

May 30, 2024

*Sent via email*

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Re: Petition for Rulemaking to Regulate Methane and Other Air Pollutants from California Livestock

Dear Ms. Cox, Mr. Brieger, and Mr. Chandler:

Thank you for submitting on behalf of Climate Action California the March 1, 2024, petition for rulemaking entitled "Petition for Rulemaking to Regulate Methane and Other Air Pollutants from California Livestock" to the California Air Resources Board (CARB or Board) and the California Department of Food and Agriculture (CDFA), pursuant to Government Code section 11340.6. CARB staff acknowledged receipt of the petition on March 1, 2024. CARB and CDFA appreciate the petitioners' agreement to extend the deadline for response to May 30, 2024, and now jointly provide a response in this letter.

The petition requests CARB and CDFA take specific actions to reduce dairy and livestock operations' emissions of methane, other greenhouse gases (GHG), and criteria pollutants, including through regulation of all dairies. The petition further requests CARB and CDFA measure dairy emissions, fund digesters and other mitigation, increase dry manure management systems, and provide technical assistance to dairies. The petition did not identify the provisions of the California Code of Regulations to be affected.

CARB and CDFA agree with the petitioners that methane, as a short-lived climate pollutant, has an outsize impact on climate change and that rapid mitigation is critical. Under state law known as Senate Bill (SB) 1383 (Lara, Stats. 2016, Ch. 395), California has set a target to reduce statewide methane emissions by 40% below 2013 emissions by 2030, and the more specific target to reduce dairy and livestock sector emissions by 40% below 2013 emissions by 2030 ("2030 target"). SB 1383 requires state actions to meet the target, including to analyze progress in meeting the target and to adopt regulations to meet the target if certain conditions are met.<sup>1</sup> Across the state, agencies and stakeholders have made considerable

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<sup>1</sup> Health and Safety Code § 39730.7(b)(4).

efforts over the last decade to reduce methane. CARB's work includes reducing methane through regulations.<sup>2</sup> CARB and CDFA's work also includes implementing state programs to provide financial support and incentives, fund research to better understand dairy and livestock emissions sources, and identify additional methane emissions reduction strategies.

The State has made meaningful progress toward achieving California's methane and greenhouse gas reduction targets and agrees with petitioners that more reductions are needed. Importantly, CARB and CDFA are committed to continuing this work to build on the progress achieved to date. However, as state agencies we must also follow the appropriate process before initiating a rulemaking pursuant to SB 1383, which requires more actions before regulations can be designed, adopted, and implemented.<sup>3</sup>

Based on CARB and CDFA's review of the petition, public comments,<sup>4</sup> relevant law, and facts regarding emissions reductions achieved to date and ongoing work to support reductions, CARB and CDFA are granting in part and denying in part this petition. Specifically, CARB and CDFA are:

- (1) Granting your petition, in part, by CARB and CDFA continuing to implement efforts to reduce methane and other pollutant emissions from livestock and dairy operations consistent with state law, including to:
  - a. Further assess through public engagement with stakeholders and community members whether statutory requirements are met and other considerations for initiating a regulatory design process pursuant to SB 1383, including evaluating data to better inform methane emission estimates and whether mandatory reporting requirements are appropriate;
  - b. Continue CDFA incentives and technical assistance programs for alternative manure management methods and digester projects;
  - c. Research and analyze nitrogenous emissions from dairy operations (including emissions of ammonia, nitrous oxide, and other NOx from soil nitrous oxide impacts); and

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<sup>2</sup> For example, CARB regulates methane from landfills and oil and gas operations. See Methane Emissions from Municipal Solid Waste Landfills, Cal. Code Regs., tit. 17, §§ 95460-95476; Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities, Cal. Code Regs., tit. 17, §§ 95665-95677.

<sup>3</sup> Senate Bill 1383 (2016) adds Sections 39730.5, 39730.6, 39730.7, and 39730.8 to the California Health and Safety Code, and adds Chapter 13.1 (commencing with Section 42652) to Part 3 of Division 30 of the Public Resources Code, relating to methane emissions. SB 1383 authorizes CARB and CDFA to take regulatory action on methane emissions from dairy and livestock operations and enteric emissions after meeting certain prerequisites.

<sup>4</sup> CARB, *2024 Livestock Methane Petition Public Comments*, [https://ww2.arb.ca.gov/approved-comments?entity\\_id=35671](https://ww2.arb.ca.gov/approved-comments?entity_id=35671).

d. Research enteric emissions reduction options.

(2) Denying your petition, in part, based on the ongoing work, by respectfully declining to immediately initiate rulemaking proceedings that would require all dairies in California to adopt some form of methane mitigation and adopt enteric emissions reduction measures; and denying your petition in part as to establishing stable funding to help dairies reduce methane given that CARB and CDFA do not appropriate state funding.

CARB intends to analyze and publicly engage with stakeholders and community members on the State's progress toward satisfying the remaining SB 1383 prerequisites later this year. As part of this engagement process, CARB plans to host a public workshop in August 2024 to discuss these topics. We thank the petitioners for ideas on future actions and look forward to collaborating with the petitioners and all stakeholders to expediently achieve these important targets. This response letter explains the reasons CARB and CDFA are denying in part and granting in part the requests of the petitioners and summarizes the impacts of ongoing programs and the work needed to collect and analyze additional information.

## **I. Methane and Criteria Pollutant Emissions Must be Further Reduced**

CARB agrees with the petitioners regarding the importance of reducing methane and criteria pollutants from the dairy and livestock sector. Methane is a significant short-lived climate pollutant. Dairy and livestock operations account for significant methane emissions and are significant contributors to statewide ammonia emissions which can lead to formation of ammonium nitrate, a component of particulate matter (PM) 2.5 emissions. This occurs in the San Joaquin Valley, where most dairy and livestock are located, and has a direct impact on many communities.

The State is responding to the challenge of methane emissions. The State has already funded incentives, technical assistance, research, and monitoring for methane emissions reduction projects and strategies for dairy and livestock operations for more than a decade. This work has been part of the State's efforts to fulfill requirements of SB 1383, California's law to urgently address short-lived climate pollutants. CARB adopted, and now implements, strategies and actions from the Short-Lived Climate Pollutant Emissions Reduction Strategy (SLCP Strategy)<sup>5</sup> to meet the 2030 target.

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<sup>5</sup> CARB, *Final Short-Lived Climate Pollutant Reduction Strategy* (March 2017), <https://ww2.arb.ca.gov/resources/documents/slcp-strategy-final>.

