

# *Ahead* OF THE HERD

Policy Solutions to Accelerate  
Livestock Methane Emissions  
Reduction in California

SEPTEMBER 2022  
Policy Report

Climate Change  
and Business  
*Research Initiative*





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Policy Solutions to Accelerate Livestock Methane Emissions Reduction in California

# ABOUT THIS REPORT

This policy report is part of a series on how specific sectors of the business community can drive key climate change solutions and how policymakers can facilitate those solutions. Each report results from workshop convenings that include expert representatives from the business, academic, policy, and environmental sectors. The convenings and resulting policy reports are sponsored by Bank of America and produced by a partnership of UC Berkeley School of Law's Center for Law, Energy & the Environment (CLEE) and UCLA School of Law's Emmett Institute on Climate Change and the Environment. The UC organizers select topics and participants based on outreach to both public- and private-sector experts for a small-group, facilitated discussion format.

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The Center for Law, Energy & the Environment (CLEE) channels the expertise and creativity of the Berkeley Law community into pragmatic policy solutions to environmental and energy challenges. CLEE works with government, business, and the nonprofit sector to help solve urgent problems requiring innovative, often interdisciplinary approaches. Drawing on the combined expertise of faculty, staff, and students across the University of California, Berkeley, CLEE strives to translate empirical findings into smart public policy solutions to better environmental and energy governance systems.

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The Emmett Institute on Climate Change and the Environment is among the leading environmental law programs in the country, with faculty members renowned for their public service, teaching excellence, and scholarship in state, federal, and international law. Located in Los Angeles, a diverse city facing unique environmental justice and climate change challenges, the Emmett Institute provides J.D. and LL.M. students unmatched opportunities for mentoring, career placement, and experiential learning. Through groundbreaking research and public interest initiatives, the Emmett Institute helps shape climate change and environmental law and policy in California, the United States, and jurisdictions around the world.

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## I. EXECUTIVE SUMMARY

California has set first-in-the-nation goals to reduce emissions of methane, one of the most potent greenhouse gases, as part of its broad strategy to address climate change. State leaders have set specific targets for livestock—the single greatest source of anthropogenic methane worldwide—and created a slate of programs to address emissions from the dairy sector, but significant progress is needed to achieve 2030 targets while protecting public health and local ecosystems.

California is home to more than 1.7 million milking cows at over 1,300 dairies. These animals are a major source of methane, a short-lived greenhouse gas with more than 80 times the climate change impact of carbon dioxide over 20 years in the atmosphere. Livestock operations—including dairy cattle, beef cattle, and other animals—generate over one third of overall methane emissions in the US and over one half of methane emissions in California. Livestock methane results from both the pooling of large quantities of manure (particularly common in California) and digestion-related gas production, called enteric emissions.

In 2016, California enacted Senate Bill 1383 (Lara, Chapter 395), which established a first-in-the-nation methane emissions reduction target: 40 percent below 2013 levels by 2030 statewide, including a target of up to 40 percent for the dairy and livestock sector. It further directed state agencies to craft a suite of plans, incentive programs, and, if needed, regulations to achieve it. California has made significant progress toward its 2030 methane emissions reduction target for the livestock sector, according to the California Air Resources Board, which oversees the target, but the state may fall short of the goal if state and industry leaders do not deliver additional funding for manure management solutions and develop solutions to address enteric emissions.<sup>2</sup>

State and industry leaders will need to press for significant additional investment, research, and consider regulatory measures to cut emissions to meet climate targets for dairy and livestock methane. The California

### LIVESTOCK AND DAIRIES

This report addresses methane emissions from California livestock with a focus on dairy cattle, which generate approximately 45 percent of state methane emissions, over half of which comes from manure. Non-dairy livestock, such as beef cattle, generate about 10 percent of state methane emissions, nearly all of which are enteric.<sup>1</sup> While the barriers and solutions described in this report primarily address dairy cattle emissions, many of the enteric solutions can address non-dairy livestock emissions, which are also key to achieving state goals.

Air Resources Board has issued a statewide strategy for reduction of short-lived climate pollutants with a focus on livestock emissions;<sup>3</sup> state working groups comprised of agricultural representatives, air quality and energy regulators, environmental justice advocates, and environmental organizations, among other stakeholders, have drafted recommendations on market development and research needs;<sup>4</sup> the state's Cap-and-Trade-funded California Climate Investments program has directed hundreds of millions of dollars in grants to livestock methane reduction projects;<sup>5</sup> and the state's Low Carbon Fuel Standard has provided robust incentives for certain emissions reduction technologies.

However, leading environmental justice advocates argue that the state's key livestock methane mitigation strategy—financial incentives to support dairy digesters for manure management—is linked to air and water quality impacts in environmental justice communities. Most California dairy cattle are housed at large-scale facilities in Fresno, Kern, and other San Joaquin Valley counties that, for myriad reasons, have long experienced some of the worst air pollution in the nation, including long-standing nonattainment of federal ambient air quality standards for ozone and particulate matter.<sup>6</sup> These areas have some of the highest rates of asthma and other air pollution-related illnesses in the state—due to agriculture and oil production, along with other industrial and transportation emissions sources—and lower-income communities and communities of color suffer disproportionately from exposure.<sup>7</sup> Environmental justice advocates argue that while dairy digesters address methane pollution, state financial incentive programs for installing them also indirectly incentivize increased concentration of large livestock operations that in turn exacerbate air and water quality impacts. They further state that a sole focus on methane emissions ignores the disproportionate health harms these communities face.<sup>8</sup>

At the same time, state leaders are investing in non-digester strategies such as alternative manure management and emerging solutions for enteric emissions. Enteric emissions strategies including feed additives, diet modification, and selective breeding show great promise; the California Department of Food and Agriculture recently gave provisional approval for use of a feed additive that is being marketed for its methane reducing potential (although CDFA did not assess this claim and only approved the product as a digestive aid). But many of these techniques pose questions around efficacy, animal and human health, consumer acceptance, and commercial viability, calling for increased research and state support.

To help advance these methane emissions reduction efforts, UC Berkeley School of Law's Center for Law, Energy & the Environment (CLEE) and UCLA School of Law's Emmett Institute on Climate Change and the Environment convened experts in April 2022 to develop recommendations for policy action. The expert participants who were convened for this report did not all agree on the path forward for livestock methane policy and practices, in particular dairy digesters, which remain a complex and contentious issue. The vision, barriers, and solutions in this report reflect the ideas of convening participants but do not represent consensus in all cases.

Participants first outlined elements of a vision for livestock methane emissions reduction that would include net reductions in dairy emissions, advance



operations that are economically and environmentally sustainable, and prioritize community needs and local environmental protection.

Participants then identified key barriers to achieving this vision for the two sources of livestock methane—manure and enteric fermentation—and discussed a set of policy solutions to overcome the barriers:

## A. BARRIERS TO MANURE EMISSIONS REDUCTION

Livestock manure generates significant methane emissions when it is stored in wet, oxygen-free (anaerobic) environments, as is currently the case at most large dairy operations in California. Anaerobic digesters are a technology that captures methane, which can then be used onsite or elsewhere to generate energy. Alternative manure management practices, meanwhile, prevent the production of methane in the first place by reducing volatile manure solids or placing manure in open-air conditions. Both approaches have the potential to significantly reduce emissions but face limitations including:

- High digester technology costs
- Air and water quality impacts and community concerns that digester strategies do not address them (and that incentive programs may encourage facility concentration)
- Questions around emissions reduction verification for downstream purchasers
- A lack of financial incentives for alternative strategies
- Concerns around driving business to lower-cost states without the same climate standards

These barriers are discussed in more detail in [Section IV](#).

### *Solutions:*

The governor or state legislature could task the California Air Resources Board and/or California Department of Food and Agriculture with providing a “one-stop shop” for reporting of water quality, air quality, and greenhouse gas emissions data and technical assistance and assessment of methane emissions reduction strategies.

The California Air Resources Board could update the Low Carbon Fuel Standard to provide more certainty to digester project developers and downstream dairy biogas buyers, better account for life-cycle impacts and ensure additionality, and better address community impacts.

The legislature and the California Department of Food and Agriculture could revamp the Alternative Manure Management Program to expand funding for and the scope of manure methane emissions reduction projects.

The legislature could fund the California Department of Food and Agriculture to support digester operation and maintenance while focusing efforts on smaller and medium-sized dairies including incorporation into existing digester clusters.

The state legislature could redirect some existing digester funding to support more alternative manure projects such as advanced solid-liquid separators or vermifiltration alongside digesters.

