Findings and Recommendations

Subgroup 1: Fostering Markets for Non-digester Projects
Senate Bill 1383 Dairy and Livestock Working Group

Introduction

California's Short-Lived Climate Pollutant Strategy and Senate Bill 1383 (Lara, 2016) call for 40% reductions in methane from dairy and livestock manure management by 2030. To help achieve that goal, SB 1383 required the formation of a dairy and livestock sector Working Group to identify and address technical, market, regulatory, and other barriers to the development of dairy and livestock methane reduction projects. Created in mid-2017, the SB 1383 Dairy and Livestock Working Group includes three subgroups focused on: (1) digesters, which capture methane generated from anaerobic manure storage for use as an energy source; (2) other alternative manure management practices (which do not include digesters), which usually seek to avoid methane production by reducing anaerobic storage of manure; and (3) research needs related to improving measurements and modeling of dairy and livestock methane inventories, validating reductions from existing practices and technologies, and developing more and better methods for reducing methane emissions from dairy and livestock manure while achieving other environmental and economic benefits and minimizing impacts.

"Subgroup 1: Fostering Markets for Non-digester Projects" was convened to prepare recommendations toward advancing non-digester manure management practices and technologies that reduce methane emissions and achieve environmental and community health co-benefits, improve agronomic outcomes, and protect the economic viability of dairy and livestock farms. Establishing a subgroup focused on non-digester practices and technologies is both a reflection of the importance of the role of non-digester options in achieving 40% reduction by 2030 – as indicated in the SLCP Strategy and SB 1383 – and a recognition that California has generated little information to date regarding these options as compared to digesters.[1]

Meeting nine times between July 2017 and May 2018, subgroup 1 solicited and gathered information about the opportunities for advancing non-digester practices and technologies to reduce methane emissions from dairies. The subgroup's 11 members brought diverse expertise to the discussion, including dairy operations, livestock waste management, agronomy, engineering, environmental law, policy, environmental justice, environmental markets, and conservation. They added to that knowledge by inviting presentations from varied experts in academia, government, nongovernmental organizations (NGOs), and the private sector. While the information gathered is complex and more information is

[1] Several Subgroup 1 members noted that the term "non-digesters" is less than ideal, defining practices by what they are not rather than by what they are. Both subgroups 1 and 2 are focused on promoting alternative, innovative practices, that is, practices not in use on the majority of California dairies today, and which are likely to reduce methane emissions. For practical reasons, the California Air Resources Board (CARB) chose to focus subgroup 2 specifically on the subcategory of innovative practices known as manure biogas digesters, while subgroup 1 was asked to identify other alternative and innovative manure management practices. For consistency with CARB's title for this subcommittee, we refer to these as non-digester practices throughout this document.

needed, subgroup 1 members found that substantial opportunities exist to reduce methane emissions from dairies with existing and developing non-digester technologies and practices.

Subgroup 1 co-chairs established and utilized a working definition of "subgroup recommendations" as being those recommendations receiving support from nine or more subgroup members; all such subgroup recommendations are included in this document. Subgroup members were given the opportunity to express their rationales for dissenting with subgroup recommendations; these are summarized in Appendix A. The subgroup recommendations are organized into six categories, with the overall goal of spurring progress in reduction of methane emissions from manure storage on California dairies, while minimizing unintended impacts and maximizing "win-win" scenarios for dairy and livestock farm owners and operators, communities, and the environment.

Executive Summary

Subgroup 1's overarching finding is that non-digester practices and technologies (hereafter "non-digester practices") are critical tools to help achieve 40% reduction in dairy and livestock methane emissions by 2030 because they (1) can reduce methane and achieve co-benefits and (2) are feasible for a wide range of dairies in California. As such, the subgroup recommends that the California Air Resources Board (CARB), California Department of Food and Agriculture (CDFA), sister agencies, NGOs, environmental justice groups and the dairy and livestock industry continue to cooperate on a two-prong strategy:

- Advance non-digester practices already known (based on the weight of current evidence) to reduce methane emissions; and
- Work actively to evaluate and advance additional technologies and practices that are less known and are equally or potentially more effective in reducing methane; solving multiple environmental challenges; and creating new economies, markets, and revenue streams.

Specifically, subgroup 1 offers the following recommendations, organized into six categories:

1) **Continue providing financial incentives for non-digester practices already known to reduce methane.** CDFA's AMMP program has identified and funded several practices and technologies known to reduce methane emissions: solid-liquid separators (SLS) with drying; scrape and vacuum collection of manure with drying; composting; and pasture-based practices. The subgroup finds that these practices remain promising and, if properly implemented, could achieve multiple environmental benefits with minimal impacts (though efforts should be made to assure that this is the case, see recommendation number 2). Early evidence suggests some of these practices and technologies rival digesters in cost-effectiveness of methane reductions.
    a. **Conduct research to establish a solid baseline of current manure management practices on California dairies. The subgroup acknowledges that some work in this area is already being conducted under research projects funded by CARB.**
    b. **Continue funding via AMMP for those non-digester practices that are already approved for funding.**
    c. **Continue to improve AMMP program implementation to reduce application complexity and enhance program impact (See Appendix B for subgroup recommendations specific to CDFA's AMMP program).**