The 2022 Scoping Plan<sup>6</sup> confirmed the need to reduce methane emissions from the dairy and livestock sector and identified and recommended multiple strategies to help achieve that end. Anaerobic digesters can maximize air and water quality protection, maximizing biomethane capture and directing biomethane toward decarbonization or as energy feedstock(s). Alternative manure management projects, including “dry” manure management, compost-bedded pack barns, increased pasturage, and implementing solid-liquid separation technologies into flush manure management systems can reduce emissions. Implementing strategies for enteric methane emissions that are cost-effective, scientifically proven, safe for animal and human health, acceptable to consumers, and that do not impact animal productivity, with financial incentives for these strategies as needed, can also reduce emissions. Finally, considering regulatory development to ensure that the 2030 target is achieved, once the conditions outlined in SB 1383 are met, is an important strategy for California to reduce emissions.

The time remaining before the target year of 2030 is a crucial period for CARB, CDFA, stakeholders, and the public and community members to continue strengthening ongoing engagement about the status of progress towards the target and what more should be done to achieve our climate targets while improving air quality.

## II. Progress and Outcomes Towards 2030 Target

Public and privately funded investments in methane emissions reduction projects have achieved significant progress toward the 2030 target. The sector is expected to achieve nearly half of the target’s required reductions, even assuming no new projects are deployed.

To fulfill a requirement of SB 1383, CARB developed the Analysis of Progress toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target (Analysis).<sup>7</sup> The Analysis showed that the sector has achieved significant progress toward the 2030 target through a combination of methane emissions reductions projects from investments made through fiscal year (FY) 2019-20, and animal population changes, which together are expected to achieve up to 4.6 MMTCO<sub>2e</sub> or about 51.1% of reductions necessary to achieve the 2030 target.

This projection assumed a continued annual decline of 0.5% in animal populations based on the trend from 2008 to 2017,<sup>8</sup> and is expected to contribute approximately 2.3 MMTCO<sub>2e</sub> of

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<sup>6</sup> CARB, *2022 Scoping Plan for Achieving Carbon Neutrality* (December 2022), <https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents>.

<sup>7</sup> CARB, *Final Analysis of Progress toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target* (March 2022), <https://ww2.arb.ca.gov/resources/documents/dairy-livestock-sb1383-analysis>.

<sup>8</sup> Animal population change trends determined by evaluating the 2007, 2012, and 2017 U.S. Department of Agriculture Census of Agriculture Reports.

the estimated annual reductions. The remaining expected annual methane emissions reductions result from implementation of 123 anaerobic digesters, contributing about 1.9 MMTCO<sub>2e</sub>, and 155 alternative manure management projects, contributing about 0.4 MMTCO<sub>2e</sub>, at California dairy operations utilizing funding up through FY 2019-20.

The Analysis did not consider any additional funding for manure methane reduction projects beyond FY 2019-20. Subsequent state funding has been awarded to 22 additional digester projects and 53 additional alternative manure management projects, all of which are expected to be operational by the end of 2026. Combining these additional projects funded to date with those considered in the Analysis results in up to 353 state and privately funded manure methane emissions reduction projects since 2013. These projects, combined with expected methane emissions reductions resulting from continued animal population decline described in CARB's Analysis, are expected to achieve as much as 5.0 MMTCO<sub>2e</sub> in annual emissions reductions, or approximately 56% of the 9.0 MMTCO<sub>2e</sub> target by 2030.

Understanding the significant progress that California has made and reliably estimating reductions that can be expected in the next few years as additional effective strategies are funded and implemented is critical to considering additional actions to meet the 2030 target. To meet the 2030 target, it is critical that the State continue to build on the progress achieved so far. CARB and CDFA will continue to evaluate the effectiveness and outcomes of these and other strategies funded to meet the 2030 target.

### **III. CARB Needs More Information Before It Can Make the SB 1383-Required Determinations to Regulate the Sector**

Petitioners are correct that SB 1383 authorizes regulations to meet the 2030 target. However, more analysis is required before regulatory design consideration can begin consistent with state law. SB 1383 requires CARB to adopt and implement regulations, consistent with the Short-Lived Climate Pollutant Strategy, of dairy and livestock manure operations and enteric emissions to achieve the 2030 dairy methane emissions reduction target only once several activities are completed and specific determinations are made.<sup>9</sup> Some of these activities have taken place, and others require further analysis before regulations can be designed and adopted for implementation.

One completed statutorily required activity is that CARB work with stakeholders to identify and address technical, market, regulatory, and other challenges and barriers to the development of dairy methane emissions reduction projects. The law requires CARB to provide a forum for public engagement across the state, to consider the development of methane emissions reductions protocols utilizing CDFA research, and to publicly report on

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<sup>9</sup> Health & Saf. Code § 39730.7, subd. (b)(1)-(4).

this progress, as further specified in statute.<sup>10</sup> The stakeholder and public engagement work and information on this progress are posted on CARB's website.<sup>11</sup> The work completed through the Dairy Working Group and the methane emissions reduction offset protocol<sup>12</sup> is available online, as described below in this response. CARB and CDFA have considered and conducted significant research, yet more research needs to be done, as also described below in this response.

The statutorily required determinations to be made before implementation are relevant to the regulatory design and must be further analyzed and considered prior to the adoption of a regulation. CARB must determine that any regulation is technologically feasible,<sup>13</sup> economically feasible (considering specific topics including milk and live cattle prices, markets for products from methane emissions reduction and electrical interconnection, and access to common carrier pipelines for biomethane generated),<sup>14</sup> cost-effective,<sup>15</sup> inclusive of provisions to minimize and mitigate potential leakage to other states and countries,<sup>16</sup> and inclusive of an evaluation of the achievements made by incentives.<sup>17</sup> The statute further requires the use of voluntary and incentive-based measures to achieve methane emission reductions from enteric emissions and requires specific determinations about impacts before regulations can be adopted to reduce enteric emissions.<sup>18</sup> Research is ongoing to ensure that any new livestock feed or drug is safe and effective.

CARB and CDFA are collecting and evaluating data on the California dairy and livestock sector from multiple sources to evaluate and maximize methane mitigation opportunities. These sources include publicly available data from other state and local agencies as well as other data sources. CARB has synthesized the data to identify industry trends, research needs and information gaps, evaluate incentive design and performance, forecast potential emissions reductions from current and emerging strategies, and analyze progress toward the 2030 target. Importantly, these data collection efforts, combined with public feedback, have helped identify a variety of mitigation strategies that have resulted in methane emissions reductions from a broad range of facilities.

As to the requirement for evaluating the progress of incentives, as described below, the State has implemented multiple incentives with public funds appropriated by the

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<sup>10</sup> Health & Saf. Code § 39730.7, subd. (b)(2) and (3).

<sup>11</sup> CARB, Dairy and Livestock Greenhouse Gas Emissions Working Group, <https://ww2.arb.ca.gov/our-work/programs/dairy-and-livestock-wg> (last visited May 3, 2024).