The California Air Resources Board, State Water Resources Control Board, and other regulatory agencies could prioritize air and water quality co-benefits alongside methane emissions reductions and could further encourage adoption of technologies that address local pollution, especially in lower-income communities and communities of color.

## B. BARRIERS TO ENTERIC EMISSIONS REDUCTION

Enteric emissions (i.e., burps from ruminant livestock including dairy cattle) represent the majority of livestock methane and are especially challenging to address because they result from internal biological processes, making each animal a source of emissions. Researchers and ranchers are developing a promising suite of solutions, but slow regulatory approvals, a lack of market and regulatory incentives, and a lack of data on effectiveness and long-term impacts—discussed in more detail in [Section IV](#)—are slowing deployment.

### *Solutions:*

The California Department of Food and Agriculture and US Food and Drug Administration could accelerate approval of feed additives with emission-reducing potential, while providing safeguards for animal and human health.

The California Air Resources Board could adopt an offset protocol for enteric emissions reduction under its Cap-and-Trade program to provide new incentives for farmer adoption.

The state legislature could provide more financial support for enteric emissions reduction strategy research and development.

Financial institutions, supply chain companies, and land managers could provide financial incentives to adopt enteric emissions reduction strategies as they become available.

## NEAR-TERM PRIORITIES

To drive near-term action on livestock methane, California leaders could:

- Create a one-stop shop for methane data reporting, technical assistance, and assessment
- Increase funding for alternative manure management and enteric strategies
- Accelerate approval of emissions-reducing feed additives while ensuring safeguards for human and animal health



## II. OVERVIEW: THE URGENCY AND OPPORTUNITY TO REDUCE LIVESTOCK METHANE EMISSIONS

### A. METHANE EMISSIONS POSE AN URGENT CLIMATE RISK AND OPPORTUNITY.

Methane emissions are shaping the immediate trajectory of the climate crisis. As a greenhouse gas, methane is over 80 times more powerful than carbon dioxide on average over 20 years (a standard comparative measure of global warming potential) but it only remains in the atmosphere for about 12 years.<sup>a</sup> Because of this short but intense life, cutting methane emissions presents a key opportunity for slowing the near-term warming of the planet and reducing the chance of reaching catastrophic tipping points.<sup>9</sup> Recognizing this need, more than 110 countries have endorsed the Global Methane Pledge, which launched at the 2021 United Nations Climate Change Conference (COP26) and aims to cut worldwide methane emissions by at least 30 percent by 2030, compared to 2020 levels. The pledge calls for “abatement of agricultural emissions through technology innovation as well as incentives and partnerships with farmers,” among other strategies. It further notes that “readily available cost-effective methane emissions measures have the potential to avoid over 0.2 degrees

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a For accounting purposes, the California Air Resources Board and many other agencies calculate the warming effect of methane in terms of carbon dioxide equivalent (CO<sub>2</sub>e), or the volume of carbon dioxide required to induce the same amount of warming. In calculating CO<sub>2</sub>e for its greenhouse gas inventory, CARB employs a 100-year timeline, referred to as Global Warming Potential 100 (GWP 100), whereby the gas is considered to be 25 times stronger than carbon dioxide. To emphasize the impact of methane in the short term, some advocate using a 20-year timeline (GWP 20), as CARB did in its Short-Lived Climate Pollutant Reduction Strategy, under which methane would be considered up to 70-80 times stronger than carbon dioxide. For more information, see <https://ww2.arb.ca.gov/ghg-slcp-inventory> and <https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane>.

Celsius of warming by 2050 while yielding important co-benefits, including improving public health and agricultural productivity.”<sup>10</sup>

Methane is part of California’s broad approach to greenhouse gas (GHG) emissions reduction, which stems from the legislative requirement to return to 1990 GHG emissions levels by 2020 per Assembly Bill (AB) 32 (Nuñez, Chapter 488, Statutes of 2006) and achieve at least a 40 percent greenhouse emissions reduction below 1990 levels by 2030 per Senate Bill (SB) 32 (Pavley, Chapter 249, Statutes 2016),<sup>11</sup> alongside an executive order calling for carbon neutrality by 2045.<sup>12</sup> The California Air Resources Board (CARB) leads the state’s greenhouse gas emissions reduction efforts through its authority under AB 32, which empowered the agency to regulate and enforce the reduction of greenhouse gas emissions, including methane.

The state legislature has also taken specific action (and delegated authority to CARB) to address methane emissions in a series of first-of-its-kind legislation.<sup>13</sup> Under Senate Bill 1122 (Rubio, Chapter 612, Statutes of 2012), utilities are required to procure at least 250 megawatts of electricity from bioenergy, including 90 percent from the dairy and agriculture sector.<sup>14</sup> Senate Bill 605 (Lara, Chapter 523, Statutes of 2014), required CARB to develop a comprehensive plan for methane and other short-lived climate pollutants (SLCPs), determining baseline inventories, locating gaps in research, and prioritizing actions that would benefit local air and water quality.<sup>15</sup>

Subsequently, Senate Bill 1383 (Lara, Chapter 396, Statutes of 2016) set stand-alone state emissions reduction targets for SLCPs, including a target of 40 percent reduction of methane emissions below 2013 levels by 2030, along with a dairy and livestock-specific reduction of 9 million metric tons of carbon dioxide equivalent (using 100-year global warming potential).<sup>16</sup> Senate Bill 1383 includes a focus on emissions of methane by livestock—the greatest source of methane in the state—and directs CARB, in consultation with other state agencies, to develop a series of strategies to address these emissions, potentially including direct regulation beginning in 2024 if certain feasibility conditions are met.<sup>b</sup> (The law is targeted specifically to address methane emissions and does not directly incorporate air or water quality protections, although it does require CARB to consult with environmental and public health experts in developing regulations.)

## **B. LIVESTOCK ARE A MAJOR SOURCE OF METHANE AND A SIGNIFICANT EMISSIONS REDUCTION CHALLENGE.**

Worldwide, livestock are the single greatest source of methane emissions and a significant source of overall greenhouse gas emissions. Cattle generate two

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b To promote methane emissions reduction efforts by sub-national governments, CLEE has developed an Agricultural Methane Framework based on key categories of action including emissions inventories and targets; regulations, performance standards, and incentives; monitoring and verification; and information and technology sharing. This approach modeled in part on California’s pathway under SB 605, SB 1383, and associated programs. For more information, visit <https://www.law.berkeley.edu/research/clee/research/climate/projectclimate/methane/>.

different types of methane emissions.<sup>17</sup> The first, enteric emissions, are part of the natural digestive process in ruminant animals (e.g., cattle, goats, sheep) in which microbes break down feed, creating methane that is primarily released through burps. The second, manure emissions, result when operators use management practices that store liquefied manure in large pools or lagoons, as is commonly done at larger livestock operations. In both cases, methane forms when organic matter (feed or manure) is stored in anaerobic or oxygen-free conditions (a stomach chamber or a waste lagoon).

In California, the livestock sector is the largest source of methane emissions, accounting for 55 percent of the total.<sup>18</sup> California's dairy manure emissions represent a large proportion (25 percent) of its methane emissions relative to enteric emissions (30 percent, including 20 percent from dairy livestock and 10 percent from non-dairy livestock) due to the state's relatively high prevalence of intensive dairy operations where manure is stored in anaerobic lagoons, generating methane. (Nationally, enteric fermentation makes up 27 percent of anthropogenic methane emissions, while manure comprises 9 percent).<sup>19</sup> The vast majority of California's livestock emissions come from its 1,300 dairies, which house 1.7 million dairy cows.<sup>20</sup> The majority of these cows are concentrated in large-scale concentrated feeding operations in the San Joaquin Valley. While manure emissions in California result almost exclusively from dairy operations, roughly one third of enteric emissions come from non-dairy livestock.

Numerous strategies can address methane emissions from livestock, including a range of established strategies for manure management and an increasingly promising set of solutions for enteric fermentation:

- **Enteric emissions** reduction strategies include methods to alter the generation of methane in the animal rumen.
  - **Feed additives** like red seaweed and 3-Nitrooxypropanol (3-NOP, an enzyme-inhibiting organic compound) can counter methane-producing organisms and could reduce enteric output by 55 and 36 percent,<sup>21</sup> respectively, in some studies of dairy cows, although none are approved for general commercial use in the United States.
  - **Selective breeding** could permanently reduce enteric emissions in entire animal populations, potentially by 24 percent.<sup>22</sup>
  - **Diet modifications** like feeding animals certain forages<sup>23</sup> and C3 grasses (i.e., cool season-adapted grasses with a three-carbon compound structure)<sup>24</sup> may aid digestion and reduce enteric methane by 45 to 75 percent,<sup>25</sup> but the safety of these techniques is still being evaluated.
- **Manure emissions** reduction strategies (a major focus of livestock methane efforts in California to date) include emissions controls at some large-scale cattle operations.