2) **Better quantify environmental benefits and impacts and address environmental justice concerns related to non-digester practices.** Some non-digester practices examined by the subgroup reduce methane and likely reduce impacts to groundwater, but other emissions benefits and impacts are unclear. Information gaps exist that must be addressed to gain a more detailed understanding of how these non-digester practices impact whole-farm emissions across GHGs, air quality, and water quality. There is also a critical need to establish a common methodology for measuring and evaluating cross-media impacts.
    a. **Develop, through cross-agency collaboration and input from non-agency scientists, a common methodology for evaluating cross-media impacts to ensure there is (1) a consistent protocol for measuring emissions and (2) a consistent methodology for assessing impacts across air, water, and GHG emissions.**

   b. **The State should assess the expected emissions increases/decreases and other environmental benefits and impacts of practices currently funded by AMMP, their magnitude, and the likely benefits and impacts to nearby communities.**
   c. **Use outcomes from 2b to articulate the expected environmental benefits and impacts of each AMMP-funded technology and practice category so that AMMP applicants need not duplicate such an assessment.**
   d. **Continue and expand research into whole-farm emissions changes related to installation of non-digester practices.**
   e. **Coordinate and integrate agency programs and efforts to expand and accelerate implementation of non-digester practices while achieving multiple environmental benefits.**

3) **Study the market for value-added manure-based products.** Multiple environmental benefits can accrue – including methane reduction and groundwater quality protection – when manure and its components (e.g. carbon, nitrogen, potassium, and phosphorus) are transferred from a dairy for use on other farms. Understanding where the most promising markets for manure-based products are, and how to develop and service these markets, is needed to identify economically viable pathways for processing, transporting, and utilizing manure through off-farm transfers. Understanding markets is increasingly more important as California approaches 2020 and the 75% organics reduction from landfills requirement.
   a. **Conduct, through agency and industry collaboration, an intensive market analysis for manure-based products, with focus on the largest and closest potential markets – including, but not limited to, other agriculture in California's Central Valley. The study should look at the different products that could be made from manure, demand for these products by market segment, the potential scale of demand in each segment, product specifications to serve each segment, and economic viability of servicing these different segments.**

4) **Evaluate new non-digester practices through commercial-scale research and development.** While CARB and CDFA are already incentivizing known methods to reduce methane, new technologies and practices that reduce methane emissions and achieve co-benefits are installed or being developed and tested in other states and countries. No known programs in California identify and evaluate these other options. Unbiased scientific data are needed to evaluate which non-digester practices should be added to the list of those accepted as reducing manure methane emissions and eligible for incentive funding. The subgroup recommends that efforts to support research and development in this area be pursued to expand practices and technologies known to reduce methane from dairy manure.
   a. **Create a non-digester research and development program with the purpose of advancing innovative non-digester practices in California by identifying the most promising options, inviting proposals, funding projects, and supporting independent evaluation of environmental and economic benefits of commercial-scale projects.**

5) **Develop data to support additional economic incentives for non-digester projects and implement regulatory changes if doing so will enable economic viability of carbon credits or**

other incentives. Unlike digesters, non-digester projects are currently not eligible to generate carbon credits in the compliance market and have limited opportunity in voluntary markets. Creation of protocols or other methods to allow these technologies to capture revenue from methane reductions may provide additional market incentives to adopt non-digester practices and to continue their implementation in the future.

a. **Conduct an economic analysis of various methane reducing technologies and practices within a carbon offset framework to evaluate if the offset sale can be economically feasible as an incentive for dairies to reduce methane emissions. Document the carbon offset framework rules that are used in the economic analysis to identify which rules create high transaction costs.**
b. **Recommend and implement appropriate changes to carbon offset framework rules, if the economic analysis finds that such changes could make carbon credits or other incentives economically viable. Framework rules that affect the economic viability of carbon credits or other incentives include, but are not limited to, the definition of additionality, whether practice or project aggregation is allowed, the discount factor used to account for risk, and the credit verification process.**

6) **Develop an outreach and education program for dairy and livestock operators.** Dairy and livestock operators are exposed to a lot of information – including misleading, unsubstantiated, and untrue claims – and most don't have the time or expertise to filter through the noise. A trusted, unbiased source of information for dairy and livestock operators is needed to enable good decision-making about non-digester manure methane reduction strategies. We suggest creation of a program that:

a. **Provides independently verified information about non-digester practices to assist dairy and livestock operators in evaluating performance claims made by vendors and others;**
b. **Includes information necessary for good decision-making, such as estimation of expected methane emissions reductions, estimation of other environmental benefits and impacts, assessment of operational and economic feasibility, and specific information for implementing the technology in California, such as local environmental regulations and site-specific operational parameters.**
c. **Involves trusted partners with experience in California – such as the University of California Cooperative Extension, Resource Conservation Districts, California Dairy Quality Assurance Program, Newtrient, and dairy and livestock producer trade associations – in the development and implementation of the program; and**
d. **Establishes and maintains a central clearinghouse (such as a website, mobile app, etc.) for program-related information, including the information referenced in 6a and 6b as well as relevant funding opportunities, application deadlines, published research, etc.**
e. **Includes farmer-centric events such as demonstration farms, field days, and other in-field activities to present information referenced in 6a and 6b and provide a comfortable space for dairy farmers to share experiences and ask questions.**

Findings and Recommendations

Subgroup 1 thanks CARB, CDFA and their sister agencies for the opportunity to provide these recommendations. Details from our meetings, presentations, and deliberations are included in the following pages.

Recommendation 1: Continue providing financial incentives for non-digester practices already known to reduce methane.

a. **Conduct research to establish a solid baseline of current manure management practices on California dairies. The subgroup acknowledges that some work in this area is already being conducted under research projects funded by CARB.**
b. **Continue funding via AMMP for those non-digester practices that are already approved for funding.**
c. **Continue to improve AMMP program implementation to reduce application complexity and enhance program impact (See Appendix B for subgroup recommendations specific to CDFA's AMMP program).**

In terms of interest by dairy and livestock operators, the Alternative Manure Management Program (AMMP) is already a success. The program provides funding for a range of non-digester practices and technologies (hereafter "non-digester practices") that are feasible for a wide variety of dairies, and some practices appear to achieve very cost-effective methane reductions. As such, AMMP is an important tool to help achieve 40% reductions in methane emissions by 2030.

