MITIGATING EMISSIONS FROM CALIFORNIA'S DAIRIES

Considering the Role of Anaerobic Digesters in Mitigating Emissions from California's Dairies

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I. Introduction

This white paper addresses several contested and commonly-raised issues related to the promotion of dairy digesters as the primary policy mechanism to reduce greenhouse gas (GHG) emissions from dairy operations in California. The purpose of this paper is to provide context for ongoing conversations regarding the role of dairy digesters in California's Low Carbon Fuel Standard (LCFS), as well as potential dairy methane regulations pursuant to SB 1383 (2016). The report analyzes and offers key takeaways for each of the following issues:

- The variety of manure management systems used on dairies and their respective prevalence and emissions;
- The appropriateness and applicability of the life cycle analysis used by the Air Resources Board (CARB) to evaluate the carbon intensity of fuels derived from dairy biogas in the LCFS program;
- The relationship between LCFS incentives for dairy biogas and dairy consolidation;
- The risk of emissions leakage were CARB to regulate dairy methane;
- The role of LCFS credits for fuels derived from dairy biogas in meeting California's climate targets.

II. Manure Management Systems and GHG Emissions

California's Low Carbon Fuel Standard (LCFS) assumes that liquid manure management systems are the standard practice for dairies and, as a result, that they are the appropriate baseline against which to compare a given climate intervention. By setting liquid manure management systems as the reference scenario, emissions reductions from digesters appear to be relatively higher because this method of manure management generates more emissions that can then be captured. While liquid manure management systems are the predominant approach in California, they are one of the more polluting manure management systems available. They are also less common in other dairying states. Dairies in all states, however, are eligible for LCFS credits and shaped by that program's incentives. This section describes how common liquid manure management systems are and what alternatives are available.

The major sources of GHG emissions in the dairying process are feed production, enteric fermentation, and manure management. These are present in all dairy operations to varying degrees. The relative contributions of feed, enteric fermentation, and manure management vary based on the practices employed. Emissions from feed production, for example, can be especially high in "high-yielding milk production systems."[2] Manure management emissions can vary significantly based on the scale of the operations and the specific practices employed, while enteric emissions tend to scale proportionally to herd size. While estimates of relative contributions vary, methane from enteric fermentation and feed production are generally thought to be the largest sources, followed by manure management.

A. Common Manure Management Systems

Livestock produce waste. Historically, when dairy farms were pasture-based and much smaller than the contemporary American dairy, cows deposited their waste in the pasture where it would degrade and incorporate into the soil over time. As dairy industrialized over the course of the 20th century, and particularly as the industry consolidated over the past 30 years, the amount of waste produced at the largest operations has become too great for the available land to absorb safely. When manure is

2 M. Henriksson, C. Cederberg, and C. Swensson, *Carbon Footprint and Land Requirement for Dairy Herds Rations: Impacts of Feed Production Practices and Regional Climate Variations*, 8 Animal 8, 1329 (2014), https://doi.org/10.1017/S1751731114000627.

land-applied above agronomic rates, or above the rate at which the crops and soil can absorb nutrients, it results in contamination to local waterways. As a result, larger-scale dairy (and other livestock) operations have had to develop new methods that allow them to collect the waste and store it until land is available and weather conditions allow for it to be safely disposed of.[3]

Manure management systems can be divided into three components: "1) manure handling, the method of manure removal or management in animal housing or grazing areas; 2) manure storage, the infrastructure and method for holding manure until its application; and 3) manure application and manner in which manure is land applied, typically for crop fertilization."[4] Different practices are available to dairies at each step in this process.

Different approaches are more suitable to different operations based on scale and location. The scale of the operation impacts the choice of manure management system for several reasons. On large-scale operations, there is generally inadequate pastureland available for grazing and inadequate cropland for manure application. As a result, feed must be purchased[5] and manure must be stored until the conditions are right and the land is available for spreading. The manure lagoon is the dominant form of manure storage for these large-scale operations. Anaerobic lagoons are designed minimize the amount of land required for spreading.[6] Concentrating manure production creates risks to air and water[7] so manure transport, storage, and spreading must all be carefully managed.

At the smaller-scale, dairies typically graze their cows and supplement with little to no purchased feed. Manure is produced at quantities and concentrations less likely to cause nutrient pollution and is typically land-applied on a regular basis (though some small and mid-sized farms may also use short-term storage for manure).

A key point of differentiation between dairy manure management systems is manure consistency: Some farms maintain their manure in solid form and others liquify the manure. Larger farms with manure lagoons tend to transport manure in liquid form, often using flush systems. Smaller farms more often maintain solid manure that can be land-applied daily.[8]

The specific practices adopted throughout the different parts of the manure management system affect one another as well, with the initial choice of manure consistency imposing decisive constraints.[9] One study found "clear patterns of related strategies, largely determined by the handling of manure as a liquid, slurry, or solid."[10] The diagram below was developed out of a survey of Wisconsin dairies to study how certain practices tend to lead to others. For example, larger operations tend to use freestall barns. The survey found that 68% of operations using freestall barns select a skid steer over various alternatives to collect

3 H.A. Aguirre-Villegas and R.A. Larson, *Evaluating Greenhouse Gas Emissions from Dairy Manure Management Practices Using Survey Data and Lifecycle Tools*, J. of Cleaner Production 143 (2017) 169e179, http://dx.doi.org/10.1016/j.jclepro.2016.12.133. This Wisconsin survey found that farms had more land per "animal unit" than larger farms, likely because "neither large farms nor permitted facilities have the sufficient land to agronomically recycle excreted P (Table C.4), suggesting that land is not increasing proportionally to the number of cows as farms grow."

4 Meredith T. Niles et al., *Manure Management Strategies Are Interconnected with Complexity Across U.S. Dairy Farms*, 17 PLoS One 6 (2022), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9165779/.

5 Food and Water Watch, *The Economic Cost of Food Monopolies: The Dirty Dairy Racket* (January 2023), https://www.foodandwaterwatch.org/wp-content/uploads/2023/01/RPT2_2301_EconomicCostofDairy-WEB.pdf ("Larger farms are less likely to graze their cattle on pasture and instead rely on purchased feed, which is the single largest source of livestock industry greenhouse gas emissions"); *see also* U.N. Food and Agriculture Organization, *Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities* (2013), https://www.fao.org/3/i3437e/i3437e.pdf ("Feed production and processing, and enteric fermentation from ruminants are the two main sources of emissions, representing 45 and 39 percent of sector emissions, respectively. Manure storage and processing represent 10 percent. The remainder is attributable to the processing and transportation of animal products.")

6 Missouri State University Extension, Lagoons for Storage/Treatment of Dairy Waste, https://extension.missouri.edu/publications/wq304.

7 *See* A. Naranjo et al., *Greenhouse Gas, Water, and Land Footprint Per Unit of Production of the California Dairy Industry Over 50 Years*, 103 J. Dairy Sci. 4 (Feb. 6, 2020), https://www.journalofdairyscience.org/article/S0022-0302(20)30074-6/fulltext

8 H.A. Aguirre-Villegas and R.A. Larson, *Evaluating Greenhouse Gas Emissions from Dairy Manure Management Practices Using Survey Data and Lifecycle Tools*, *supra* note 3.

9 *See generally* Meredith T. Niles et al., *Manure Management Strategies Are Interconnected with Complexity Across U.S. Dairy Farms, supra* note 4.

10 *Id*.

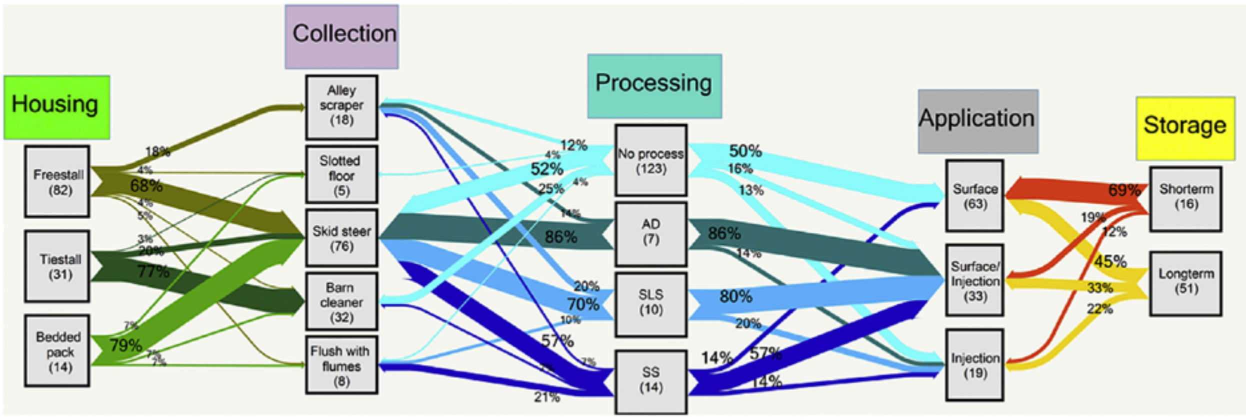


Fig. 3. Probabilities (%) of adopting a manure management practice (rectangular boxes) given the adoption of another practice. Values in parenthesis represent number of farms. Totals <100% indicate missing values.

FIGURE 1 Via H.A. Aguirre-Villegas and R.A. Larson, Evaluating Greenhouse Gas Emissions from Dairy Manure Management Practices Using SurveyData and Lifecycle Tools, Journal of Cleaner Production 143 (2017) 169e179, http://dx.doi.org/10.1016/j.jclepro.2016.12.133.

manure. Smaller operations tend to use tiestall barns and the survey found that 77% of tiestall barns select a barn cleaner over various alternatives to collect manure. The kinds of collection processes in turn impact the ways that manure can be efficiently stored, processed, and so on.

The fact that manure management processes are interrelated matters because it determines how flexible and open to change these systems are. The Wisconsin study came to the crucial conclusion that: "the inter-related nature of these systems demonstrates how MMS [Manure Management Systems] are often locked in across farm systems through structural and equipment investments... This suggests that changing MMS is complex and requires not only a shift in the potential handling method, but also potential shifts in storage and application equipment as well. Flush handling can't easily shift to scraper handling, without potentially shifting from liquid to a slurry and then investing in a surface application tank or truck system."[11]

The study also found that dairies using solid manure management systems were "highly heterogenous, where farmers may have a suite of alternative manure management strategies available to them, and substitution is viable."[12] The study found that dairies using liquid manure management systems, on the other hand, had "very few substitutes in their MMS, suggesting greater investment in certain infrastructures, which are not easily changed."[13]

This of particular concern in California, where liquid manure management systems dominate. It is not good news for advocates interested in relying on technological changes to reduce emissions from the dairy industry. It means that mitigation interventions can be constrained by decisions about manure consistency and ultimately by the scale of operation. This means that taking dairy decarbonization seriously requires reconsidering the federal and state policies that have consistently favored industrial-scale facilities.

1. *Prevalence of Different Manure Management Systems*

Confinement dairies with liquid manure management systems are more common in California than nationally. Manure lagoons are used on 58%

11 *Id.*
12 *Id.*
13 *Id.*

Manure Share (MS) and Methane Conversion Factor (MCF) of Manure Management Systems

Waste Management System	Pasture	Daily Spread	Solid Storage	Liquid/ Slurry	Anaerobic Lagoon	Deep Pit
MS by system and location						
U.S. Average	7%	15%	23%	21%	32%	2%
California	1%	11%	9%	21%	58%	0%
Wisconsin	7%	12%	42%	24%	12%	4%
MCF by system and location						
U.S. Average	1.2%	0.2%	2.6%	28.6%	69.9%	28.6%
California	1.5%	0.5%	4.0%	35%	75%	35%
Wisconsin	1.0%	0.1%	2.0%	22%	66%	22%

FIGURE 2 Via Jeongwoo Han, Marianne Mintz, and Michael Wang, Waste-to-Wheel Analysis of Anaerobic-Digestion-Based Renewable Natural Gas Pathways with the GREET Model ANL/ESD/11-6, note 13.

percent of dairies in California and 32% percent of dairies nationally.[14] In Tulare and Glenn Counties specifically, one survey found that 96% of dairies use storage or treatment ponds.[15] A 2011 survey of California dairies found that most had freestalls for housing and collect manure thorough flushing and/or daily scraping.[16]

Wisconsin is the number two state for dairy nationally after California, but the practices of Wisconsin dairies look different than those in California. Manure lagoons and liquid manure management systems are less common than in California. A survey of Wisconsin dairies found that they are prevalent on larger operations[17] but uncommon on smaller farms. Because Wisconsin had more smaller farms at the time of the survey, liquid systems were less common overall. 70% of permitted (larger) facilities used liquid manure management systems while 80% of smaller farms used solid manure management systems. Smaller Wisconsin operations tend to land-apply manure immediately, while the largest permitted operations rely heavily on long-term storage (lagoons). The major processing techniques used in the Wisconsin survey were: sand separation (50%), anaerobic digestion and solid-liquid separation (20%), solid-liquid separation and sand separation (10%).

Note that a key difference between dairies in California and colder climates like Wisconsin is that land application is rarely possible during the winter, because the ground is frozen. Instead, permitted facilities typically land apply in batches in the spring and the fall. Additionally, concerns around runoff due to rains when manure is land applied several times a week may be reduced due to California's drier climate.

California's model of dairying generally and manure management specifically has proliferated

14 Jeongwoo Han, Marianne Mintz, and Michael Wang, *Waste-to-Wheel Analysis of Anaerobic-Digestion-Based Renewable Natural Gas Pathways with the GREET Model ANL/ESD/11-6*, Argonne National Laboratory (September 2011), https://publications.anl.gov/anlpubs/2011/12/71742.pdf.

15 D. Meyer et al., *Survey of Dairy Housing and Manure Management Practices in California*, 94 J. Dairy Sci. 9, 4744 (Sept. 2011), https://www.journalofdairyscience.org/article/S0022-0302(11)00489-9/fulltext.

16 H.A. Aguirre-Villegas and R.A. Larson, citing Meyer et al. 2011.

17 *Id.* ("large and permitted facilities handle slurry and liquid manure and have freestalls.")

in other states in recent years.[18] Some analyses distinguish between "traditional" dairying states like New York and Wisconsin, which still tend to have smaller farms on average, and "modern" dairying states, which tend to be in the West where the California-model has become more common.

2. *GHG Impacts of Different Manure Management Systems*

The variability in the climate, geography, scale, and practices of American dairies makes it challenging to make general comparisons regarding their emissions. Due in part to the many possible permutations of these practices and scales, there are limited comparative studies of emissions from small, pasture-based operations and large-scale dairy CAFOs. However, one of the few such studies "indicated that for the metric of milk production per farmland area, the environmental impact (in relation to potential resource utilization and pollutants) was lower for the pasture-based system than the confinement system. Furthermore, the pasture-based system had a lower total environmental impact compared with the confinement system."[19]

The same study acknowledged, however, that "some studies suggested that economies of scale and efficient management could put large farms in a better environmental position (Saam et al., 2005)."[20] The California dairy industry regularly makes this claim, touting its increasing efficiency as decreasing emissions intensity per cow. However, this perspective "misses the holistic economic and environmental impact of concentrating production on larger farms."[21]

Scale, of course, affects emissions and other environmental impacts on dairies. The volume of manure produced has direct implications for GHG emissions. Not only does more manure mean more emissions, but it typically means longer storage periods during which manure can emit GHGs.[22]

The manure form/consistency also has direct implications for GHG emissions. For example, "solid manures have less available water and are usually stored in stock piles that promote aeration, which reduces CH4 emissions. Liquid manures are stored on pits that promote anaerobic conditions, increasing CH4 emissions. Larger dilutions of manure imply larger manure volumes to be handled, which affects GHG emissions due to increased energy consumption"[23] Liquifying manure using flush systems can reduce ammonia emissions in the barn, but increases methane emissions.[24]

18 Rick Barrett and Lee Bergquist, *Industrial Dairy Farming is Taking Over in Wisconsin, Crowding Out Family Operations and Raising Environmental Concerns*, Milwaukee Journal Sentinel (Dec. 6, 2019), https://www.jsonline.com/in-depth/news/special-reports/dairy-crisis/2019/12/06/industrial-dairy-impacts-wisconsin-environment-family-farms/4318671002/ ("…massive milking operations, popularized in California, shatter the traditional model of Wisconsin farms. With so many cattle, they run the risk of contaminating groundwater and overwhelming lakes, rivers and streams with runoff pollution while making it harder for smaller farms to compete."); Lilli LeGardeur, *Milk It*, Louisiana Life (Jan. 4, 2008), https://www.louisianalife.com/milk-it/ ("90 percent of Louisiana dairy farms are "pasture-based," … In confinement dairying – a relatively new style popular out West – cows are fenced inside dirt-floor lots and have all their food delivered … Confinement dairying, by the way, is also called California-style dairying, after the state where it originated. So, to a Louisiana dairy farmer, those TV commercials depicting California cows gallivanting in fields of clover are doubly irritating. They know that most of those California critters never set foot in a grassy pasture. As one local farmer so adroitly observed, "Happy Cows – my ass.""); David Barboza, *America's Cheese State Fights to Stay that Way, Wisconsin Struggles to Keep Pace with West,* New York Times (June 28, 2001), https://www.nytimes.com/2001/06/28/business/america-s-cheese-state-fights-stay-that-way-wisconsin-struggles-keep-pace-with.html ("With the California-style operations, as they are called, about 2,000 megafarms, with an average herd size of 650 cows, produce more milk than 18,000 mostly smaller farms in Wisconsin, where the average herd is 80.")

19 Alice Moscovici Joubran et al., *Invited Review: A 2020 Perspective on Pasture-Based Dairy Systems and Products*, 104 J. Dairy Sci. 7, 7364 (July 2021), citing O'Brien et al., 2012; O'Brien and Hennessy, 2017, https://www.sciencedirect.com/science/article/pii/S0022030221005166.

20 H.A. Aguirre-Villegas and R.A. Larson, *Evaluating Greenhouse Gas Emissions from Dairy Manure Management Practices Using Survey Data and Lifecycle Tools*, *supra* note 3.

21 Claire Kelloway, *Fewer Global Dairy Corporations Drive Overproduction and Pollution, Harming Small Farmers, Report Finds*, Food & Power (July 18, 2020), https://www.foodandpower.net/latest/2020/06/18/fewer-global-dairy-corporations-drive-overproduction-and-pollution-harming-small-farmers-report-finds?rq=dairy.

22 H.A. Aguirre-Villegas and R.A. Larson, *Evaluating Greenhouse Gas Emissions from Dairy Manure Management Practices Using Survey Data and Lifecycle Tools.*

23 *Id*. at 172.

24 Cal. Air Res. Board, Short-Live Climate Pollutant Reduction Strategy (March 2017), https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf; Alice Rocha, *How Handling Manure Waste from Dairy Cattle Impacts Greenhouse Gas Emissions and Climate Impacts*, UC Davis CLEAR Center (May 14, 2021), https://clear.ucdavis.edu/explainers/how-handling-manure-waste-dairy-cattle-impacts-greenhouse-gas-emissions-and-climate ("Scraping and vacuuming, on the other hand, may leave thin layers of manure on the ground which can come in contact with cattle urine causing the emission of ammonia. The latter is generated by a reaction between urea in urine and the urease enzyme in manure.")

The Wisconsin survey modeled emissions from the dairy industry there, and found that:

- Long-term storage is common on larger farms handling liquid manure, which generally increases GHG emissions.
- A natural crust formation during storage creates aerobic conditions on the surface and reduces wind velocity, decreasing methane and ammonia emissions respectively, but increasing nitrous oxide emissions. Total GHG emissions are higher without this crust.
- Frequent manure application reduces both GHG and ammonia emissions from storage due to the shorter retention times and the reduced surface area. These emissions can increase, however, during application as more ammoniacal nitrogen and volatile solids are available to promote nitrous oxide, methane, and ammonia release. Daily or weekly application can also lead to runoff and leaching during precipitation events or snowmelt, resulting in potential eutrophication and loss of valuable nutrients.[25]

Regarding anaerobic digestion in particular, the Wisconsin survey found that:

- Out of the reported processing technologies, anaerobic digestion is the most effective to reduce GHG emissions from both energy and manure.
- Emission reductions from energy come from the displaced emissions that biogas-based electricity has when replacing grid electricity.
- Reductions from manure are mostly from the capture of methane during digestion which is then converted to carbon dioxide during combustion, as well as the reduction of carbon available to produce methane in storage.
- Solid-liquid separation further reduces GHG emissions as fewer volatile solids enter long term storage within the liquid fraction.
- After digestion, ammonia emissions are increased during digestate storage because: 1) mineralization in the digester increases ammoniacal nitrogen, and 2) the inexistence of a natural crust on the storage surface reduces the physical barrier that prevents aeration.[26]

B. Enteric and Other Non-Manure Management Emissions

Reducing emissions from manure management is critical. However, manure management contributes fewer emissions than enteric fermentation.[27] The reduction of enteric emissions has generally been sidelined as a more challenging technical problem because it is based on the natural feature of the ruminant digestive system. Considering the impact of various interventions on both enteric and manure management emissions, however, should be a component of any effort to meet climate targets for dairy.