<sup>12</sup> CARB, *Compliance Offset Protocols*, <https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/compliance-offset-protocols/livestock-projects>.

<sup>13</sup> Health & Saf. Code § 39730.7, subd. (b)(4)(A).

<sup>14</sup> Health & Saf. Code § 39607.7, subd. (b)(4)(B).

<sup>15</sup> Health & Saf. Code § 39670.7, subd. (b)(4)(C).

<sup>16</sup> Health & Saf. Code § 39670.7, subd. (b)(4)(D).

<sup>17</sup> Health & Saf. Code § 39730.7, subd. (b)(4)(E).

<sup>18</sup> Health & Saf. Code § 39670.7, subd. (f).

Legislature, including competitive cost-sharing grants for digester projects through the Dairy Digester Research and Development Program (DDRDP),<sup>19</sup> non-digester projects through the Alternative Manure Management Program (AMMP),<sup>20</sup> and more recently, the Dairy PLUS program,<sup>21</sup> which offers competitive grant funding for advanced manure management practices that reduce both methane emissions and nutrient surplus. CARB provides additional incentive support through its regulatory GHG emissions reduction programs, along with incentive programs from other state agencies including the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC), and federal programs.<sup>22</sup> CARB would incorporate its evaluation of incentives into any regulation.

As to the requirements related to technological and economic feasibility, cost-effectiveness, and leakage, CARB needs additional information and analysis to make the remaining determinations. This includes information about the varied dairy and livestock operations, including facility characteristics, economic factors affecting milk and cattle prices, market opportunities for products generated by dairy and livestock manure management, and an improved, holistic understanding of emissions sources and tradeoffs from implementing methane reduction strategies. The State also needs more information about factors affecting emissions leakage and potential strategies to minimize or mitigate any potential leakage.

CARB and CDFA will continue to collaborate and analyze available data to make assessments and facilitate public stakeholder and community member engagement to determine an appropriate scope and design for any potential future regulation, including whether mandatory reporting requirements are appropriate. For these reasons, CARB is not immediately initiating a rulemaking that will require all dairy and livestock facilities to adopt a mitigation strategy until it has addressed these prerequisite statutory requirements. CARB and CDFA will analyze and publicly engage on the State's progress toward satisfying the remaining SB 1383 prerequisites and look forward to working with stakeholders and community members to collaborate on next steps, research analysis, and strategy development before initiating this rulemaking.

The next sections summarize other state activities to implement SB 1383 and support methane and criteria emissions reductions.

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<sup>19</sup> CDFA, *Dairy Digester Research and Development Program*, <https://www.caclimateinvestments.ca.gov/dairy-digester>.

<sup>20</sup> CDFA, *Alternative Manure Management Program*, <https://www.caclimateinvestments.ca.gov/alternative-manure>.

<sup>21</sup> CDFA, *Dairy PLUS Program*, <https://www.cdfa.ca.gov/oefi/dairyplus/>.

<sup>22</sup> Additional State funding and incentive support are described in Appendix B.



## **IV. CARB and CDFA have Engaged in Significant Stakeholder Collaboration to Analyze Barriers and Recommend Solutions for Reductions and Policy Considerations**

Stakeholder collaborations with state agencies have resulted in recommendations for strategies to reduce emissions and respond to barriers. SB 1383 directs CARB to work with stakeholders to “identify and address technical, market, regulatory, and other challenges and barriers to developing dairy methane emissions reduction projects.”<sup>23</sup> In response, CARB, in collaboration with CDFA, the CPUC, and the CEC, convened the Dairy and Livestock Greenhouse Gas Emissions Working Group<sup>24</sup> (Working Group) and its three subgroups focused on discussing barriers and solutions related to non-digester projects, digester projects, and research needs. From May 2017 through December 2018, the Working Group and its subgroups held 31 meetings to facilitate discussions among government, industry, academia, the environmental justice community, and the public. In November 2018, the subgroups presented final recommendations<sup>25</sup> on overcoming barriers to methane reduction projects and a research prospectus identifying potential research needs to the convening agencies.

Where able, CARB and CDFA have made progress on implementing recommendations from each of the three subgroups, including continued incentives and implementation of additional manure methane emissions reduction projects, new strategy evaluation, improved understanding of existing strategies, manure product market assessment (including implementation of the Manure Recycling and Innovative Products Task Force),<sup>26</sup> and research implementation. Much of this work is described in the sections below. The Working Group and subgroups held publicly noticed meetings in Sacramento, Bakersfield, and Santa Rosa, which included options for remote participation and, in some cases, Spanish translation services to facilitate broader public engagement.

CARB and CDFA have continued to engage on these topics since forming the initial Working Group. In March 2022, CARB staff facilitated an all-day public workshop on

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<sup>23</sup> Health & Saf. Code § 39730.7, subd. (b)(2)(A).

<sup>24</sup> CARB, *Dairy and Livestock Greenhouse Gas Emissions Working Group*, <https://ww2.arb.ca.gov/our-work/programs/dairy-and-livestock-wg>.

<sup>25</sup> California Dairy and Livestock Greenhouse Gas Reduction Working Group, *Recommendations to the State of California’s Dairy and Livestock Greenhouse Gas Reduction Working Group* (November 26, 2018), <https://ww2.arb.ca.gov/sites/default/files/2020-11/dairy-subgroup-recs-112618.pdf>.

<sup>26</sup> More information on the Manure Recycling and Innovative Products Task Force available at: <https://www.cdfa.ca.gov/oefi/mrip/>.



Methane, Dairies and Livestock, and Renewable Natural Gas in California.<sup>27</sup> The workshop included 11 distinct topic sessions and two public comment periods.

Workshop topic sessions included:

- Statutory requirements for dairy and livestock methane emissions reductions,
- An overview of dairies in California (including operational, sectoral, and product trends, and environmental impacts and permitting requirements),
- Community perspectives on dairies, perspectives on the future of dairies in California (from environmental justice advocates and industry representatives),
- An overview of mitigation technologies, funding, and economics,
- An overview of the dairy and livestock GHG emissions working group and subgroups,
- An overview of CARB's Low Carbon Fuel Standard (LCFS) Program and dairy pathways,
- An overview of findings from CARB's 2022 analysis of progress toward the 2030 target, and
- Considerations for methane mitigation incentives and regulation.

The Working Group recommendations will continue to be relevant as CARB and CDFA analyze and publicly engage on the State's progress toward satisfying the remaining SB 1383 prerequisites later this year.