As of March 2018, CDFA had announced $9.9 million in AMMP funding for 18 projects that are expected to reduce greenhouse gas emissions by about 328,000 metric tons carbon dioxide equivalent (CO2e) over the next five years (656,000 MTCO2e over 10 years). Though it was just the first round of funding for a new program, three times as many project applications were received than were funded, suggesting a high level of dairy and livestock operator interest in the program and types of projects eligible. Additionally, projected per-project emissions reductions suggest many AMMP projects are cost-competitive with digesters – some realizing emissions reductions in the range of $10-20 per metric ton CO2e, based on an analysis of publicly available information from CDFA on awarded projects. Finally, AMMP projects were also awarded to a diverse group of dairies – in both size and region – which supports subgroup discussions about non-digester projects being feasible for a wide range of dairies. Meanwhile, CDFA opened a second application cycle in March 2018, offering between $19 million and $33 million for more projects, and received 63 applications requesting $34.5 million before the May 22 deadline.

During meetings in August and September 2017, the subgroup was provided technical presentations demonstrating that most manure methane emissions occur during anaerobic conditions, predominantly when manure is stored in a wet form.

Experts were also clear that reliable information on current manure management practices is incredibly limited and that research is desperately needed to establish baseline status for benchmarking purposes. In the absence of reliable baseline data, experts relied on anecdotal evidence suggesting that coarse separation technologies like solid liquid separation (SLS) have already been implemented on up to 30 percent of California dairies, and there is relatively high level of producer acceptance for these

technologies. Similarly, equipment options for scraping and vacuuming manure – while still uncommon in California – are relatively well understood and accepted in the industry.

Scientists and experts presenting before the subgroup suggested the following as potential impacts for AMMP practices (see Appendix C for additional information on subgroup findings regarding these practices):

- Adding SLS to a flush system will decrease methane, nitrous oxide and volatile organic compounds (VOC) emissions while other emissions such as ammonia might increase, although they suggested the increases would likely be small. The extent of these benefits and impacts are highly dependent upon how manure is handled, stored, and used after it has been collected.
- Methane reductions from SLS might be greater than estimated in CARB's Quantification Methodology (QM) since early results from research at UC Davis suggest SLS removed higher amounts of volatile solids than are currently estimated in the QM for AMMP. Establishment of consistent protocols for determining methane reduction is necessary to ensure consistency in measuring VS removal rates.
- Converting from flush to scrape manure collection systems can decrease methane emissions and impacts to water quality but could increase air quality impacts like PM and VOCs, although the extent of these benefits and impacts are highly dependent upon how manure is handled, stored, and used after it has been collected.
- Composting can reduce methane emissions and water quality impacts but could increase ammonia and VOC emissions, although these are regulated by San Joaquin Valley authorities and can be controlled to some extent through management practices.
- Increasing the amount of time cows spend on pasture will reduce methane emissions from manure management and the overall carbon footprint of the farm. Pasture-based management in arid portions of the state could increase water consumption.

Current UC Davis research co-funded by CDFA and CARB measures emissions of GHG, VOCs, and ammonia on dairies before and after installation of AMMPs. Results of the study will help verify and quantify methane reductions from non-digester practices and will improve quantification and understanding of other environmental emissions.

Based on the above, the subgroup finds that there is substantial evidence to support continued use of non-digester practices that reduce or prevent manure solids from being stored in anaerobic conditions to achieve methane emission reductions.

Recommendation 2: Better quantify environmental benefits and impacts and address environmental justice concerns related to non-digester practices.

a. **Develop, through cross-agency collaboration and input from non-agency scientists, a common methodology for evaluating cross-media impacts to ensure there is (1) a consistent protocol for measuring emissions and (2) a consistent methodology for assessing and comparing impacts across air, water, and GHG emissions.**
b. **The State should assess the expected emissions increases/decreases and other environmental benefits and impacts of practices currently funded by AMMP. The assessment should include**

expected emissions increases/decreases, their magnitude, and the likely impacts and benefits to nearby communities.

c. **Use outcomes from 2b to articulate the expected environmental benefits and impacts of each AMMP-funded technology and practice category so that AMMP applicants need not duplicate such an assessment.**
d. **Continue and expand research into whole-farm emissions changes related to installation of non-digester practices (such as is currently being carried out by UC Davis).**
e. **Coordinate and integrate agency programs and efforts to expand and accelerate implementation of non-digester practices while achieving multiple environmental benefits.**

As noted in the previous section, the weight of evidence supports use of currently funded AMMPs as a method to reduce methane emissions. However, very little research has directly measured how implementation of AMMP practices affects other emissions at dairies – that is, whether there are net emissions increases or decreases and the magnitude of those changes. Some subgroup members expressed concern about the uncertainty related to quantification of the multiple environmental benefits and impacts of non-digester practices.

To improve its understanding of environmental justice concerns, the subgroup heard presentations in both October of 2017 and April of 2018 from CARB and leading organizations focused on the environment and environmental justice, including Leadership Counsel for Justice and Accountability, Central California Asthma Collaborative (CCAC) and Clean Water Action. CARB representatives discussed the environmental justice perspectives they've collected during their outreach. Presenters identified pollutants of concern associated with dairies, including methane, particulate matter (PM10 and PM 2.5), ammonia, volatile organic compounds (VOCs), hydrogen sulfide, and nitrate in groundwater. They also noted that SB 1383's requirements include "minimizing impacts to disadvantaged communities." Their specific suggestions for meeting those 1383 requirements included community outreach, community benefits agreements, buffer zones, transportation safety measures related to moving manure offsite, community air monitoring, and more.