While enteric fermentation and manure management primarily generate methane, the substantial emissions from feed production include nitrous oxide which is "emitted from cultivated soils and significantly influenced by cultivation practices, especially nitrogen (N) fertilization."[28] Emissions from feed vary based on the amount of feed imported and the composition of rations which themselves can vary based on geography and climate. Dairy feed can be homegrown—either on pasture or harvested corn or grass fermented as silage—or imported (including concentrates, silage, byproducts, and other grains).

Most dairy cows in California eat what's called

25 H.A. Aguirre-Villegas and R.A. Larson, *Evaluating Greenhouse Gas Emissions from Dairy Manure Management Practices Using Survey Data and Lifecycle Tools*, *supra* note 3.

26 *Id*.

27 *Id*.

28 M. Henriksson, C. Cederberg, and C. Swensson, *Carbon Footprint and Land Requirement for Dairy Herds Rations: Impacts of Feed Production Practices and Regional Climate Variations*, citing Bouwman et al., 2002, *supra* note 2.

29 Conor McCabe, *Dairy Cows – the Original Upcyclers: How Ruminant Digestion Turns Byproducts into High-Quality Nutrition*, UC Davis CLEAR Center (Jan. 07, 2022), https://clear.ucdavis.edu/explainers/dairy-cows-original-upcyclers.

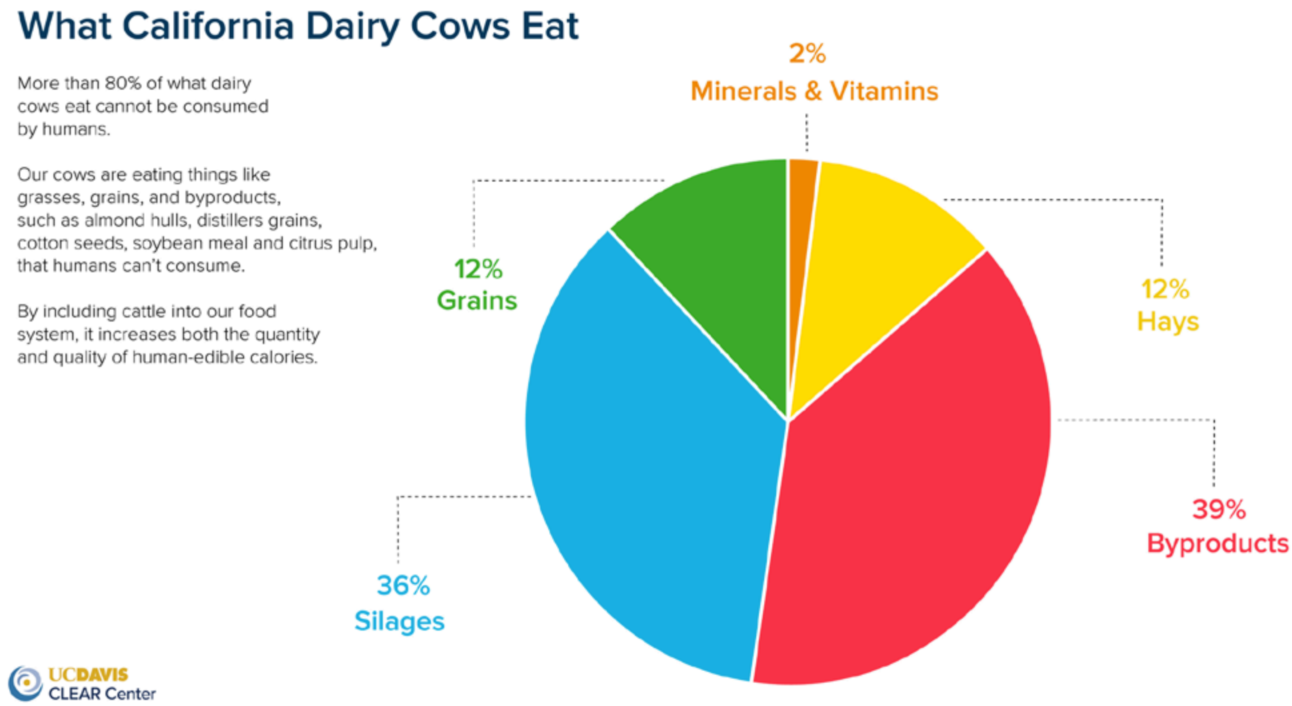


Figure 3: Composition of dairy cattle diets across 40 California dairies. Byproducts include cotton seeds, canola meal, dried distillers grains, almond hulls, soy hulls, whey, fat supplements, soybean meal, corn gluten, wheat byproducts, and rice bran.
Credit: CLEAR Center

FIGURE 3 Via Conor McCabe, Dairy Cows – the Original Upcyclers: How Ruminant Digestion Turns Byproducts into High-Quality Nutrition, supra note 29.

a "total mixed ration."[29] Total mixed ration "is essentially a nutritionally formulated feed mix, combining feeds formulated to a specific nutrient content. Such feeds may contain forage (grass silage, hay, or straw), grains (corn, oats, wheat, and barley), protein feeds (soybean, cottonseed, linseed, and groundnut), minerals, vitamins, feed additives, and by-products."[30]

The nutrition profile of grasses consumed through grazing, in contrast, is different, "with potential nutritional benefits, compared with conventional milk derived from total mixed ration."[31] The emissions intensity of each method is also different, depending on the particular composition of grazing forage and of a total mixed ration diet. For example, "Some studies have demonstrated benefits of inclusion of white clover in pasture, due to its ability to reduce nitrous oxide emissions, fix atmospheric nitrogen, and reduce carbon footprint (Ledgard et al., 2009; Yan et al., 2013)."[32] The UC Davis article also cites a Cornell study claiming that the emissions from using byproducts as dairy feed are 60% less than the alternative, which they define as sending the byproducts to a landfill for incineration.

30 Alice Moscovici Joubran et al., *Invited Review: A 2020 Perspective on Pasture-Based Dairy Systems and Products, supra* note 19.
31 *Id.*
32 *Id.*

C. California's Dairy Methane Reduction Strategy

According to California's Short-Lived Climate Pollutant Strategy, "California's dairy and livestock industries account for more than half of the State's total methane emissions and for about five percent of the State's GHG inventory."[33] On dairies, the strategy attributes 20% of emissions to enteric fermentation and 25% to manure management. California has more dairy cows and more dairy methane emissions than any other state.[34] Crucially, the strategy explains that California "also has higher per-milking cow methane emissions than most of the rest of the United States, due to the widespread use of flush water lagoon systems for collecting and storing manure."

The SLCP Strategy noted several potential mitigation measures, including switching away from flush water lagoon systems and switching to pasture-based dairy management.[35] CARB also convened a sub-working group in 2018, which put forth many recommendations on non-digester interventions. In practice, however, CARB has overwhelmingly focused mitigation efforts on the construction and operation of anaerobic digesters ("biogas control systems") on dairy operations and applies a high baseline emissions standard to California operations. Digesters capture the methane emitted from anaerobic lagoons, resulting in the perpetuation of flush water lagoon systems.

California's Alternative Manure Management Program (AMMP) has sought to support measures to mitigate manure emissions other than digesters. All measures other than digesters have been deemed "alternative manure management strategies," despite the fact that they remain commonplace practices is other parts of the country. From 2015-2021, the California Department of Food and Agriculture awarded $195 million to dairy digester projects through the DDRP program and $68.3 million to AMMP projects.

D. Key Takeaways: Manure Management Systems and GHG Emissions

Generalizing about GHG emissions from manure management can be challenging because emissions vary based on factors including soil type, climate, and the specific GHG, but the following are generally true:

- **The more cows an operation has, the more manure is produced, and the more methane is generated**, all else being equal. Decreasing per-cow emissions will not necessarily lead to overall methane reductions if the industry grows.

- **Anaerobic lagoons generate more methane emissions than shorter-term manure storage or more frequent land application.** This is because the manure is stored for a longer period of time and generates more emissions in liquid form.

- **Liquifying manure using flush systems can decrease ammonia emissions but will increase methane emissions**. Flushing also requires large quantities of water. See CARB's Short-Lived Climate Strategy for a discussion of emissions from California dairy practices.

- **Manure lagoons and liquid manure management systems are standard on industrialized dairies because they operate at a scale that makes regular land application of manure unsafe, requiring long-term manure storage.** The industrialized model of dairying generates too much manure to spread regularly on the land without causing nutrient pollution. As a result, industrial-scale dairies must store

33 Cal. Air Res. Board, Short-Live Climate Pollutant Reduction Strategy (March 2017), https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf.
34 *Id*. at 63.
35 *Id*. at 65.

manure for long periods of time, land applying only when cropland is available and the climactic conditions are appropriate. This requires operations to transport manure from barns to manure lagoons where it can be stored.

- **Manure lagoons and liquid manure management systems are far less common on small and mid-sized dairies, which can apply manure to land more frequently.** Smaller operations often have adequate land to spread manure safely at more regular intervals. As a result, they don't have to store manure for long periods of time—one of the major sources of methane emissions. This also gives smaller operations more flexibility and a greater range of options for how they manage manure. Not only do smaller operations generate fewer emissions, but their systems are less rigid than those of industrial operations. They can adapt to new mitigation measures more easily.

- **The industrialized model of dairying was pioneered in California and exported nationally. Industrialized dairies are more common in California than anywhere else in the country.[36] California's incentives for digesters are again promoting an industrialized model of dairying nationwide.** Dairy digesters, and the lucrative LCFS credits that manure biogas can generate, are only feasible on the largest dairies operations. While industrial-scale facilities are the norm in California, this isn't the case in many other dairying states where smaller operations are still more common. Smaller scale dairies aren't suited to digesters precisely because they do not have highly emitting lagoons; however, lucrative LCFS incentives for digesters are available nationwide. At the same time, additional revenue from LCFS credits further bolsters the competitive edge of the largest operations. Creating incentives for dairies to adopt liquid manure management practices with anaerobic lagoons could increase emissions in other states where these polluting systems are less common.

- **California is also promoting alternative manure management practices, but these have been funded at a fraction of the rate of digesters.** What CARB calls "alternative manure management strategies" are not radical departures from dairying practice. The Alternative Manure Management Program (AMMP) defines these practices as essentially anything that's not a digester (those practices "that don't include use of an anaerobic digester, and support management of manure in a dry form.")[37] The broad range of practices that fit within this definition—like solid separation, conversion from flush to scrape in conjunction with some form of drying or composting of collected manure, and pasture-based management—are common nationwide.[38]

- **Even with CARB's aggressive digester push, California is significantly behind on its methane targets** and, according to CARB's analysis, relying on digesters alone to reach the target would cost an additional $3.9 billion. See CARB's 2022 Dairy and Livestock Methane Progress Report here.

36 See, *e.g.*, Dr. John W. Siebert, *A Word from the Bad Guys*, UC Davis (Oct. 1984), http://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/c709e8dc-9761-4850-bd9d-735f0d1092d9; (UC Davis professor speaks directly to dairy farms outside of California to address the perception that California dairies are "heartless corporate farms"); Rick Barrett and Lee Bergquist, *Industrial Dairy Farming Is Taking Over in Wisconsin, Crowing out Family Operations and Raising Environmental Concerns*, Milwaukee Journal Sentinel (Feb. 11, 2020), https://www.jsonline.com/in-depth/news/special-reports/dairy-crisis/2019/12/06/industrial-dairy-impacts-wisconsin-environment-family-farms/4318671002/ ("...massive milking operations, popularized in California, shatter the traditional model of Wisconsin farms...); Lili LeGardeur, *Milk It*, Louisiana Life (Jan. 4, 2008), https://www.louisianalife.com/milk-it/ ("90 percent of Louisiana dairy farms are "pasture-based," ... In confinement dairying – a relatively new style popular out West – cows are fenced inside dirt-floor lots and have all their food delivered ... Confinement dairying, by the way, is also called California-style dairying, after the state where it originated.").

37 Cal. Dep't of Food and Ag., Alternative Manure Management Program, https://www.cdfa.ca.gov/oefi/AMMP/.

38 *Id.*

Around the country, in California, and in the Central Valley itself, farmers and community members are reimagining our food systems. California policymakers have a crucial role to play leading the nation in this conversation. California policymakers should be thinking creatively and holistically about what a just transition would look like for California dairies and the policy mechanisms that would be required to support a more sustainable industry.

III. Life Cycle Analysis Assumptions and Applications

The Low Carbon Fuel Standard (LCFS) allows dairies to generate credits for the production of manure biogas-derived transportation fuels. These credits are intended to incentivize the construction and operation of anaerobic digesters on dairy operations.

The LCFS calculates the carbon intensity (CI) of different transportation fuels by analyzing the life-cycle greenhouse gas emissions associated with a given fuel. To conduct these life cycle analyses, the LCFS uses "fuel pathways," which delineate which processes are included in a given fuel's life cycle. The program employs a version of the "GREET" model, which stands for the "The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation" model.[39] The GREET model was developed by Argonne National Laboratory.

There are several different kinds of pathways in the LCFS program. Lookup table pathways are applied to conventional fuels where the basic values are well-established. Fuel producers can simply look up the CI values for these fuels because they are set by CARB. Tier 1 pathways allow producers of alternative fuels to input operational data into a simplified version of the CA-GREET model to calculate the CI of their fuel. Tier 2 pathways allow alternative fuel producers to use the full CA-GREET model to conduct a custom CI analysis.

Evaluating the completeness and accuracy of LCFS manure biogas life cycle analyses is challenging because almost all participating swine and dairy operations have opted to use the customizable Tier 2 pathway. This means there is not one single life cycle analysis for biogas; instead, most of the several hundred producers that generate credits for the capture of manure methane have conducted their own customized analysis using the CA-GREET model. However, there are several issues apparent in CARB's Tier 1 pathway and considerations regarding the GREET model overall.

Life cycle analyses generally could be critiqued on a number of bases, including the emissions they opt to include, the reference scenario they assume, how emissions are quantified, and whether the model's assumptions are borne out in on-the-ground monitoring. Based on forthcoming research, it is our understanding is that, *when all is working as intended*, CARB's life cycle analysis for manure-derived biofuels generally reflects the actual emissions and reductions from biogas control systems. That is, if we accept the assumptions built into the model, the emissions and reductions counted by the model are generally accurate in practice when biogas systems are functioning as intended. The primary issues with the life cycle analyses for manure-derived biofuels, therefore, are high-level disagreements about the appropriate reference scenario and the life cycle analysis' focus on transportation emissions at the expense of agricultural emissions, as well as more specific monitoring to groundtruth those assumptions and to monitor for fugitive emis-

39 Argonne National Laboratory, *GREET: The Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model: The Gold Standard for Life Cycle Analysis of Technologies and Energy Systems* (May 2020), https://www.anl.gov/sites/www/files/2020-10/GREET_Impact_Sheet.pdf.

40 Our research on this topic was informed by a background interview with an environmental scientist who shared their evaluation of monitoring concerns as well information about forthcoming research.

sions, which are a "substantial" concern.[40]

A. Groundtruthing Life Cycle Analysis Estimates and Reported Reductions with Data

One article describes the downside to "bottom-up" emissions analyses like CARB's:

> *Bottom-up inventories, including those used by the US Environmental Protection Agency (US EPA, 2017) and the California Air Resources Board (Charrier, 2016), estimate dairy emission rates at the state level based on the total number of cows and herd demographics and on the average statewide manure management approach, CH_4 emissions factor, and climate. However, livestock emissions, especially from dairies, remain one of the largest uncertainties in these inventories (Maasakkers et al., 2016), as there is no comprehensive information source for the number of cows or manure management strategies*.[41]

California has a lot riding on the reported (on-paper) emissions reductions from dairy digesters. These estimates should be groundtruthed with actual monitoring. On its own terms—that is, if concerns about the assumptions made in CARB's life cycle analysis models are temporarily set aside—forthcoming research based on a single facility suggests that CARB's manure biogas life cycle analyses are accurate when biogas control systems are working as intended. However, biogas control systems may not always work as intended. One environmental scientist our team spoke with cited "substantial" concern about fugitive emissions from digester systems. Fugitive emissions are essentially leaks where the captured methane can escape and be vented to the atmosphere.

CARB itself came to this conclusion in the wake of a methane survey, acknowledging:

> "As expected with any new technology, during the initial operational deployment of [anaerobic digesters (AD)] situations may arise including leaks or higher-than-predicted venting that can impact the desired methane control efficiency. Characterizing potential AD fugitive emissions through the use of tools like the NASA JPL flyovers can help achieve and maintain the expected methane reductions by helping digester operators optimize their systems and reduce revenue loss."[42]

CARB requires an engineering review for biogas pathway applications, but no ongoing monitoring at the facility level, and does not conduct ongoing monitoring at the regional level itself. Monitoring for methane from dairies overall is challenging because the emissions are so dispersed, intermittent, and can depend on variables like soil type and weather. Unfortunately, unlike other air pollutants like ammonia, methane monitoring is not well-suited to community monitoring efforts. Fortunately, California is home to environmental scientists with this expertise. One environmental scientist suggested that a cost-effective approach to monitoring that prioritized measurable and preventable emissions would be third-party monitoring of fugitive emissions from biogas control systems. At a bare minimum, CARB should be collaborating with these scientists to ensure the methane emissions it reports as captured are not leaking out through biogas control system.

41 Alison R. Marklein et al., *Facility-Scale Inventory of Dairy Methane Emissions in California: Implications for Mitigation*, 13 Earth System Sci. Data 3 (March 22, 2021), https://essd.copernicus.org/articles/13/1151/2021/essd-13-1151-2021.html.

42 Cal. Air Res. Board, *Introduction to the Phase I Report of the California Methane Survey from the Staff of the California Air Resources Board* (October 2, 2017), https://ww2.arb.ca.gov/sites/default/files/2020-07/ca_ch4_survey_phase1_report_2017.pdf.

B. High-Level Life Cycle Analysis Concerns: Reference Scenario Assumptions

The purpose of the CA-GREET model is to estimate the CI of transportation fuels. In evaluating the emissions impact of the displacement of conventional fuels by new, alternative fuels, the structure of the analysis is to assume a static baseline or reference scenario. The analysis can then evaluate a specific alternative fuel intervention against that reference scenario, where the new fuel is the only change. In the manure biogas life cycle analyses, therefore, the model assumes a dairying reference scenario upon which the transportation fuel intervention operates. CARB's reference scenario is based on the dominant approach to dairying in California. That is, CARB's life cycle analysis assumes the ongoing presence of industrial-scale confinement dairies with liquid manure management systems. There are two important critiques of this assumption:

- Rather than seek to change the dairying model to one that generates fewer GHG emissions, CARB takes this system as a given and builds on top of it.
- Because LCFS credits are available nationally, but the reference scenario is based on the (more-polluting) California model of dairying, the program could incentivize a harmful shift in practices from out-of-state dairies at the same time it entrenches those practices at home.

The reference scenario is illustrated concretely by the life cycle analysis' assumption that, if not for the addition of an anaerobic digester, manure would be stored in anaerobic lagoons and, if not for the digester, manure methane would be vented directly to the atmosphere. This is not the case on many of the thousands of farms otherwise eligible for LCFS credits nationwide.[43] Rather than devise a mitigation intervention applicable to these farms, CARB simply excludes them from the program if their practices do not match those in the reference scenario. This is unfortunate, because it limits eligibility for the lucrative LCFS credits to operations with the most polluting practices (those that match the reference scenario).[44]

Manure lagoons are used on 58% percent of dairies in California but only 32% percent of dairies nationally.[45] One early GREET study acknowledged that not all dairies use anaerobic lagoons, explaining: "EPA also estimates MCFs of wet (e.g. anaerobic lagoon, liquid slurry and deep pit) and dry (e.g. daily spread and pasture) manure management systems for cool, temperate and warm climate zones… Note that in Wisconsin, solid storage is used for a larger share and anaerobic lagoons for a smaller share of manure than in the United States as a whole, while in California more than 50% of manure is treated by anaerobic lagoon."[46] But given the concentration of this model of dairying in California's Central Valley, CARB has settled on this reference scenario.

In addition to ensuring that LCFS credits are only available to the largest polluters, this reference scenario allows these operations to claim massive emissions reductions since reductions are equivalent to their "captured" or "avoided" emissions.[47]

43 LCFS credits are not limited to California dairies. Operators need only to inject the resulting natural gas into a common carrier pipeline in North America and link the energetic attributes of that biogas with a pipeline withdrawal for natural gas sold in California. The same principle is applied for electricity generated in the combustion of biogas on-site. (Note, however, that the 2023 SRIA for the new LCFS regulation did propose altering the book-and-claim accounting system.)

44 Traditional pasture-based dairies leave manure in pasture where it is deposited by cows. This is possible because manure is produced in quantities below agronomic rates—the available land can adequately and safely absorb the nutrients from the manure. Industrial scale operations collect and store manure for two reasons. First, they generally hold livestock in confinement, so the manure isn't deposited in pasture as a matter of course and needs to be cleaned out of barns. Second, too much manure is produced on industrial-scale facilities for the available land to absorb nutrients without creating serious environmental harms. As a result, manure is collected and stored in "lagoons." To transport manure into lagoons, manure is typically flushed out of barns, liquifying it and creating new emissions in the process. Manure from the lagoons can periodically be spread on land ("land-applied") at or below agronomic rates.