- **Anaerobic digesters** capture methane during anaerobic decomposition so it can be used as a replacement for fossil gas or otherwise destroyed, potentially reducing methane emissions by up to 85 percent.<sup>26</sup> In California, the captured gas is commonly used for electricity generation (including via onsite combustion, which can generate local criteria air pollution) or as a transportation fuel. The state’s Dairy Digester Research and Development Program (DDRDP) has funded over 100 digesters to date, accounting for the majority of agricultural methane emissions reductions in California, and digester operators can generate revenue through the state’s Low Carbon Fuel Standard.<sup>27</sup> These facilities can be controversial due to the concentrated livestock operations they rely on, which pose risks to groundwater (e.g., with nitrogen pollution from manure) and air quality (e.g., with smog- and fine particulate-matter promoting compounds such as ammonia).<sup>28</sup> Stakeholders disagree over the extent to which increased herd concentration in California results from long-term industry and financial trends or from the incentives created by methane reduction policies.
- **Alternative manure management** techniques are designed to prevent the formation of manure methane in anaerobic conditions in the first place (unlike digesters, which capture methane for use). These include mechanical or chemical separation of solids and liquids, conversion from flush to solid/dry/scrape manure management systems, cooling of manure (e.g., by storing it outside, which is already standard practice in California), and increasing the time that animals spend on pasture.<sup>29</sup> In addition, emerging technologies for manure nutrient removal and recovery (including algal and evaporation-based systems) can reduce the substrates in the manure stream that can lead to methane, ammonia, and other air pollutant emissions.<sup>c</sup>

**C. CALIFORNIA HAS BUILT FIRST-IN-THE-NATION LIVESTOCK METHANE EMISSIONS REDUCTION PROGRAMS, BUT MORE PROGRESS IS NEEDED AND ENVIRONMENTAL JUSTICE, ANIMAL HEALTH, AND OTHER CONCERNS REMAIN.**

Senate Bill 1383 required CARB to create and implement a plan for reducing emissions of methane and other short-lived climate pollutants, which CARB approved in 2017. CARB’s Short-Lived Climate Pollutant Reduction Strategy

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c While alternative manure management projects typically do not draw the same level of community concern as dairy digesters, and are more viable for smaller farms to implement, they often involve the use of fossil fuel-powered separation and management equipment which can be a source of local air pollution.

includes elements focused on reducing dairy and livestock emissions 40 percent by 2030, compared to 2013 levels. CARB and other California agencies have developed a cluster of incentive and market-based programs designed to achieve this target with a core focus on the state's high manure emissions. These include, for example:

- **The Dairy Digester Research and Development Program (DDRDP)**, which offsets up to half of the capital costs for anaerobic digester construction, and the **Alternative Manure Management Program (AMMP)**, which provides matching funds for improved manure management practices.<sup>30</sup> Both programs are funded through the California Climate Investments (CCI) program using Cap-and-Trade auction revenues and, according to CCI analysis, rank among its most cost-effective greenhouse gas reduction projects.<sup>31</sup>
- **The California Low Carbon Fuel Standard (LCFS)** Program, which allows digester projects to generate tradable carbon credits representing relative lifecycle GHG emissions reductions (as does the federal Renewable Fuel Standard program). The LCFS requires statewide reductions in the carbon intensity of transportation fuels sold in-state by operating a market in which suppliers of lower-carbon fuels can sell credits to suppliers of higher-emitting fuels.<sup>32</sup> Because biomethane from dairies uses methane that would otherwise be vented, it can receive an extremely low (or negative) lifecycle carbon intensity score. This can result in more LCFS credits per reported fuel volumes than other low carbon fuels. In recent years, LCFS credit prices have ranged from over \$100 to a high of over \$200 per metric ton of carbon dioxide equivalent. Some analysts and advocates view the negative carbon intensity as inconsistent with other fuels when manure methane results from a production choice (i.e., methane-generating manure storage practices) and see the credit price as an unreasonably high subsidy.<sup>33</sup> But industry leaders argue that liquid manure management practices are independently effective and state programs only incentivize digester installation.
- **California's Cap-and-Trade program**, which offers another potential revenue source through the generation of compliance offset credits that can be purchased by other covered emitters.<sup>34</sup> To prevent double counting, CARB prohibits dairies from participating in both the LCFS Program and Cap-and-Trade Program compliance offsets program at the same time.<sup>d</sup>

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d Within an emissions cap, offset programs do not speed or slow “the pace of overall climate mitigation” but instead “increase[] the total climate pollution allowed in capped sectors in exchange for climate benefits claimed” in an uncapped sector or jurisdiction and thereby “act to reduce total program compliance costs (by providing a greater number of options by which covered emitters can comply with program requirements) and create funding for mitigation activities outside program caps.” Digester projects represent 3.5 percent of total offset credits issued by CARB under the Cap-and-Trade Program, and covered emitters have used offsets for approximately 6.3 percent of covered emissions. *2021 Annual Report of the Independent Emissions Market Advisory Committee* (February 2022), pp. 28-29, available at <https://calepa.ca.gov/wp-content/uploads/sites/6/2022/02/2021-IEMAC-Annual-Report.pdf>. By contrast, biomethane constituted over 10 percent of LCFS credits in late 2021. CARB, *2021 LCFS Reporting Tool (LRT) Quarterly Data Summary Report No. 4* (April 2022), available at [https://ww2.arb.ca.gov/sites/default/files/2022-04/Q4%202021%20Data%20Summary\\_042922.pdf](https://ww2.arb.ca.gov/sites/default/files/2022-04/Q4%202021%20Data%20Summary_042922.pdf).



- **California Public Utilities Commission programs** which incentivize bioenergy use for electricity generation including the Bioenergy Market Adjusting Tariff (BioMAT), renewable gas procurement initiatives, and pilot projects.<sup>35</sup>

Many environmental justice advocates argue that the market for dairy biogas rewards larger, more concentrated animal operations and encourages them to add more cattle to generate more manure (sometimes described as a “perverse incentive” problem),<sup>36</sup> although industry leaders counter that greater herd sizes are a result of market forces rather than state programs. Herd growth in lower-income communities and communities of color can worsen existing air and water pollution. Manure, for instance, is a source of nitrogen, which, when applied on nearby fields—a common practice for dairy and livestock operations—contaminates groundwater and harms ecosystems.<sup>37</sup> Further, dairy operations contribute significantly to the release of volatile organic compounds (VOCs) and ammonia, which, in turn, produce smog in the summer and fine particulate matter in the winter. These pollutants are associated with the development of respiratory and cardiac diseases and increased levels of premature death in the San Joaquin Valley.<sup>38</sup> Some also argue that incentivizing dairy biogas is counterproductive as a climate solution, promoting the continued use of fossil fuel infrastructure and delaying a full energy transition. In contrast, state programs tend to approach dairy biogas as an important tool to transition away from fossil gas in hard-to-decarbonize sectors.<sup>39</sup>

Environmental justice and community advocates presented these arguments to CARB in a petition to amend the LCFS Regulation with regard to dairy biogas in late 2021, arguing that the program currently “exacerbate[s] discriminatory environmental and public health harms [and] increases harmful pollution to air, water, and land.” The petitioners requested that CARB exclude dairy biogas from the LCFS entirely or, alternatively, amend the LCFS regulation to ensure full life-cycle emissions analysis, additionality of reductions, compliance with civil rights law, and air and water quality protection.<sup>40</sup> CARB denied the petition to amend the LCFS.<sup>41</sup>

At the same time, development of enteric emissions reduction strategies including feed supplements and additives, diet modifications, and vaccines will hinge in part on analysis and resolution of concerns around impacts to animal health. While the California Department of Food and Agriculture recently issued the first provisional approval to a digestive aid feed supplement being marketed for its methane-reducing potential, significant analysis will be needed for this and other techniques to ensure they do not negatively affect animal health or reproduction (or the safety, quality, or quantity of products).<sup>42</sup>

In March 2022, CARB issued a progress report on SB 1383’s livestock programs projecting that, if the state does not provide further grant funding to reduce dairy methane, it will be just halfway to its dairy and livestock methane target in 2030.<sup>43</sup> The agency found that it would cost between \$0.7 billion and \$3.9 billion to reach the dairy and livestock methane target depending on the techniques used, some of which carry tradeoffs.<sup>44</sup> For instance, dairy digesters powered by internal combustion engines are the lowest-cost option for operators but would harm local air quality.<sup>45</sup> To close the agricultural

methane emissions gap, CARB found that the state would need a mix of dairy digesters, enteric strategies, alternative manure management practices, and herd size reductions in line with existing market trends.<sup>46</sup> The agency further concluded that the determinants of success would be capital funding for new projects, stable revenue streams for biogas, and the availability and uptake of enteric strategies.