Environmental justice advocates are particularly concerned about using the state's Greenhouse Gas Reduction Fund (GGRF) to incentivize AMMP practices without community consultation and mitigation if these practices result in impacts to communities. One of the environmental justice presenters said that projects should create "no new on-farm emissions" and several environmental justice groups have stated that there should be "no negative environmental impacts" from projects. Through conversation, the subgroup clarified the difference between emissions and impact, acknowledging that not all changes in emissions necessarily result in an impact to communities. The subgroup also discussed that impact is dependent upon several factors, including proximity to communities and the extent to which the community itself might already be suffering from disproportionate and cumulative impacts.

Subgroup members agreed that the purpose of non-digester projects is to reduce emissions of methane, but those reductions should not come at the cost of substantial impacts related to increases of other emissions on the dairy or livestock facility. At the same time, the subgroup acknowledged during several meetings that there is a high likelihood any change in manure management will result in some increased emissions, given the nature of the carbon and nitrogen cycles. Therefore, the subgroup believes it is important to consider the relative magnitude of any emissions increases, the resulting potential for impacts to communities, and the availability of mitigation measures.

The subgroup was presented extensive evidence highlighting the complexity of estimating whole-farm, cross-media emissions changes resulting from implementation of non-digester practices. However, the subgroup was not presented evidence suggesting that AMMP-funded practices create significant impacts related to emissions increases (see Recommendation #1 for a summary of potential increases). The subgroup agrees that the State should be responsible for identifying potential emissions impacts associated with categories of AMMP-funded practices, and that this responsibility should not fall to individual dairy and livestock operators. If potential emissions impacts are deemed substantial, then a producer requesting AMMP funding should include how they will address those impacts within his or her application.

Several subgroup members observed that several State programs and efforts are related to non-digester practices, but they could benefit from more coordinated implementation. Examples include CDFA's Healthy Soils Program, Assembly Bill 1045 (Irwin, 2015, requiring coordinated permitting and regulation of composting operations), water quality regulations, air quality regulations, and landfill diversion goals, among others. Better coordination between and across these efforts is needed to avoid redundancies and potential conflicting outcomes, resulting in cost-effectively maximizing environmental benefits and minimizing potential negative impacts. For example, CDFA could facilitate opportunities to connect dairy and livestock producers interested in generating composted manure under AMMP with cropland producers interested in using compost as part of their soil management under Healthy Soils.

The subgroup recognizes the concerns of environmental justice advocates and agrees there is a need to fill knowledge gaps related to quantifying the environmental benefits and impacts. However, the subgroup believes it is reasonable to proceed with efforts to continue to reduce emissions of dairy and livestock manure methane and achieve other air and water benefits via AMMP-funded non-digester practices, as mentioned in Recommendation #1. Meanwhile, the subgroup urges a near-term assessment of expected environmental benefits and impacts from AMMP-funded practices, in addition to continued field research to quantify the cross-media emissions changes resulting from implementation of non-digester practices.

Finally, and importantly, the subgroup recommends that agencies responsible for air, water, and GHG emissions from dairies work together, along with relevant experts, to establish a common protocol for measuring and assessing cross-media impacts.

Recommendation 3: Study the market for value-added manure products

a. **Conduct, through agency and industry collaboration, an intensive market analysis for manure-based products, with focus on the largest and closest potential markets – including, but not limited to, other agriculture in California's Central Valley. The study should look at the different products that could be made from manure, demand for these products by market segment, the potential scale of demand in each segment, product specifications to serve each segment, and economic viability of servicing these different segments.**

A central precept for reducing methane via non-digester practices is avoiding the time and amount of manure stored in aerobic conditions. Digesters allow manure to be stored anaerobically but capture the

emissions of methane and convert it to energy. With non-digester practices, anaerobic storage is avoided or reduced in the first place. However, there are consequences in California to avoiding anaerobic storage. One of these is that when manure is collected, dried, and stored in solid form, its potential for subsequent use as a nutrient on the dairy's forage crops is largely limited to application prior to planting. This necessitates export from the dairy of manure that cannot be used. Economically viable export of manure depends on ensuring there is an end user that wants the manure and is willing to pay a price that covers the cost of storage, processing, and transport.

It is tempting to conclude that a sufficient market already exists for dairy and livestock manure. California grows more than 400 different crops on approximately 9 million irrigated acres. Most of these acres depend on synthetic fertilizer and other soil amendments to provide plant nutrients and enhance soil health. Manure contains organic matter and many nutrients – carbon, nitrogen, potassium, and phosphorus – that can be helpful to other crops if delivered in the right form and the right quantities. Manure can also be made into products for non-agricultural markets. However, the market potential for these different products has not been studied comprehensively.

In December 2017, the subgroup was presented information by experts regarding the potential for expanding production and export of manure-based compost to reduce dairy and livestock methane emissions and water quality impacts and to increase soil health and soil carbon sequestration. To realize these multiple benefits, one of the experts recommended addressing barriers to (larger) entry into the compost market, such as regulatory confusion and uncertainty, and ensuring standards of compost quality to allow wider use on crops for human consumption. They also stated that demand seemed promising but that very little information was available and market research was needed.

In March 2018, the subgroup was presented information from experts dedicated to assessing new technologies for increasing value of manure and addressing environmental challenges associated with manure management. These experts noted many options for manure processing, from mechanical separation with and without polymers to membranes of different efficiencies to remove salts, centrifuges, vermiculture, nitrification/denitrification systems, evaporative systems, torrefaction, pyrolysis, gasification, hydrothermal carbonization and more. These technologies can make manure into bedding, compost, humus, custom fertilizer, biochar, algae, worm castings, and even fuel. However, little is known about the market demand and economics for most of these products, making it difficult to know which opportunities to pursue.

It is clear to the subgroup that much can be done with manure, and all of it comes with cost and risk. To determine which costs and risks make sense, a better understanding of potential markets for manure products is needed. As one expert reported to the subgroup, there is an "undeveloped market for innovative and leading-edge products," and among its recommendations were that CARB, CDFA and others "fund market research and promotional support for manure derived products."