## **V. Funding Supports Emissions Reductions, Research, Technical Assistance, and Inventory Improvements**

Funding and incentive support of various strategies have been critical for methane emissions reductions from the California dairy and livestock sector and will likely continue to be critical. These funds have supported project implementation, research of new and emerging methane emissions reduction strategies, and technical assistance to stakeholders. Nearly all methane emissions reduction projects implemented have received state incentive funding and are among the most cost-effective greenhouse gas reduction projects.

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<sup>27</sup> CARB, *Workshop on Methane, Dairies and Livestock, and Renewable Natural Gas in California*, <https://ww2.arb.ca.gov/events/workshop-methane-dairies-and-livestock-and-renewable-natural-gas-california>.

Additionally, CARB's Cap-and-Trade Program<sup>28</sup> and LCFS Program<sup>29</sup> are regulatory GHG emissions reduction programs that provide important additional support for digester projects, along with other state and federal cost sharing and incentive programs.<sup>30</sup>

There is widespread agreement that stable funding is necessary to help dairies implement digesters and other methane mitigation measures, as well as engage in research and access technical assistance. CARB's SLCP Strategy and 2022 Analysis of Progress Toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target<sup>31</sup> (Analysis) recognize this need and estimate total costs and the minimum annual Legislative appropriation needed to achieve the 2030 target. However, neither CARB nor CDFA make appropriations for such programs. To date, state and federal funding has been distributed through multiple mechanisms ranging from grants and cost-sharing programs that reduce construction costs to environmental crediting and energy product offtake agreements for electricity and biomethane.

New, long-term, stable funding could further accelerate the capture of California's dairy manure and enteric methane emissions, direct captured biomethane to difficult-to-decarbonize sectors and accelerate the adoption of alternative manure management projects that provide climate and environmental co-benefits, including water quality improvements and conservation, reduction of synthetic fertilizer usage, improvement of nutrient management, and groundwater protection.

CARB and CDFA will continue to work with relevant state agencies to track the progress achieved by state and federal incentives, and to report on the outcomes of that progress to demonstrate the effectiveness of stable funding mechanisms.

## **a) Dairy Digester Research and Development Program**

CDFA's DDRDP<sup>32</sup> was established in 2014 to award competitive grants for anaerobic digesters that result in manure methane emission reductions at California dairies while minimizing and mitigating other adverse environmental impacts over the minimum ten-year

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<sup>28</sup> CARB, *Cap-and-Trade Program*, <https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program>. California's Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms (Cap-and-Trade) regulations are published at title 17, CCR, sections 95801 through 96022.

<sup>29</sup> CARB, *Low Carbon Fuel Standard*, <https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard>. California's LCFS regulations are published at title 17, California Code of Regulations (CCR), sections 95480 through 95503.

<sup>30</sup> See Appendix B.

<sup>31</sup> CARB, *Final 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>.

<sup>32</sup> CDFA, *Dairy Digester Research and Development Program*, <https://www.caclimateinvestments.ca.gov/dairy-digester>.

project operational life. DDRDP incentive grants fund up to 50% of the total project costs and up to \$1.6 million per project, or \$1 million per project if the awardee previously received an AMMP grant. Applicants must provide the remaining funds in eligible matching funds. To date, award recipients have provided \$489 million in matching funds.

DDRDP projects are among the most cost-effective GHG emissions reductions projects compared to other California Climate Investment (CCI) funded programs.<sup>33</sup> As of April 2024, there have been seven grant solicitations with \$227 million in total funding awarded to 140 projects producing renewable fuels, electricity, and hydrogen production feedstock. These projects are estimated to achieve 2.45 MMTCO<sub>2</sub>e<sup>34</sup> in annual methane emissions reductions at a cost of approximately \$29 per MTCO<sub>2</sub>e, with approximately \$9 representing state investment. Importantly, 67% of project funds provide jobs, economic, environmental, and financial benefits to priority populations<sup>35</sup> as defined by the CCI Funding Guidelines.<sup>36</sup>

In addition to methane emissions reductions, DDRDP project co-benefits may include nuisance reduction (odor, flies, pathogens, weed seeds), fossil fuel reduction or replacement, energy and fuel cost savings, renewable fuel and energy generation, compost production, fertilizer reductions, direction of biomethane to hard-to-decarbonize sectors, and local and remote criteria pollutant reductions. The DDRDP program also promotes surface and groundwater quality protection by requiring digester designs that meet the most stringent water quality protection requirements. Program requirements and benefits are further outlined in the DDRDP.<sup>37</sup>

## b) Alternative Manure Management Program

CDFA's Alternative Manure Management Program (AMMP)<sup>38</sup> awards competitive grant funding to California dairy operations to implement non-digestion manure management practices that reduce methane emissions and maximize environmental benefits over the

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<sup>33</sup> CARB, *2023 Annual Report: Cap-and-Trade Auction Proceeds*,

[https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/ccli\\_annual\\_report\\_2023.pdf](https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/ccli_annual_report_2023.pdf).

<sup>34</sup> These estimates include the anaerobic digestion projects receiving Aliso Canyon Mitigation Settlement funds, which will result in an estimated additional 0.3 MMTCO<sub>2</sub>e in annual methane emissions reductions. Since these projects count toward natural gas sector mitigation, they do not count toward the 2030 target.

<sup>35</sup> CARB, *2023 Annual Report: Cap-and-Trade Auction Proceeds*,

[https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/ccli\\_annual\\_report\\_2023.pdf](https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/ccli_annual_report_2023.pdf).

<sup>36</sup> CARB, *Funding Guidelines for Agencies that Administer California Climate Investments* (August 2018),

<https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/2018-funding-guidelines.pdf>.

<sup>37</sup> CDFA, *Dairy Digester Research and Development Program*, <https://www.caclimateinvestments.ca.gov/dairy-digester>.

<sup>38</sup> CDFA, *Alternative Manure Management Program*, <https://www.caclimateinvestments.ca.gov/alternative-manure#:~:text=Alternative%20Manure%20Management%20Program%20provides%20financial%20incentive%20to,scrape%20manure%20collection%20and%20enhanced%20pasture-based%20management%20practices>.

minimum five-year project lifetime. AMMP supports a diverse range of manure management practices that provide methane mitigation options to the wide variety of dairy operations across the state. Factors like size, management style, location and proximity to infrastructure, and economic feasibility impact manure management system selection. AMMP funds strategies to reduce manure methane emissions at operations where a digester may be infeasible through practices that reduce anaerobic management of manure, thereby reducing methane formation.