45 Jeongwoo Han, Marianne Mintz, and Michael Wang, *Waste-to-Wheel Analysis of Anaerobic-Digestion-Based Renewable Natural Gas Pathways with the GREET Model ANL/ESD/11-6.*

46 *Id*.

This means that the more emissions they generate, the more they can capture, the more reductions they can claim publicly, and the more revenue they obtain through LCFS credits. Finally, by calculating credits that are issued nationally based on a California-specific reference scenario, the program risks shifting practices in other states towards California's more polluting model of dairying.

C. High-Level Life Cycle Analysis Concerns: Focus on Transportation, Not Agriculture

The goal of the GREET model used by CARB is to estimate life cycle emissions of transportation fuels, not to estimate emissions from agriculture. Transportation fuel life cycle analyses differ markedly from agriculture life cycle analyses.[48] Biofuels like manure biogas straddle agriculture and transportation fuel life cycle analyses, requiring value judgements about where to set system boundaries. Life cycle analyses for biofuels are well-characterized by the paper cited above as follows:

> *Particularly with biofuels, policy-related requirements, modeling assumptions, analysis limitations, and software can have a significant effect on results (Agostini, Giuntoli, Marelli, & Amaducci, 2020; Hoekman & Broch, 2018; Obnamia, Dias, MacLean, & Saville, 2019). As a result, users need to carefully consider the context, usefulness, and applicability of these complex analyses. Many biofuel life cycle accounting policies and studies try to evaluate the changes that biofuel production has on food production systems. To evaluate impacts to production systems, most analyses use some metric to first assess the status quo such as a reference system (Hoekman & Broch, 2018), business-as-usual (BAU) scenario, or baseline, and then quantify changes that biofuel production creates. As a result, most biofuel-related system boundaries (Figure 8) also include quantifications which involve product substitution or displacement (Vadenbo, Hellweg, & Astrup, 2017).*[49]

A paper by Argonne National Laboratory scientists reiterates that, in the case of biofuels, "GHG emissions for RNG pathways are highly dependent on the specifics of the reference case, as well as on the process energy emissions and methane conversion factors assumed for the RNG pathways."[50] The goal of the LCFS biogas life cycle analysis is to compare the status quo with an alternative where anaerobic digesters are used to capture methane and the resulting transportation fuel displaces conventional fuel use.

Concretely:[51] the GREET model's life cycle anal-

47 Cal. Air Res. Board, *Tier 1 Simplified CI Calculator Instruction Manual: Biomethane from Anaerobic Digestion of Dairy and Swine Manure*, https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/tier1-dsm-im.pdf?_ga=2.140068787.1623257348.1702923028-1380165209.1657241991.

48 Writing on fuel life cycle analyses, scientists from Argonne National Library explained: "A fuel cycle typically includes feedstock recovery and transportation, fuel production, transportation and distribution, and combustion as an end use." Jeongwoo Han, Marianne Mintz, and Michael Wang, *Waste-to-Wheel Analysis of Anaerobic-Digestion-Based Renewable Natural Gas Pathways with the GREET Model ANL/ESD/11-6*. A different paper by Argonne National Laboratory scientists characterized the system boundaries for animal agriculture systems, on the other hand, as follows: "The process considered for animal systems in cradle-to-farm-gate system boundaries normally include feed production, animal husbandry, manure storage and farm management. Farm-gate-to-grave systems include processes such as transportation of product from farm to processing plants, manufacturing of packing materials such as bottles for milk and cartons for eggs, and distribution to retailers and consumers." Heidi Sieverding et al., *A Life Cycle Analysis (LCA) Primer for the Agricultural Community*, 112 Agronomy J. 5, 3788 (May 6, 2020), https://acsess.onlinelibrary.wiley.com/doi/pdfdirect/10.1002/agj2.20279.

49 *Id*.

50 *Id*.

51 The LCFS calculator for Tier 1 pathway for biogas from swine and dairy manure requires applicants to "add facility information and verifiable monthly feedstock, operational energy use, fuel production and co-product data, and transport distances used in calculating the CI of biomethane from dairy and swine manure digesters." Cal. Air Res. Board, *Tier 1 Simplified CI Calculator Instruction Manual Biomethane from Anaerobic Digestion of Dairy and Swine Manure* (June 20, 2023), https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/t1_biomethane_DSM_instruction_manual_v0620023.pdf. The Tier 1 calculator quantifies baseline emissions (of anaerobic lagoons and non-anaerobic storage) as well as emissions associated with the biogas control systems themselves (like emissions from venting events and emissions from effluent ponds), and other emissions not related to the biogas control system itself. The calculator then quantifies avoided methane by comparing baseline methane emissions to project methane emissions. Note that new models for the life cycle analysis are expected to be published for public comment on Tuesday, December 19, 2023. The Tier 2 pathway for manure biogas is simply a customized version of the full CA-GREET 3.0 model. As such, it requires far more input from the producer than the simplified Tier 1 pathway. Additionally, users can choose either a United States or IPCC reference scenario. If they choose a United States reference scenario, they can further specify a reference scenario by state.

ysis for manure biogas begins at manure storage in the lagoon. Beginning the life cycle analysis with manure storage leaves out all emissions that occur before storage: emissions from feed production, general dairy operations, enteric fermentation, and the collection and transportation of manure to lagoons. The justification for starting the life cycle analysis with manure storage in the lagoon is that the manure will be stored in lagoons regardless of the addition of an anaerobic digester incentivized by LCFS credits.[52] That is, CARB assumes a reference scenario based on liquid manure management systems with anaerobic lagoons, as discussed *supra*. Upstream emissions should be considered if CARB seeks to understand the impact of the LCFS on agricultural emissions. Excluding these emissions is justifiable to the extent that CARB limits use of the life cycle analysis to claims about transportation fuel reductions.

At the other end, the life cycle analysis model is bounded by the end-use of the energy generated, either the combustion of RNG as transportation fuel or as electricity. The life cycle analysis also excludes emissions from the storage and disposal of digestate,[53] the by-product of anaerobic digestion. The exclusion of digestate is justifiable if CARB also excludes emissions from manure land application in the reference scenario. An environmental scientist consulted for this research explained that forthcoming research at a single dairy found that emissions from land application and from digestate application are likely comparable. The scientist also stressed that a generalized comparative analysis of manure application versus digestate application would be extremely challenging to implement because emissions are dispersed and vary based on soil conditions, climate, and the specific pollutant studies.[54]

Focusing life cycle analyses on transportation fuels is an intentional and understandable choice by CARB given the intended function of the LCFS. CARB is required to "[c]onsider the significance of the contribution of each source or category of sources to statewide emissions of greenhouse gases."[55] Transportation is the largest source of greenhouse gas emissions in California at 38%.[56] Agriculture is responsible for 9% of emissions in California.[57] Because CARB focuses on transportation fuel life cycle emissions (and, by extension, assumes the existing system of dairying), the Board's decision not to include upstream emissions from dairy operations is justifiable. No life cycle analysis can include all processes and all systems. The exclusion of upstream emissions, however, remains justifiable *only so long as* CARB's focus remains fixed on transportation emissions. CARB should not claim reductions from dairying overall without having analyzed emissions upstream of manure storage.

However, CARB makes a great deal of the avoided methane from agriculture, in addition to the displacement of conventional transportation fuels. This is a key reason that LCFS credit values are so high. CARB also frequently touts emissions reductions from the dairy sector on the basis of

52 Jeongwoo Han, Marianne Mintz, and Michael Wang, *Waste-to-Wheel Analysis of Anaerobic-Digestion-Based Renewable Natural Gas Pathways with the GREET Model ANL/ESD/11-6* (waste is collected in both the reference case (current manure management) and the "new" AD cases.").

53 Anaerobic digester residue is eventually land-applied and still generates emissions, as one GREET study acknowledged. *Id.* That study explained that "62% of the C in the residue is assumed to become CO 2 , and the rest (38%) is assumed to remain stored in the soil." *Id.* That study further asserted that the impacts of anaerobic digester residue land application, "that is, synthetic fertilizer displacement and N2 O and NOx emissions—should be included in LCAs of AD pathways." *Id.* The solid digestate "may be recycled for animal bedding or as a soil amendment, but this is not considered in our analysis." Heidi Sieverding et al., *A Life Cycle Analysis (LCA) Primer for the Agricultural Community, supra* note 48.

54 Indeed, existing literature shows variation in emissions based on a number of factors including different methods of digestate storage and processing. Holly et al., for example, found that storage of digestate with limited oxygen increased nitrous oxide emissions. Holly et al., *Greenhouse Gas and Ammonia Emissions from Digested and Separated Dairy Manure During Storage and After Land Application*, 239 Ag., Ecosystems, and Env't 410 (Feb. 15, 2017), https://www.sciencedirect.com/science/article/pii/S0167880917300701. That study also concluded that "[nitrous oxide] from digester separated solids was much higher than the separated solids without digestion." *Id.*

55 Cal. Health & Safety Code § 38562.

56 Cal. Air Res. Board, Current California GHG Emission Inventory Data, https://ww2.arb.ca.gov/ghg-inventory-data.

57 *Id.*

the LCFS analysis. While the LCFS can estimate a total quantity of emissions captured by anaerobic digesters, the narrow transportation focus of the LCFS has allowed the agency to ignore the fact that this invention locks in the most highly emitting form of dairying, precluding broader reductions.

The dairy sector is responsible for more than half of California's methane emissions.[58] Making claims about reductions from the dairy sector requires a full analysis of dairy emissions. Yet in CARB's *Analysis of Progress Towards Achieving the 2030 Dairy and Livestock Sector Methane Emissions Targets*, the agency begins with primacy of digesters, rather than with a holistic analysis of dairy emissions.[59] CARB's narrative of its process reflects this, stating: "To understand what level of resources are needed to achieve the target, CARB staff looked at existing dairy methane emissions reduction efforts, including both grant programs that fund the initial capital costs and market-based programs that incentivize GHG emissions reductions or low carbon fuel production."[60] But existing emissions reduction efforts have been defined through the transportation lens of the LCFS, which assumes the perpetuation of California's most highly-emitting dairying model. This assumption should not be the starting point for CARB's dairy mitigation strategy.

There is a second broader critique of the limitations of a baseline scenario based on the status quo at a time when we need to decarbonize all sectors simultaneously. The choice is less between the status quo and anaerobic digesters but between anaerobic digesters and a host of other policy choices. Because the dairy digester intervention only evaluates how transportation emissions will change as a result, it risks locking in or increasing dairying emissions at a time when they, too, need to decline.

While relying on a static reference scenario is necessary in any single analysis to draw a meaningful comparison between two alternatives, we are in a time of major transition: We need to decarbonize all sectors—including agriculture—simultaneously, using multiple different tactics. This presents conceptual difficulties for a binary life cycle analysis comparing a static baseline and one potential intervention. The LCFS relies on a static reference scenario of "Current Manure Management" to find that this intervention is better, but it's an intervention that increases the value of manure while other interventions could decrease the value of the manure. The manure biogas life cycle analysis' reliance on a static baseline freezes the reference scenario, both in theory and practice, first by assuming its existence into the future and second by investing in transportation fuel reductions that rely on that status quo.

D. Key Takeaways: Life Cycle Analysis Assumptions and Applications

- **We need to decarbonize all sectors—including both agriculture and transportation—simultaneously**. California policymakers should work to ensure that interventions in one sector are not locking in or increasing emissions elsewhere.

- **Because the LCFS focuses on transportation sector emissions, the fact that the dairy digester intervention locks in emissions-intensive practices in the dairy sector has been given little attention.** CARB's life cycle analysis for biogas-derived fuels assumes the ongoing presence of industrial-scale confinement dairies with liquid manure management systems, locking these systems in both in theory and practice. Because the life cycle

58 Cal. Air Res. Board, Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target (March 2022), https://ww2.arb.ca.gov/sites/default/files/2022-03/final-dairy-livestock-SB1383-analysis.pdf.

59 *Id*.

60 *Id*.

analysis uses this dairying model as its baseline scenario, only dairies that use this model are eligible for lucrative LCFS credits.

- **The LCFS rewards captured (or "avoided") methane. This means that the more emissions dairy operations generate, the more they can capture, the more reductions they can claim publicly, and the more revenue they obtain through LCFS credits**.

- **The life cycle analysis used for transportation fuels is not an appropriate analysis to apply when analyzing overall dairy emissions, because it excludes the bulk of emissions from dairy operations**. The LCFS life cycle analysis was designed to measure the change in transportation sector emissions; it should not be used as the starting point for CARB's broader dairy mitigation strategy.

- **Dairy emissions and leaks from biogas systems are not actively monitored to groundtruth the LCFS' bottom-up estimates for captured methane despite concerns about fugitive emissions.**

IV. Consolidation and LCFS Credits

Dairy industry stakeholders argue[61] that the trend towards consolidation in dairy predates and is independent of the adoption of digester technology and Low Carbon Fuel Standard (LCFS) incentives. This is correct. Consolidation in the dairy industry is a consistent, long-term trend that far predates the LCFS and the embrace of dairy digesters. This fact does not preclude the possibility that LCFS incentives for digesters contribute to that trend in a meaningful way. This section describes the history, geography, and major drivers of consolidation in the American dairy industry. We cannot draw clear conclusions about the impact of the LCFS yet—the data needed to evaluate its effects will be released later in 2024 in the 2022 USDA Agriculture Census. Understanding the drivers of consolidation and pressures on dairy operations still provides essential context for understanding the stakes of incentivizing dairy digesters over other potential interventions.

Among other impacts, dairy consolidation has resulted in the loss of thousands of small and mid-sized farms, contributed to the decline of rural economies and communities, and increased environmental and environmental justice concerns by densely concentrating operations in a few parts of the country. Consolidation matters in the context of the LCFS and the dairy digester push for several reasons:

- First, consolidation of the dairy industry set the stage for the dairy digester push. The consolidation trend has resulted in the dominance of ever-larger, industrial-scale operations over the smaller-scale dairies that were dominant as recently as the 1980s. These factory farms rely on manure lagoons to store the manure they generate, which generates methane emissions for the duration of storage.

- Second, the credits provided by the LCFS may impact the consolidation trend, by encouraging the growth of already-large operations or encouraging operations to merge in order to take advantage of the lucrative credits available for operations that can manage a biogas control system.

- Third, even if the LCFS does not directly incentivize operations to grow or merge, it provides an additional revenue stream for the large-scale operations where digesters are an appropriate intervention. This impact would

61 Ermias Kebreab, Frank Mitloehner, and Daniel A. Sumner, *Meeting the Call: How California is Pioneering a Pathway to Significant Dairy Sector Methane Reduction,* UCDavis CLEAR Center (December 2022), https://clear.ucdavis.edu/sites/g/files/dgvnsk7876/files/inline-files/Meeting-the-Call-California-Pathway-to-Methane-Reduction_0.pdf.

not necessarily be limited to California, as LCFS credits are available to dairies nationwide.

A. Dairy consolidation is a long-term trend.

The trend towards consolidation in dairy is unmistakable and far predates the adoption of the LCFS (adopted in 2009).[62] The trend is clear both nationally and in California. A 2020 USDA report using data from the most recent USDA Agricultural Census (2017) found that since at least the late 1980s, the average dairy herd size has risen consistently, and the number of dairy operations has decreased consistently.[63] The decline in dairies and increase in herd sizes reflects the loss of small and mid-sized farms as production has shifted toward much larger farms.[64] Not only have larger dairies proliferated during this period, but frontier of what is considered "large" has progressively increased.[65]

1. Dairy consolidation coincided with a decline of small farms in the Midwest and the East and growth in industrial-scale operations in the West.

The dairy industry has trended towards consolidation nationally, but the geography of consolidation has varied. The Midwest and the Northeast have "long had many small commercial dairy farms, while production in the major Western Dairy States has revolved around large farms."[66] As the industry has consolidated, the decline of small commercial dairy farms has been "concentrated in the Midwest and the Northeast and in four states in particular: Minnesota, New York, Pennsylvania, and Wisconsin."[67] Alongside the decline in Midwestern and Northeastern small commercial dairies, "[p]roduction has shifted to Western States and is concentrated in a smaller number of counties."[68] That is to say: the decline of small farms in the Midwest and the Northeast (as well as California's dwindling pasture-based operations in Marin and Sonoma Counties)[69] have fueled the growth of the industrial-scale dairies that populate California's Central Valley and other western states.

62 Cal. Air Res. Bd., *Session 9: Overview of Low Carbon Fuel Standard & Dairy/Swine Manure Fuel Pathways* (March 29, 2022), https://ww2.arb.ca.gov/sites/default/files/2022-04/dairy-ws-session-9-CARB.pdf.

63 Commercial dairies declined at an annual average rate of 4.2 percent from 1978 through 2017.The median herd size increased dramatically over this period as well. The report found that the midpoint herd size has risen consistently from 80 or more cows in 1987 to 1,300 cows in 2017. James M. MacDonald, Jonathan Law, and Roberto Mosheim, *Consolidation in U.S. Dairy Farming*, ERR-274 (July 2020), https://www.ers.usda.gov/webdocs/publications/98901/err-274.pdf (this number is for dairies with over 10 cows which closely correlates to dairies that sell milk.)

64 *Id*. at Report Summary. The small commercial farms of 10-99 cows that were typical in 1992 have seen "large and persistent declines." *Id*. at 10. These operations have decreased by "over 80 percent in 1992–2017 for farms with 10–49 cows and over 70 percent for those with 50–99 cows." *Id*. at 10. In 2017 they made up only 12.6 percent of U.S. dairies. *Id*. at 10. Large dairies, on the other hand, make up a larger share of the industry than ever before. The USDA report found that, "In 1992, the census counted 564 farms with at least 1,000 cows, and those farms accounted for less than 10 percent of all cows. Twenty-five years later, nearly 2,000 farms had herds of that size, and they accounted for 55 percent of U.S. inventory." *Id*. at 11.

65 However, the total number of farms with at least 2,000 cows doubled between the 1997 and 2002 censuses, and then nearly doubled again between the 2002 and 2012 censuses, with continuing increases since. The frontier—the size of a dairy farm that we would call "large"—keeps expanding." *Id*.

66 *Id*.

67 *Id*.

68 *Id*.

69 Greig Tor Guthey, Lauren Gwin, and Sally Fairfax, *Creative Preservation in California's Dairy Industry,* 93 Geo. R. 2 (April 2003), 171, https://www.jstor.org/stable/30033905.

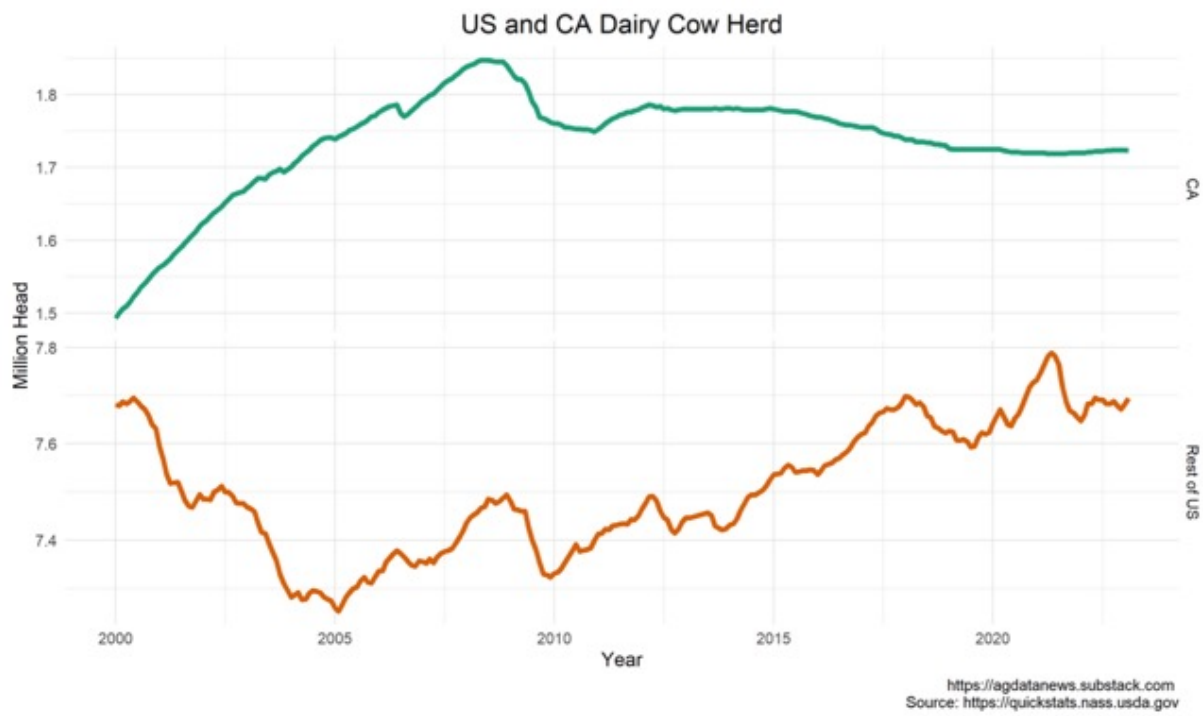


FIGURE 4 Via Aaron David Smith, Are Manure Subsidies Causing Farmers to Milk More Cows? (April 7, 2023), available at https://asmith.ucdavis.edu/news/are-digesters

The California dairy industry began consolidating before other major dairying states like Wisconsin and New York, generating pressure for other states to consolidate in order to compete with California's new mega-dairies. California surpassed Wisconsin as the top producer of milk nationally in 1993 and has held that position ever since.[70]

California led the way nationally in consolidating and industrializing the industry[71] for several reasons. The University of California provided essential research (as respective land grant universities did in other states); the intense urbanization pressures around Los Angeles County resulted in several cycles of "urban encroachment, farm relocation, and herd expansion" throughout the mid-century; and California's unique geography "created ideal conditions for growth, despite several setbacks related to land prices, water availability, and the relatively late start for the industry."[72]

The industrialization of California dairies was facilitated by University of California research into "breeding and genetic experimentation to increase the productivity of cows and milkfat content of the milk and the development of dairy-farm building plans that were structurally appropriate

70 Sophie Barrowman, *Transformations in California's Dairy Industry: Mapping Regional Variations in Milk Production and Operations,* Master of Arts Thesis, University of Cal. Davis Geo. Dep't, https://escholarship.org/uc/item/4tx1m87s (citing Sumner 2020).