Recommendation 4: Evaluate new non-digester practices through commercial-scale research and development.

a. Create a non-digester research and development program with the purpose of advancing innovative non-digester practices in California by identifying the most promising options,

inviting proposals, funding projects, and supporting independent evaluation of environmental and economic benefits of commercial-scale projects.

There are numerous non-digester practices and technologies currently being developed for manure management, but these are largely being tested outside of California. This is in part because much of the research and development in California to reduce methane from manure management has focused on anaerobic digesters. Given the complex challenges to manage multiple environmental impacts in addition to methane and the need to find solutions that are feasible for diverse dairy and livestock types, the subgroup finds that it is important to increase efforts to innovate methane-reducing manure management options in the state beyond digesters. For maximum impact, these efforts should be aligned with a better understanding of the potential markets for manure-based products and the resulting multiple benefits of improved distribution of manure, as discussed in Recommendation #3.

While solid-liquid separation (SLS) systems and vacuum trucks are increasingly common at California dairies, the subgroup was presented little information about how the state or dairy and livestock industry are working to evaluate and advance non-digester practices on California dairies. This is a concern because the current non-digester strategies funded by AMMP are limited in their capabilities. For example, SLS reduces methane from liquid manure storage structures by prevention methane formation. However, it provides no added value to improving plant available nutrient forms to enhance water quality protection. Similarly, scrape systems collect manure, and similar to SLS do not provide added value through transformation of nitrogen or concentration of nutrients for more effective off-site transport. Composting shows promise for multiple environmental benefits but continues to be challenged by its contributions to ammonia and VOC emissions as well as regulatory confusion and uncertainty. Pasture-based practices can result in multiple environmental benefits, but applicability is limited by economic and climatic conditions.

As mentioned in the previous section, experts presented many other technologies with promise to decrease methane and provide other benefits. However, there are only a few examples of these technologies being tested on dairies in California. The testing that has been done has been funded by industry and/or philanthropy, for example gasification at a dairy in Southern California and vermifiltration (use of a “worm farm” and organic materials to form a biofilter to remove nitrogen from manure flush water) at a dairy in the San Joaquin Valley. Meanwhile, other techniques, such as separation with use of polymers, centrifuges, are actively being tested on dairies in other states.

The subgroup recommends development of a program to incentivize research and development of the most promising non-digester practices and to test those technologies on dairies in California. This should be done in a manner that verifies that the technologies are operationally feasible under California conditions – which are quite different from many other dairy and livestock regions – and also measures the environmental and economic impacts. Such a program could ensure that third-party, independent verification of environmental and economic performance is performed, considering not only the ability to reduce methane but also to deliver other environmental and economic benefits.

Specifically, the subgroup recommends a program or process that prioritizes the most promising new non-digester practices and technologies, conducts commercial-scale scientific studies on those options, and identifies which of the options should be considered eligible to reduce methane inventory and receive incentive funding.

Recommendation 5: Develop data to support additional economic incentives for non-digester projects and implement regulatory changes if doing so will enable economic viability of carbon credits or other incentives.

a. **Conduct an economic analysis of various methane reducing technologies and practices within a carbon offset framework to evaluate if the offset sale can be economically feasible as an incentive for dairies to reduce methane emissions. Document the carbon offset framework rules that are used in the economic analysis to identify rules that create high transaction costs.**
b. **Recommend and implement appropriate changes to carbon offset framework rules, if the economic analysis finds that such changes could make carbon credits or other incentives economically viable. If so, pursue those regulatory changes. Framework rules that affect the economic viability of carbon credits or other incentives include, but are not limited to, the definition of additionality, whether practice or project aggregation is allowed, the discount factor used to account for risk, and the credit verification process.**

Some non-digester practices show real promise to reduce manure methane emissions, but their ability to provide a financial return on investment remains a potential barrier to adoption for many. While digesters generally require more construction capital than non-digester practices, they also come with the promise of a revenue stream from electricity or fuel sales and carbon credits. In contrast, AMMP-fundable projects produce no energy to sell (although there are emerging technologies not yet funded by AMMP that could potentially produce fuels or energy). In addition, there is substantial uncertainty about the market value of other potential outputs of non-digester technologies, such as manure-based products. Finally, there are no schemes under California regulation to create and sell carbon credits or other environmental credits for implementation of non-digester practices.

In May 2018, the subgroup received presentations from several experts in carbon markets and other environmental crediting schemes. It was clear to the subgroup that crediting schemes are complex and that this complexity can be a barrier to those who would seek to bank and sell offset credits related to non-digester projects. Transaction costs, meeting additionality requirements, time needed to develop offsets, and low and uncertain carbon prices were discussed as key challenges. Further complicating the issue is the uncertainty related to actual methane emissions baselines on dairies (per Recommendation 1a) and the reduction of emissions when non-digester practices are implemented (per Recommendation 2c).

Nevertheless, experts discussed potential methods to manage uncertainty and increase access to credit markets. These ideas included the following: streamlining verification requirements; aggregating projects; establishing practical ways to stack environmental credits; fast tracking new compliance offset protocols; and other ways to increase the certainty of the price for carbon. The subgroup also discussed assessing the feasibility of incentivizing on-going operations and maintenance of non-digester practices, considering long-term programs of direct financial support, compatibility with environmental crediting programs, or other approaches.

Given the importance of realizing income streams for environmental services as a means for incentivizing non-digester methane reductions, the subgroup finds that efforts should be made to

explore crediting dairies that adopt non-digester methane reduction strategies, including a robust assessment of the feasibility of different options considering transaction costs and other challenges described above.