Eligible AMMP practices include increased pasture-based management, alternative manure storage including compost bedded pack barns or slatted floor pit storage manure collection, solid-liquid separation, and converting from flush manure management to solid manure management. AMMP incentive grants fund up to 100% of total project cost with a maximum award of \$750,000 per project. While strongly encouraged, matching funds are not required. As of April 2024, AMMP has awarded over \$106 million to 170 incentive and demonstration projects through six grant solicitations, with over \$20 million in matching funds proposed. Collectively, these projects are estimated to achieve approximately 0.3 MMTCO<sub>2e</sub> in annual methane emissions reductions with 90% of 2020 and 69% of 2022 projects providing benefits to priority populations. In addition to methane emissions reductions, AMMP project co-benefits may include criteria and toxic pollutant emissions reductions, reduced odors, flies, and fossil fuel use, value added product production, and improved soil health, water use efficiency, and nutrient management.

Through careful tracking and consideration, CARB and CDFA have identified various effective alternative manure management practices with scientifically proven manure methane emissions reduction effectiveness. However, emerging strategies require additional study before they can be incorporated into AMMP, assumed to be suitable for all operations, or proven to be sufficiently effective at achieving methane emissions reductions. This approach highlights the importance of the collaborative process CARB and CDFA use to evaluate potentially effective practices and strategies.

For example, aeration technology can potentially reduce lagoon methane emissions, but may be technologically infeasible and result in unintended nitrogenous emissions, including ammonia and nitrous oxide. Similarly, while CARB and CDFA support reducing or eliminating wet or lagoon-style manure in favor of "dry" management and affiliated methods, in some cases, this conversion may result in unintended air quality impacts. While conversion from flush management may reduce manure methane formation, widespread conversion to dry management may result in potential emissions tradeoffs including increased ammonia, particulate matter, nitrous oxide, and volatile organic compound emissions. These tradeoffs may result from manure composting, increased equipment usage, or increased usage of synthetic fertilizers. CARB and CDFA support future research to better understand these and other potential emissions tradeoffs before requiring significant reduction or elimination of liquid manure.

The efficacy and downstream impacts of manure and lagoon additives are uncertain, so requiring their use is premature. Composting manure with additives like biochar has demonstrated considerable mitigation potential but with uncertain upstream and downstream impacts. Similarly, the few lagoon additive experiments conducted to date have shown potential methane emissions reductions in the laboratory setting, but farm-scale research is needed before conclusions on their actual effectiveness can be drawn. Given the uncertainty surrounding potential downstream impacts on emissions, water quality, and forage production, more research on their overall effectiveness, benefits, and impacts is necessary before they can be considered viable methane emissions reduction strategies.

### **c) Dairy PLUS Program**

The Dairy PLUS Program awards competitive grants to California dairy farms to implement advanced manure management practices that reduce methane emissions and nutrient surpluses. The California Dairy Research Foundation (CDRF), in collaboration with CDFA and other organizations, received \$85 million from the U.S. Department of Agriculture, to be awarded over five years, that provide incentives for dairy producers to adopt these advanced practices, assess associated GHG emissions reductions and nutrient benefits, provide outreach and technical assistance, and develop climate-smart product markets. The Dairy PLUS Program will provide \$75 million in incentive funds through three solicitations.

Eligible Dairy PLUS Program primary practices include vermifiltration, solid-liquid separation through a weeping wall or assisted by flocculants and/or bead filters; secondary practices include subsurface drip irrigation and aerated composting. To date, CDFA and CDRF have awarded \$17.9 million to 15 projects, including 12 complementary AMMP projects and three complementary DDRDP projects. These projects are expected to reduce approximately 0.12 MMTCO<sub>2</sub>e when combined with the associated AMMP and DDRDP projects over the project lifespans.<sup>39</sup>

In addition to GHG emissions reductions, Dairy PLUS Program project co-benefits include criteria and toxic pollutant emissions reductions, soil health co-benefits, fossil fuel reductions, and improved nitrogen management which results in improved water quality protection and transforming manure into fertilizer and soil amendment that promotes soil health and carbon sequestration.

### **d) Livestock Enteric Methane Emission Reduction Research Program**

Enteric strategies, especially feed additives, hold considerable methane mitigation potential and could make significant contributions toward the 2030 target. Though multiple additives

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<sup>39</sup> Since Dairy Plus Program projects are highly interconnected with AMMP and DDRDP grants, it is not possible at this time to assess the share of the GHG emission reduction coming from AMMP, DDRDP and Dairy Plus Program individually.

and other enteric strategies are undergoing research and development, there are currently an insufficient number of commercially available and scientifically proven additives, preventing widespread adoption of effective strategies through voluntary action or by mandate.

To facilitate further adoption, CDFA's Livestock Enteric Methane Emission Reduction Research Program (LEMER-RP)<sup>40</sup> awarded \$9.2 million in competitive grants to demonstration trials evaluating additives and dietary modifications with the potential to reduce dairy and livestock enteric methane emissions. These projects may help identify safe, effective feed additives and strategies with practical on-farm implementation potential. In total, six projects were funded and are being implemented.<sup>41</sup> This research program is intended to inform regulatory approval of animal feeds, drugs, or feeding strategies that reduce livestock enteric methane emissions. Additionally, the Food and Drug Administration is updating its animal feed review process and seeks legislative authority to develop a regulatory pathway for impact those that reduce enteric methane.<sup>42</sup>

### **e) New Incentive Program for Enteric Emissions Reduction**

In 2023, California allocated \$25 million to CDFA to develop an incentive program for producers adopting an enteric methane-reducing feed additive or strategy. However, budgetary constraints and uncertainty surrounding the availability of scientifically proven enteric reduction strategies reduced that allocation to \$2 million. The \$2 million is allocated for developing the framework of an evidence-based program focused on enteric methane reduction through feed additives in the event increased funding is later reallocated. CDFA intends to use this funding to develop an incentive program for reducing enteric emissions that broadly stimulates practices adoption and reduction tracking.

### **f) Programmatic Support Available for Livestock Projects**

CARB regulatory GHG emissions reduction programs complement available state funding to offer additional support to digester projects through the Cap-and-Trade and LCFS programs. CARB adopted the Compliance Offset Protocol for Livestock Projects<sup>43</sup> ("Protocol") for projects that install manure biogas capture and destruction technologies to

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<sup>40</sup> CDFA, *Enteric Methane Emission Reduction Programs*, <https://www.cdfa.ca.gov/oefi/enteric/>.

<sup>41</sup> CDFA, *2023 Livestock Enteric Methane Emission Reduction Research Program (LEMER-RP) Projects Selected for Award Funds* (December 2023), [https://www.cdfa.ca.gov/oefi/enteric/docs/LEMER-RP\\_Selected\\_Projects.pdf](https://www.cdfa.ca.gov/oefi/enteric/docs/LEMER-RP_Selected_Projects.pdf).

<sup>42</sup> U.S. Food and Drug Administration, *FDA Letter to Industry: Industry Encouraged to Contact FDA Regarding Novel Animal Foods with Drug Claims*, <https://www.fda.gov/animal-veterinary/resources-you/fda-letter-industry-industry-encouraged-contact-fda-regarding-novel-animal-foods-drug-claims>.