71 In California, dairies are concentrated in the San Joaquin Valley, in particular in Tulare and Merced counties. The dairies in this region are "almost all confinement-style dairies." There are also some remaining dairies in western San Bernadino and Riverside Counties, but these areas have seen significant decline due to urbanization. North of San Francisco, in Marin, Sonoma, and Humboldt Counties, there is a small cohort of smaller-scale pasture-based and organic dairies. Daniel A. Sumner, California Agriculture: Dimensions and Issues, Chapter 6: California Dairy: Resilience in a Challenging Environment, 143, https://s.giannini.ucop.edu/uploads/pub/2021/01/21/chapter_6_dairy_2020.pdf.

72 Sophie Barrowman, *Transformations in California's Dairy Industry: Mapping Regional Variations in Milk Production and Operations,* Master of Arts Thesis, University of Cal. Davis Geo. Dep't, (citing Butler andWolf 2000). *See also* James Sterngold, *Urban Sprawl Benefits Dairies in California*, New York Times (Oct. 22, 1999), https://www.nytimes.com/1999/10/22/us/urban-sprawl-benefits-dairies-in-california.html. Other contributing factors included: "the geographic isolation of the state requiring sufficient in-state processing facilities; the large and diverse population creating demand and labor for the industry; and the early adoption, or rather invention, of dairy science technology." *Id.*

for California's warmer climate."[73] The combination of advances in breeding, the pressures of urbanization, and the introduction of drylot feeding by Dutch immigrants pushed industrialization forward, beginning with Los Angeles County.[74] While urban encroachment in the broader Los Angeles area pushed farms out of the region, farmers were often able to sell land at high prices to developers giving them the capital needed to build out newer, larger facilities, often in the Central Valley.

Drylot feeding (also known as zero-grazing) is the "practice of concentrating cows into a small acreage and bringing their food to them." This practice was "revolutionary" for the dairy industry in California.[75] It was well-suited to California and particularly to the Central Valley, because "the abundance of local agricultural by-products like sugar beets and citrus and the availability of cheap hay made drylot feeding affordable, actually increasing milk production per cow compared to grazing."[76] The abundance of agricultural by-products remains a major benefit to California's dairy industry today.

California's climate also contributed to the unprecedented growth of the state's dairy industry. A UC Davis marketing memo from 1984 aimed at changing eastern and midwestern dairies' perception of California dairies as "heartless corporate farms," explained that the climate also facilitated regular expansion: "Due to the ideal climate, cows do not need the elaborate shelter that is required in other parts of the U.S. That means that when times are good, California dairy farmers add cows. In contrast, dairy farmers in other areas of the U.S. must add facilities before they can add cows."[77] Traditional dairying states like New York and Wisconsin experience weather variation throughout the year that requires modifying their practices, including but not limited to housing.

The California dairy industry only benefitted from the loss of small farms in the Midwest and East, however, until other states, particularly other western states, adopted the scale and industry structure that had given California dairies a competitive edge. In 2004, California dairies had the largest herd size in the country. Since then (through 2017, at least, the most recent year for which we have consistent USDA data) other major dairying states have increased herd sizes dramatically to compete, or as Sumner asserts simply: "dairy industries in other states have become more like those in California."[78]

73 *Id*. citing Hutchison 1946.
74 *Id*. citing Gilbert and Wehr 2003.
75 *Id*. citing Gilbert and Wehr 2003.
76 *Id*.
77 Dr. John W. Siebert, *A Word from the Bad Guys*, UC Davis (Oct. 1984), http://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/c709e8dc-9761-4850-bd9d-735f0d1092d9.
78 Daniel A. Sumner, California Agriculture: Dimensions and Issues, Chapter 6: California Dairy: Resilience in a Challenging Environment, 143, https://s.giannini.ucop.edu/uploads/pub/2021/01/21/chapter_6_dairy_2020.pdf.

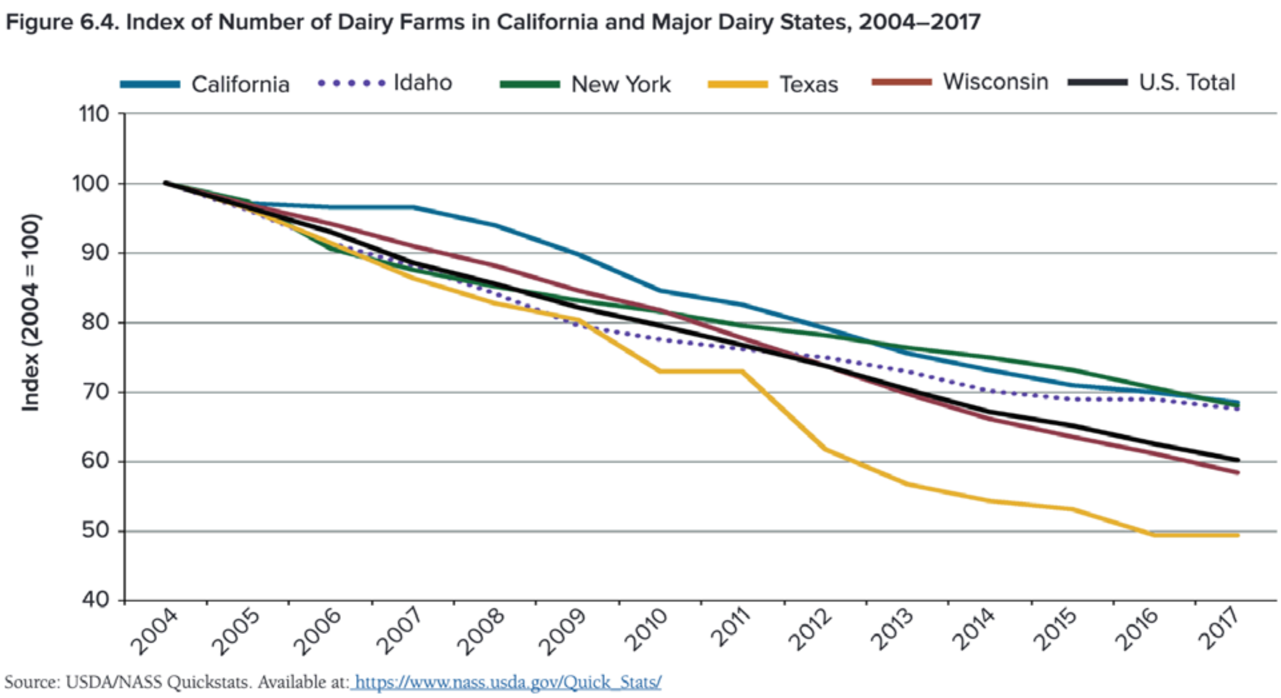


FIGURE 5 Via Daniel Sumner, California Agriculture: Dimensions and Issues (data sourced from USDA/NASS Quickstats), https://s.giannini.ucop.edu/uploads/pub/2021/01/21/chapter_6_dairy_2020.pdf.

2. *Drivers of consolidation include declining domestic demand, dismantling of supply management policies, trade policies that promote exports, and economies of scale.*

Major drivers of consolidation include declining domestic demand, changes to federal programs and subsidies, and economies of scale. Analyses of consolidation often point vaguely to "economic forces,"[79] but these economic forces have been constructed by policy choices. A Food and Power piece characterizes the problem like this:

> *Dairy farmers, particularly in the U.S. and Europe, are stuck in a cycle of consolidation and overproduction. Fewer, more powerful buyers, paired with declining domestic demand and dismantled supply management policies, have pushed the prices paid to farmers below their cost of production. In response, farmers seek to lower their costs per gallon and survive on high volumes. But as more farms seek a larger scale, milk production continues to increase, perpetuating oversupply, low milk prices, and a reliance on export markets.*[80]

The 2020 USDA report described "powerful cost incentives behind farm consolidation." Due to economies of scale, "larger farms are more likely to realize positive net financial returns to milk production..."[81] But economies of scale apply to most agricultural operations and the pace

79 See *e.g.* Ermias Kebreab, Frank Mitloenher, and Daniel A. Sumner, *Meeting the Call: How California is Pioneering a Pathway to Significant Dairy Sector Methane Reduction*, UCDavis CLEAR Center (December 2022), https://clear.ucdavis.edu/sites/g/files/dgvnsk7876/files/inline-files/Meeting-the-California-Pathway-to-Methane-Reduction_0.pdf.

80 Claire Kelloway, *Fewer Global Dairy Corporations Drive Overproduction and Pollution, Harming Small Farmers, Report Finds* (June 18, 2020), Food & Power, https://www.foodandpower.net/latest/2020/06/18/fewer-global-dairy-corporations-drive-overproduction-and-pollution-harming-small-farmers-report-finds?rq=dairy.

81 For more on economies of scale, *see* James Macdonald, *Scale Economies Provide Advantages to Large Dairy Farms* (August 3, 2020), U.S.D.A. Econ. Res. Service, https://www.ers.usda.gov/amber-waves/2020/august/scale-economies-provide-advantages-to-large-dairy-farms/.

of dairy consolidation "far exceeds the pace of consolidation seen in most of U.S. agriculture."[82]

One of the major developments that exacerbated the trend towards consolidation was the embrace of export markets in the early 2000s. Historically,[83] the American dairy industry was focused on the domestic market.[84] Around the turn of the 21st century this began to change. A 2016 USDA report on the dairy export[85] market explains: "From 2004 to 2014, the value of U.S. dairy product exports more than quadrupled."[86] This was a "significant change for an industry previously focused primarily on domestic rather than international demand."[87]

According to the 2016 USDA report, exports increased due to increasing incomes in developing countries ("demand"), free trade agreements opening up new markets (the North American Free Trade Agreement in particular), market-based reforms in China, and finally, a reduction of "domestic support and export subsidies for dairy products in recent years, bringing about greater openness of world markets."[88]

At the domestic level, major changes came to longstanding price supports for dairy, which had long set floors on dairy prices. According to the 2016 USDA report: "The Milk Price Support Program (MPSP) was established by the Agricultural Act of 1949 and was amended several times over the years. Through the program, the Federal Government purchased dairy products in order to support milk prices at specified levels."[89] The purpose of the program (ultimately repealed in the 2014 Farm Act) was to correct for an oversupply of dairy that made it impossible for dairy farmers to adequately support themselves.

Removing the price supports that made smaller-scale dairying possible was necessary to embrace export markets but created incentives for consolidation. Today, American dairies "must compete aggressively for a share of consumer food budgets and for resources and investment capital," not just in the United States but globally.[90] The growth of the export market and broader globalization of the dairy industry has also "tended to emphasize the strength of multinational dairy firms."[91] At the level of the individual dairy operation, industrial-scale facilities are better able to operate in this landscape and contend with the greater and demand price volatility.

At the international level, the Uruguay Round of the General Agreement on Tariffs and Trade concluded in 1994 "with an agreement that fundamentally changed the treatment of national agricultural policies under the multilateral rules of global trade."[92] The Uruguay Round Agreement on Agriculture[93] brought national agricultural policies under the purview of the newly formed World Trade Organization, such that "trade-distorting policies" could be disciplined or constrained.[94]

82 *Id*.

83 Protectionism in agriculture has often been framed as a national security concern (or more recently as food sovereignty). These concerns remain very live today. See, *e.g.* Dr. Krista Versteeg, *It's Time to Talk about Food and Agricultural Security* (March 21, 2023), U.S. Dep't Homeland Sec. Science and Tech., https://www.dhs.gov/science-and-technology/news/2023/03/21/its-time-talk-about-food-and-agriculture-security.

84 Jess Cessna, Lindsay Kuberka, Christopher G. Davis, and Roger Hoskin, *Growth of U.S. Dairy Exports,* U.S.D.A. Econ. Res. Service (November 2016), https://www.govinfo.gov/content/pkg/GOVPUB-A93-PURL-gpo75564/pdf/GOVPUB-A93-PURL-gpo75564.pdf.

85 Note that dairy exports are typically dry milk or milk powder, which is "traded internationally at higher volumes than liquid milk products, since liquid products are bulky and often perishable, making them costly to ship and store." Powdered milks are often reconstituted in low-income countries, but are also common products in other dairy products and can be used as animal feed. Other dairy products traded internationally include cheese, infant formula, butter or butterfat products, whey products, casein products, and lactose. *Id*.

86 *Id*.

87 *Id*.

88 *Id*.

89 *Id*. at 21.

90 Donald Blayney and Mark Gehlhar, *U.S. Dairy at a New Crossroads in a Global Setting*, U.S.D.A. Econ. Res. Service, https://www.ers.usda.gov/amber-waves/2005/november/u-s-dairy-at-a-new-crossroads-in-a-global-setting/.

91 *Id*.

92 *Id*. quoting Burfisher, 2001. *See also* Don P. Balyney, Terry L. Crawford, and Christopher G. Davis, *Dairy Export Markets: Changing the Structure of US Dairy Demand*, 19 Int'l Food and Agribus. Mgmt Rev. B (2016), https://www.ifama.org/resources/Documents/v19ib/1220150087.pdf.

93 Agriculture became the most important issue in the failed Doha Round.

94 Donald Blayney and Mark Gehlhar, *U.S. Dairy at a New Crossroads in a Global Setting*.

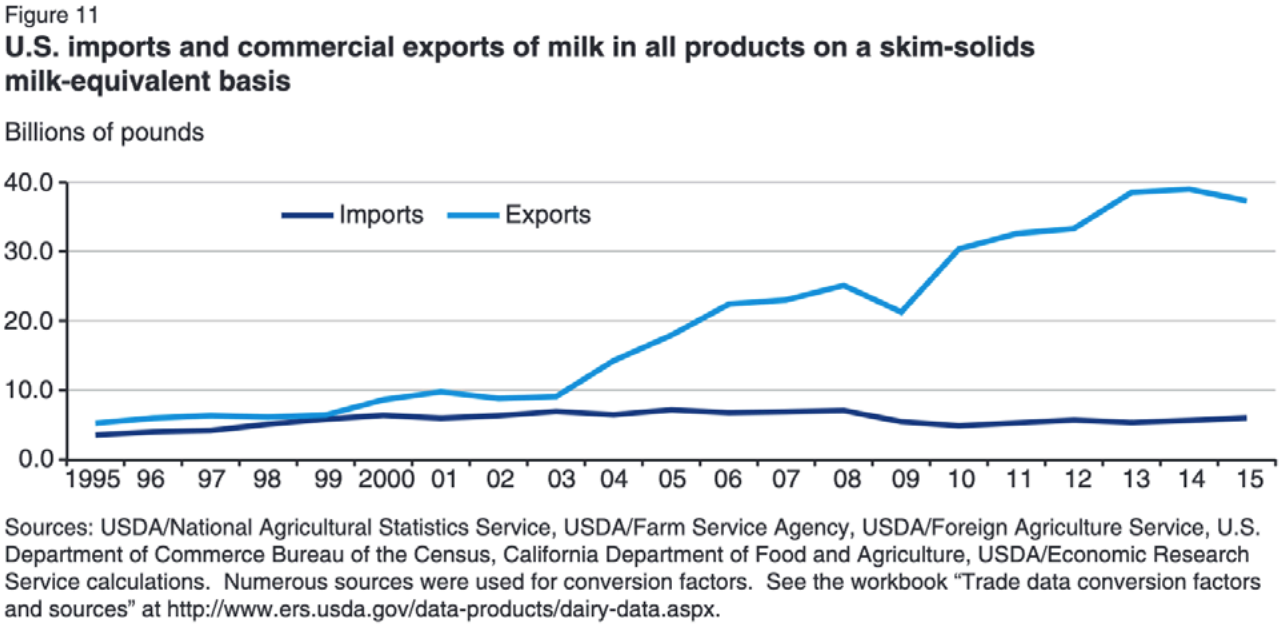


FIGURE 6 Via Jess Cessna, Lindsay Kuberka, Christopher G. Davis, and Roger Hoskin, Growth of U.S. Dairy Exports, U.S.D.A. ECON. RES. SERVICE, supra note 84.

Implementation was phased in over a 6-year period that concluded in 2000 – 2001, just as U.S. dairy exports began dramatically increasing.

The growth of the U.S. dairy export market has not only accelerated consolidation but resulted in "greater variability in demand and prices."[95] California's dairy industry exports "about a third of all U.S. dairy exports, about twice its share of national production," making it particularly susceptible to the pressures of the global market, as will be discussed in more detail in the leakage section.[96]

B. Data that can be used to analyze the impact of the LCFS will become available in 2024.

The USDA consolidation report uses the most recent agriculture census data from 2017, but the LCFS adopted the inclusion of fuels from dairy and swine manure in 2017.[97] The use of fuels from dairy and swine manure in California appears to have taken off in earnest in 2018,[98] and therefore the impacts on the industry as a whole are not likely to be observable in the 2017 agriculture census data. (UC Davis agro-economist Aaron David Smith notes, "Data from the 2022 census will enable us to see whether the number of cattle on large farms has increased during the digester boom, but it will not be released until next year.")[99] USDA recently announced that the 2022 Agriculture Census will be released on February 13, 2024.[100]

95 *Id*.

96 Daniel A. Sumner, California Agriculture: Dimensions and Issues, Chapter 6: California Dairy: Resilience in a Challenging Environment, 143, https://s.giannini.ucop.edu/uploads/pub/2021/01/21/chapter_6_dairy_2020.pdf.

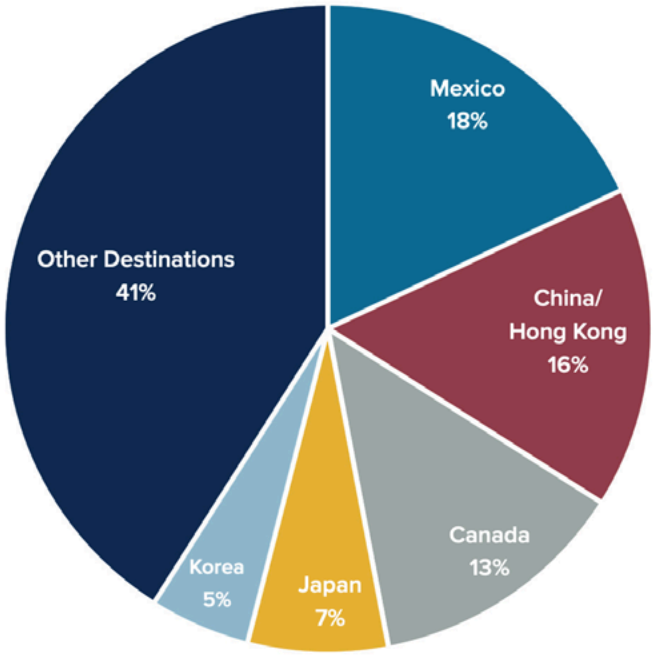
97 Cal. Air Res. Bd., *Session 9: Overview of Low Carbon Fuel Standard & Dairy/Swine Manure Fuel Pathways* (March 29, 2022), https://ww2.arb.ca.gov/sites/default/files/2022-04/dairy-ws-session-9-CARB.pdf but it says specifically a simplified calculator was adopted in 2019 and we know most applications are tier 2 anyway. The presentation says there were already 67 applied DSM pathways by Jan 1 2019. Table on slide 7 suggests credits first generated for dairy biomethane in 2017.

98 Cal. Air Res. Bd., *Session 9: Overview of Low Carbon Fuel Standard & Dairy/Swine Manure Fuel Pathways*.

99 Aaron David Smith, *Are Manure Subsidies Causing Farmers to Milk More Cows?* Ag Data News (April 7, 2023), https://asmith.ucdavis.edu/news/are-digesters.