Recommendation 6: Develop an effective outreach and education program that delivers essential, unbiased information to California dairy and livestock operators to support good decision-making about non-digester manure methane reduction strategies. The program should:

a. **Provide independently verified information about non-digester practices to assist dairy and livestock operators in evaluating performance claims made by vendors and others;**
b. **Include information necessary for good decision-making, such as estimation of expected methane emissions reductions, estimation of other environmental benefits and impacts, assessment of operational and economic feasibility, and specific "how to" information needed for implementing the technology in California, such as local environmental regulations and site-specific operational parameters;**
c. **Involve trusted partners with experience in California – such as the University of California Cooperative Extension, Resources Conservation Districts, California Dairy Quality Assurance Program, Newtrient, and dairy and livestock producer trade associations – in the development and implementation of the program; and**
d. **Establish and maintain a central clearinghouse (such as a website, mobile app, etc.) for program-related information, including the information referenced in 6a and 6b as well as relevant funding opportunities, application deadlines, published research, etc.**
e. **Includes farmer-centric events such as demonstration farms, field days, and other in-field activities to present information referenced in 6a and 6b and provide a comfortable space for dairy farmers to share experiences and ask questions.**

A large portion of this subgroup's work was related to gathering, reviewing, evaluating, and interpreting as much information as possible about non-digester practices. Information is power, and it helped the subgroup make informed decisions when forming its recommendations related to the effectiveness of various practices and technologies, needs related to project funding and other incentives, and further research needs. While much is known about the ability of non-digester practices to reduce methane emissions by reducing volatile solids flows entering anaerobic conditions, substantial unknowns and uncertainties remain.

Only through many meetings, dozens of technical presentations and hours of discussion was the subgroup – many of whom are already experts in one or more facets of relevant subject matter – able to gain a comprehensive enough understanding of all the issues necessary to formulate these recommendations. The owners and operators of dairy and livestock facilities do not have the ability to devote this time and effort to understanding their options. Yet their understanding is critical to moving forward, because they are the ultimate decision-makers for determining whether methane emissions reductions will occur on dairies.

It is therefore essential that there be an efficient method to transfer information – both what is known now and what is learned in coming years – to dairy and livestock operators for decision support. The subgroup recommends that an education and outreach program be developed to provide this

information to dairy and livestock operators and help them understand their opportunities and options for reducing dairy and livestock methane in a cost-effective manner.

The subgroup noted that for such outreach to be effective, it must contain accurate, up-to-date, and independently verified information about effective practices and technologies. It should help producers understand the consequences of selecting specific non-digester practices, including operational changes, economic opportunities or costs, and whole-farm environmental impacts and benefits. Particularly in cases of technology transfer from other industries or regions, it will be important to identify steps needed to be successful in California, such as regulatory compliance, permitting requirements, and ensuring the practice is aligned with California-style dairy and livestock facility structures, manure management capabilities, and changing climate.

The education and outreach should be coordinated with organizations known and trusted as sources of reliable information by the dairy and livestock producer community. The outreach efforts should include expertise in localized environmental regulations and agency participations. These include the University of California Cooperative Extension, Resource Conservation Districts, the California Dairy Quality Assurance Program, dairy and livestock producer trade associations, and other industry groups.

While in-person regional workshops and distribution of printed materials will likely be an important tactic for outreach, the subgroup recognized the need for a central clearinghouse of information related to non-digester practices, such as a dedicated website or mobile applications. Such a clearinghouse should be regularly updated as new research results are published and new technologies or practices become available.

APPENDIX A: Dissenting Opinions

The following list identifies where one or more subgroup members did not agree with the subgroup recommendations. The recommendations where there was dissent are identified, then the subgroup member, followed by the subgroup member's rationale for dissent.

All recommendations (1 through 6):

Dissenting: Phoebe Seaton, Leadership Counsel for Justice and Accountability:

- Ms. Seaton said she does not want to commit to a position of supporting the use of Greenhouse Gas Reduction Fund (GGRF) monies to support dairies in methane reduction efforts, given the significant needs and opportunities for investments from the GGRF. However, she said that if GGRF monies are allocated to dairies, such funding should be allocated to non-digester practices and technologies.
- Ms. Seaton does not support public investments that have built-in preferences for large-scale agricultural operations or that result in negative local air and water quality impacts in nearby, especially disadvantaged, communities.

Recommendation 1. Continue incentives for current non-digester technologies already known to reduce methane.

Dissenting: Phoebe Seaton, Leadership Counsel for Justice and Accountability:

- Ms. Seaton does not agree that incentives should necessarily continue for all currently eligible AMMP practices. She believes that to the degree incentives are offered, those incentives should be limited to only those practices that have no net negative impacts on nearby communities and should contribute to dairy and livestock operations that – on a comprehensive level – demonstrate sustainable practices throughout the operation, including ensuring that operations are protective of groundwater, air quality, surface water, working conditions, and animal welfare. She strongly supports continued research that will help elevate those practices that result in co-benefits and that do not result in negative local impacts to air or water quality.

Recommendation 2: Better quantify environmental benefits and impacts and address environmental justice concerns related to non-digester practices.

Phoebe Seaton, Leadership Counsel for Justice and Accountability:

- Ms. Seaton agrees that CARB should assess multiple environmental impacts and benefits of AMMP-eligible practices and technologies, but she is concerned that the recommendations as drafted do not provide sufficient certainty that practices will not result in negative localized impacts.

APPENDIX B: Subgroup Recommendations for Improving AMMP Program Implementation

I. Program Transparency and Public Participation

A. Conduct new workshops and allow public comment period prior to finalizing the next program. Areas for public comment should include scoring criteria and point allocations, Quantification Methodology (QM), and application requirements. Point allocations should be done in a way that emphasizes actual GHG reductions, and normalized calculations should be retained to allow different dairy and livestock sizes to participate.