<sup>43</sup> CARB, *Compliance Offset Protocols*, <https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/compliance-offset-protocols/livestock-projects>.

generate saleable compliance offset credits under the Cap-and-Trade Program. The Protocol provides eligibility rules, methods to quantify GHG reductions, monitoring requirements, and procedures for preparing project data reports. The quantification method established by the Protocol was used to develop the framework for determining the lifecycle carbon intensity of fuel pathways associated with digester projects under the LCFS regulation, which allows such projects to generate marketable credits based on reported transportation fuel production. The CPUC also implements BioMAT and a biomethane procurement program to provide reliable revenue for the beneficial use of captured methane, consistent with the SLCP Strategy and SB 1440 (Hueso, Stats. 2018, Ch. 739). A list of programs contributing incentives to support dairy and livestock methane emissions reductions is provided in Appendix B.

## **g) Technical Assistance Available for Dairies**

Technical assistance increases the accessibility of incentive funding to California livestock operations that otherwise may not have the resources or technical expertise to apply for and participate in climate-smart agriculture incentive programs. Assembly Bill (AB) 2377 (Irwin, Stats. 2018, Ch. 868)<sup>44</sup> authorized CDFA to administer a technical assistance grant program and required several climate-smart agriculture incentive programs, including AMMP, to make 5% of appropriated funding available for technical assistance including outreach and education, project design assistance, application assistance, implementation, and reporting. The Climate Smart Agriculture Technical Assistance Grant Program<sup>45</sup> prioritizes smaller farms and socially disadvantaged farmers and promotes, among other climate-smart agriculture practices, on-farm methane reduction and sustainability regardless of a farm's size.

Applicants and award recipients receive free technical assistance for application, on-farm practice implementation, and project verification. For AMMP, technical assistance providers (TAPs) are located statewide, ensuring access to assistance to all who require it. TAPs work closely with CDFA program staff to train and coordinate outreach efforts through all grant phases. Technical assistance is also provided to Dairy Plus Program participants through a partnership with CDRF.

To assist CDFA's grant programs in reaching a broader and more diverse audience, TAPs conduct workshops to provide information to local communities, with some offering non-English language assistance. They provide guidance on climate-smart agriculture practices and project design, and assist with administrative tasks, including completing grant applications, connecting recipients to vendors, on-farm practice implementation assistance, invoicing activities, verifying appropriate use of grant funds, and ensuring program

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<sup>44</sup> Assembly Bill 2377 (2018) adds Section 570 to the Food and Agricultural Code, relating to agriculture.

<sup>45</sup> CDFA, *Climate Smart Agriculture Technical Assistance*, <https://www.cdfa.ca.gov/oefi/technical/>.



requirements are met. CDFA staff also host public application assistance workshops which are available to TAPs and eligible farmers during grant solicitation periods. These workshops provide program overviews, discuss funding availability and eligible practices, and describe the application process.

## **h) Improvements to Emissions Modeling and Aerial Detection Efforts to Support Leak Detection and Repair**

With the support of existing funding sources, CARB is refining its ability to identify methane emissions sources. This includes emissions from previously unidentified sources and leaks from digesters and associated infrastructure. Remote sensing efforts, including aerial, satellite-based, and other remote sensing monitoring technology, can help support CARB to identify and quantify methane emissions sources and can also provide frequent monitoring that allows facilities to identify “fugitive” methane sources and, where feasible, fix leaking infrastructure. Additionally, remote sensing technology can help the State understand the impact of meteorological conditions on methane sources and refine modeling assumptions that can improve methane quantification statewide.

California’s Greenhouse Gas Emissions Inventory (AB 32 GHG Inventory) follows standards for sub-national and national inventory development and aligns with Intergovernmental Panel on Climate Change criteria and U.S. EPA methods. This approach allows for comparison of the state inventory with other sub-national and international inventories through common methodologies and requirements for accuracy, making it important to carefully consider changes to the inventory. CARB updated the 2021 AB 32 GHG Inventory (2023 edition)<sup>46</sup> to reflect the acceleration in the portion of dairy manure managed by anaerobic digesters. This shows that over 60 anaerobic digesters were operational and managed at least 8.9% of the statewide dairy population’s manure in 2021, leading to a reduction of over 1 MMTCO<sub>2</sub>e per year attributable to digester adoption since 2017. The forthcoming GHG Inventory will incorporate the latest statewide population and digester project data, enabling a more accurate estimate of emissions reductions and progress toward the 2030 target achieved as of 2022. Additional facility-level detail and data sources could help improve current emissions estimates.<sup>47</sup> To this end, CARB is evaluating the best-available state and local data to determine its utility for model improvement and policy development.

Using currently available technologies is costly and technically and scientifically challenging. Accurately and continuously measuring air pollutant emissions at large area sources like each of California’s 1,100+ independent dairy operations is complicated. Comprehensive

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<sup>46</sup> CARB, *Greenhouse Gas Inventory*, <https://ww2.arb.ca.gov/our-work/programs/greenhouse-gas-inventory>.

<sup>47</sup> Amini, S, et al., *Evaluating California Dairy Methane Emission Factors Using Short-Term Ground-Level and Airborne Measurements* (2022). Partially CARB-funded mobile emissions monitoring campaign Contract 16RD018.

measurements that capture long-term and seasonal variability, as well as potential tradeoffs from implementing methane emissions reductions projects, require technical expertise, careful study design and planning, and specialized equipment designed for operation in extreme conditions (such as heat and dust). Each of these factors increases overall project cost. As a result, a more straightforward approach is to estimate emissions using widely accepted data and methods, which is consistent with other national and sub-national emissions inventories. CARB is committed to continuous improvement of emissions inventories through new research, incorporation of best available data sources and technologies, and use of site-specific data where feasible.

## i) Research

Research funded by the State on dairy and livestock methane and criteria emissions continues to inform a deeper understanding of the complexities of manure management and enteric fermentation to inform better program design and regulatory consideration. Extensive research to date, including research prescribed in the Working Group research prospectus, has included literature reviews, measurement campaigns, and model development to better understand emissions and emissions reduction strategies. These efforts have focused on the effectiveness of alternative manure management strategies, downstream emissions from anaerobic digestion, enteric fermentation, emissions characterization, and emissions model development. CARB and CDFA continue pursuing additional research to better understand potential emissions reduction strategies and their co-benefits, impacts, and potential emissions tradeoffs.<sup>48</sup>

Notably, since 2022, CDFA has implemented two dairy research programs evaluating methane emissions reduction strategies. In addition to the enteric research described above, the California Livestock Methane Measurement, Mitigation and Thriving Environments Research Program (CLIM3ATE-RP)<sup>49</sup> awarded \$4.74 million in funds to research projects that evaluated methane emissions reduction strategy verification, alternative methane reduction strategies, and manure recycling and innovative products development. These studies include evaluation of AMMP project implementation costs and benefits, the potential for feed byproducts to reduce enteric methane emissions from dairy cows, developing a testing and reporting standard for measuring ruminant enteric methane emissions, evaluating the enteric methane emissions reduction potential of seaweed, and assessing pre-and post-project GHG and criteria air pollutants impact of DDRDP and AMMP projects.