100 U.S. Dep't of Ag., Agriculture Census, https://www.nass.usda.gov/AgCensus/.

Figure 6.10. California Dairy Product Destinations, Share of 2018 Exports



Source: University of California Agricultural Issues Center

FIGURE 7 Via Daniel A. Sumner, CALIFORNIA AGRICULTURE: DIMENSIONS AND ISSUES, Chapter 6: California Dairy: Resilience in a Challenging Environment, 143, https://s.giannini.ucop.edu/uploads/pub/2021/01/21/chapter_6_dairy_2020.pdf.

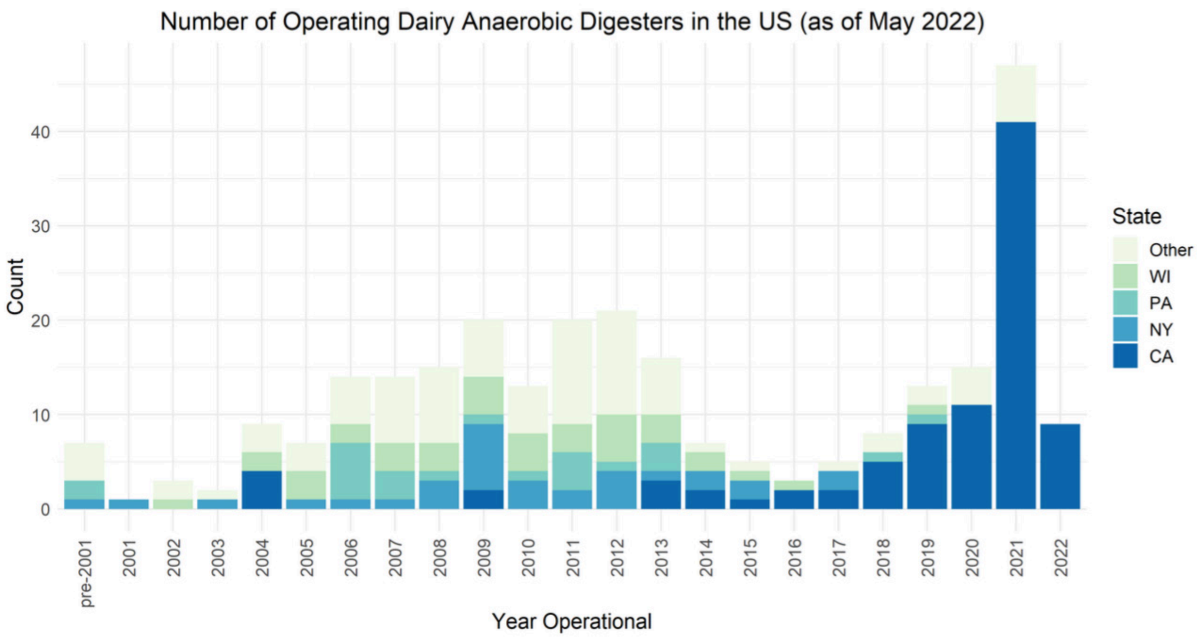


FIGURE 8 Via Aaron David Smith, Are Manure Subsidies Causing Farmers to Milk More Cows? (April 7, 2023), Ag Data News https://asmith.ucdavis.edu/news/are-digesters.

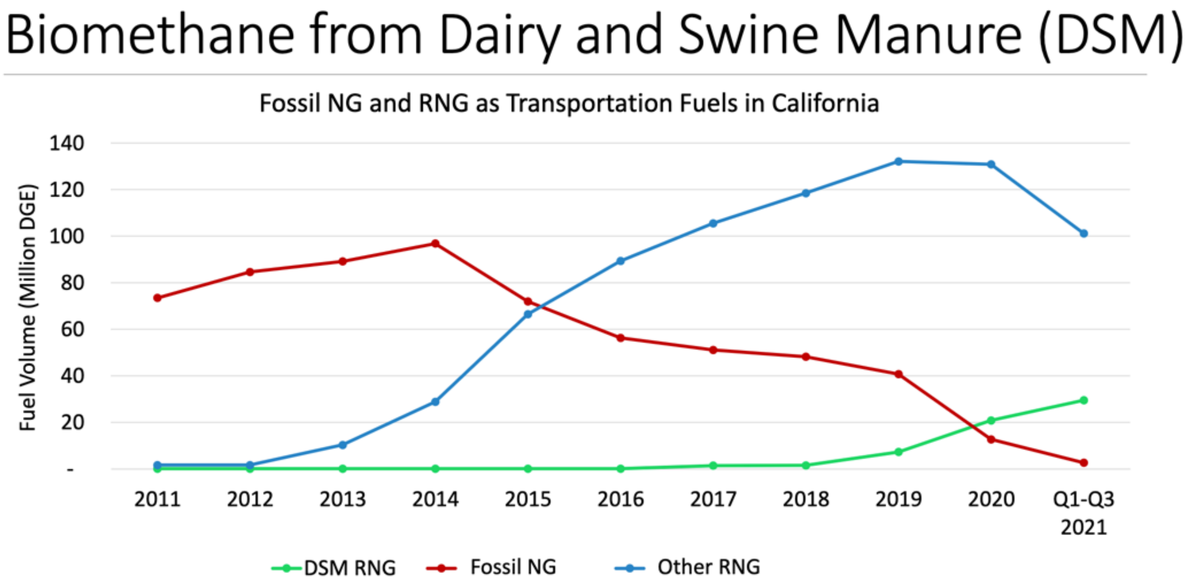


FIGURE 9 Via Cal. Air Res. Bd., Session 9: Overview of Low Carbon Fuel Standard & Dairy/Swine Manure Fuel Pathways (March 29, 2022), *https://ww2.arb.ca.gov/sites/default/files/2022-04/dairy-ws-session-9-CARB.pdf*.

C. Key Takeaways: Consolidation and LCFS Credits

- **The data required to analyze the impact of the LCFS on dairy consolidation will not be available until February 13, 2024.** The most recent Agriculture Census year is 2017, which is too early to show the effects of LCFS credits on California dairy. Any impact from the LCFS would likely be small, but dairy operations operate on slim margins so even a small shift in incentives could accelerate the pre-existing trend.

- **Dairy consolidation is a long-term trend driven by policy choices.** Small and mid-sized dairies in the Midwest and the East declined dramatically over past decades, as mega-dairies concentrated in the West, and particularly in California, have ballooned. There are many causes of consolidation including the dismantling of supply side management programs and the opening of export markets, which multiplied economies of scale.

- **There is a symbiotic relationship between industrialization, consolidation, and the push for dairy digesters.** Consolidation has resulted in fewer, ever-larger dairy operations. The larger operations become, the more manure they must manage and the more likely they are to rely on a manure lagoon. Dairy consolidation has set the stage for the digester push as the California dairy industry has become dominated by industrial-scale operations with manure lagoons.

- **Investing in industrial dairies further bolsters the competitive edge of these mega-operations at the expense of more sustainable dairying models and burdens environmental justice communities.** Smaller-scale dairies and pasture-based dairies have been fighting to preserve their competitive edge, but the LCFS provides credits that are generally only available to the largest dairies. Industrial dairying also contributes to and exacerbates ongoing environmental justice harms (the EPA states: "The San Joaquin Valley has some of the nation's worst air quality, failing to meet federal health standards for both ozone (smog) and particulate pollution").[101] And because industrial dairying has been historically prevalent in California, California environmental justice communities in the Central Valley have long experienced these harms.

V. Emissions Leakage Risk

Industry stakeholders assert that regulating methane from dairies[102] will push dairies out of business or out of state, exacerbating overall GHG emissions.[103] The movement of an industry and its emissions to another jurisdiction in order to avoid regulatory costs is called emissions leakage, and could present legal concerns.

AB 32 (2006) requires CARB to "minimize leakage to the extent feasible" in regulations promulgated under Parts IV and V of the Global Warming Solutions Act of 2006.[104] This includes the LCFS, promulgated under Part IV as an early action measure. The statute defines leakage as "a reduction in emissions of greenhouse gases within the state that is offset by an increase in emissions of greenhouse gases outside the state."[105] SB 1383 (2016) also requires CARB to "minimize and mitigate leakage to other states or countries as appropriate" in any potential regulation of dairy methane.[106]

The claim that regulating dairy methane will result in leakage has two parts that demand scrutiny. The first is the predictive assertion that if regulation is implemented, facilities will a) not be able to bear the costs of doing business and b) will be adequately mobile to move. The second is the premise that California leads the nation in "climate-smart dairy farming." If California dairies generate more emissions than dairies in other states,[107] outmigration of dairies won't necessarily result in equivalent or increased overall GHG emissions.

Additional political concerns are sometimes wrapped into the legal leakage claims. Generally, these arguments slip other value-laden claims about the loss of California dairy operations into the discussion, including the loss of jobs, the economic and cultural loss of the dairy industry, and sometimes implications that industry moving out-of-state will result in greater environmental degradation beyond GHG emissions. These important points bear discussion, but they are distinct from the legal emissions leakage argument.

The argument that methane regulation could lead to emissions leakage holds water if:

a) Other states are a more appealing place to operate than California;
b) The industry is adequately mobile to move;
c) The move would result in equivalent or a net increase in emissions.[108]

Legally, regulators are not required to prevent leakage altogether. They are required to "minimize" leakage in the context of the LCFS and to "minimize and mitigate" leakage in the context

101 U.S. Env't Prot. Agency, EPA Activities for Cleaner Air, https://www.epa.gov/sanjoaquinvalley/epa-activities-cleaner-air.

102 Excluding dairies from the LCFS should not result in inter-state leakage, because out-of-state dairies are currently eligible for LCFS credits. That is: there is no existing benefit to California dairies that CARB could remove at their expense relative to out-of-state operations. The claim the adoption of new regulations will result in leakage, however, deserves more attention.

103 A Dairy Cares comment letter, for example, argued: *"The analysis also shows that misguided efforts to change course by forced conversion to pasture-based operations, direct regulation of dairy farms, or limitations on dairy digester incentives will not only fail to achieve the desired greenhouse gas emission reductions but will exacerbate the problem by causing significant emissions "leakage". As demand for dairy products continues to increase across the U.S. and world, the dairy industry is likely to respond to costly direct regulation by leaving for states with less costly regulations and less commitment to climate protection."* The Dairy Cares website, for example, asserts: "California leads the nation in climate-smart dairy farming, and cows leaving results in a "leakage" of methane emissions."

104 Cal. Health & Safety Code § 38562 (b)(8).

105 Cal. Health & Safety Code § 38562 (b)(8).

106 Cal. Health & Safety Code § 39730.7.

107 I use climate-friendly, rather than climate-smart to convey an industry generating fewer GHG emissions. Climate smart is a term favored by industry that doesn't require overall emissions to decrease but simply for the industry to employ "smart" technologies. As such, it does the work of defining success on the industry's terms while conveying a more general sense of climate-friendly practices.

108 The leakage argument typically focuses exclusively on GHG emissions, but a consideration of other forms of pollution is appropriate as well.

of new dairy methane regulations pursuant to SB 1383. This discussion surveys research on leakage risk generally before evaluating each of the three criteria above and offering a final analysis of the risk of legal leakage if methane regulations are enacted or LCFS credits are diminished.

A. Leakage Risk Generally

Emissions leakage describes the movement of industry, and by extension that industry's emissions, out of one jurisdiction and into another in response to emissions regulation.[109] Leakage is a greater risk in industries that are "trade-exposed"[110] and in industries that are mobile. Trade-exposed industries are competing on the slim margins of global market and, if they are mobile, able to relocate with relative ease.

There is very little evidence that leakage in response to emissions regulation is common in practice.[111] Despite significant theoretical backing for leakage, research has consistently found virtually no evidence of emissions leakage.[112] A CARB-commissioned analysis from 2016 found that most early empirical studies on the trade effects of pollution control regulations established "no relationship, or a counter-intuitive positive relationship, between energy costs and net imports."[113] One "more sophisticated" study determined that "for most industries, environmental compliance costs have been too small to affect trade flows in an economically significant way."[114] One explanation for the low rates of leakage is the effective use of various policy tools to mitigate leakage risk.[115] These tools will be discussed further below in the legal analysis section.

The concept of leakage rests on an idealized notion of a frictionless global market. In practice, uprooting industries comes with its own costs and global markets have not operated as seamlessly as in economics textbooks. Research has found that risk of leakage is linked to the measure of industry's mobility. The Fowlie et al. study cited above found that while more mobile industries are indeed susceptible to leakage, "pollution intensity is positively correlated with [industry's] measures of immobility."[116] That is: more mobile industries are susceptible to leakage but the most polluting industries tend to be the most immobile.

Additionally, while regulation can result in a decline of in-state industry, typically only a portion of the decline in in-state production ends up migrating out-of-state.[117] A different CARB analysis on leakage risk from several food sectors, including cheese processing, found that a $20 million carbon compliance cost in California

109 Meredith L. Fowlie, Mar Reguant, and Stephen P. Ryan, *Measuring Leakage Risk* (May 2016), https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/meetings/20160518/ucb-intl-leakage.pdf. A 2016 CARB-commissioned analysis on mitigating leakage characterizes the basic concern as follows: "An increase in relative operating costs can, in turn, adversely impact the ability of regulated firms to compete in a global market. If this shifts production outside the regulated jurisdiction, any associated increase in emissions can undermine the effectiveness of regional policies."

110 RFF uses the term "trade-exposed industry" and one RFF reports notes that highly emitting industries and industries highly exposed to international competition are particularly prone to leakage. Juha Siikamäki, Clayton Munnings, Jeffrey Ferris, and Daniel Morris, *Climate Policy, International Trade, and Emissions Leakage,* Resources for the Future, https://media.rff.org/documents/RFF-Bck-EmissionsLeakage.pdf. See also *Mitigating Emissions Leakage in Incomplete Carbon Markets,* 9 J. of the Ass'n of Env't and Res. Econ. 2, 307-343, 2022.

111 Meredith L. Fowlie, Mar Reguant, and Stephen P. Ryan, *Measuring Leakage Risk* (May 2016), *supra* note 109, at 8.

112 Michael Grubb *et al., Carbon Leakage, Consumption, and Trade*, 47 Ann. R. of Env't and Res. 753 (Sept. 2022), https://www.annualreviews.org/doi/pdf/10.1146/annurev-environ-120820-053625 (Studies find no evidence that climate policies lead to carbon leakage, but this is partly due to shielding of key industrial sectors, which is incompatible with deep decarbonization."); Florian Misch and Philippe Wingender, Revisitng Carbon Leakage, IMF Working Papers, 207 (Aug. 6, 2021), https://www.elibrary.imf.org/view/journals/001/2021/207/article-A001-en.xml ("The large body of the existing theoretical literature (which we review in the Appendix) has not reached consensus on the approximate magnitude or even the sign of carbon leakage… The empirical literature is smaller, and the results mostly imply that carbon leakage is limited.")

113 *Id.;* A 2015 report on the European Union's Emissions Trading System found "no evidence for production displacement," "no evidence for future 'carbon leakage' risk, and that "industry confirm[ed] lack of 'carbon leakage' risk." Carbon Market Watch, *Carbon Leakage Myth Busters* (Oct. 2015), https://carbonmarketwatch.org/wp-content/uploads/2015/10/CMW-Carbon-leakage-myth-buster-WEB-single-final.pdf.

114 *Id*.

115 *Commentary: What is Carbon Leakage? Clarifying Misconceptions for a Better Mitigation Effort*, London School of Econ. And Poli. Sci. (Dec. 8, 2021), https://www.lse.ac.uk/granthaminstitute/news/what-is-carbon-leakage-clarifying-misconceptions-for-a-better-mitigation-effort/.

116 *Id*.

117 Meredith L. Fowlie, Mar Reguant, and Stephen P. Ryan, *Measuring Leakage Risk* (May 2016), *supra* note 109 (about 1/6th of production decline moves out of state).

would lead to production decrease of .05% of the California cheese supply or 525.07 metric tons. That study further concluded that for cheese, 57% of that .05% California decrease would move out of state, resulting in a production leakage of 301.83 metric tons.[118] (Note that cheese processing is distinct from dairying, so these numbers, while instructive generally, are not directly on point for our purposes.)[119]

The food processing leakage study explained that emissions leakage can be determined from these production leakage numbers by "adjusting the market transfer effect for the relative emissions-intensity of the plants acquiring and losing market."[120] The authors refrained from making concrete predictions for cheese processing emissions leakage, instead citing variability in practices. They did, however, suggest that California food processing relies more on natural gas while other states rely more on coal, so some emissions leakage would likely occur in that sector.[121]

Overall, the research on emissions leakage suggests that the risk of major production leakage—of entire industries moving out of state—is low. Instead, depending on the costs of newly imposed regulation, the more likely outcome is a small decline in California production and some portion of that decline shifting out-of-state. Moving alone (production leakage), even because of emissions regulation, is not necessarily emissions leakage. Operations must move because of emissions regulation and must, in their new jurisdiction, emit as much or more methane as they had in California. In the context of dairy, the relevant comparison would be whether the practices of out-of-state dairies are more- or less-carbon intensive than in-state dairies.

It is impossible to predict what the costs of regulation and the attendant decline in California production might be, since no methane regulation for dairy has been proposed by CARB. In terms of LCFS credits, it is extremely unlikely that change to LCFS crediting would result in emissions leakage. Emissions leakage is causal[122] and depends on regulatory asymmetries, but LCFS credits are available to dairy operations nationally. This means a change in LCFS crediting would not result in the kind of regulatory asymmetries that cause leakage.

B. Relative Mobility of California Dairies

One study defines mobility as "an inherent characteristic of industry, which is closely related to the industry's own production and technical attributes, and reflects the ability of the industry to transfer flexibly among regions."[123] Measures of industry mobility appear to be relatively less studied than regulatory impacts on competitiveness, but one CARB-commissioned analysis used capital intensity as a proxy for immobility.[124] A study of Chinese industry mobility further identified several key measures of mobility including sunk costs, asset specificity, and difficulty of labor

118 Dr. Stephen F. Hamilton, Dr. Ethan Ligon, Dr. Aric Shafran, and Dr. Sofia Villas-Boas, *Production and Emissions Leakage from California's Cap-and-Trade Program in Food Processing Industries: Case Study of Tomato, Sugar, Wet Corn and Cheese Markets* (May 9, 2016), https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/meetings/20160518/calpoly-food-process-leakage.pdf.

119 The CARB analysis was conducted for food processing sectors, rather than agriculture, because food processing is covered by cap-and-trade. CARB has pioneered efforts to reduce leakage in its cap-and-trade program.

120 Dr. Stephen F. Hamilton, Dr. Ethan Ligon, Dr. Aric Shafran, and Dr. Sofia Villas-Boas, *Production and Emissions Leakage from California's Cap-and-Trade Program in Food Processing Industries: Case Study of Tomato, Sugar, Wet Corn and Cheese Markets* at 43.

121 In the cheese processing plant study, the authors looked at general food processing statistics and assumed that, "[f]or the case of California food processors, the typical plant operates on natural gas; however, global food processing plants including those in other U.S. states rely on other sources such as coal and fuel oil." As a result, the authors suggested generally that food processing outmigration would result in increased net emissions, though they qualified that with the need for more specific data. *Production and Emissions Leakage from California's Cap-and-Trade Program in Food Processing Industries: Case Study of Tomato, Sugar, Wet Corn and Cheese Markets* at 43.

122 *Commentary: What is Carbon Leakage? Clarifying Misconception for a Better Mitigation Effort*, *supra* note 115.

123 Jianmin Dou and Xu Han, *How Does the Industry Mobility Affect Pollution Industry in China: Empirical Test on Pollution Haven Hypothesis and Porter Hypothesis*, 217 J. Cleaner Prod. 105 (April 20, 2019), https://www.sciencedirect.com/science/article/pii/S0959652619301647?casa_token=w8DPvD0fDUEAAAAA:fCh8su48J0KAzSBZXru34w404UX2TyDro5xOoaHLJ6SiVTjZABtruzpOAZ4Afn1xYu6ftyhdXw#bib41 (citing Stem 2007).

124 Fowlie et al., *Measuring Leakage Risk*, *supra* note 109 ("Capital intensity serves as a proxy for immobility; highly capital-intensive firms tend to be harder to relocate.")

force transfer.[125] The same study found generally that more mobile industries are more likely move in response to regulation, while less mobile industries are more likely to innovate.