To meet the 2030 target, SB 1383 prioritizes incentives but requires CARB to implement regulations for manure methane, if needed, as early as 2024—an action that would be the first of its kind for agricultural methane worldwide (and would bring the sector closer to many other industrial sectors whose emissions CARB regulates). CARB may only adopt these regulations if they are technologically feasible, economically viable, cost-effective, designed to address leakage of emissions to other states, and employed after an evaluation of earlier incentive programs.<sup>47</sup> SB 1383 also limits CARB’s development of regulations for enteric emissions until the agency determines they are cost-effective and scientifically proven.<sup>48</sup>

Many advocates for animal welfare, ecological sustainability, and environmental justice see direct regulation as a necessary tool to address local pollution and health risks associated with large livestock operations. They note that other California industries are required to mitigate or pay for environmental threats and suggest that the state employ stringent regulatory measures to alleviate the local impacts of dairies.<sup>49</sup> Industry leaders argue that direct regulation would cause dairy operations to leave California for unregulated states; SB 1383 expressly requires CARB to ensure any regulation includes “provisions to minimize and mitigate potential leakage to other states or countries, as appropriate.”<sup>50</sup>

## REGULATING LIVESTOCK METHANE

California's central greenhouse gas emissions statutes, AB 32 and SB 32, broadly direct the Air Resources Board to adopt rules and regulations to achieve the statewide emissions reduction target.<sup>51</sup> However, SB 1383 provides a specific mandate with regard to livestock manure methane emissions.<sup>52</sup> The law directs CARB to adopt regulations to reduce emissions from livestock manure management in line with the state target, subject to key constraints:

- The regulations may not take effect until 2024
- The regulations must be technologically and economically feasible

In addition, SB 1383 prohibits CARB from enacting regulatory strategies for enteric emissions reduction until the agency can determine that emissions reduction measures are cost-effective, scientifically proven, and not damaging to animal or human health or consumer acceptance.<sup>53</sup>

Convening participants from the environmental justice community preferred direct regulation of livestock methane to achieve emissions reductions while addressing local air and water quality problems. CARB's analysis of progress toward the SB 1383 goals emphasized that further efforts are needed to achieve state targets and that they must be consistent with other state objectives including "reduced impacts to air and water quality, improved soil health, reduced impacts to environmental justice communities, and...minimizing emissions leakage." CARB also acknowledged that development of regulations may be necessary to deliver that action,<sup>54</sup> although it could increase risk of leakage to other jurisdictions.

Given the statutory prerequisites to developing regulations under SB 1383, policymakers at CARB would need to undertake further work, including stakeholder outreach and research on markets for manure-based products, to initiate a regulation. Amendments to state law might be necessary for a more defined and certain call to regulation for manure emissions, for a clear target for enteric strategies (once approved) to help address the more than 4 MMTCO<sub>2</sub>e gap between current emissions reduction trends and 2030 targets that CARB has identified, or to more completely address the complex and significant environmental and community health concerns in many California communities that neighbor dairies.

### III. VISION FOR ACCELERATING LIVESTOCK METHANE EMISSIONS REDUCTION IN CALIFORNIA

Participants at the April 2022 convening outlined a vision for reducing methane emissions from California’s livestock sector and beyond. While participants did not arrive at total consensus, key components included:

- **Net reductions in sectoral emissions** in line with California’s 2030 target for methane emissions and 2045 goal of statewide carbon neutrality
- **Sustainable levels of methane emissions and economic operations** achieved through an appropriate and cost-effective balance of:
  - Employing dairy digesters and alternative manure management practices to address manure emissions
  - Developing feed additives and dietary modifications to address enteric emissions
  - Transitioning to pasture-based operations where feasible (including application of enteric emissions reduction strategies)
  - Producing more milk from fewer cows to reduce emissions per unit of product
- **Prioritization of local community needs** and input including:
  - Active roles in local permitting and decision-making
  - Air and water quality protection and improvements
  - Economic opportunity and revitalization
- **Limited “leakage”** of (and consumer reliance on) livestock operations to other jurisdictions with weaker climate and environmental protections, including through development of federal Clean Air Act standards
- **Appropriate limitations on the generation of credits** to ensure that net emissions are reduced over time
- Robust **atmospheric verification and modeling** of emissions levels and reductions
- Support for **research and development** to expand the suite of all emissions reduction strategies, as well as incentives to encourage adoption of enteric solutions

The result would be a California livestock sector delivering high-nutrition, low-emissions food to meet consumer demand.



## IV. BARRIERS AND PRIORITY POLICY SOLUTIONS

Convening participants identified a range of barriers to achieving their visions for accelerating livestock methane emissions reduction. This section describes those barriers and details the top-priority policy solutions participants identified to overcome them, although not all participants agree with all solutions identified.

Alongside the manure- and enteric-specific barriers identified below, participants highlighted a broad need for inter-agency alignment in supporting emissions reduction solutions in both categories. In particular, they noted a need to promote environmental and health goals along with climate targets while helping smaller dairies navigate permitting challenges and financial barriers.

### A. BARRIERS TO MANURE EMISSIONS REDUCTION

Manure emissions are responsible for approximately one quarter of California's total methane emissions and just under half of all in-state livestock emissions.<sup>55</sup> Manure emissions are also the fourth-largest source of anthropogenic methane emissions nationwide.<sup>56</sup> Overall manure methane emissions are higher in California relative to other states because California is the nation's leading dairy producer and has a high prevalence of large-scale dairies with anaerobic manure management. (While overall manure methane from California dairies is high, the GHG-intensity of dairy products produced in California is among the lowest in the world.) California state programs have supported construction over 100 digesters to process manure, mostly at larger dairies or clusters of facilities. These digesters use the captured methane to generate electricity or produce biofuels (and renewable fuel credits associated with them), which provide a revenue stream that supports construction and operation of the facilities, and in some cases generates profit.<sup>57</sup>

However, the high cost of digester installation means that adoption relies on incentives and grant funding, and digesters remain controversial in many areas where they have been installed. For small operators, the offset value alone is unlikely to result in recuperation of the large capital cost of infrastructure. Meanwhile, local air and water quality impacts associated with concentrated livestock facilities—which environmental justice advocates and communities have highlighted as a concern in the design of emissions reduction incentive programs—are a key consideration in the appropriateness of digester development. Extensive research has led to established and emerging solutions to reduce manure emissions—including certain solid-liquid separation technologies and vermifiltration (a system that reduces methane and other air pollutants by increasing aeration)—that may reduce methane while mitigating environmental and public health concerns. While dairies and ranches throughout the state are embracing the potential for significant emissions reductions, they face market and regulatory uncertainties and other financial barriers to implement management strategies.

Key barriers to manure emissions reduction include:

#### **High cost of technology, especially for medium and small farms**

The capital cost of an on-farm anaerobic digester is typically in the millions of dollars and can exceed \$15 million depending upon the size of the operation and technology used.<sup>58</sup> Maintenance and operational costs can also be high. As a result, single digesters are mostly fit for large operations and those near existing natural gas pipeline infrastructure, whereas small and medium-sized farms typically do not produce manure at the scale necessary to justify the costs of installing and maintaining a digester. However, dairies may be able to connect to existing cluster projects to capitalize on economies of scale, making them more economically viable. While state leaders have begun to prioritize smaller dairies for digester incentives, financial limitations can still mean these operations face challenges in implementing the technology (and in competing with larger operations more generally).

#### **Air and water quality impacts**

Concentrated dairy operations can cause significant air and water pollution regardless of their methane control strategies. As a result, some participants identified digesters as a threat to public health and environmental justice. Federal, state, and academic research in California has focused on analyzing environmental impacts from dairy manure digesters for more than two decades.<sup>59</sup> Environmental justice advocates have argued that incentives for digesters encourage larger herd sizes and more intense dairy operations, which they say could exacerbate already serious air and water quality impacts for local communities.<sup>60</sup> Dairy representatives, meanwhile, maintain that herd sizes are a function of large economic trends and are not influenced by state emissions programs. Environmental justice advocates note that pollution and odors stem from the presence of large-scale waste lagoons—which are unique to concentrated livestock operations—as well as over-application of waste on cropland, pre- and post-digester waste management, volatile organic compounds from fresh manure and silage, release of ammonia that contributes to fine particulate matter, pollution from trucking,

and dust (including from large-scale feed storage). Their counterparts, however, argue that digesters have either a neutral or positive effect on certain pollutants.

