to capture methane. Other projects, such as compost pack barns and solid separators, are designed to reduce methane production on farms. More than 213 dairy methane reduction projects have been incentivized with state funds to date (CDFA, 2019). These efforts alone are expected to achieve more than 2.2 million additional metric tons of GHG reduction each year, as the projects continue to be implemented (CDFA, 2019). Hundreds of additional dairy methane reduction projects are expected in future years.



Figure 9. Manure solid separator, climate-smart dairy project on a California dairy farm.

As discussed earlier, enteric emissions (belching) from cows account for a significant share (45 percent) of total dairy methane emissions in California. Identifying solutions to reduce these emissions will also be necessary to meet state goals. While research into enteric emission mitigation is being conducted, and some feed additives show promise, commercially proven and cost-effective solutions are not yet available (Webinar on CARB's Analysis of Progress Toward Achieving Methane Emissions Target from Dairy and Livestock Sector, 2020).

What is Climate Neutrality?
Climate neutrality is when an entity or industry has no net global warming impact. Same as “warming neutral.”

Dairy farms also create other GHGs, such as CO₂ and nitrous oxide (N₂O), from the use of farm equipment for dairy management and the utilization of manure for growing crops. These emissions account for about 20 percent of all GHGs produced by the dairy production sector (Naranjo et al., 2020). Reducing or offsetting these emissions will also be necessary for the state's dairy production sector to achieve climate neutrality, or the point at which operations and resulting emissions are stable and no longer adding to global warming (no net global warming impact). California dairies are also reducing the amount of CO₂ they emit into the atmosphere through the adoption of solar energy and electrification of feed mixing and water pumping operations. Fossil fuel use per unit of milk produced has dropped by 58.5 percent from 1964 to 2014 (Naranjo et al., 2020). As dairy methane emissions are reduced further below current levels, then resulting cooling effects can offset some of the remaining CO₂ and other gases contributed by dairy production.



Conclusions and Policy Considerations

A continued focus on methane is necessary, as it is a powerful GHG and an important contributor to climate change. Under all scenarios, methane is significant, second only to carbon dioxide in terms of its overall contribution to global, human-driven climate change (Lynch, 2019). Over the last decade, global methane concentrations have increased (Lynch, 2019). Agriculture, including animal agriculture, is partially responsible for the increase, as dairy and meat production and consumption continue to expand globally, particularly in low- and middle-income countries. That notwithstanding, evidence is growing that shale gas production is a larger source of methane emissions than previously assumed (Howarth, 2019). Like every sector of the global economy, agriculture must do its part if we are to succeed in achieving the overarching goal of limiting global warming. Equally important, California acting alone cannot accomplish significant global dairy methane emission reductions.

A renewed focus on how we consider and address the climate impact of methane emissions is also warranted (Lynch, 2019). As discussed in this paper, rethinking methane's role in climate is important, because there are significant differences in how methane and carbon dioxide—the main human-generated GHG—affect climate (Lynch, 2019). Different goals should be identified and set for CO₂, CH₄, and other GHGs. Designing effective policies to limit global warming also requires knowledge of how different mitigation measures impact temperature, including in targeting appropriate programs to incentivize voluntary adoption of methane reduction technologies and practices. Voluntary dairy methane reduction will need to be continued, as it is an important climate mitigation tool.

Recognizing how methane impacts global climate is also critical to assessing whether the state and world are on track to meet the goals of the Paris Agreement and limit warming to well below 2°C. Comparing GHGs with each other using GWP* preserves the link between emissions and warming or cooling of the atmosphere (Schleussner et al., 2019). It also provides an informative and better suited way to assess the relative merits of different options for reducing GHG emissions, especially in ambitious mitigation scenarios (Cain, 2019). More accurate expression of mitigation efforts in terms of their direct contribution to future warming also better informs burden-sharing and long-term policies and measures in pursuit of ambitious global temperature goals (Allen, 2018; Schleussner et al., 2019).



Figure 10. California climate-smart dairy with a digester, manure solid separator, and solar installation.



Reducing methane emissions and achieving climate neutrality is no small undertaking. California is among the most efficient producers of milk and dairy products, and its life-cycle carbon footprint (per gallon of milk produced) is among the lowest of any region in the world. Achieving these or similar levels of production efficiency (more milk with fewer cows) is a critical first step for other dairy regions to begin stabilizing methane emissions and work toward climate neutrality. The impact of such an accomplishment would have profound climate effects. Attaining California's level of production efficiency in all global dairy production regions could reduce total global GHG emissions by as much as 1.73 percent (E. Kebreab, calculations based on Naranjo et al., 2020 and FAO & GDP, 2018).