Industrial-scale confinement dairies are highly capital intensive (and intensification of capital, land, and animals is one of the major trends in dairying in recent decades).[126] Barns and lagoons require significant, long-term investments that become sunk costs. The addition of digesters makes these operations even more capital intensive and less likely to move. Livestock itself is mobile, but like other highly polluting industries, industrial dairies cannot simply pick up and move anywhere. They are limited to areas that are zoned for agriculture and where the addition of thousands of cows and their waste will not be challenged by local communities. Industrial-scale facilities relying on export markets must consider proximity to processing facilities and/or to ports, as well as attendant freight costs. Labor force transfer could impose additional challenges. The National Milk Producers Federation states "[e]ven as technology become a greater park of agriculture, much of dairy farming remains labor-intensive."[127] The dairy labor supply is currently tight. The industry is facing labor shortages "with no foreseeable end in sight."[128]

C. Relative Appeal of Other States

The likelihood of production leakage depends on whether other states' practices and environments—regulatory and otherwise—make them more appealing than California. There is a lot of talk about how challenging the landscape is for California dairies[129]; however, the dairy industry in California is doing relatively well compared to other states. California has remained the top milk producer in the country since 1993.[130] California houses one in five of the nation's cows and produces one fifth of the milk produced in the United States.[131] Dairy farming is the leading agricultural commodity in California, generating $7.57 billion cash receipts from milk (in 2021) and handily sells more milk than any other state.[132] The export value of California dairy was $2.5 billion dollars in 2021.[133] In the most recent agriculture census, Tulare County alone had $1.8 billion in milk sales—5% of milk sales nationally—and four out of five of the top counties for milk sales were in California.[134] None of these statistics suggest a baseline environment that is significantly worse for dairy operators in California than in other states.

There has been a slight decline in California production and cow inventories from 2007-2017

125 Jianmin Dou and Xu Han, *supra* note 123.

126 Sara D. Short, *Characteristics and Production Costs of U.S. Dairy Operations,* US Dep't of Ag. Econ. Res. Service (February 2004), https://www.ers.usda.gov/webdocs/publications/47156/28499_sb974-6_1_.pdf?v=0; Milena Bojovic and Andrew McGregor, *Review of Megatrends in the Global Dairy Sector: What are the Socioecological Implications*, 40 Ag. And Human Values, 373 (2023), https://link.springer.com/article/10.1007/s10460-022-10338-x.

127 Nat'l Milk Prod. Fed., Labor and Immigration, https://www.nmpf.org/issues/labor-rural-policy/labor-and-immigration-reform-efforts/.

128 Taylor Leach, *Dairy Farmers Face Labor Challenges Never Seen Before*, Dairy Herd Mgmt. (Dec 6., 2022), https://www.dairyherd.com/news/labor/dairy-farmers-face-labor-challenges-never-seen.

129 A Congressional Research Service report on emissions leakage explains, "There is every incentive for any industry facing a cost increase from carbon policies to claim that its competitive position could be diminished, thereby justifying special consideration by the government." Larry Parker and John Blodgett, *"Carbon Leakage" and Trade: Issues and Approaches*, Congressional Res. Service (Dec. 19, 2008), https://www.everycrsreport.com/files/20081219_R40100_1464249ac98c462316e637e26ca75217dd95a47c.pdf.

130 Cal. Dep't Food and Ag., California Dairy Pressroom and Resources, Real California Dairy Facts, https://www.californiadairypressroom.com/Press_Kit/Dairy_Industry_Facts.

131 *Id*.

132 *Id.*; U.S. Dep't of Ag., *2017 Ag. Census Highlights: Dairy Cattle and Milk Production,* https://www.nass.usda.gov/Publications/Highlights/2019/2017Census_DairyCattle_and_Milk_Production.pdf.

133 Cal. Dep't of Food and Ag., *California Agricultural Exports 2021-2022*, https://www.cdfa.ca.gov/Statistics/PDFs/2022_Exports_Publication.pdf.

134 U.S. Dep't of Ag., *2017 Ag. Census Highlights: Dairy Cattle and Milk Production,* https://www.nass.usda.gov/Publications/Highlights/2019/2017Census_DairyCattle_and_Milk_Production.pdf.

(the year of the most recent USDA agriculture census), with production and inventory "rising noticeably in Idaho and in the Plains States of Texas, Kansas, and South Dakota."[135] Attrition of California dairy herds and gains in nearby states suggest that California is losing some of the comparative advantage it possessed for the past few decades, but does not validate claims[136] that such migration would be prompted by emissions regulation. Migration is already occurring with no emissions regulations on the books. The fact that the industry is already migrating suggests that hypothetical future emissions regulations would not be the sole cause of such migration, diminishing the case for leakage. There may be broader concerns about the environmental impacts of dairies moving out of state, but these concerns are distinct from the legal concern around emissions leakage.

Some of the commonly identified issues for California dairies include environmental regulation, drought, milk prices, fluctuating demand for dry milk (one of California's major exports),[137] and labor shortages.[138] A 2010 survey found that the top three concerns for both California and Wisconsin dairy operators were: environmental regulations, volatile milk prices, and high prices of inputs.[139] The remainder of this section will briefly survey these concerns.

1. Environmental Quality Regulation

Environmental regulations unrelated to GHG emissions will not influence whether an out-of-state move will result in GHG emissions leakage, but they can impact how appealing that initial move is. California's regulation of air and water quality are comparable to other agricultural states.

Like all states, California is subject to the federal Clean Water Act. At the federal level, the Clean Water Act does not require discharge permits (under the National Pollution Discharge Elimination System (NPDES) program) as a matter of course for agricultural operations.[140] Instead, permits are only federally required where operations are shown to have discharged. It can take extensive documentation of violations of the Clean Water Act and can entail multiple enforcement actions before a NPDES permit is required.

NPDES permitting authority is generally delegated to states. In California, NDPES permits are issued by Regional Water Control Boards. Accord-

135 A Dairy Cares comment letter on LCFS virtual community meetings states, "The regulatory burdens and resulting high cost of doing business in California and resulting economics of dairy production in a national market are driving consolidation, not the presence of LCFS incentives." Michael Boccadero, *Dairy Cares Comments on LCFS Virtual Community Meetings, available at* https://ww2.arb.ca.gov/approved-comments?entity_id=28876.

136 A UC Davis report, for example, asserts that "Ongoing attrition and consolidation in the state's dairy sector is evidence of leakage risk." While attrition is an indication of the general health of the industry, that is unrelated to the causal analysis of emissions leakage, which asks whether emissions regulations specifically have shifted or increased net emissions. Ermias Kebreab, Frank Mitloehner, and Daniel A. Sumner, *Meeting the Call: How California is Pioneering a Pathway to Significant Dairy Methane Reduction*, UC Davis CLEAR Center (Dec. 2022), https://clear.ucdavis.edu/sites/g/files/dgvnsk7876/files/inline-files/Meeting-the-Call-California-Pathway-to-Methane-Reduction_0.pdf.

137 Jeff Daniels, *Outside States to California Dairy Farmers: We Have Water*, CNBC (Feb. 10, 2015), https://www.cnbc.com/2015/02/10/california-drought-states-tempt-california-dairy-farms--we-have-water.html ("The USDA economist said it's not just the drought and high cost of feed that has been hurting California dairy producers but a decline in the dry milk market that's been "a big export market for them. They've taken a disproportionate hit on that market. Strong dollar is contributing and China has retreated from the market.")

138 Dave Natzke, *State of the Dairy 2022: California in a 'State' of its Own,* Progressive Dairy (March 10, 2022), https://www.agproud.com/articles/54489-state-of-the-dairy-2022-california-in-a-state-of-its-own ("Outside of milk markets, Raudabaugh splits California dairy farmers into two major burden-carrying groups: those facing water woes and those encountering labor shortages.")

139 Andre de Witte, Jessica Nowak, Frederike Schierholz, and Birthe J. Lassen, *Dairy Farming in Wisconsin and California: Different Challenges –Different Future?* The Snapshot Survey (Spring 2010) http://www.agribenchmark.org/fileadmin/Dateiablage/B-Dairy/Misc/10_Snapshot_USA.pdf.

140 In the early decades of the Clean Water Act, agricultural activities were deemed nonpoint sources. In the early 2000s, CAFOs of a certain size were designated as point sources and therefore were required to seek permits. Prompt litigation brought by the pork industry, however, resulted in a rebuttable presumption that CAFOs do not discharge and are therefore not federally required to obtain National Pollutant Discharge Elimination System (NPDES) permits (though states can still require them). In 2022, a large group of advocates petitioned EPA to rescind the rebuttable presumption that CAFOs do not discharge but EPA did not act on the petition. *Earthjustice Petition to U.S. EPA to Adopt a Rebuttable Presumption that Large CAFOs Using Wet Manure Management Systems Actually Discharge Pollutants Under the Clean Water Act* (October 2022s), *available at* https://earthjustice.org/wp-content/uploads/cafopresumptionpetitionfinal_oct2022.pdf.

ingly, much of the important water quality regulation occurs at the regional level.[141] Today, Central Valley Regional Water Control Board Order No. R5-2013-0122 applies to most dairies.[142] Order No. R5-2013-0122 requires existing dairies to enroll (unless they are not eligible because they have recently expanded). Dairies must submit waste and nutrient management plans and participate in groundwater monitoring to ensure they are in compliance.[143] Since the general order, new and expanding dairies in the region have been issued individual permits.[144] California's Porter-Cologne Water Quality Control Act also requires operations that discharge waste that could impact the quality of state waters to be permitted. (In 2022, only about 7% of California's 1,083 CAFOs were required to have NDPES permits; the rest were permitted under state general orders.)

The Central Valley's water quality permitting is not particularly onerous relative to permitting regimes in other agricultural states. In some respects, it is more lax, particularly given the concentration of CAFOs spreading waste in the Central Valley. For example, Order No. R5-2013-0122 allows dairy operations to apply potassium and phosphorus in excess of agronomic rates unless application causes "adverse impacts," at which point operations are to stop application.[145] This is a weaker standard than under federal regulations and in other states.[146] The Order generally does not require operations to submit their waste management plans to the permitting agency for review; nor are operations required to make their nutrient waste management plans available for public review.[147] By contrast, both Idaho and Texas require nutrient management plans to be approved by a regulating agency and South Dakota requires nutrient management plans to be made available for public review.[148] Industry complaints about water quality permitting are not unique to dairies in California. They are ubiquitous in many western dairying states.[149]

Air emissions like ammonia, volatile organic compounds (VOCs), and particulate matter from

141 Statewide Water Quality Regulations for Confined Animal Facilities, Subchapter 2. Confined Animals, https://www.waterboards.ca.gov/centralvalley/water_issues/confined_animal_facilities/program_regs_requirements/dairy/dairyreg.pdf. The Central Valley Regional Water Control Board had just required NPDES permits for dairies under Order No. R5-2010- 0118, and the order was then revised to reflect the decision in National Pork Producers Council v. Environmental Protection Agency. National Pork Producers Council, et al v. United States Environmental Protection Agency (5th Cir 2011) 635 F 3d 738. It was replaced with Order R5-2011-0091. Cal. Water Boards, Central Valley Region, Confined Animal Facilities – Dairy Program Regulations and Requirements, https://www.waterboards.ca.gov/centralvalley/water_issues/confined_animal_facilities/program_regs_requirements/dairy/.

142 Cal. Regional Water Quality Control Board, Central Valley Region, Order R5-2013-0122, Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies.

143 *Id*.

144 Eamon Norman, *Cal. Air Res. Bd. Workshop: Air Quality Regulations for Dairies in the San Joaquin Valley* (March 29, 2022), https://ww2.arb.ca.gov/sites/default/files/2022-04/dairy-ws-session-2-SJVAPCD.pdf; Attachment C: Permitting Requirements for Dairies in California, https://www.waterboards.ca.gov/northcoast/water_issues/programs/dairies/pdf/AttC_Summary_of_Permitting_at_Dairies.pdf; Cal. Regional Water Quality Control Board, Central Valley Region, Order R5-2007-0035: Waste Discharge requirements General Order for Existing Milk Cow Dairies, California Regional Water Quality Control Board.

145 Cal. Regional Water Quality Control Board, Central Valley Region, Order R5-2013-0122, Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies at C-11.

146 Earthjustice Petition at 49, *supra* note 140.

147 *Id*.

148 Farmers Assuring Responsible Management, Nutrient Management Fact Sheet: South Dakota (March 2021), https://nationaldairyfarm.com/wp-content/uploads/2023/01/NMP-Fact-Sheet-South-Dakota.pdf; Farmers Assuring Responsible Management, Nutrient Management Fact Sheet: Texas (January 2021) https://nationaldairyfarm.com/wp-content/uploads/2021/09/NMP-Fact-Sheet-Texas.pdf.

149 In Utah: Catherine Merlo, *Western Water Woes: Dairies Grapple with Uncertain Supplies, Ever-Tougher Regulations,* Dairy Herd Management (May 3, 2010), https://www.dairyherd.com/news/western-water-woes-dairies-grapple-uncertain-supplies-ever-tougher-regulations (Mike Kohler, the executive director of Dairy Producers of Utah, which represents 90% of the state's 245 dairies and 90,000 milk cows, argued that water-quality regulations most important issue to dairies there: "The problem isn't obtaining water but managing manure under an increasingly aggressive Environmental Protection Agency."); In New Mexico: *Id.* ("State legislation passed last year required New Mexico's Water Quality Control Commission to identify specific requirements for discharging dairy wastewater to protect groundwater quality. The Environment Department says more than 65% of New Mexico's 150 dairies have polluted groundwater beneath their facilities."; In Texas: Texas Comm'n on Env't Quality, *Interoffice Memorandum: Commission Approval for Proposed Rulemaking Land Application and Disposal of Dairy Waste Docket No: 202301229-RUL* (Oct. 20, 2023), *available at* https://www.tceq.texas.gov/downloads/rules/current/23139321_pex.pdf; In Idaho: *Watering Idaho: Is the Dairy Industry Putting Rural Drinking Water at Risk*, Boise State Public Radio News (Sept. 21, 2016), https://www.boisestatepublicradio.org/environment/2016-09-21/watering-idaho-is-the-dairy-industry-putting-rural-drinking-water-at-risk (On the requirement that dairies have waste management plans); In Washington: Courtney Flatt, *WA Dairies Must Do More to Clean Up Their Act, Judges Rule*, Northwest Public Broadcasting (July 13, 2021), https://crosscut.com/environment/2021/07/wa-dairies-must-do-more-clean-their-act-judges-rule .

dairies are a major concern generally and even more so in the Central Valley.[150] The state regulatory regime for air pollution is entwined with California's State Implementation Plans (SIPs), which are required to remedy the San Joaquin Valley's decades-long nonattainment of federal air quality standards under the Clean Air Act.

In 2003, SB 700 was passed to resolve a conflict between California and federal law. One of the changes the law made was to remove an air permitting exemption for agricultural operations. California now treats large dairy operations like other large sources of air pollutants and makes these farms subject to air district permits if emissions exceed half of a major source threshold.[151] In practice, 96% of dairies in the San Joaquin Valley obtain air permits.[152] The regulation of CAFOs as stationary sources is distinctive and a response to the San Joaquin Valley's severe air quality issues and the dairy industry's role in generating emissions. At least some research suggests that "air quality regulations have not raised farm costs significantly" for California dairies.[153]

California does not currently regulate GHG emissions from dairies, though CARB has the authority to do so as of January 2024. Industry stakeholders and even reporters often describe SB 1383 as imposing a regulatory burden on dairies.[154] But SB 1383 imposes no affirmative obligations on dairies currently. Instead, the law sets industry-wide targets and mandates that *CARB* implement a strategy to meet those targets.[155] Still, the potential for future methane regulations on dairies is viewed as a negative and statewide methane regulations on dairies are undoubtedly less likely to be promulgated in some other major western dairying states than in California.

2. Drought

Drought and overall lack of water resources in California presents serious challenges to the state's dairy industry.[156] Adequate water is important to irrigate feed crops (alfalfa is very water intensive) and to manage the flush systems many California dairies rely on. The lack of water is also a problem for manure spreading at agronomic rates—if there's no water to grow crops, there is no crop to uptake the nutrients and spreading could result in groundwater contamination. Geoff Vanden Heuvel of the California Milk Producer Council observes: "Because the predominant method of manure disposal or utilization as it was, was fertilizer on crops, which if the water supply becomes limited to grow those crops, then that creates a problem."[157]

150 A. Rotz et al., *Environmental Assessments of United States Dairy Farms,* J. of Cleaner Prod. 315 (2021) 128153, https://www.sciencedirect.com/science/article/pii/S0959652621023714 (Ammonia in particular is one of the most serious harms from dairies: "dairy farms may emit as much as 24% of that [ammonia] estimated for the whole country.")

151 SB 700 (Florez, 2003).

152 Eamon Norman, *Cal. Air Res. Bd. Workshop: Air Quality Regulations for Dairies in the San Joaquin Valley* (March 29, 2022), https://ww2.arb.ca.gov/sites/default/files/2022-04/dairy-ws-session-2-SJVAPCD.pdf.

153 Josué Medllín-Azuara et al., *Assessment of California Crop and Livestock Potential to Adapt to Climate Change (Prepare for California's Fourth Climate Change Assessment),* Publication number: CCCA4-CNRA-2018-018, University of California, Davis and University of California, Merced (2018), https://www.energy.ca.gov/sites/default/files/2019-11/Agriculture_CCCA4-CNRA-2018-018_ADA.pdf.

154 *See, e.g.* A UC Davis blog asserting that the dairy sector "is mandated to reduce methane emissions by 40% by 2030." *California Dairy Sector Poised for Climate Neutrality by 2030, per US Davis Research*, UC Davis CLEAR Center (May 2, 2023) https://clear.ucdavis.edu/news/california-dairy-sector-poised-climate-neutrality-2030-uc-davis-researchers; An agriculture trade publication writes that SB 1383 "require[es] livestock and dairy operations to reduce manure methane emissions by 40% by 2030." Dave Natzke, *State of Dairy 2022: California in a 'State' of its Own*, Progressive Dairy (March 10, 2022), https://www.agproud.com/articles/54489-state-of-the-dairy-2022-california-in-a-state-of-its-own.

155 ENVIRONMENTAL PROTECTION—POLLUTION—REDUCTION, 2016 Cal. Legis. Serv. Ch. 395 (S.B. 1383) (WEST) ("This bill would require the state board, no later than January 1, 2018, to approve and begin implementing that comprehensive strategy to reduce emissions of short-lived climate pollutants to achieve a reduction in methane by 40% ... below 2013 levels by 2030, as specified.")

156 *See, e.g. Are California Farmers Really Leaving for Greener Pastures?* Dairy Herd Management (Dec. 23, 2022), https://www.dairyherd.com/news/business/top-10-stories-2022-are-california-farmers-really-leaving-greener-pastures ("RaboResearch started exploring g the idea of dairy cows migrating toward the center of the country a couple years ago. The Reason? Water issues in the West, as well as a way to be closer to an abundance of feed. And Rabo says today, that scenario is already playing out.")

157 *California Water Crisis Challenges Dairy, Vanden Heuvel Says,* Nat'l Milk Prod. Federal Dairy Defined Podcast (Sept. 12, 2022), https://www.nmpf.org/california-water-crisis-challenges-dairy-vanden-heuvel-says/.

While drought and inadequate water is first and foremast a climactic problem, California's system of water use is often viewed as another source of burdensome regulation by dairy operators.[158] State regulators have to step in in order to manage the water supply and protect the state's water resources. Overdrawn basins have had to submit implementation plans under the Sustainable Groundwater Management Act of 2014.[159] Combined with drought years, this has put increasing pressure on dairies, particularly in the southern San Joaquin Valley.[160]

At least one state (Iowa) touted its "abundant water" at California's dairy expo in an attempt to entice dairy operators to move.[161] But drought and water resources issues generally are also major concerns in many of the western dairying states where California dairy operations might be likely to move.[162]

3. Milk Prices

Milk prices are an essential part of what makes a given state more or less appealing to dairy operations. About 75% of U.S. milk production is covered the Federal Milk Marketing order (FMMO).[163] The FMMO applies to and establishes minimum uniform prices for the exchange of milk from dairy operations to dairy processers within specific areas.[164] There are 11 different FMMO regions in the United States. Historically, California set its prices in a separate but similar program,[165] but joined the FMMO in 2018.[166] California comprises its own region in the FMMO. At least some dairy operators seem to think the FMMO has improved California milk prices relative to the old system.[167] There has also been pushback to the new system.[168]

Under both systems, California's milk prices have been relatively low. Daniel Sumner asserts that California's relatively low milk prices stem from its role as a net exporter and the cost pressure on milk processers here. He cautiously predicts that, because these specific pressures are unlikely to change in the near future, "a return to rapid growth of California milk production seems unlikely. However, the inherent strengths of the California dairy industry remain. Therefore, it also seems unlikely that significant aggregate declines in California milk production are on the horizon."

158 *Id*. ("It's a combination of droughts, but also what we call manmade drought.")

159 *Id*. ("And then those agencies in critically overdrafted basins, which is most of the Central Valley, had a requirement that by January 31 of 2020, they had to submit a plan that would show how that area was going to become sustainable by the year 2040.")

160 *Id.* "And in the Southern San Joaquin Valley, south of Fresno is just naturally drier than the northern part of the Central Valley. And so it's facing kind of the crunch quicker than maybe other areas, but we have a lot of dairy in the Southern San Joaquin Valley."

161 Karen Bohnert, *Dairy's Future, Who Will the Top Dairy States Be in the Next Decade,* Dairy Herd Management (August 31, 2021), https://www.dairyherd.com/news/dairy-production/dairys-future-who-will-top-dairy-states-be-next-decade (The Dairy Iowa banner here at the expo touts the state's "abundant land, water, feed and forage supply." It also cites a "positive business climate," among other things."); Jeff Daniels, *Outside States to California: We Have Water,* CNBC (Feb. 10, 2015), https://www.cnbc.com/2015/02/10/california-drought-states-tempt-california-dairy-farms--we-have-water.html.