Dairy and livestock operations are significant contributors to statewide ammonia emissions, which can lead to the formation of ammonium nitrate, a component of particulate matter

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<sup>48</sup> More information on criteria pollutant related research is included in Appendix A.

<sup>49</sup> CDFA, *2022 California Livestock Methane Measurement, Mitigation and Thriving Environments Research Program* (CLIM3ATE-RP), <https://www.cdfa.ca.gov/oefi/research/>.

(PM) 2.5 emissions, including in the San Joaquin Valley, where most California dairy and livestock are located. CARB is currently contracting a project that involves evaluating dairy digestate and nitrogenous emissions (for example, ammonia) from dairy operations. Additionally, there is an internal effort at CARB to develop and improve process-based modeling systems to help estimate ammonia emissions from livestock operations. Based on research and extensive air quality modeling conducted by CARB and other institutions, reducing ammonia emissions by up to 30% will not lower overall levels of PM2.5 in the San Joaquin Valley. Other strategies for reducing PM2.5 levels may be more effective than reducing ammonia emissions.<sup>50</sup> Note also that regulation, permitting, and enforcement actions related to non-methane emissions (including criteria pollutants, ammonia, and particulate matter) at dairy and livestock operations are typically the responsibility of the state's 35 air pollution control and air quality management districts (Air Districts). These local Air Districts review project proposals, perform health risk assessments, and determine health-protective, facility-specific operational requirements for stationary emissions sources, which can include dairy and livestock operations.

CARB is also evaluating ammonia and other criteria pollutant emissions from dairies to improve the emissions inventory. This work will evaluate existing dairy emission factors, spatial distribution of dairies in air quality modeling, and comprehensiveness of facility activity data, including cattle population. This effort will include emissions estimates for dairy manure land application to ensure a more holistic and robust sectoral inventory of air pollutant emissions. CARB is also evaluating ammonia and criteria air pollutant emissions from other livestock categories, including non-dairy cattle and silage.

CARB is working to fill knowledge gaps on ammonia emissions information, including conducting research on ammonia emissions from alternative manure management practices and from dairy manure lagoons. These studies will help inform development of CARB's ammonia emission inventory, state implementation plan(s), and community air protection programs while helping to understand how changes in manure management practices may achieve additional emission reductions. CARB has also developed a mobile measurement platform equipped with a state-of-the-science ammonia analyzer and other advanced analytical instruments to improve the understanding of various ammonia sources in California.

In addition to the projects described above, in May 2024, CARB held a public workshop to kick-off the Soil Nitrogenous Emissions Subject Matter Expert Review Panel (SMERP).<sup>51</sup> The

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<sup>50</sup> PM2.5 can lead to direct health impacts. Long-term (months to years) exposure has been linked to premature death, particularly in people who have chronic heart or lung diseases, and reduced lung function growth in children. Additionally, PM2.5 emissions can impact attainment status of State and federal ambient air quality standards.

<sup>51</sup> CARB, *Subject Matter Expert Review Panel on Nitrogenous Emissions from Soils*, <https://ww2.arb.ca.gov/subject-matter-expert-review-panel-nitrogenous-emissions-soils>.

SMERP, comprised of five technical experts, serves to independently evaluate existing data and science to improve our current understanding of nitrogenous emissions, including oxides of nitrogen (NO<sub>x</sub>), nitrous oxide, and ammonia from soils, particularly in California. CARB intends to continue collecting and evaluating information on potential strategies to reduce criteria pollutant emissions, especially those that concurrently achieve GHG emissions reductions.

A comprehensive list and description of CARB and CDFA dairy and livestock research efforts is available in Appendix A.

## VI. Determination and Conclusion

Therefore, after careful consideration of your petition, the relevant law, and the ongoing development of various initiatives by CARB and CDFA to support methane reductions at dairy and livestock operations, we have reached a decision on your petition pursuant to Government Code section 11340.7. The Code provides that a state agency “may grant or deny the petition in part and may grant any other relief or take any other action it may determine to be warranted by the petition.”<sup>52</sup> We are denying your petition in part and granting other relief in part, as described above. Specifically, to grant in part as to ongoing work related to assessing the prerequisites to SB 1383 later this year and engaging with stakeholders and community members including at an August 2024 workshop, continuing to evaluate emissions data and conducting additional analyses of progress toward the 2030 target, continuing incentives and technical assistance work, and researching and supporting strategies to address criteria pollutants and methane emissions from the dairy and livestock sector, and to deny in part as to immediately initiating a rulemaking.

The record upon which this decision is based includes the petition and its exhibits, this letter, the materials referenced herein, and its attachments. While CARB is denying the petition to initiate a rulemaking immediately, CARB appreciates the petitioners’ continued engagement as CARB makes further outreach and analysis regarding implementation of its dairy initiatives, including consideration of SB 1383 status.

In accordance with Government Code section 11340.7, subdivision (d), a copy of this letter is being transmitted to the Office of Administrative Law for publication in the California Regulatory Notice Register. The California Air Resources Board contact persons for this matter are Meena Kaypour, Attorney, available at (951) 848-6354 or [Meena.Kaypour@arb.ca.gov](mailto:Meena.Kaypour@arb.ca.gov), and Abigail May, Senior Attorney, available at (279) 208-7125

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<sup>52</sup> Government Code § 11340.7 provides that an agency addressing a petition shall “identify the agency, the party submitting the petition, the provisions of the California Code of Regulations requested to be affected, reference to authority to take the action requested, the reasons supporting the agency determination, an agency contact person, and the right of interested persons to obtain a copy of the petition from the agency.” This response fulfills those requirements.

or [Abigail.May@arb.ca.gov](mailto:Abigail.May@arb.ca.gov). The California Department of Food and Agriculture contact person for this matter is Haig Baghdassarian, Deputy Secretary and Chief Counsel, available at (916) 654-1393 or [Haig.Baghdassarian@cdfa.ca.gov](mailto:Haig.Baghdassarian@cdfa.ca.gov). Interested parties may obtain a copy of the petition upon request to Chris Hopkins, available at (279) 208-7347 or [Chris.Hopkins@arb.ca.gov](mailto:Chris.Hopkins@arb.ca.gov). Upon request, physical copies can be obtained from 1001 I Street, Sacramento, California, 95814.