B. Clearly explain the criteria and process for how CDFA will determine the final AMMP funding amount within the stated range of $19-33 million and how that intersects with the DDRDP process.

II. Application

A. Ensure that timeline for completing applications is no less than 8 weeks.

B. Simplify application.

C. Consider a phased application, e.g. short concept first, followed by a full proposal with more details if the short concept is accepted.

1. Seek input from technical assistance providers, engineers, and AMMP's Technical Advisory Committee on how this would work, including the level of detail needed in the short concept stage and what, if any, assurance would be made to applicants that are passed to the full proposal stage to allow for greater certainty for producers investing in new engineering and design costs.

D. Potential non-methane environmental benefits and impacts should be predetermined at the practice level vs. expecting farmers to determine them, given how complicated the science is (see Subgroup Recommendation #2b). These should be reviewed and updated over time as our knowledge evolves.

III. Practices

A. Improve the formal process by which new practices can be introduced and vetted for inclusion in the AMMP, like the process in Healthy Soils Program.

IV. QM & Calculator

A. Adapt QM calculator so it allows stacking of practices, and clearly explain how to use calculator to do that.

B. Account for different separator efficiencies.

C. Revise volatile solids numbers in flush to scrape scenario to account for time not spent in freestall and for liquid that is separated out of slurry.

V. Technical Assistance (TA)

A. Continue providing more 1:1 technical assistance vs. workshops.

B. Ensure TA providers have right expertise (this wasn't always the case in the last rounds). Specifically, TA providers should have permitting expertise and a good knowledge of how AMMP itself works is critical, in addition to understanding dairies. CDFA may consider training to support long-term development of needed technical expertise in this area.

C. Evaluate prior TA programs to assess if they did a good job, including what worked and what didn't.

VI. Support / Additional Information

A. Provide a lot more guidance / clarity on the permitting requirements (e.g. what is and is not actually required for different practices vs. a list of potential permits that may or may not apply). This was a major obstacle in the past programs and should be relatively easy to address.

B. Provide a summary feedback document, pulling together feedback CDFA sent/will send to past applicants (anonymized/generalized).

C. Based on the summary feedback and other input received, create one or two example applications that show what CDFA is looking for / what "good" looks like.

D. Allow more frequent or on-going Q&A.

1. Time periods for submitting and responding to questions were too far apart.
2. Allow individuals to submit questions and then post the Q&A for all to see within a short time frame.

APPENDIX C: Key Findings from Discussions about Currently Eligible AMMP Projects

Solid Separation in Flush Collection Systems

In flush systems, the addition of mechanical solids-liquid separation (SLS) followed by dry storage of removed solids reduces methane compared to wet (anaerobic) storage of those solids. Mechanical SLS is somewhat common in CA, but still exists only on a minority of dairies (approximately 30% according to professional judgment of subgroup members). The performance of SLS in removing volatile solids and the resulting methane emissions reductions depends on many factors, including the age of the SLS system, system design, system maintenance, liquid manure flow rates, composition of the manure, particle sizes, and materials used for bedding, among others. Additionally, different sampling methodologies or protocols can result in substantially different results for volatiles solids removal rates. Therefore, it is important for the State to establish and use consistent protocols for measuring VS removal rates to determine methane reductions.

In September 2017, a team of University of California, Davis scientists conducting research on SLS systems presented interim results of their work to the subgroup (project headed by Ruihong Zhang, presentation housed on subgroup 1's website). The research goal was to establish performance of SLS systems already operating on California dairies. The research team concluded that SLS reduces emissions of methane from anaerobic lagoons by reducing volatile solids stored in those lagoons. They cautioned that proper storage of solids post separation (in aerobic conditions) is essential to prevent increasing emissions elsewhere on the dairy and livestock facilities. Importantly, the scientists' early results suggested SLS removed higher amounts of volatile solids than are currently estimated in CARB's Quantification Methodology (CARB estimates 17 percent removal while the scientists' presented results showed a range of 58 to 64 percent VS removal at two dairies). The scientists speculated that use of SLS would result in a reduction of emissions of volatile organic compounds (VOCs) and nitrous oxide from manure storage, but would likely result in increased ammonia emissions, particularly from lagoons, although these changes were not expected to be large on a whole-farm basis.

Scrape or Vacuum Collection Followed by Dry Storage

The subgroup heard presentations from several experts, including subgroup member and civil engineer David DeGroot, Till Angermann (hydrogeologist and Technical Program Manager for the Central Valley Dairy Representative Monitoring Program) and Dr. Frank Mitloehner of UC Davis. Each of these presentations covered multiple topics but included information about scrape and vacuum collection systems. The subgroup learned that:

- Methane reduction can be achieved by:
  - Converting flush collection to scrape collection followed by dry (aerobic or mostly aerobic) storage; or
  - Increasing the amount of manure stored in dry or aerobic conditions on existing scrape collection systems.

- Scrape collection systems are currently not common in California's Central Valley, especially as a primary manure collection method, and infrastructure to provide equipment and service is limited.
- SLS is likely still needed to dry scraped slurry, but it will be a different type than what is used on flush systems.
- Drying of slurry with mechanical SLS will still generate some portion of volatile solids in liquid form. ARB's QM Calculator for AMMP does not currently account for this.
- Compared to flush systems, scrape collection with drying of solids can make it easier to export nutrients to other farms, resulting in water quality benefits for dairies with excess nutrients.
- It remains unclear how scrape might impact non-methane emissions downstream, particularly nitrous oxide, ammonia, and VOCs. Dr. Frank Mitloehner suggested that unpublished research found that using scraping to collect manure from barn floors increased ammonia emissions compared to flushing, although this does not necessarily mean an overall increase in whole-farm ammonia emissions, which may also be affected by changes past the point of barn manure collection e.g. how the manure is further processed and stored.
- Environmental benefits and impacts are highly dependent upon how manure is handled, stored, and used after it has been collected.