A full understanding of the potential climate impact of all greenhouse gases is also important in ensuring effective policies are developed to address methane and other flow pollutants in line with their effects. Dairy production primarily produces flow emissions (80 percent is methane) with smaller amounts of stock emissions, such as CO₂ and N₂O (Naranjo et al., 2020). Policy or consumption decisions that trade off and result in greater concentrations of CO₂ and N₂O, while reducing methane, may ultimately leave a warmer planet behind in the long term (Frame et al., 2018).

Attaining California's level of production efficiency in all global dairy production regions could reduce total global GHG emissions by as much as 1.73 percent.

California's experience and efforts have identified crucial approaches that have worked to create low-carbon livestock and reduce the climate impacts of dairy production. Adopting sustainable farming practices to vastly improve production efficiency is probably the single-most important step other dairy-producing countries can take to begin to stabilize regional and global methane emissions and begin to achieve climate neutrality. The United Nations Food and Agriculture Organization (FAO) estimates that improved management practices alone could reduce net global methane emissions by 30 percent (FAO, 2019). These efforts will be critical to reduce livestock methane emissions and present important opportunities for reaching global climate mitigation targets. Further reductions in methane emissions will lead to atmospheric concentrations falling relatively quickly, which could reduce some of the warming already experienced (Lynch, 2019).

CASE STUDY: CALIFORNIA DAIRY METHANE REDUCTION

Fully understanding the climate cooling potential of dairy methane reduction efforts in California is critical for state regulators and policymakers. California is seeking to reduce dairy methane emissions by roughly 7.2 million metric tons (MMT) per year by 2030 (40% reduction). What will this mean for California's overall emissions reduction goal of being "net zero" by 2045?











Figure 11. Digester on California dairy farm.

Achieving the state's goal of reducing dairy methane emissions by 7.2 MMTCO₂e annually will provide about 20 MMT of annual reduction (cooling) equivalent each year from 2030 to 2045. These reductions will be critical to mitigate continually accumulating CO₂ emissions from other sectors of the economy, and the achievement of the state's "net zero" long-term goal. In the race to manage global warming, reducing methane can provide fast returns.

This analysis using GWP* shows the true value of the state's dairy methane reduction efforts and programs such as CDFA's Dairy Digester Research and Development Program (DDRDP) and Alternative Manure Management Program (AMMP), which are expected to incentivize more than half of the 7.2 MMT of methane reduction. This analysis also underscores the importance of continuing to fully fund these California Climate Investment Programs at a minimum of \$85 million per year. (CARB Preliminary Analysis of Dairy Methane Reduction Progress, May 2020).

Cumulative Overview of the DDRDP & AMMP

| Program | 108 <small>(total 2015, 2017, 2018, 2019)</small> | \$181.6 million | 19.7 million MTCO ₂ e <small>(10-yr project life)</small> | \$9 Ranked #2 of 68 programs |
|------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| | Number of Projects Funded  | Total State Funding Awarded  | Total GHG Reductions  | State Cost Per 1 Ton GHG Reduced  |
| Dairy Digester Research and Development Program (DDRDP) | | | | |
| Alternative Manure Management Program (AMMP) | 105 <small>(total 2017, 2018, 2019)</small> | \$63 million | 1.1 million MTCO ₂ e <small>(5-yr project life)</small> | \$49 Ranked #7 of 68 programs |
| | Number of Projects Funded  | Total State Funding Awarded  | Total GHG Reductions  | State Cost Per 1 Ton GHG Reduced  |

Sources: Report of Funded Projects - CDFA DDRDP 2020; Report of Funded Projects - CDFA AMMP 2020; California Climate Investments 2020 Annual Report

ABOUT THE AUTHORS

Frank Mitloehner, Ph.D., Professor and Air Quality Specialist, Director, CLEAR Center, UC Davis



Frank Mitloehner is a professor and air quality specialist for Cooperative Extension in the Department of Animal Science at the University of California, Davis. Dr. Mitloehner has served as chairman of a global United Nations Food and Agriculture Organization partnership project to benchmark the environmental footprint of livestock production. Dr. Mitloehner serves as the North American scientific lead for the Global Feed LCA Institute. Dr. Mitloehner is a work group member of the President's Council of Advisors on Science and Technology (PCAST) and a member of the National Academies of Science Institute of Medicine (IOM) committee on "A Framework for Assessing the Health, Environmental, and Social Effects of the Food System."