While local environmental concerns can apply to large-scale livestock operations in general, communities have raised them in the context of state strategies to address climate impacts. These programs, they argue, accelerate the long-running trend (driven by industry economics) of facility concentration and do not adequately address local impacts. Advocates also note that on-site use of dairy biogas in internal combustion engine generators can generate substantial local criteria air pollution.<sup>61</sup> (While most digesters in California use pipeline injection, which requires removal of harmful constituents, some facilities utilize the gas onsite in internal combustion engine generators, which can result in local air quality impacts.) For example, dairy manure is the largest source of ammonia emissions in the San Joaquin Valley and around the nation.<sup>62</sup> One analysis during the winter of 2018 found that more than half of the region's particulate matter emissions came from dairy ammonia releases,<sup>63</sup> another found the use of anaerobic digesters increased ammonia emissions by 80 percent because of the increase of ammonia-causing nitrogen in digestate.<sup>64</sup> (In the absence of digesters, dairy operations normally manage manure in open lagoons that do not capture methane or other air pollutants but may not generate the same ammonia emissions.)

Advocates also argue that dairy intensification harms groundwater by adding excess nitrogen from manure. While some digesters (known as thermophilic digesters) can reach high temperatures that eliminate dangerous pathogens such as *E. coli* and *Salmonella*, they are more energy-intensive and more expensive to run.<sup>65</sup> As with local air pollution, this concern largely relates to incentives for concentrated operations (and increased total quantities of manure at those operations) rather than to digester operation specifically, which in most cases includes the same wastewater management practices as other large, pre-digester dairies. (State-funded digesters must also meet heightened wastewater management and monitoring requirements.)

### Verification and accounting

Manure methane can be difficult to measure. While manure emissions can be directly measured in digesters, methane emissions from alternative manure management projects are more difficult to quantify. For alternative management strategies, direct measurement is expensive and can only be applied in limited fashion although modeling approaches are reaching greater accuracy.<sup>66</sup> For large companies that buy milk wholesale to produce dairy food products, a lack of streamlined verification of emissions reductions—and concerns around double counting if multiple entities take credit for the same reductions—can limit the ability to include manure methane emissions reductions in accounting toward their corporate carbon neutrality pledges. While market programs like the Low Carbon Fuel Standard provide some

## LOCAL ENVIRONMENTAL IMPACTS

The community and environmental justice concerns around local environmental impacts of large-scale dairies—particularly in the San Joaquin Valley, which experiences some of the worst air quality in the nation due to a range of factors including large-scale agricultural operations—highlight an especially challenging aspect of livestock methane policy. State climate, environmental, and agricultural leaders will need to continue working closely together in coming years to ensure that strategies to achieve climate targets and align with environmental and community health needs.



certainty and financial incentives for producers, the potential for double counting and the limited verifiability of reductions from non-digester projects may limit the ability of actors along the rest of the supply chain to accurately claim environmental benefits.

### Lack of financial incentives for alternative strategies

In addition to anaerobic digesters that capture biomethane for beneficial use, alternative manure management technologies that avoid methane production in the first place need further research and incentives. The state's Alternative Manure Management Program has funded over one hundred projects, but greater progress and investment is needed to drive further emissions reduction. Technologies such as advanced solid-liquid separation and vermifiltration show promise in reducing methane while providing air and water quality benefits. However, these methods have fewer revenue streams to offset costs than digesters, creating additional financial barriers to adoption.

### Threat of emissions leakage

As with any state-level emissions reduction strategy, efforts to reduce methane emissions from California livestock can create the risk that new costs imposed on operations will drive business to other states without the same climate standards, causing the emissions to “leak” outside the state. While California's strategies to date have been entirely incentive-based, adoption of state regulatory standards could pose a leakage threat without careful policy design.

***Solution: The Governor or state legislature could task the California Air Resources Board and/or California Department of Food and Agriculture with providing a “one-stop shop” for reporting of water quality, air quality, and greenhouse gas emissions, and technical assistance and assessment of methane emissions reduction strategies.***

As farmers try to address methane emissions from cattle, the diversity of oversight over manure management can create a significant compliance and information-tracking challenge. Participants generally agreed on the need to fund a robust suite of atmospheric measurements to verify manure methane emissions reductions at the farm scale, and then create a mechanism by which dairy farmers/digester operators can iteratively work with independent emissions verification teams to reduce manure methane emissions and ensure targets are met.

Some participants noted the lack of a central agency that had comprehensive, readily available data on digesters, emissions reductions, and environmental impacts. (Currently, EPA's AgStar program maintains a nationwide digester database with limited information, while the California Climate Investments program provides aggregate data for state-supported projects.<sup>67</sup>) The California Air Resources Board, Department of Food and Agriculture, State Water Resources Control Board, regional water boards, regional air districts, and local governments all have a role in gathering data from dairies. These agencies share much of this information, but problems still exist in transparently sharing

data. Especially for small dairies, participants cited the high cost and time it takes to communicate with multiple agencies. The need to share air and water quality data, in addition to atmospheric data for methane emissions, is a key step to measuring the holistic impacts of dairy production.

One example of government alignment on data collection and monitoring was CARB and CDFA's research collaboration between 2016 and 2018 to fund studies to monitor greenhouse gas and air pollutant emissions before and after implementation of various alternative manure management practices at six Alternative Manure Management Program (AMMP) funded dairies. In a complementary effort, CARB installed flux towers to measure methane emissions on three of the six AMMP-funded dairies.<sup>68</sup> CARB has also partnered with CDFA on review of applications to the DDRDP and AMMP programs, and CARB and CDFA partnered with multiple other state agencies in the SB 1383 working group processes. As the state further ramps up emissions reduction efforts to achieve SB 1383's 2030 target, and in particular if CARB takes up direct regulatory authority under the statute, the need for and value of such alignment will become urgent.

CARB and CDFA—with their collective expertise in assessing air pollution and overseeing livestock operations—could collaboratively lead a “one-stop shop” for operators to report their greenhouse gas, air and water quality, and other data; the agencies could match the reporting with state or third-party facility monitoring data to track performance and inform further research. While such a program should not override or abridge current permitting requirements (and air quality permit requirements, in particular, are dictated by federal law and US EPA regulation), it could create streamlined permit applications or provide technical assistance to reduce burdens on operators. Given the agencies' distinct statutory authorities and areas of expertise, the program would require new legislation to create this new legal authority, require participation by water regulators and local agencies, and provide funding for staff.

In addition, this one-stop shop could provide a single portal for farmer technical assistance on alternative manure management strategies, permitting, incentives, and regulatory compliance. As the agencies begin to work directly with product developers and farms on implementing enteric solutions, the program could also integrate reporting and technical assistance on implementation of feed additives, supplements, and other strategies and help facilitate faster approvals of promising new products. The DDRDP and AMMP program websites offer significant resources on permitting and program guidelines, but they could benefit from additional dedicated staff time to support knowledge on federal incentives such as US Department of Agriculture grant programs and federal energy production tax credits. And if CARB takes up regulatory authority under SB 1383, the two agencies could take advantage of the collaboration on data and verification to facilitate regulatory rollout and compliance.

*Solution: The California Air Resources Board could update the Low Carbon Fuel Standard to provide more certainty to digester project developers and downstream dairy biogas buyers, better account for life-cycle impacts and ensure additionality, and better account for community impacts.*

According to CARB’s March 2022 SB 1383 report, digesters account for the vast majority of statewide methane reductions achieved to date, and these reductions will need to increase—alongside further measures across all strategies—in order to meet the 2030 target.<sup>69</sup> The Low Carbon Fuel Standard (LCFS) has provided a helpful financial incentive for dairy biogas production, creating a profitable market for manure methane.<sup>70</sup>

Some participants noted that while digester adoption continues, more market certainty for farmers, digester developers, and investors would help accelerate it. (Other participants called for overhaul of the LCFS to either exclude dairy biogas or substantially incorporate environmental and environmental justice considerations.) The LCFS and other incentives have played critical roles in launching the capture and use of biomethane from the dairy sector, but the industry faces uncertainty about the availability and value of credits in the future, as well as the significance of the program’s greenhouse gas emissions reductions. At the same time, some participants noted that the program could better account for the full impacts of in-state and out-of-state dairy operations and ensure net reductions in statewide GHG emissions. Participants suggested multiple potential updates to strengthen the program, including:

- CARB could update the carbon intensity lifecycle analysis for biogas and electricity derived from anaerobic digesters in order to quantify emissions generated prior to the production of manure, such as enteric methane emissions from the manure-producing animals or carbon emissions associated with manure lagoon construction or operation. Such updates could better account for the full climate impact of dairy biogas production and—to the extent out-of-state dairies involve higher upstream emissions—could help ensure they don’t crowd out more regulated facilities in California.
- CARB could consider steps to limit access to multiple state-supported incentive programs such as restricting LCFS eligibility for operators who also receive state grants.
- CARB could establish a certified LCFS pathway specifically for in-state dairy operations to deliver renewable electricity to the grid for electric vehicle charging. This addition could allow dairies to access another potential source of revenue limited to in-state power generation.
- CARB could create a separate LCFS pathway for difficult-to-decarbonize sectors, where biogas can provide an interim pathway to meet industrial power demands. By helping to direct dairy biomethane to end uses such as refining, high-heat industrial facilities, food processing, cement, steel production, and computer chip fabrication, CARB could help reduce system-wide methane emissions and reduce

fossil gas consumption. Such a program could build on the California Public Utilities Commission’s Renewable Gas Procurement program.<sup>71</sup>

- CARB could create a price floor or minimum price for in-state dairy biogas to create market certainty about the long-term value of digester projects—particularly mid-sized operations that have traditionally lacked access to sufficient capital—and potentially expedite the timeline for project deployment by building the case for investing in digesters. CARB has also evaluated potential financial mechanisms to effectively guarantee minimum LCFS credit values for dairy projects, finding that new state funding would be needed to support such a program and that CARB should not be responsible for administering it since it could conflict (or create the appearance of a conflict) with the agency’s LCFS administration.<sup>72</sup>
- CARB could create a new environmental justice and community review process for LCFS updates and consider strategies to ensure the LCFS does not increase local emissions of toxic and criteria air pollution, given the high level of community concern that incentive programs exacerbate local environmental and health impacts, and in light of the agency’s dual mandates to address greenhouse gas and local air pollutant emissions.

***Solution: The legislature and the California Department of Food and Agriculture could revamp the Alternative Manure Management Program to expand funding and the scope of eligible manure methane emissions reduction projects.***

The Alternative Manure Management Program (AMMP) provides grants for farmers to implement non-digester waste emissions reduction strategies including pasture-based management, alternative manure treatment and storage (e.g., compost bedded pack barns), and drying techniques (e.g., solid separation or conversion from flush to scrape manure collection). According to CDFA data, the agency has yet to award a project primarily focused on pasture-based management.<sup>73</sup>

Although CDFA continues to implement new concepts, such as the Alternative Manure Management Program Demonstration Projects for “New Technologies and Practices” and “Advancing Practices Farmer-To-Farmer,” participants indicated that the programs’ incentives are insufficient for farmers to develop emerging strategies. CDFA could consider updating program award criteria to increase funding for demonstration projects with the greatest emissions reduction potential. CDFA could also allow Alternative Manure Management Program grant funds to be used for pre-commercial or new technology development, currently not allowed. Since the program generally has more applicants than awardees, increased funding from the legislature would be needed to expand the number of funded projects to include more demonstration projects.

In addition, the current Alternative Manure Management Program requirements for grazing-based practices are limited and do not include some emerging industry practices, like grazing for wildfire resilience.<sup>74</sup> Future program iterations

could expand existing financial and technical assistance to farmers looking to implement pasture-based strategies with significant emissions reduction potential, which has posed a challenge to date due to the potential for increased enteric emissions from more grass-based diets. (Some participants also noted that pasture-based practices may not be widely possible in many of California's climate zones, a challenge that will grow with warmer and more drought-prone conditions.)

***Solution: The legislature could fund the California Department of Food and Agriculture to support digester operation and maintenance while focusing efforts on smaller and medium dairies including incorporation into existing digester clusters.***

Some participants noted that digester project operators and dairy professionals need ongoing support for maintenance and upgrades to optimize emissions reductions and address system inefficiencies and technology breakdown. The Dairy Digester Research and Development Program (DDRDP), which provides financial assistance for digester installation, does not currently support these operation and maintenance costs.<sup>75</sup> These costs range from traditional facility maintenance to operation of hydrogen sulfide treatment systems which are vital to mitigate hazardous gas emissions from digesters and must be installed at the outset of operation. While large digester developers can typically manage operational costs to ensure revenue generation, smaller and medium-sized dairies may need some assistance with ongoing performance management. With additional funds allocated by the legislature, CDFA could expand the program to cover a portion of these costs to ensure maximum emissions reduction and offer more certainty to smaller farmers seeking to add a digester.

Environmental review, permitting, and other pre-development costs can also limit project development, particularly for smaller dairies. Pre-development costs, project timelines, and financing rates, influence the overall cost and speed of getting a project operational. By financially supporting pre-development as an allowable cost under the DDRDP, CDFA could help dairies analyze site-specific factors such as physical landscape, interconnection with electricity or gas infrastructure, and variability in LCFS credit or electricity prices. State financial support for feasibility analyses, environmental review, and other pre-development needs could help operators refine proposals and identify the best possible approach for developing and financing any project.

Some smaller dairies have found success in forming clusters of dairies that feed one digester. These cluster projects can serve many neighboring dairies in a community, sharing both costs and revenues. This business model can take two hub-and-spoke forms: centralized digester or centralized processing.<sup>76</sup> In a centralized digester model, waste feedstocks from multiple locations are collected and transported to a centralized anaerobic digester, allowing the community to build one digester and distribute the biogas and digestate. In a centralized processing model, digesters at multiple locations send the biogas to a centralized processing facility, providing a cost-sharing opportunity and economies of scale for expensive processing equipment and interconnection costs.

However, environmental justice and community advocates have raised serious environmental concerns about bringing more dairies into digester clusters, which could exacerbate the concentration of manure in single locations, thus increasing odor and potential groundwater contamination issues in neighboring communities, even as the total number of dairy cattle statewide does not grow. While more funding for operation and maintenance could help farmers address increased amounts of manure, policymakers will need to prevent the unintended environmental and environmental justice harms of bringing more potential contamination to already-burdened areas.

Some participants noted that policymakers can take action to better align digester support with environmental goals. For example, CDFA prioritizes DDRDP projects that minimize environmental impacts, including NOx and other air pollutants. Following passage of SB 859 (Chapter 368, Statutes of 2016), the state legislature required an assessment of environmental co-benefits and community benefits, and digester operators have shifted from onsite combustion or trucking of digester gas to pipeline injection projects with lower local air quality impacts.<sup>77</sup>

***Solution: The state legislature could redirect some existing digester funding to support more alternative manure projects such as advanced solid-liquid separators or vermifiltration alongside digesters.***

Because there is a limit to how many dairy digesters will be financially and operationally feasible in the state, eventually the Dairy Digester Research and Development Program will reach the end of its growth period. Participants suggested that state leaders should then move funding toward other emissions-reducing strategies.

For example, the liquids and solids that come out of a digester can still pose air and water quality threats. Post-treatment practices such as processing to filter out nutrients can reduce additional methane emissions and potentially address air and water quality issues. CARB could conduct more analysis of alternative manure management practices to consider methane and air pollution reduction benefits, operational feasibility, and cost-effectiveness of combining solid-liquid separation with other processes, such as digesters, composting, or flush to scrape.

Solid-liquid separation of livestock manure is a processing technology that partially separates the solids from the liquid manure using gravitational force, sedimentation basin, or a machine.<sup>78</sup> All digester projects require some form of separation mechanism. For some projects, separation can improve economics by reducing hauling costs for dairies who need to transport manure to a digester or facility elsewhere.<sup>79</sup> This process can simplify waste handling and disposal by reducing the amount of manure solids entering manure management and storage systems. Separation can also reduce odors by changing how volatile solids are stored under anaerobic conditions. While reducing ammonia emissions, separation preserves nitrogen in liquid and solid wastes, potentially resulting in impacts to water quality. In combination with digesters, solid-liquid separation can reduce greenhouse gas emissions by as much as 41 percent.<sup>80</sup>

Because digester implementation and management can lead to slight increases in ammonia concentrations,<sup>81</sup> advanced solid-liquid separation can reduce the important precursor emissions through technology stacking. By stacking a solid-liquid separator to separate solids after the digestion process from the effluent, this advanced separation technology has the potential to reach higher greenhouse gas and ammonia emissions reductions with improved technology efficiencies and management.<sup>82</sup>

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### PUTTING WORMS TO WORK

One promising strategy to mitigate the production of methane in dairy wastewater involves worm filtration processes,<sup>83</sup> which the company BioFiltro has demonstrated in pilot projects at small and large farms funded by Washington Conservation Commission grants.<sup>84</sup> The system can best be described as a larger, more sophisticated version of an aerated worm bin that reduces nitrogen and phosphorus from the liquid stream of manure through vermifiltration—a system that simultaneously reduces methane by increasing aeration and treats separated solids, providing odor, methane, and air emissions reductions.<sup>85</sup> The resulting worm castings produce a natural and nutrient-rich fertilizer and the resulting liquid contains far less solids and nutrients reducing methane emissions. While scaling units to meet the demand of California dairies will take time, they have the potential to mitigate the production of methane in aqueous environments.