Reductions in Pasture Systems Manure Methane Emissions through Storage Changes

The subgroup heard presentations from several experts in pasture management, manure management in pasture systems, and measuring manure-related emissions, all of which contained important information related to understanding the opportunities to reduce methane emissions in pasture systems. Experts presenting included subgroup member Dr. Deanne Meyer of UC Davis, Dr. Al Rotz of the USDA Agricultural Research Service, Dr. Randi Black of University of California Cooperative Extension, and subgroup member Cody Nicholson Stratton, a pasture dairy operator from Humboldt County.

These experts shared the following:

- Pasture dairies on average are significantly smaller on average than non-pasture dairies (numerous sources).
- Most pasture dairies collect and store some manure for some part of the year, through scraping or flushing (Stratton). Reducing the amount of time that manure is stored anaerobically will reduce emissions (Meyer).
- Pasture systems overall produce slightly less methane per unit of milk produced, but they are also less profitable and use more land to produce the same amount of milk (Rotz).
- Pasture systems produce far less methane from manure storage than confined animal operation (because less manure is stored under anaerobic conditions), but pasture systems produced more enteric (direct from the cow) methane. Rotz compared dairies in one study where grazing operations produced less than half of the methane from manure management compared to confined animal systems (4 to 5 grams methane per kilogram of milk for former versus greater than 10 grams methane per kilogram of milk for latter).
- Greater enteric emissions from grazing animals partially offset the reduced manure methane emissions (studies grazing systems produced 23-25 grams methane per kilogram of milk

compared to 26 to 29 grams methane per kilogram of milk when both sources of methane were considered), according to Rotz.

- Manure management emissions in grazing systems (or in any dairy or livestock system) can be reduced by reducing the amount of manure that is stored anaerobically, and the amount of time it is stored (Meyer). This can include reducing the amount of manure that is flushed and substituting dryer, non-anaerobic storage or compost pack barns.
- For grazing systems, one way to reduce anaerobic manure storage is to increase the animals' time on pasture. In pasture systems on California's North Coast, animals can be on pasture for as few as 120 days annually or as much as 365 days (Stratton). One way to increase time on pasture is to use pasture lanes (designed to not become too muddy in winter) for cows to access different pastures and return for milking (Black).
- Enteric emissions on pastures can also be potentially reduced by changes in the pasture mix, such as more legumes, use of concentrate as a feed additive to increase digestibility, and through breeding and genetics (Black).

Composting

Ryan Flaherty from Sustainable Conservation presented findings from a report they wrote assessing the environmental, economic, regulatory, and policy considerations for increasing the production and distribution of manure-based compost.

Environmental impacts: To assess environmental impacts, Sustainable Conservation reviewed existing research. They compared impacts of open windrow composting to raw manure stored in piles, looking at both the production/storage stage as well as the use phase (e.g. land application). Their findings suggest overall GHG, water quality, and soil health benefits with some potential air quality impacts. Methane reductions are significantly greater when compost uses solids that were previously stored in slurry pits or lagoons. Net VOC emissions may increase with composting, although studies using pure manure feedstocks are needed to verify and quantify. Ammonia emissions do appear to increase with composting, but all these emissions occur during the composting stage where mitigation measures are available. About 50% of ammonia emissions from raw manure occur during land application where mitigation is difficult.

Economics: The market for manure-based compost seems promising, although there is a lack of reliable information and research is needed. There is a sizeable and daily potential supply of manure feedstock: Sustainable Conservation estimated that if dairies composted just 5% of the approximately 93,000 tons of total manure produced every day in the San Joaquin Valley, this would result in about 1.9 million tons of compost per year. Dairy producers appear interested in composting their manure but are confused and uncertain about permitting requirements. Demand appears strong, but more research is needed, especially to understand how much compost the market can handle at a profitable price. Customers will likely pay more for manure compost because it has less contaminants and higher nutrient content compared to green waste compost, but they require assurances about quality and consistency.

Policy: Many state policies exist that should support the composting of manure, including SB 1383, Short-Lived Climate Pollutant Strategy, AMMP, Healthy Soils Initiative, and AB 1045 (organic waste: composting).

Regulations: Sustainable Conservation found that permitting requirements for composting manure are confusing and unclear, and this is currently a barrier to more dairies producing compost. There is general confusion due to lack of alignment on definitions, thresholds, and measurement units between regulatory authorities. There is also confusion and lack of clarity within specific regulatory authority. For example, it is unclear what will be required of dairies who wish to compost given the different requirements in the State Water Resources Control Board's Composting General Order and the Regional Water Quality Control Board's Dairy General Order. In another example, the San Joaquin Valley Air Pollution Control District doesn't have specific, pre-determined air quality mitigation measures for on-dairy composting, but dairy producers assume they will be cost-prohibitive. Sustainable Conservation's key recommendations are to: conduct research to fill in environmental impact gaps, especially VOCs; conduct formal assessment of the market potential for manure-based compost; and align and clarify permitting requirements, especially for on-dairy composting of manure.

Dr. Cynthia Daley from CSU Chico presented on the work she has done assessing the benefits of compost, primarily to soil health and grass/crop production. She reviewed how compost is produced, including critical factors to producing good compost, such as carbon to nitrogen ratio, aeration, moisture, and temperature, among others. Key benefits mentioned include improved soil structure and porosity, better permeability and holding capacity, less erosion, neutralization of pH, improved ability for soils to hold nutrients, increased nutrient availability for plants, enhanced microbial activity, disease suppression, and enhanced soil carbon sequestration. She also mentioned work being done by Marin Carbon Project, New Mexico State University, and Texas A&M to measure the carbon, soil, and/or crop benefits of composting and other regenerative agricultural practices.