Sincerely,



Steven S. Cliff, Ph.D., Executive Officer, California Air Resources Board



Karen Ross, Secretary, California Department of Food and Agriculture

Enclosures (2):      Appendix A: Dairy and Livestock Research Summary  
                                 Appendix B: Programs Contributing Funding or Incentives to Support  
                                 Dairy and Livestock Methane Emissions Reduction Projects

cc:      Christine Birdsong, Undersecretary, California Department of Food and Agriculture  
         Virginia Jameson, Deputy Secretary, California Department of Food and Agriculture  
         Haig Baghdassarian, Deputy Secretary and Chief Counsel, California Department of  
         Food and Agriculture  
  
         Tawny Mata, Director, Office of Environmental Farming and Innovation, California  
         Department of Food and Agriculture  
  
         Liane M. Randolph, Chair, California Air Resources Board  
  
         California Air Resources Board Honorable Board Members  
  
         Ellen M. Peter, Chief Counsel, California Air Resources Board  
  
         Edie Chang, Deputy Executive Officer, California Air Resources Board  
  
         Chanell Fletcher, Deputy Executive Officer, California Air Resources Board  
  
         Rajinder Sahota, Deputy Executive Officer, California Air Resources Board  
  
         Matthew Botill, Chief, Industrial Sources Division, California Air Resources Board  
  
         Matthew Harrison, Branch Chief, Project Assessment Branch, California Air Resources  
         Board  
  
         Abigail May, Senior Attorney, Legal Office, California Air Resources Board  
  
         Meena Kaypour, Attorney, Legal Office, California Air Resources Board

## **Appendix A**

### **Dairy and Livestock Research Summary**

To date, California Air Resources Board (CARB) and California Department of Food and Agriculture (CDFA) have funded or conducted multiple dairy and livestock research studies, literature reviews, measurement campaigns, and model development efforts. Those efforts are summarized below:

#### **Research on Effectiveness of Alternative Manure Management Practices**

- 1) Mitloehner, F. *Benchmarking of pre-AMMP dairy emissions* (2019). CDFA-funded UC Davis study.
- 2) Mitloehner, F. *Post-AMMP Dairy Emissions of GHG, Ammonia and Hydrogen Sulfide from a Pastured Dairy and Compost-Bedded Pack Barn Project* (2021). CARB-funded UC Davis study.
- 3) CARB used in-house eddy covariance monitoring equipment to assess the real-time, long-term methane emissions of three study dairies.

#### **Research on Effectiveness of Digestate Land Application Emissions**

- 4) Horwath, W. *Liquid and Soil Sample Collection and Analyses of Dairy Digestate and Lagoon Effluent during Storage and Land Application Phases* (in-progress). CARB-funded UC Davis study.
- 5) Zondlo, M. *Eddy Covariance Monitoring of Nitrogenous Emissions from Land Application of Manure and Digester Effluent* (in-progress). CARB-funded Princeton study.

#### **Research on Biomethane Constituents**

- 6) Kleeman, M. *Evaluation and Identification of Constituents Found in Common Carrier Pipeline Natural Gas, Biogas, and Upgraded Biomethane in California* (in-progress). CARB-funded UC Davis study.

#### **Literature Reviews on Dairy and Livestock Manure Methane Reduction Strategies**

- 7) Kaffka, S. *Evaluation of Dairy Manure Management Practices for Greenhouse Gas Emissions Mitigation in California, Final Technical Report to the State of California Air Resources Board* (2016). CARB-funded UC Davis literature review.
- 8) Kaffka, S. et al., *Research and Technical Analysis to Support and Improve the Alternative Manure Management Program Quantification Methodology*, UC Davis California Biomass Collaborative (2020). CARB-funded UC Davis literature review.

### **Literature Reviews on Enteric Methane Reducing Strategies**

- 9) Appuhamy, R. and Kebreab, E. *Characterizing California-Specific Cattle Feed Rations and Improve Modeling of Enteric Fermentation for California's Greenhouse Gas Inventory* (2018). CARB Contract 16RD001.
- 10) Kebreab, E. and Feng, Xiaoyu, *Strategies to Reduce Methane Emissions from Enteric and Lagoon Sources* (2021). CARB-funded UC Davis literature review.

### **Onsite, Mobile, Flyover, and Satellite-based Emissions Measurement and Monitoring Campaigns**

- 11) Amini, S, et al. *Evaluating California Dairy Methane Emission Factors Using Short-Term Ground-Level and Airborne Measurements* (2022). Partially CARB-funded mobile emissions monitoring campaign Contract 16RD018.
- 12) Duren, R. et al., *California Institute of Technology Jet Propulsion Laboratory (JPL) The California Methane Survey* (2020). Partially CARB funded JPL flyover-based monitoring campaign. CARB Contract 15RD028.
- 13) California Satellite Partnership. <https://ww2.arb.ca.gov/our-work/programs/california-satellite-partnership>.
- 14) Satellite Data Purchase Program. <https://ww2.arb.ca.gov/our-work/programs/satellite-data-purchase-program>.

### **California Dairy Emissions Model**

- 15) Kebreab, E. *Development of the California Dairy Emissions Model* (2022). CARB-funded UC Davis model development.

### **Enteric Testing Standard Development and Calibration**

- 16) Kebreab, E. *Development of a Testing Standard and a Mechanistic Model for Enteric Fermentation Methane Emissions* (in-progress). Ongoing CARB-funded UC Davis model and testing standard development.



## Appendix B

### Programs Contributing Funding or Incentives to Support Dairy and Livestock Methane Emissions Reduction Projects

Each of the following programs, organized by administering agency, have contributed funding or incentive support to dairy and livestock methane emissions reduction projects:

- California Air Resources Board:
  - *Cap and Trade Program.*
  - *Low Carbon Fuel Standard.*
- California Department of Food and Agriculture:
  - *Dairy Digester Research and Development Program.*
  - *Alternative Manure Management Program.*
  - *Dairy Plus Program.*
- California Public Utilities Commission:
  - *Bioenergy Market Adjusting Tariff* (BioMAT) (established pursuant to SB 1122).
  - *Biomethane Monetary Incentive Program* (AB 2313).
  - *Dairy Biomethane Pipeline Injection Pilot Projects* (SB 1383).
  - *Renewable Gas Procurement Program* (SB 1440).
- California Energy Commission:
  - *Clean Transportation Program.*
- United States Department of Agriculture - Rural Development:
  - *Rural Energy for America Program.*
- United States Department of Agriculture - Natural Resources Conservation Service:
  - *Environmental Quality Incentives Program.*
- United States Environmental Protection Agency:
  - *Renewable Fuel Standard Program.*