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Redirecting existing funds from the Dairy Digester Research and Development Program towards the Alternative Manure Management Program could help farmers optimize the treatment and use of post-digester waste products while still driving methane emissions reductions. This reform could build on the existing technical assistance components of the Alternative Manure Management Program, including CDFA's funding for free one-on-one assistance to dairy and livestock operators interested in applying for the Alternative Manure Management Program and partnership with the University of California, Division of Agriculture and Natural Resources to offer Climate Smart Agriculture technical assistance to applicants.<sup>86</sup>

In addition, some participants noted a lack of state funding for agroecological solutions. These holistic approaches to manure management, which include pasture and rotational grazing methods, can address methane, reduce water and air quality impacts, support worker and community health, and shift farmers away from high herd densities that are linked to local pollution.<sup>87</sup> Other participants were skeptical of the potential for widespread use of agroecological approaches in California, as the state's hot climate and lack of water may not allow for pasture-based and grazing approaches in Central Valley areas that currently house most of the state's dairy cattle. Further research may be needed to assess where and to what extent agroecological approaches present a viable alternative to concentrated facilities considering the differences in land and water use.

The legislature could tap existing programs such as the California Infrastructure and Economic Development Bank’s new Climate Catalyst Revolving Loan Fund for additional funding to move beyond traditional digester strategies.<sup>88</sup> Participants noted that ongoing revenue could be put towards pilot projects that address air and water quality impacts in sensitive receptor communities. Participants emphasized the importance of aligning such programs in conjunction with the State Water Resources Control Board, California Air Resources Board, regional water boards, and regional air districts to ensure holistic implementation. Participants also noted that CDFA could add incentives for healthy soils, nitrate management plans, and biofiltration, given increased interest in the subject matter.

***Solution: The California Air Resources Board, State Water Resources Control Board, and other regulatory agencies could prioritize air and water quality co-benefits alongside methane emissions reductions and could further encourage adoption of technologies that address local pollution concerns alongside methane reductions, especially in lower income communities and communities of color.***

Many participants noted that while state air and water quality regulatory agencies have made progress in working with dairies, San Joaquin Valley communities, especially those near dairy operations, experience significant pollution impacts. Some participants advocated direct regulation of dairy methane (including moving away from credit-based systems that can result in a high concentration of polluting facilities in underserved communities) to rapidly reduce emissions, coordinate air and water quality protection efforts, and ensure emissions reduction in all areas of the state and in accordance with AB 32 and with SB 197’s (E. Garcia, Chapter 250, Statutes of 260) requirement to prioritize communities that are disproportionately impacted by climate change and public health threats.<sup>89</sup> See [page 19](#) for an overview of direct regulation considerations. Should CARB proceed with regulations under SB 1383, it could provide an opportunity to ensure greater environmental protection particularly if any further digester expansion is anticipated. More broadly, state leaders could consider additional funding for health impact analysis regarding digester project implementation—potentially through the one-stop shop discussed earlier in this section—to better inform policy decision-making around air and water quality impacts.

Participants also discussed the benefits of alternative manure management practices as a means to mitigate some of the air and water quality concerns associated with digesters and storage of manure in anaerobic environments. Greater emphasis on dry handling practices—whether through state incentive programs such as Alternative Manure Management Program or direct regulation—could help address environmental justice-centered concerns around greater concentration of herds and associated local impacts. CDFA’s Healthy Soils program, which incentivizes purchases of compost which could derive from alternative manure management projects, is a potential avenue to drive this change.



Additionally, CDFA could allow for greater alignment between Alternative Manure Management Program projects to reduce methane and other dairy proposals to reduce nitrogen pollution. Currently, farmers can include nutrient management strategies in applications for Alternative Manure Management Program, but they cannot receive program funding for them separately since they do not reduce methane emissions. Given the ecosystem and community health benefits of nutrient management projects, future iterations of the program could consider allowing sequential integration to promote greater overall investment.

## **B. BARRIERS TO ENTERIC EMISSIONS REDUCTION**

Enteric emissions are responsible for approximately one third of California's methane emissions and over half of all in-state livestock emissions.<sup>90</sup> They are also the single leading source of anthropogenic methane emissions nationwide.<sup>91</sup> Solutions to reduce enteric emissions—including feed additives such as red seaweed and 3-NOP, diet modifications, and selective breeding—are in development and showing great promise around the world, but they have yet to achieve significant commercial uptake and, in some cases, necessary federal approval. Recent meta-analyses suggest that global adoption of enteric emissions reductions strategies could substantially reduce livestock methane emissions in line with 2030 targets for a 1.5-degree temperature increase, although low- and middle-income countries face significant challenges.<sup>92</sup> While dairies and ranches throughout the state are embracing their potential for significant enteric emissions reductions, they face knowledge gaps on effectiveness and long-term impacts as well as a lack of financial or regulatory incentives to implement new strategies.

Key barriers to these emerging emissions reduction solutions include:

### **Slow regulatory approval processes**

Some of the most promising solutions for enteric emissions reduction are feed additives like red seaweed and 3-NOP that are regulated by the US Food and Drug Administration (FDA) and have not received agency approval for general commercial use.<sup>93</sup> FDA generally regulates these products as animal drugs (since their core purpose is to alter the function of the animal's rumen) rather than feed additives, requiring a clinical trial process which can take up to five years.<sup>94</sup> Certain essential oil- and fruit/vegetable extract-based additives have already received FDA approval, but more effective 3-NOP and red seaweed strategies are still likely years from full approval.<sup>95</sup> While the California Department of Food and Agriculture recently granted provisional approval of a red seaweed supplement (as a digestive aid, not a methane strategy), this approval applies only for in-state use of a single feed additive, in contrast with formal FDA approval for nationwide use.

### **Cost concerns and lack of market and regulatory incentives**

Participants noted that while methane-reducing feed additives may not ultimately impose significant new costs—potentially adding less than 5 percent to feed

budgets once commercially available—they still represent an additional cost that few operators will take on without a clear regulatory or financial incentive. Furthermore, other promising measures such as diet modification, breeding, and vaccination, which could function with feed additives to form a long-term and scalable enteric emissions reduction regimen, could increase costs. In addition, some participants expressed concern around the scale of production needed to fully integrate feed additives and other strategies into the California and US livestock sectors. Absent a state regulatory requirement, financial support, and/or incentives, or consumer demand to reduce enteric emissions, these strategies may remain largely out of use for all but the most environmentally conscious operations.

### Lack of data on effectiveness and long-term impacts

Research on certain strategies such as red seaweed and 3-NOP has shown potential for enteric emissions reductions of 50 percent or greater in some trials.<sup>96</sup> However, few studies have included large-scale analysis in the field, and significant questions remain around long-term effectiveness (versus animal tolerance or adaptation), implementation at scale (including at small-scale and pasture-based operations where feed additives are challenging to integrate), and potential impacts to animal health, human health, product quality, consumer safety, and animal productivity. Effectiveness of non-additive strategies is also promising but uncertain, and the appropriate use of multiple measures to develop a comprehensive, maximally effective and safe strategy is still being developed. In addition, methods to model and measure benefits are expanding but can prove costly. As a result—with benefits promising but unclear and impacts to herds and operations not fully known—many operators are hesitant or unable to implement the most promising strategies. They need commercially available and approved products as well as accelerated research to build trust, acceptability, and understanding.

***Solution: The California Department of Food and Agriculture and US Food and Drug Administration could accelerate approval of feed additives with emission-reducing potential, while providing safeguards for animal and human health.***

The California Department of Food and Agriculture has regulatory authority to provisionally approve animal feed additives for use within the state, while the US Food and Drug Administration must approve any additives for use nationwide. (CDFA does not have authority to approve or verify methane emissions reduction claims.) In May 2022 CDFA approved the use of red seaweed (as configured in Blue Ocean Barns' Brominata supplement) for commercial use as a digestive aid in California dairies.<sup>97</sup> The approval, which was based on a 40-day feeding trial, is provisional—it applies only to use in California, since FDA has not yet approved it; it is limited to the Blue Ocean Barns products, which are the only ones CDFA tested; and it only approved use as a digestive aid, as CDFA did not formally approve any methane emissions reduction claims, though early trials have demonstrated promising results.