162 Catherine Merlo, *Western Water Woes: Dairies Grapple with Uncertain Supplies, Ever-Tougher Regulations,* Dairy Herd Management (May 3, 2010) https://www.dairyherd.com/news/western-water-woes-dairies-grapple-uncertain-supplies-ever-tougher-regulations.

163 *Federal Milk Marketing Orders: An Overview,* Cong. Res. Serv. (June 15, 2022), https://sgp.fas.org/crs/misc/R45044.pdf.

164 U.S. Dep't of Ag., *An Oveview of the Federal Milk Marketing Order Program*, https://www.ams.usda.gov/sites/default/files/media/DairyFMMOBooklet.pdf.

165 Cal. Dep't of Food and Ag., *Milk Pricing in California*, https://www.cdfa.ca.gov/dairy/pdf/Milk_Pricing_in_CA.pdf.

166 7 CFR 1051, 26547-26556 *available at* https://www.federalregister.gov/documents/2018/06/08/2018-12245/milk-in-california-federal-milk-marketing-order-promulgation; *USDA to Hear Proposals on Federal Milk Pricing System*, Paso Robles Press (Aug. 18, 2023) https://pasoroblespress.com/special-sections/agriculture/usda-to-hear-proposals-on-federal-milk-pricing-system/. In 2022, the average Class I price in California was $25.74. This was higher than in the Pacific Northwest area (by about 20 cents) and in the Central area (by 12 cents). It was lower than in the Southwest area (by about 90 cents) and in Arizona (by about twenty cents). U.S. Dep't of Ag, Class I Milk Price, https://www.ams.usda.gov/sites/default/files/media/ClassIPrices2022.pdf.

167 Geoff Vanden Heuvel, *California's Milk Price Has Shown Improvement*, Hoard's Dairyman (March 24, 2022), https://hoards.com/article-31723-californias-milk-price-has-shown-improvement.html.

168 Dave Natzke, *State of the Dairy 2022: California in a 'State' of its Own*, Progressive Dairy (March 10, 2022), https://www.agproud.com/articles/54489-state-of-the-dairy-2022-california-in-a-state-of-its-own/ ("Since joining the FMMO system at the end of 2018, dairy cooperatives in California gained far more economic flexibility, especially as it relates to pooling, weakening the farmer safety net, she explained.")

4. Demand, Trade Exposure, and California's Comparative Advantage

California carved out its place in the national market by pioneering industrial drylot dairies, but newer dairying states in the West and some older dairying states in the Midwest, like Wisconsin, have now adopted the California model, eroding California's competitive advantage. Traditional dairying states have followed the pattern of consolidation and increased herd sizes to an extent since the early 2000s; however, they've also made greater progress in milk yields. One analysis suggests that traditional dairying states may have focused gains on milk yields rather than increases in herd sizes to the extent of modern states, like California, because of a more stringent regulatory environment:

> *The fact that milk yield in traditional states grew more rapidly after the introduction of genomic testing in dairy genetics suggests that genetics may have played a role in the observed yield increase. It is also possible that, due to zoning and environmental regulations, traditional dairy states are simply more limited in their ability to grow cow numbers. Having exhausted their ability to grow production through cow numbers, they are instead turning to improving yield. This mirrors a larger trend in US crop production where output growth is driven mostly through productivity gains rather than putting more acres into production.*[169]

The overall dairy herd size nationally also appears to be leveling off.[170] Demand for fluid milk is down among younger people[171] and the dairy industry saw a major change[172] in demand nationally and major price fluctuations[173] over the course of the COVID-19 pandemic. This included a "relative shift towards production of storable dairy products." This shift may have helped fuel the gradual move towards the center of the country. Milk production was historically concentrated on the coasts because the perishability of milk required the cows to be near market. This is changing as the dairy industry shifts away from fluid milk.[174]

California's role as a net exporter[175] also results in relatively greater trade exposure and

169 Jared Hutchins and Joe Janzen, *Production Trends in the US Dairy Sector*, FarmDocDaily (Oct. 30, 2023), https://farmdocdaily.illinois.edu/2023/10/production-trends-in-the-us-dairy-sector.html.

170 *Id.* ("In the past two years, cow numbers have begun to level off, perhaps reacting to uncertainty the ability and willingness of the supply chain to continue to accept the volume of milk that it does. It may also be that the total number of dairy cows in the country is reaching a long-run, stable level. This is especially the case if zoning and environmental regulation prevent modern dairy states from expanding cow numbers as they have in the past two decades. If growth in the US dairy herd does level off, we may even see modern dairy states follow the lead of the traditional states and drive growth through yield improvement rather than more cows.")

171 Kim Severson, *Got Milk? Not This Generation*, N.Y. Times (April 4, 2023), https://www.nytimes.com/2023/04/04/dining/milk-dairy-industry-gen-z.html.

172 *Dairy Supply Chains Will Need to Adjust as Consumer Behavior Changes*, Cal. Dairy (July 15, 2020), https://californiadairymagazine.com/2020/07/15/dairy-supply-chains-will-need-to-adjust-as-consumer-behavior-changes/.

173 The large fluctuations in the cheese and all-milk prices seen in Figures 4 and 5 underlie the broader effect of the COVID-19 pandemic on dairy prices. Daniel A. Sumner, Tristan M. Hanon, and Scott Somerville, *Effects of the COVID-19 Pandemic on the Western Dairy Industry,* Western Econ. Forum (June 2021), https://ageconsearch.umn.edu/record/311305/?ln=en.

174 *As California Farmers are Pressed, Dairy Cows Flee for Texas and Arizona,* The Bullvine (Sept. 21, 2022), https://www.thebullvine.com/news/as-california-farmers-are-pressed-dairy-cows-flee-for-texas-and-arizona/. ("According to Boccadoro, milk production has been moved to the Midwestern states as a result of a decline in the demand for fluid milk and a rise in the demand for cheese, yogurt, butter, whey protein, and other milk-related products. Since the pandemic started in 2020, demand for dairy products has grown by 2000%.")

175 This section has focused on inter-state rather than international outmigration. That said, it is notable that the United States is a net exporter of dairy. Int'l Dairy Foods Ass'n, The Importance of Trade for U.S. Dairy, https://www.idfa.org/trade. A UC Davis blog asserts: "While the rise in greenhouse gas emissions in developing countries is largely due to domestic growth, it's no secret that companies from wealthy countries set up factories in foreign countries to cut costs and avoid regulations, thus further contributing to global pollution." In the context of dairy, however, recent years have seen a surge in U.S. dairies catering specifically to the Chinese export market. Agricultural exports to China and the value of agricultural exports has increased every year since 2018, rather than vice versa. U.S. Dep't of Ag. Foreign Ag/Serv., Record U.S. FY 2022 Agriculture Exports to China (Jan. 6, 2023), https://fas.usda.gov/data/record-us-fy-2022-agricultural-exports-china; Amanda Lockwood, *Everything to Know Before Exporting to China*, Dairy Foods, https://www.dairyfoods.com/articles/96607-everything-to-know-before-exporting-to-china. China is the leading importer of nearly every major dairy product. Aidan Connolly, *China is Sneezing, Will it Give the U.S. Dairy Industry a Cold*, Dairy Herd Management (Nov. 29, 2023), https://www.dairyherd.com/news/business/china-sneezing-will-it-give-us-dairy-industry-cold. In recent years, western states have seen the growth of export-only factor dairies. Lynne Terry, *While Small Dairy Farms Shut Down, This Mega-Dairy is Shipping Milk to China*, Civil Easts (Nov. 27, 2018), https://civileats.com/2018/11/27/while-small-dairy-farms-shut-down-this-mega-dairy-is-shipping-milk-to-china/. Moreover, the U.S. dairy industry's major competitors in the Chinese market are the European Union and New Zealand, not developing countries. U.S. Dairy Export Council Staff, *Slow Whey Demand in China Holds Back U.S. Dairy Exports in July*, The U.S. Dairy Exporter Blog (Sept. 7, 2023), https://blog.usdec.org/usdairyexporter/slow-whey-demand-in-china-holds-back-us-dairy-exports-in-july-0. While new emissions regulations could (and probably would) influence these trends, the baseline situation is one in which the U.S. already is better situated to produce and export.

consistently lower prices than the national average.[176] Given this role, tariffs imposed on U.S. dairy products by Mexico and China during the Trump administration may have taken a disproportionate toll on California dairies.[177] As in the discussion of consolidation above, however, the data here is largely from the 2017 USDA Agriculture Census and so will not show the impacts of the LCFS. Additionally, Chinese demand has decreased in recent years, depressing global milk prices.[178] As a net-exporter, California has been particularly impacted as dry milk prices have fallen.[179]

There are also factors that cut against departure for California dairies. California's location on the West Coast and the Central Valley's proximity to urban markets have long been important to the industry. One analyst argued, "California has the second largest population in the country. You need to have milk close to the population, and because there's already infrastructure there, there will always be dairy in California."[180]

The California dairy industry is unlikely to find that other states can replicate the benefits of the Central Valley without any of the perceived challenges. One analyst suggested: "I think we'll continue to see consolidation in the dairy industry in California, the smaller herds are going to really have a tough time of it like they have for the last 10 or 15 years. I still think we'll see some producers migrate out, but it'll continue, I think to be a trickle. I'm not sure that it's going to accelerate significantly."[181]

D. Emissions Implications of Dairies Moving Out of State

Production leakage does not necessarily entail emissions leakage, the focus of the legal leakage concerns. Production leakage only results in emissions leakage where the state that hosts the influx of new dairy operations has a more highly emitting dairy industry and model. Emissions from different dairying models vary based on the regulatory regime, but also from the practices commonly employed, standard operation size, soil characteristics, and regional climate.[182]

Some stakeholders assume that California has a stricter regulatory regime for dairies in California and that California dairies emit fewer GHGs. But California currently does not regulate methane from dairies. Anaerobic digesters capture emissions, but they capture emissions from the high baseline generated by industrial-scale facilities.

There is little evidence that California's baseline model of dairying—confinement-based operations with liquid manure management—emits fewer GHGs than other models. On the contrary, confinement dairies with liquid manure

176 Daniel A. Sumner, California Agriculture: Dimensions and Issues, *Chapter 6: California Dairy: Resilience in a Challenging Environment*, https://s.giannini.ucop.edu/uploads/pub/2021/01/21/chapter_6_dairy_2020.pdf ("But, the lower California prices are due to the fact that California is a net exporter of milk products to the rest of the United States and the world, and not because of identified deficiencies in government regulations.")

177 Michael Hiltzik, *Column: California's Dairy Farmers Were Struggling to Regain Profitability. Then Came the Trade Wars*, L.A. Times (October 26, 2018), https://www.latimes.com/business/hiltzik/la-fi-hiltzik-caltrump-dairy-20181026-story.html.

178 Zahra Tayeb, *Economic Slump Means a Glass of Milk Could Soon Cost a Lot Less*, Business Insider (Aug. 3, 2023), https://www.businessinsider.com/china-economy-milk-powder-prices-fall-demand-slump-2023-8.

179 Tracy Withers, *Milk Powder Price Sinks to Three-Year Low as Dairy Demand Wanes*, BNN Bloomberg (Aug. 1, 2023), https://www.bnnbloomberg.ca/milk-powder-price-sinks-to-three-year-low-as-dairy-demand-wanes-1.1953649.

180 *Are California Farmers Leaving for Greener Pastures?* Dairy Herd Management (Dec. 23, 2022), https://www.dairyherd.com/news/business/top-10-stories-2022-are-california-farmers-really-leaving-greener-pastures.

181 *Id. See also* quote from Mike North in the same article ("Mike North of ever.ag says dairy farmers who are in a water deficit area may be forced to relocate, but he says there will always be dairy cows in California. However, consolidation is something he thinks will continue to happen in the state, largely due to the drought. "What's happening is the people that are water threatened may be looking to reduce their herd, but producers who aren't water threatened are buying their cattle and quotas. So, you won't see the number of dairy cattle in California dramatically drop," says North").

182 Rotz et al. ("No clear trends were found that indicated that a given management approach or farm size consistently provided lower environmental footprints. Often differences occurred due to differences in soil characteristics and climate, so a management approach that produces lower footprints for one environmental metric in one region may not function well for other metrics or locations. For example, NH3 and other manure emissions can be a concern for open lot dairies in the west with long-term manure storage, whereas nutrient runoff and water quality issues are often the greater concern for eastern farms using tie stall and free stall barns with less or no storage of manure.")

A. Rotz et al. Journal of Cleaner Production 315 (2021) 128153

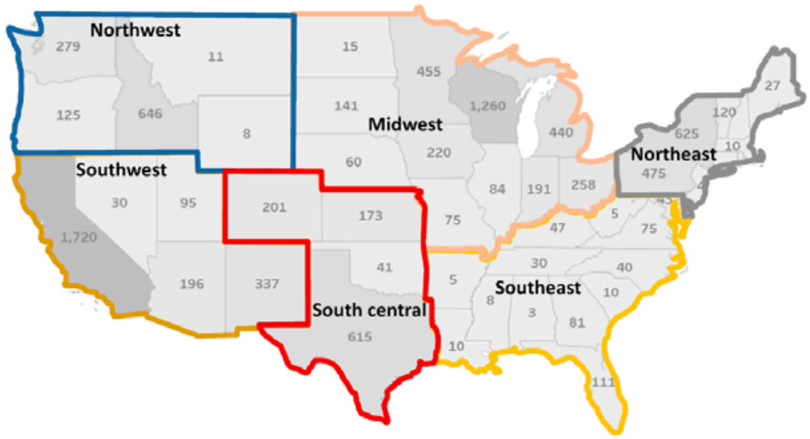


Fig. 1. Dairy regions of the United States used in our evaluation of the environmental footprints of dairy farms. Numbers are thousands of dairy cows in each state (NASS, 2020).

Table 1
Number of each type of dairy farm simulated to represent each region of the U.S.

Region	Amish	Organic	Grazing	Semiconfined	Confined <1000 cows	Confined 1000+ cows
Northeast	1	2	4	6	4	3
Southeast	0	0	5	9	4	2
Midwest	1	2	2	3	8	4
South central	0	1	2	3	6	8
Northwest	0	1	2	0	5	12
Southwest	0	1	1	0	1	17

FIGURE 10 Via A. Rotz et al., Environmental Assessment of U.S. Dairy Farms, supra note 150.

management systems are associated with higher emissions than other dairying systems.[183] This model is more common in the Southwest, and in California in particular, than in other parts of the country.[184] The dairying practices associated with the lowest GHG intensity are smaller grazing operations, which are primarily found in the East and the Midwest.[185]

The adoption of anaerobic digesters significantly reduces the GHG intensity of the California dairying model by capturing emissions generated by the long-term storage of liquified manure in lagoons. But it reduces the emissions from a high baseline relative to other common dairying models. Additionally, while anaerobic digesters capture emissions from manure lagoons, they do not address environmental harms, including but not limited to GHG emissions, beyond the lagoon.

Confinement-based dairies rely heavily on purchased feed. According to the Rotz et al. analysis, about 67% of the total fossil energy consumption by dairies nationally was used to

183 The study also determined that each of these farm management styles resulted in different environmental footprints generally and GHG emissions specifically. The results of the study provide insight into both the leakage discussion and the broader concerns about the LCFS: "Farms with the lowest intensity were often smaller grazing operations with little or no long-term storage of manure. For example, five grazing dairies in the northeast had a mean footprint of 0.88 kg CO2e/kg FPCM. Larger dairies that used an anaerobic digester also had below average intensities (0.69–0.87 kg CO2e/kg FPCM). Dairies with the greater intensity were often confinement operations with long-term liquid manure storage (i.e., large lagoons or retention ponds), particularly in the warmer regions of the country (six operations in the southwest averaged 1.09 kg CO2e/kg FPCM). Often the greatest intensities were associated with dairies that had lower FPCM production per cow along with the use of long-term manure storage." A. Rotz et al., *Environmental Assessments of U.S. Dairy Farms*, J. of Cleaner Prod. 315 (2021) 128153, https://www.sciencedirect.com/science/article/pii/S0959652621023714.

184 One study that determined the environmental footprint of dairy nationally found that the largest confinement dairies were found in the southwest region, where dairies were concentrated in California. The northwest region also had similar concentrations of the largest confinement operations but the other regions had a more varied breakdown, that typically included some smaller confinement operations, semiconfined operations, grazing, and organic operations.

185 A. Rotz et al., *Environmental Assessment of U.S. Dairy Farms*.

produce feed. About 97% of blue water consumption by dairies nationally was used to produce feed. Confinement-based dairies typically lack adequate land to spread manure regularly, necessitating long-term storage of manure which results in greater GHG and ammonia emissions.

The geography and climate of the southwestern region also influences environmental impacts in California, particularly when paired with the dominant model of confinement dairying. The amount of freshwater withdrawals varies regionally, but is highest in the Southwest. Overall, less water is consumed in regions that produce most of their feed on the farm without irrigation. Dairies on the West Coast rely heavily on irrigated feed crops.[186]

In terms of NOx emissions, "portions varied across the country, with less NH3 emission and greater NO3 loss in the eastern regions and greater NH3 emission and less NO3 loss in the dry conditions of the west."[187] In terms of GHG emissions, "manure contributed a lower proportion in the Northeast (17%) due to cooler temperatures and less use of long-term storage, and manure contributed a greater portion in the Southwest (28%) due to warmer temperatures and more use of long-term storage (IPCC, 2006a; Rotz, 2018). The enteric CH4 portion was also greater in the two eastern regions (47%) due to greater use of forage in cow diets."[188]

A comparison between California, as the nation's top dairy producing state, and Wisconsin, the second, illustrates California's role as leading the industrialization of dairy. California dairies are larger and the industry is more consolidated than in Wisconsin. A 2010 survey of California and Wisconsin farmers found that "While farms in Wisconsin are mostly medium-sized family farms, Californian farms operate on a much larger scale but are still owned by the family."[189] In 2014, Wisconsin had almost seven times more licensed dairy herds than California, but the average herd size was about 10 times smaller than the average herd size in California.[190] California first surpassed Wisconsin in dairy production in 1993 after a period of rapid growth and concentration in California (increasing production from 16.6 billion pounds of milk in 1988 to 22.9 billion pounds in 1993).[191] As discussed, the pressures of urbanization in Southern California in the early 1990s resulted in the loss of dairies in that region, but it also allowed them to sell their land at very high prices which they could use to build larger operations in the Central Valley.[192]

There is little evidence to suggest the baseline system of dairying in California is more climate-friendly or environmentally friendly than dairying nationally. However, the states the industry would be most likely to move to may not reflect the national average either. The states that have seen the most dairy growth in recent years are other western states adopting the California model of confinement-based operations with liquid manure management. Therefore, their practices may be similar to the practices of California dairies and, it is likely that they have fewer incentives for digesters, which is the primary method of reducing emissions from these dairies without otherwise altering practices. LCFS credits are available to any operation in the continental

186 Rotz et al. ("The lowest consumers were farms in the Midwest, Northeast, and Southeast regions that produced most of their feed on the farm without irrigation. The greatest consumers were farms in the Northwest and Southwest that relied almost entirely on irrigated feed crops.")

187 *Id*.

188 *Id*.

189 André de Witte, Jessica Novak, Freiderike Schierholz, and Birthe J. Lassen, *Dairy Farming in Wisconsin and California: Different Challenges — Different Future?* Snapshot Survey (Spring 2010), http://www.agribenchmark.org/fileadmin/Dateiablage/B-Dairy/Misc/10_Snapshot_USA.pdf.

190 *Wisconsin vs. California Dairy System Adaption*, University of Wisconsin Food Production Systems and Sustainability, https://kb.wisc.edu/dairynutrient/375fsc/page.php?id=48427.

191 John Oncken, *The Milk Continues to Flow*, Wis. State Farmer (Jan. 27, 2021), https://www.wisfarmer.com/story/opinion/columnists/2021/01/27/milk-continues-flow-california-and-wisconsin/6664991002/.

192 *Id*. ("Of course, they did not just move their 500 to 1000 cows. Instead, they built new and bigger and the strip from Bakersfield north to Sacramento sprouted new dairies, many of them 2,000 to 5,000 cows in size and all housed in freestall barns (copied from the new dairies being built in the Midwest) and away from the mud and rains of the corral type housing used in their former location.").

United States through book-and-claim accounting and federal incentives to support the construction of digesters are available, but California also offers substantial assistance for digester construction in the form of loans and grants.

E. Legal Leakage and Mitigation Measures

The nature of the leakage risk depends on the specific approach to GHG regulation, but several policy tools are available to reduce the likelihood of leakage generally. The primary tools are production incentives/output-based rebating and border climate adjustments.

Border climate adjustments "impose a fee on imported energy-intensive and trade-exposed products and a refund for exports of the same products."[193] They have been challenging to implement in practice.[194] Border climate adjustments are unlikely to be feasible for intra-American leakage, because they would impose a carbon tax on imports from other states, almost certainly generating litigation under the Dormant Commerce Clause.