Ermias Kebreab, Ph.D., Professor and Sesnon Endowed Chair, Director, World Food Center, Associate Dean of Global Engagement, UC Davis



Ermias Kebreab serves as the Sesnon Endowed Chair in Sustainable Animal Agriculture at the Department of Animal Science, UC Davis. Dr. Kebreab was appointed Associate Dean of Global Engagement and Director, World Food Center in 2018. He is a contributing author to the 2019 Intergovernmental Panel on Climate Change (IPCC) guideline and chairs the feed additive committee at the Food and Agriculture Organization of the United Nations. Dr. Kebreab conducts research on reducing the impact of animal agriculture on the environment, including the sustainable use of feed additives. Dr. Kebreab received several awards, including International Agriculture Award and AFIA Ruminant Nutrition Award from American Society of Animal Science.

Michael Boccadoro, Executive Director, Dairy Cares



With more than 30 years of experience in the public affairs arena, Michael Boccadoro has distinctive expertise in the areas of energy, environmental regulation, and sustainability. Mr. Boccadoro serves as the Executive Director of Dairy Cares, a statewide coalition that works to ensure the long-term sustainability of California's family dairy farms. He has been at the forefront of California's dairy methane reduction efforts and the development of incentive programs to encourage voluntary implementation. Mr. Boccadoro received his Bachelor of Arts degree in economics and political science from the University of California, Davis.

REFERENCES

- Allen, M.R., Fuglestedt, J.S., Shine, K.P., Reisinger, A., Pierrehumbert, R.T., & Forster P.M. (2016). New use of global warming potentials to compare cumulative and short-lived climate pollutants. *Nature Climate Change*. 6. 773–6. Retrieved from <https://www.nature.com/articles/nclimate2998?cacheBust=1508877188307>
- Allen, M.R., Shine, K.P., Fuglestedt, J.S., Millar, R.J., Cain, M., Frame, D.J., & Macey, A.H. (2018). A solution to the misrepresentations of CO₂-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *npj Climate and Atmospheric Science*. 1(16). Retrieved from <https://www.nature.com/articles/s41612-018-0026-8>
- California Air Resources Board. (2019, August 12). California 2017 Greenhouse Gas Inventory. Retrieved from https://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_bygas.pdf
- California Air Resources Board. (2015). California's methane inventory based on the 2015 edition the CARB greenhouse gas inventory. Retrieved from <https://www.arb.ca.gov/ghg-slcip-inventory>
- California Department of Food and Agriculture. (2019, September 18). CDFA Awards Nearly \$102 Million for Dairy Methane Reduction Projects [Press release]. Retrieved from https://www.cdfa.ca.gov/egov/Press_Releases/Press_Release.asp?PRnum=19-085
- California Department of Food and Agriculture Dairy Marketing, Milk Pooling, and Milk and Dairy Foods Safety Branches. (2017). [California dairy cows and milk productions]. Unpublished raw historical data.
- Cain, M. (2018). Guest post: A new way to assess 'global warming potential' of short-lived pollutants. *Carbon Brief*. Retrieved from <https://www.carbonbrief.org/guest-post-a-new-way-to-assess-globalwarming-potential-of-short-lived-pollutants>
- Cain, M., Lynch, J., Allen, M.R., Fuglestedt, D.J. & Macey, A.H. (2019). Improved calculation of warming-equivalent emissions for short-lived climate pollutants. *npj Climate and Atmospheric Science*. 2(29). Retrieved from <https://www.nature.com/articles/s41612-019-0086-4>
- Dairy Cares. (2019, August 28). Cows vs Cars? [Video file]. Retrieved from <https://www.youtube.com/watch?v=RW8BcIS27al&vl=en>
- Dairy Industries International. (2019). Sustainability project aims for net zero climate impact in US Dairy. Retrieved from <https://www.dairyindustries.com/news/32149/sustainability-project-aims-for-net-zero-climate-impact-in-us-dairy/>
- Fairlie, S. (2019). A Convenient Untruth. *Resilience*. Retrieved from <https://www.resilience.org/stories/2019-05-10/a-convenient-untruth/>
- FAO. (2019). Five practical actions towards low-carbon livestock. Rome. Retrieved from <http://www.fao.org/documents/card/en/c/ca7089en/>

FAO and GDP. (2018). Climate change and the global dairy cattle sector – The role of the dairy sector in a low-carbon future. Rome. 36 pp. Licence: CC BY-NC-SA- 3.0 IGO. Retrieved from <https://dairysustainabilityframework.org/wp-content/uploads/2019/01/Climate-Change-and-the-Global-Dairy-Cattle-Sector.pdf>