Participants emphasized the importance of both rapid, full approval of additional red seaweed products and other emission-reducing additives by CDFA for use in-state and accelerated approval by FDA for use around the country, since nationwide implementation will be vital to development of a competitive, low-cost market among both additive producers and dairy and ranch operators. While CDFA's approval of red seaweed is a major development, the likely five-year national approval timeline for FDA could prove a significant barrier to rapid development and uptake in line with state and federal emissions reduction priorities. To accelerate implementation, CDFA could build on its provisional Brominata approval and fast-track approval of other promising feed additives (potentially engaging with CARB to verify emissions reduction claims) while ensuring adequate protections for animal and human health and safety.

At the same time, participants emphasized the importance of FDA approaching methane emission-reducing additives with greater priority and speed than traditional feed additives, calling for the agency to develop a special accelerated process to reduce time and cost required for clinical trials while still requiring robust health and safety reviews. State leaders could call for this limited-case exception based on the urgency of methane emissions reduction, the magnitude of enteric emissions, and the goal of ensuring that consumers do not ultimately pay the cost of the clinical trial process through increased prices for better-performing products. Participants also suggested that FDA consider an emergency authorization process given the potential scale of environmental benefits. While state-specific approval (such as CDFA's approval of Brominata) is a promising start, full federal approvals are ultimately the surest pathway to encourage rapid emissions reduction with adequate protections.

Participants pointed to the European Union's 2022 regulatory approval of Bovaer, a Dutch 3-NOP product, for use in dairy cattle as an example of a rapid but rigorous feed additive-oriented review process.<sup>98</sup> Participants suggested that California leaders could point to the EU process—which took approximately two years from application to approval—as a preferable alternative for urgent methane emission-reducing strategies.<sup>99</sup>

***Solution: The California Air Resources Board could adopt an offset protocol for enteric emissions reduction under its Cap-and-Trade program to provide new incentives for farmer adoption.***

California's greenhouse gas Cap-and-Trade program allows limited use of offset credits for covered entities to achieve compliance. Offsets credits are only permitted if they adhere to an offset protocol approved by the California Air Resources Board which ensures that the emissions offsets are real, additional (i.e., would not have otherwise occurred), quantifiable, permanent, verifiable, and enforceable.<sup>100</sup> CARB has approved a limited number of offset protocols to date covering six emissions reduction project types, including livestock manure emissions reduction projects.<sup>101</sup>

The ability to generate verified offset credits in the California Cap-and-Trade market can generate key financial support and predictability for new projects. To encourage adoption of enteric emissions reduction strategies and

development of new products and technologies, CARB could adopt an offset protocol for verified emissions reductions. One third party proposed a voluntary enteric protocol in December 2021.<sup>102</sup>

While CARB must review proposed protocols for conformity with statutory and Cap-and-Trade regulatory requirements (including agency civil rights obligations under Section 11135 of the California Government Code and the federal Civil Rights Act of 1964), and go through a robust regulatory process to incorporate them into the regulation, approving a voluntary protocol or developing a CARB-approved protocol could send a relatively rapid signal to operators and researchers that there could be a strong market for enteric emissions reductions. Key issues for CARB consideration may include the uncertainty of regulatory approval for emerging enteric emissions reduction strategies and methodology adjustments for beef cattle.

Participants also noted that the development of greenhouse gas markets to scale enteric solutions can potentially limit brands' ability to count—and pay a premium for—emissions reductions generated by their suppliers. (This concern also applies for more established manure emissions reduction strategies.) Major multinational brands are beginning to establish supply chain decarbonization targets and market their progress to consumers; many of these brands want to be careful to avoid double-counting (and thus devaluing) claimed reductions. If a supplier of lower-carbon meat or dairy sells credits (such as in the California Cap-and-Trade offset market) associated with its emissions reductions, then a purchasing brand cannot accurately claim the full value of the carbon reductions within its supply chain, since the buyer of the credits is claiming them as well. To count supplier emissions reductions within their supply chains, brands need to ensure that those emissions reductions are not also sold in carbon credit or offset markets.<sup>103</sup> Thus, to limit double-counting and ensure that incorporation of enteric solutions in a market- or credit-based program is transitional, voluntary market leaders could include structures such as a timed phase-out or financial disincentives for suppliers who profit from selling emissions reduction to brands while selling credits in the market.

***Solution: The state legislature could provide more financial support for enteric emissions reduction strategy research and development.***

According to the California Air Resources Board, the Dairy Digester Research and Development Program and Alternative Manure Management Program have been two of the most substantial successes of the California Climate Investments program—generating nearly 30 percent of all cap-and-trade funded greenhouse gas emissions reductions at a cost of approximately \$9-\$62 per ton.<sup>104</sup> The state has cumulatively invested \$289 million in these programs.

**A NOTE ON OFFSETS**

Since offset credits by definition offset emissions from a buyer in another sector, they are perhaps better understood as incentivizing new technologies and reducing compliance costs than as driving new net emissions reductions from the credit-generating sector. Many environmental and environmental justice advocates, including some in the participant group, argue against the use of offsets in general, pointing out that they allow credit-buying industries to continue emitting toxic and criteria co-pollutants that would not be permitted under direct regulation, typically in or near lower-income communities and communities of color.

Given the early stage of enteric emissions strategies and the significant need for further research to refine key solutions, craft comprehensive and marketable approaches, and ensure animal and consumer safety, leaders in the state legislature could direct a similar allocation of funds to enteric research and development. The legislature could create new enteric research programs through California Climate Investments or stand-alone programs (using recent budget surpluses) for the Air Resources Board and Department of Food and Agriculture to administer. Key focus areas could include:

- Analyzing whether animal rumens adapt to feed additives and what frequency of feeding maximizes benefits
- Developing effective strategies for reliable delivery of additives in pasture-based and beef cattle operations where no centralized feeding takes place
- Identifying in-state production opportunities and global needs to scale red seaweed and other promising additives for market adoption
- Investigating emerging non-additive solutions such as selective breeding and vaccination
- Crafting programs to conduct farmer and rancher outreach and education on the use and benefits of additives and other strategies
- Examining consumer willingness to pay, acceptance of feed modifications for emissions reduction, and openness to brand marketing and informational strategies

Participants pointed to the April 2022 launch of the Global Methane Hub research initiative as a potential opportunity to match and leverage research funds.<sup>105</sup> Some participants also suggested direct state payments from CDFA or CARB (potentially via the California Climate Investments program) to purchase and use enteric emissions reducing feeds and supplements. However, other participants noted the importance of ensuring that state financial support is narrowly targeted to promoting market certainty to achieve climate goals rather than broader investor goals.

***Solution: Financial institutions, supply chain companies, and land managers could provide financial incentives to adopt enteric emissions reduction strategies as they become available.***

Since many farms and livestock operations (particularly smaller ones) run on narrow financial margins, their owners are typically risk-averse with regard to process changes and emerging innovations. They are also significant users of debt financing and insurance products. To incentivize enteric emissions reductions and align with their own institutional goals to reduce portfolio greenhouse gas emissions, banks and lenders could provide preferential low-cost financing to operations that commit to certain enteric strategies and targets. In addition, the California Department of Insurance—whose current commissioner authored SB 1383—could use its leadership position in the National Association of Insurance Commissioners to advance discussion of

insurance-based mechanisms to mitigate risk for farmers and ranchers that adopt emerging enteric strategies. Supply chain companies could also consider more aggressive preferential purchasing and labeling programs to incentivize uptake and advertise high-performing suppliers. Finally, as an incentive for pasture-based strategies, federal and state land managers could offer grazing lease discounts to ranchers that commit to implementing enteric strategies.



## V. CONCLUSION

As an international leader in climate policy and a pioneer in strategies to reduce methane emissions in particular, California is uniquely positioned to spearhead global efforts to address the significant climate impacts of the meat and dairy industries. The state's leadership in setting a methane-specific emissions reduction target, investing in manure emissions reduction projects, and approving cutting-edge strategies with the potential to reduce enteric emissions provides a template for setting and achieving emissions reduction goals in other jurisdictions. At the same time, environmental justice advocates have expressed concerns regarding the link between state incentives, concentrated feeding operations, and air and water pollution in vulnerable communities as well as the additionality of methane emissions reductions in offset and credit programs.

To meet statutory targets, agency and industry leaders will need to continue and accelerate investment in well-known and emerging solutions, particularly for enteric emissions reduction. Those leaders will also have to achieve more stringent air and water quality protections for neighboring communities, potentially in coordination with direct methane regulation under SB 1383, to ensure that methane reductions do not come at the cost of local environmental and community health. The ultimate goal—a California livestock industry that is sustainable for the climate and the communities that host it—could serve as an example for governments around the world seeking to address this high-priority source of greenhouse gases.



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