Output-based rebates "consist of payments to energy-intensive and trade-exposed firms based on their production."[195] They have been found to "significantly reduce simulated emissions leakage."[196] Output-based rebating is similar to free allocations of emissions allowances, such as those used by California's cap-and-trade program.[197] Allocating allowances to regulated industry in the cap-and-trade program is intended to give enterprises time to transfer to less GHG-intensive technologies but also to prevent leakage. The level of allocations "will decline over time to settle at a level needed to prevent leakage."[198]

Output-based rebating has two side effects that make it important to carefully target subsidies to the industries actually at risk of leakage: "First, an opportunity cost is incurred when allowances are allocated for free or tax revenues are recycled to industrial producers. Second, output-based rebating dilutes the carbon price signal received by firms receiving the subsidy."[199]

While these tools have been effective in preventing leakage in other jurisdictions, it's crucial that they accurately target sectors seriously at risk of leakage. It's not clear that this is the case for dairy—further empirical research would be required. Moreover, the effectiveness of these policies in preventing leakage is due to the fact that they shield "key industrial sectors, which is incompatible with deep decarbonization."[200]

In the context of dairies, CARB would have to more deeply analyze how methane regulations would influence dairy operator behavior—in the absence of a specific regulation, it's challenging to determine whether it would actually prompt dairies to leave beyond the pre-existing decline. If it was determined that methane regulations were going to prompt industry departure, this kind of rebate could be carefully tailored to, for example, compensate dairies just enough to make the costs of leaving unappealing. Such rebates could also be tied to ongoing compliance with methane regulations.

In addition to the policy tools designed to address emissions leakage, policymakers should also consider that trade-exposure is one of the major leakage risk factors. The major changes

193 Noah Kaufman, John Larsen, Ben King, and Peter Marsters, *Output-Based Rebates: An Alternative to Border Carbon Adjustments for Preserving US Competitiveness*, Columbia Center on Global Energy Policy, https://www.energypolicy.columbia.edu/wp-content/uploads/2020/12/OBR-commentary-designed-v5-12.01.20.pdf.

194 *Mitigating Emissions Leakage in Incomplete Carbon Markets*, 9 J. of the Ass'n of Env't and Res. Econ. 2, 307-343 (2022).

195 Noah Kaufman, John Larsen, Ben King, and Peter Marsters, *Output-Based Rebates: An Alternative to Border Carbon Adjustments for Preserving US Competitiveness*, Columbia Center on Global Energy Policy, https://www.energypolicy.columbia.edu/wp-content/uploads/2020/12/OBR-commentary-designed-v5-12.01.20.pdf.

196 *Mitigating Emissions Leakage in Incomplete Carbon Markets* at 4, *supra* note 194.

197 Cal. Air Res. Board, *Proposed Regulation to Implement the California Cap-and Trade Program Part I, Vol. 1,* https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2010/capandtrade10/capisor.pdf#page=56

198 *Id*.

199 *Id*.

200 Michael Grubb et al., *Carbon Leakage, Consumption, and Trade*, 47 Ann. R. of Env't and Res., 753 (Sept. 2022), https://www.annualreviews.org/doi/pdf/10.1146/annurev-environ-120820-053625.

to the dairy industry's export market over the past few decades have, therefore, increased the risk of leakage. As discussed, the opening of the export market also contributed to price depression and consolidation in the dairy industry. There are several farmer-led movements in the Northeast and the Midwest calling for a return of supply-side management programs specifically in order to preserve a healthy dairy industry and to reduce the environmental harms associated with confinement dairying.[201] This push is in line with the recent political trends, including resurgence in interest in industrial policy[202] and bipartisan pushback[203] against the free-trade line that has dominated U.S. politics for several decades.

The impact of free trade agreements makes it challenging to address the export market and supply-side management issue that has contributed to depressed milk prices, but it should prompt a deeper consideration of how California dairying can both be economically robust and sustainable into the future. These concerns should be especially important given the need to consider food security and the resilience of regional food systems in the face of climate change.

Overall, the likelihood of methane regulation and certainly of any changes to LCFS crediting running afoul of the legal requirement that CARB minimize leakage is low. Each step in the process—that dairies would leave the state in large numbers, that they would generate significantly more emissions out-of-state, and that CARB would not have policy options to minimize these events—is unlikely.

F. Key Takeaways: Emissions Leakage Risk

- **Research tells us that leakage is much less likely in practice than in theory.** Most of the literature on leakage suggests that it is very limited in practice. The textbook economics that envisions leakage imagines a frictionless global market, but uprooting industries incur additional costs that operators may not be willing to bear. Additionally, there are effective mitigation measures available that are commonly employed to reduce leakage risk. Multiple studies have found that while compliance costs can result in small in-state decreases, only a portion of those decreases are accounted for by moves out of state. For more on the risk of leakage in practice, see the CARB-commissioned *Mitigating Leakage Risk.*

- **Leakage risk is also closely tied to industry mobility. Industrial-scale dairying is capital-intensive, requires substantial sunk costs, and is facing a labor shortage, all of which erect barriers to mobility.** Dairy is more mobile than oil and gas production, which requires location at the source of fossil fuels; however, several characteristics of industrial-scale dairies are impediments to mobility.

201 Northeast Farmers Calling for a new supply-side model for organic dairy: *Northeast Dairy Task Force, Recommendations to USDA* (Dec. 16, 2021), https://agriculture.vermont.gov/sites/agriculture/files/Northeast%20Dairy%20Task%20Force%20-%20Recommendations%20to%20USDA.pdf; Wisconsin Farmer Union's Dairy Together advocating for supply management: Sarah E. Loloyd, *Dairy Together: Building a Farmer-Led Movement for Supply Management,* Disparity to Parity, https://disparitytoparity.org/dairy-together-building-a-farmer-led-movement-for-supply-management/ ("The vicious cycle of too much milk, leading to low prices, where only bigger and bigger farms can survive, which then leads to more milk produced, continues to speed up… A coordinated supply response is needed."); National Family Farm Coalition advocating for supply management: Kathryn Anderson, *Supply Management, Parity Prices, and Ecological Thinking as the Foundation for a Practice Agriculture System*, Disparity to Parity, https://disparitytoparity.org/supply-management-parity-prices-and-ecological-thinking-as-the-foundation-for-a-practical-agriculture-system/ ("Supply management and parity pricing directly mitigate environmental impacts by reducing the total volume of production. Importantly, supply management also indirectly improves agriculture's ecological footprint by 1) allowing the small and mid-scale farms that are best suited for diverse and ecological farming to thrive and 2) providing sufficient income for farmers to invest in conservation and regenerative practices.").

202 Anshu Siripurapu and Noah Berman, *Is Industrial Policy Making a Comeback?* Council on Foreign Relations, (Sept. 18, 2023), https://www.cfr.org/backgrounder/industrial-policy-making-comeback.

203 *See, e.g.* John Harwood, *Bipartisan Support for Free Trade Has Been Left Behind as the 2020 Race Barrels Ahead*, CNBC (Sept. 20, 2019), https://www.cnbc.com/2019/09/20/republicans-and-democrats-oppose-free-trade-in-2020-white-house-race.html; Washington Post Editorial Board, *A Bipartisan Retreat on Trade*, Wash. Post (July 31, 2019), https://www.washingtonpost.com/opinions/a-bipartisan-retreat-on-trade/2019/07/31/5473185a-b2f0-11e9-951e-de024209545d_story.html; Mohamed Younis, *Sharply Fewer in U.S. View Foreign Trade as Opportunity,* Gallup (March 31, 2021), https://news.gallup.com/poll/342419/sharply-fewer-view-foreign-trade-opportunity.aspx.

- **California's Central Valley still offers many benefits to dairy operators. Many of the challenges facing California dairies exist nationally or in other western states.** Dairies have struggled nationally for decades, but California has remained the top dairy producer in the country since 1993. On most metrics, California's dairy industry is the most successful in the country. While there are real challenges facing California dairies, many of these challenges are also facing dairies nationwide (like the ongoing trend towards consolidation) or in other western states (like drought and access to adequate water). Dairy operators may find policymakers less likely to directly regulate methane in Texas or in Kansas, but by moving, they would lose benefits like close proximity to urban markets and ports, cheap by-product feed, proximity to major transportation corridors, a milder climate etc.

- **While there has been a decline in California dairy operations in recent years, this movement is caused by a range of pre-existing factors.** Emissions leakage is a causal phenomenon. Outmigration followed by increased net emissions is only leakage if it was caused by emissions regulation. If anything, the fact that the industry has been moving out of state *prior* to any emissions regulations diminishes the likelihood that emissions regulations alone will cause outmigration and attendant emissions leakage. There are other valid and important concerns about the outmigration of dairy operations, but the legal leakage issue is not raised by these departures in the absence of any emissions regulation. Some of the reasons dairies have left California include: California slowly losing its competitive edge as other western states adopt its model of industrial-scale dairying, lack of reliable access to water, increased feed and manure management costs, and increased urbanization pressures.

- **The industry moving out of state ("production leakage") on its own does not necessarily result in emissions leakage. Despite stereotypes of California as a strict environmental regulator, it's not assured that dairies would emit more GHGs if they moved to other states.** Emissions leakage occurs when emissions regulations push and industry and their emissions out of state. This means emissions leakage requires that net emissions stay the same or increase as the result of the move. California-style dairies, however, generally have higher baseline emissions overall and per-cow than small and mid-sized dairies. California pioneered the most industrialized and highest emitting model of dairying in the country. California-style industrialized dairies are proliferating nationally, but they still are not the norm in many "traditional" dairying states, where smaller-scale, lower-emitting models remain more common. It's unlikely that California dairies would move to traditional dairying states, but if they did, net emissions could actually be reduced.

- **Mega-dairies outside of California are increasingly likely to employ anaerobic digesters.** California's main contribution to mitigation of dairy emissions has been the push for dairy digesters. The incentives provided by LCFS credits are available to any dairy operation nationally that plugs into a common carrier pipeline or the grid, however, not just California dairies. This means the LCFS does not incentivize climate-friendly behavior in California more than in any other state. Where California does have an edge is in grant funding for digesters through the

DDRP program. Other states have comparable programs. While other states' programs are less-well funded, this may reflect in part the fact that no state has more industrial dairies than California. Federal funding for digesters is also available, as is private funding.[204]

California dairies are more likely to relocate to other "modern" dairying states in the West, which have generally attempted to replicate California-style mega-dairies. Many of these states are also embracing digesters now, sometimes with the help of California-based companies like Brightmark (which has digester projects in South Carolina, Iowa, Michigan, Washington, Wisconsin, Florida, New York, and South Dakota)[205] and California Bioenergy (which has about 50 projects in California and has recently ventured to South Dakota).[206] A few indications of the surge in digesters in states that would be likely destinations for dairies exiting California:

- In Idaho, a "goldrush" to build dairy digesters specifically due to LCFS credits;
- In Washington, an "explosion of growth" and $22 million public investment in dairy digesters based on a CARB report touting its success;
- In Iowa, a "huge uptick" in dairy digesters from 2022 to 2023
- In Arizona, dairy digesters are a "hot investment;"
- In South Dakota, $150 million in private funding from California Bioenergy goes to three new dairy digester clusters in 2023;
- In Kansas, one of the top states for dairy growth, Shell is constructing a dairy digester;
- In Oregon, where "manure is big business," public funds and a Biomass Tax Credit program have incentivized digesters.

- **California regulators are obligated to minimize emissions leakage to the extent reasonable, not to ensure zero leakage.** Legally, CARB is only required to minimize or mitigate leakage, and there are policy tools available to help do this, like carefully designed output-based rebates. More generally, the dairy market is global, so leakage is possible from virtually any jurisdiction seeking to regulate dairy emissions. The question should be whether the amount of emissions leakage is so great as to frustrate the emissions reductions sought by the regulation.

204 *See, e.g.* Sarah Zimmerman, *Environmental Groups Blast USDA for Extending Climate Funding to Dairy Digesters*, Ag. Dive (Nov. 2, 2023), https://www.agriculturedive.com/news/climate-activists-digesters-dairy-biofuels-usda-ira/698611/; Grace van Deelan, Emma Foehringer Merchant, *Just Two Development Companies Drive One of California's Most Controversial Climate Programs: Manure Digesters*, Inside Climate News (Sept. 20, 2022), https://insideclimatenews.org/news/20092022/just-two-development-companies-drive-one-of-californias-most-controversial-climate-programs-manure-digesters/.

205 *Brightmark Energy to Build Its First Dairy RNG Project in South Dakota*, Bioenergy Int'l (Feb. 6, 2020) https://bioenergyinternational.com/brightmark-energy-to-build-its-first-dairy-rng-project-in-south-dakota/.

206 California Bioenergy, Projects, https://calbioenergy.com/projects/.

207 Michael Boccadero, *Dairy Cares Comment Letter on LCFS Virtual Community Meetings* (June 14, 2023) ("The LCFS is a Necessary Measure to Reach the SB 1383 Targets. Removing Dairies would Lead to Significant, Unavoidable Impacts.").

VI. California's Climate Targets and Credits for Dairy Digesters

Some[207] have argued that California cannot meet its climate targets without LCFS incentives for biogas from dairy manure. The implication is that by eliminating LCFS incentives for biogas, advocates would jeopardize climate progress. More specifically, the argument is that reducing incentives will make dairies less likely to construct biogas control systems and, as a result, methane from existing manure lagoons will continue to be vented. This section examines the two relevant sets of targets—California's overall climate targets established under SB 32 and California's 2030 methane targets set by SB 1383—and evaluates the extent to which this claim is accurate.

A. California's Overall Climate Targets

California's most recent update to the Scoping Plan calls to cut greenhouse gas emissions by 48 percent below 1990 levels by 2030 and 85 percent below 1990 levels by 2045.[208] The Scoping Plan "approaches decarbonization from two perspectives: (1) managing a phasedown of existing energy sources and technology and (2) ramping up, developing, and deploying alternative clean energy sources and technology over time."[209]

Short lived climate pollutants,[210] like methane, 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."[211] The dairy and livestock sectors contribute more than half of the state's methane emissions.

B. California's Dairy Methane Targets

The three largest sources of methane emissions in California are the dairy and livestock industry, landfills, and oil and gas systems.[212] CARB took early action measures to address landfills and oil and gas directly (the Landfill Methane Regulation, Cal. Code of Regs., tit. 17, §§ 95460, et seq. and the Oil and Gas Methane Regulation, Cal. Code of Regs., tit. 17, §§ 95665–77) but declined to do so for the dairy and livestock sectors.

The SLCP Strategy's approach to dairy and livestock was characterized by CARB as a "carrot-then-stick" approach, prioritizing voluntary, incentive-based mechanisms in early years to "overcome technical and market barriers."[213] In the 2022 Scoping Plan CARB explained, "Under this "carrot-then-stick" strategy, incentives are replaced with requirements as the solutions become increasingly feasible and cost-effective."[214] Theoretically, the stick element could be implemented as of January 2024, per SB 1383. However, CARB has not indicated it intends to begin rulemaking on this issue.

SLCP reductions are "necessary to achieve the State's 2030 GHG emissions target, as described in the 2017 Scoping Plan Update, as well as the mid-century carbon neutrality goal."[215] The 2017 Short-Lived Climate Pollutant Reduction Strategy included a target of 40% reduction in total methane emissions as well as a separate 40 percent reduction in methane specifically from dairy and

208 Cal. Air Res. Board, *Press Release 22-44: California releases final proposal for world-leading climate action plan that drastically reduces fossil fuel dependence, slashes pollution* (Nov. 16, 2022), https://ww2.arb.ca.gov/news/california-releases-final-2022-climate-scoping-plan-proposal.

209 Cal. Air Res. Board, *2022 Scoping Plan for Achieving Carbon Neutrality* (November 16, 2022), https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp.pdf.

210 Short lived climate pollutants include black carbon (soot), methane (CH4), and fluorinated gases (F-gases, including hydrofluorocarbons [HFCs]). Cal. Air Res. Board, *2022 Scoping Plan* at 222.

211 Cal. Air Res. Board, *Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target* (Final) (March 2022), https://ww2.arb.ca.gov/sites/default/files/2022-03/final-dairy-livestock-SB1383-analysis.pdf.

212 Cal. Air Res. Board, *2022 Scoping Plan, supra* note 209.

213 *Id.*

214 *Id.*

215 Cal. Air Res. Board, *Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target, supra* note 211.

livestock operations.[216] California's target of a 40 percent methane reduction below 2013 levels for the dairy and livestock sector by 2030 constitutes a reduction of 9 million metric tons carbon dioxide equivalent (MMTCO2e).[217]

California is not on track to meet these targets for dairy and livestock even with the LCFS incentives. The progress report projects that the dairy and livestock sector will achieve "just over half of the annual methane emissions reductions necessary to achieve the target by 2030 through modifications to manure management systems—primarily using anaerobic digesters—and additional reductions through decreases in animal populations."[218] The SB 1383 progress report concludes that, to meet SB 1383 targets, "approximately 230 additional digesters may be needed, at a cost between $0.7 and $3.9 billion depending on the types of technologies selected."[219] The report also finds, on the other hand, that "based on currently funded projects and reduction trends observed to date, staff's analysis indicates that the State would be unable to achieve the 2030 dairy and livestock sector target through deployment of alternative manure management practices alone."[220] That is, according the CARB's projections, California cannot meet its goals with just digesters or with just alternative manure management practices.

The intra-agency Dairy and Livestock Greenhouse Gas Emissions working group, which consisted of CARB, CDFA, California Energy Commission, and CPUC principals, convened three stakeholder subgroups in 2017 and 2018. Subgroup 1 provided recommendations on non-digester manure management practices, Subgroup 2 provided recommendations on overcoming barriers to implementing livestock digester projects, and Subgroup 3 provided recommendations on research needs related to dairy and livestock emissions reductions. CARB has pursued dairy digester projects as the Board's primary tool to reduce dairy emissions since the recommendations were made final in 2018.[221] Subgroup 3 published a Dairy research Prospectus to Achieve California's SB 1383 Climate Goals.[222]

Beginning January 1, 2024, CARB has authority to regulate GHG emissions from agriculture, "provided that CARB, in consultation with CDFA, determine the regulations are technologically and economically feasible, cost-effective, include provisions to minimize and mitigate potential leakage, and include an evaluation of the achievements made by incentive-based programs."[223] "SB 1383 intends to prioritize the use of voluntary and incentive-based measures to achieve those reductions before regulations are implemented"; however, the progress report projects that California is on track to reach less than half of dairy and livestock reduction targets by 2030.[224] Additionally, the progress report concludes that meeting targets will "require implementation of additional methane emissions reductions strategies, and continued collaboration among agencies and other stakeholders," but the Board has made no indication that it intends to initiate rulemaking.[225]

216 Cal. Air Res. Board, *2022 Scoping Plan, supra* note 209.

217 Cal. Air Res. Board, *Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target*, *supra* note 211.

218 Cal. Air Res. Board, *Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target*.

219 *Id.*

220 *Id.*

221 In addition to reductions from digesters, CARB's projections include "a continued annual animal population decrease of 0.5 percent per year through 2030." Cal. Air Res. Board, *2022 Scoping Plan*. A UC Davis report cited *supra* also assumes ongoing herd attrition. It's not clear how assumptions of herd attrition interact with claims that leakage is imminent—this is an area for future research.

222 Cal. Air Res. Board, Dairy and Livestock Subgroup #3, *Dairy Research Prospectus to Achieve California's SB 1383 Climate Goals* (Nov. 26, 2018), https://ww2.arb.ca.gov/sites/default/files/classic/cc/dairy/dsg3/dsg3_final_dairy_air_research_prospectus_11-26-18.pdf.

223 Cal. Air Res. Board, *Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target*.

224 *Id.*

225 *Id.*

C. Key Takeaways: California's Climate Targets and Credits for Dairy Digesters

- **Dairy digesters are necessary for California to achieve its GHG reduction targets at this point, but so are a range of non-digester interventions that have not been seriously pursued.** Methane captured by digesters accounts for most of the reductions counted towards the methane reduction targets for dairy and livestock, but even with these large reductions California is not on track to meet targets for dairy and livestock. California policymakers should look to the report by the 2018 CARB-convened working group on non-digester tactics to reduce dairy methane emissions to understand alternative, more holistic approaches to reduce GHG emissions from dairies.

- **CARB will not be able to accurately assess and select interventions if it relies on the LCFS life cycle analysis for manure biogas to analyze dairy emissions.** The life cycle analysis CARB uses measures the carbon intensity of transportation fuels produced from manure biogas, not the carbon intensity of milk (this is discussed at length in the carbon intensity discussion). A holistic life cycle analysis of milk produced on California dairies and feed production would prompt different kinds of interventions, since more emissions are generated from enteric fermentation than from manure management. The life cycle analysis for transportation fuels used by the LCFS *assumes* the dairy industry is static—the dependent variable in that analysis is the change in transportation fuel from conventional fuels to manure-derived biogas. This is a valid assumption to make in the context of a transportation program, like the LCFS, but should not drive the broader strategy to achieve emissions reductions from the dairy industry. California policymakers should be considering a suite of options to reform and support the dairy industry transition to a less-emitting model.

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