Frame, D., Macey, A.H., & Allen, M. (2018). Why methane should be treated differently compared to long-lived greenhouse gases. The Conversation. Retrieved from <https://theconversation.com/why-methane-should-be-treated-differently-compared-to-long-lived-greenhouse-gases-97845>

Howarth, R. W. (2019). Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane?. Biogeosciences, 16, 3033–3046. Retrieved from <https://doi.org/10.5194/bg-16-3033-2019>

Lynch, J. (2019). Agricultural methane and its role as a greenhouse gas. Food Climate Research Network, University of Oxford. Retrieved from <https://foodsource.org.uk/building-blocks/agricultural-methane-and-its-role-greenhouse-gas>

Naranjo, A., Johnson, A., Rossow, H., & Kebreab, E. (2020). Greenhouse gas, water, and land footprint per unit of production of the California dairy industry over 50 years. Journal of Dairy Science. 103, 3760-3. Retrieved from [https://www.journalofdairyscience.org/article/S0022-0302\(20\)30074-6/fulltext](https://www.journalofdairyscience.org/article/S0022-0302(20)30074-6/fulltext)

Schleussner C., Nauels, A., Schaeffer, M., Hare, W., & Rogelj, J. (2019). Inconsistencies when applying novel metrics for emissions accounting to the Paris agreement. Environmental Research Letters. 14(12). Retrieved from <https://iopscience.iop.org/article/10.1088/1748-9326/ab56e7/meta>

United States Department of Agriculture, National Agricultural Statistics Service. (2019). Milk Production, Disposition, and Income 2018 Summary. Retrieved from <https://usda.library.cornell.edu/concern/publications/4b29b5974>

| GWP* | Projected emission | Target annual reduction (by 2030) | Target reduction (by 2030) | CH4 emission (ton) | CH4 emission (GWP) |
|------------------|--------------------|-----------------------------------|----------------------------|--------------------|--------------------|
| MMT CO2e | (MMT CO2e) | (annual reduction) | (MMT CO2e) | (ton) | (MMT CO2e) |
| Reference Period | 14.2245697 | | | 568982.787 | 14.2245697 |
| | 14.5136493 | | | 580545.972 | 14.5136493 |
| | 15.6902132 | | | 627608.528 | 15.6902132 |
| | 16.0893447 | | | 643573.79 | 16.0893447 |
| | 15.4337949 | | | 617351.797 | 15.4337949 |
| | 15.8896823 | | | 635587.29 | 15.8896823 |
| | 16.2933885 | | | 651735.54 | 16.2933885 |
| | 18.3082896 | | | 732331.584 | 18.3082896 |
| | 18.5623299 | | | 742493.195 | 18.5623299 |
| | 17.8830598 | | | 715322.394 | 17.8830598 |
| | 18.5081353 | | | 740325.413 | 18.5081353 |
| | 18.4484971 | | | 737939.885 | 18.4484971 |
| | 18.9550121 | | | 758200.486 | 18.9550121 |
| | 18.106066 | 0.51731617 | 7.24242642 | 724242.642 | 18.106066 |
| | 18.3656318 | | | 734625.272 | 18.3656318 |
| | 17.9379584 | | | 717518.337 | 17.9379584 |
| | 17.8386093 | | | 713544.371 | 17.8386093 |
| | 17.3212931 | | | | |
| | 16.8039769 | | | | |
| | 16.2866608 | | | | |
| | 9.73524209 | 15.7693446 | | | |
| | 6.58192884 | 15.2520284 | | | |
| | 0.10054949 | 14.7347122 | | | |
| | 3.46545848 | 14.2173961 | | | |
| | 3.07641135 | 13.7000799 | | | |
| 6.85525353 | 13.1827637 | | | | |
| 10.4384166 | 12.6654476 | | | | |
| 20.0635605 | 12.1481314 | | | | |
| 23.0854762 | 11.6308152 | | | | |
| 22.6074782 | 11.113499 | | | | |
| 27.020776 | 10.5961829 | | | | |
| 26.7971327 | 10.5961829 | | | | |
| 28.6965641 | 10.5961829 | | | | |
| 25.5130162 | 10.5961829 | | | | |
| 26.4863878 | 10.5961829 | | | | |
| 24.8826126 | 10.5961829 | | | | |
| 24.5100533 | 10.5961829 | | | | |
| 22.5701177 | 10.5961829 | | | | |
| 20.630182 | 10.5961829 | | | | |
| 18.6902464 | 10.5961829 | | | | |
| 16.7503108 | 10.5961829 | | | | |
| 14.8103751 | 10.5961829 | | | | |
| 12.8704395 | 10.5961829 | | | | |
| 10.9305038 | 10.5961829 | | | | |
| 8.99056816 | 10.5961829 | | | | |
| 7.05063252 | 10.5961829 | | | | |
| -19.82499494 | | | | | |
| (2030 - 2045) | | | | | Annual reduction |

Appendix B: Calculation of GHG reductions to be achieved if all global dairy production regions achieved the same level of production efficiency (carbon intensity).

1. Obtain California dairy industry's carbon intensity, or kg of CO2e per kg of energy and-protein corrected milk (ECM). Highlighted in green.

[https://www.journalofdairyscience.org/article/S0022-0302\(20\)30074-6/fulltext](https://www.journalofdairyscience.org/article/S0022-0302(20)30074-6/fulltext)

2. Obtain carbon intensity data for dairy regions throughout the globe:

<https://dairysustainabilityframework.org/wp-content/uploads/2019/01/Climate-Change-and-the-Global-Dairy-Cattle-Sector.pdf>

3. Calculate percent of GHG reduction that would be achieved if the entire global dairy sector achieved California's carbon intensity, using both models.

| REG_ANNEX5 | 2015 Data | | | | Business As Usual | IF production was like CA model 2 | | IF production was like CA model 1 | |
|-----------------------------|---------------------------|---------|-----------------|------------------|------------------------|-----------------------------------|------------------------|-----------------------------------|------------------------|
| | Billion kg milk | % share | Billion kg FPCM | kg CO2e/ kg FPCM | billion kg CO2e/region | billion kg CO2e/region | % reduction by country | billion kg CO2e/region | % reduction by country |
| Central & South America | 80.75 | 12.0% | 80.87 | 3.36 | 271.7232 | 90.5744 | 67% | 93.8092 | 65% |
| East Asia | 53.19 | 8.1% | 54.4 | 2.43 | 132.192 | 60.928 | 54% | 63.104 | 52% |
| Eastern Europe | 42.06 | 6.3% | 42.68 | 1.34 | 57.1912 | 47.8016 | 16% | 49.5088 | 13% |
| North America | 102.07 | 14.5% | 97.41 | 1.29 | 125.6589 | 109.0992 | 13% | 112.9956 | 10% |
| Oceania | 31.43 | 5.1% | 34.07 | 1.31 | 44.6317 | 38.1584 | 15% | 39.5212 | 11% |
| Russian Federation | 30.52 | 4.6% | 31.03 | 1.39 | 43.1317 | 34.7536 | 19% | 35.9948 | 17% |
| South Asia | 97.39 | 14.6% | 98.55 | 4.1 | 404.055 | 110.376 | 73% | 114.318 | 72% |
| Sub-Saharan Africa | 22.04 | 3.4% | 23.18 | 6.67 | 154.6106 | 25.9616 | 83% | 26.8888 | 83% |
| West Asia & Northern Africa | 60.31 | 9.2% | 62.12 | 4.41 | 273.9492 | 69.5744 | 75% | 72.0592 | 74% |
| Western Europe | 146.73 | 22.1% | 149.1 | 1.37 | 204.267 | 166.992 | 18% | 172.956 | 15% |
| Global | 666.49 | 100% | 673.41 | | 1711.4105 | 754.2192 | 56% | 781.1556 | 54% |
| california model 2 | CDFA model | | | 1.12 | | | | | |
| california model 1 | sampled dairies model CAD | | | 1.16 | | | | | |

4. Convert "Business as Usual" Global Dairy CO2e into MTCO2e.

5. Obtain Total Global GHG emissions data: <https://www.ipcc.ch/site/assets/uploads/2018/12/UNEP-1.pdf>

6. Calculate Percent of Total Global GHG emissions that would be reduced if entire global dairy sector achieved California's carbon intensity, using both models.

| | IF production was like CA model 2 | IF production was like CA model 1 |
|----------------------------------------------------------|-----------------------------------|-----------------------------------|
| Global Dairy GHG Emissions (BAU) (MTCO2e) | 1,711,800,000 | |
| Total Global GHG Emissions (Gigatons) | 53.5 | |
| Total Global GHG Emissions (MTCO2e) | 53,500,000,000 | |
| Global Dairy Emissions (at CA carbon intensity) (MTCO2e) | 754,390,853 | 781,333,383 |
| Percent of Total Global GHGs reduced | 1.79% | 1.74% |