Diversified Strategies for Reducing Methane Emissions from Dairy Operations

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CalCAN
California Climate & Agriculture Network

About CalCAN

The California Climate and Agriculture Network (CalCAN) is a network of sustainable agriculture advocates, farmers, ranchers and agricultural experts that advances policy solutions at the nexus of sustainable agriculture and climate change.

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Introduction

Methane comprises six percent of the total greenhouse gas (GHG) emissions generated in California. It is a very potent GHG with a global warming potential about 25 times that of carbon dioxide over a 100-year period.[1] Agriculture is responsible for about 60 percent of California's methane emissions, and the state's dairies are the primary source of those emissions. Approximately equal levels of emissions come from dairy manure management systems and from the digestive process of enteric fermentation in dairy cattle rumens that generate methane exhaled by the animals.[2]

California has taken significant steps to reduce GHGs, including methane, but more remains to be done. In 2014, the state enacted Senate Bill 605 (Lara), which requires the California Air Resources Board (CARB) to develop a strategy by the end of 2015 to further reduce Short-Lived Climate Pollutant (SLCP) emissions, including methane. In January 2015, Governor Brown set a target for reducing GHG emissions to 40 percent below 1990 levels by 2030.

In September 2015, CARB released its draft *Short-Lived Climate Pollutant Reduction Strategy* (*'Draft Strategy'*).[3] The *Draft Strategy* proposes measures to drastically reduce dairy-related methane emissions by 2030, through a combination of voluntary and regulatory actions.[4] The proposed reductions in agricultural methane emissions are an integral piece of CARB's 2030 SLCP goals. The ambitious nature of these targets makes it clear that significant investment of public dollars in agricultural solutions will be needed to achieve the desired result.

This policy memo from the California Climate and Agriculture Network (CalCAN) recommends ways that CARB and the lead department, the California Department of Food and Agriculture (CDFA), can incentivize agricultural methane reduction strategies that make the wisest use of public dollars while maximizing environmental, economic, and public health benefits. Through both their current and planned investments in agricultural methane solutions, CARB and CDFA should promote actions that produce lasting methane reductions while supporting a diverse dairy industry that provides multiple benefits to the state.

Summary of Recommendations

1. Diversify the SLCP Strategy beyond a focus on funding anaerobic digestion systems and reconsider digester strategies to ensure long-term benefits of public investment.
2. To maximize the benefits of public investment, focus on digester strategies that support long-term operation of at least 20 years. Pursue projects and funding structures that shift digester operation and maintenance away from individual dairy producers to third-party operators that can provide performance guarantees on state-subsidized digesters. Ensure that California dairies benefit from a non-regulatory approach, which addresses GHG emissions and reduces financial risk while providing compensation for the use of their manure waste.
3. Provide adequate incentives for co-digestion projects that offer the dual benefits of reduced methane emissions from dairy manure and landfills.
4. Develop dry manure management incentives that result in economical methane reductions, job creation, and provide other co-benefits, like compost production.
5. Develop demonstration projects for pasture-based dairy practices, bringing together interested dairy operators, technical providers and university researchers to create opportunities for 'mixed' dairy systems that incorporate aspects of pasture grazing into their operations.
6. Support research and demonstration on strategies that reduce emissions from enteric fermentation. Include strategies that are relevant for organic and pasture-based systems because they maximize environmental co-benefits.

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[1] Given the urgency of the climate challenge, some prefer to express methane's global warming potential (GWP) over a shorter 20-year timespan. Methane's GWP over a 20-year period is approximately 72 to 75 times that of carbon dioxide.

[2] California Air Resources Board. May 2015. Short-lived Climate Pollutant Reduction Strategy: Concept Paper ('Concept Paper'), pp. 21-22. Online at: http://www.arb.ca.gov/cc/shortlived/concept_paper.pdf

[3] California Air Resources Board. September 2015. Draft Short-lived Climate Pollutant Reduction Strategy ('Draft Strategy'). Online at: http://www.arb.ca.gov/cc/shortlived/2015draft.pdf

[4] Specifically, CARB's proposal calls for reducing methane emissions from dairy manure management by 20 percent in 2020, 50 percent in 2025, and 75 percent in 2030. *See* Draft Strategy, p. 45.

Understanding the California Dairy Industry Context

As California moves forward on strategies to reduce agricultural methane emissions, it is important to understand the current state of our dairy industry. Dairy farm economics, the impacts of climate extremes (such as drought), the global nature of the industry, consumer preferences, and other environmental concerns (e.g., air and water quality impacts) will all influence the success of methane reduction strategies.

A full review of these issues is beyond the scope of this paper, but we note that in recent years the California industry has experienced declines in the total number of dairies[5] and consolidation into larger dairies, mainly in response to unstable milk prices, global oversupply of dairy products, greater concentration of milk buyers, and rising feed costs during the state's severe drought. One bright spot in the industry has been the growing consumer demand for organic dairy products. As a consequence, the number of cows under organic management in California—which requires a minimum four months per year of feeding cows on pasture—increased from just under 10,000 cows in 2001 to nearly 58,000 cows in 2011 (the latest year of data).[6]

As more dairy producers exit the industry, pursue larger operations to stay afloat, or consider alternative strategies like organic production, the state's SLCP Strategy presents an opportunity to address multiple concerns for the industry and our environment. No one strategy will work for all dairies. California's dairy industry is considerably diverse, with farm scales, management systems, land types, business structures, and regulatory requirements varying significantly from region to region. State investment should be designed to benefit dairy operators across many contexts, helping all dairies prepare for the challenges ahead.


NRCS employee discusses manure management with dairy farmers in Stanislaus County

As CalCAN reviewed CARB's *Draft Strategy*, we used these questions to guide our recommendations:

- Does the strategy provide the producer with flexibility to change herd size (e.g., decrease the number of cows) to adjust to dairy prices? Or does it commit dairies to maintaining (or expanding) their herds?
- Does the strategy address multiple environmental benefits, including improved air and water quality, in addition to reduced methane?
- Does the strategy produce additional economic opportunities for the dairy producer? For the region (e.g., does the strategy create jobs)?

We discuss our recommendations in detail below.

[5] The number of dairies in the state has decline significantly in the past few years, from 2,165 dairies in 2007 to 1,500 dairies in 2013. Online at: https://www.cdfa.ca.gov/Statistics/PDFs/CropYearStats2013_NASS.pdf. For more on the increase in large dairies see the Census of Agriculture from USDA: http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/California
[6] Data from USDA's Economic Research Service. Online at: http://www.ers.usda.gov/data-products/organic-production.aspx#25766

Recommendations

A. Promoting Diverse Strategies to Maximize Effectiveness of Public Investment

The *Draft Strategy* rightly recognizes that "the optimal mix of technologies and manure management practices to reduce methane emissions, protect air and water quality, and support dairy economics will depend on dairy-specific factors and vary across the state."[7] However, most of the state's efforts to reduce agricultural methane have focused primarily on the retrofitting of one mode of production—large confined dairy operations using 'wet' manure management systems—with anaerobic digesters intended to concentrate and destroy the methane they generate. By pursuing an expanded set of strategies, California can reach a more diverse set of dairy operations, giving them the tools and flexibility they need to address the changes ahead.

While anaerobic digesters can provide clear benefits in some contexts, and should continue to be promoted as a valuable methane reduction strategy, important improvements can be made to the ways in which these technologies are incentivized by the state (see Recommendations #2 and #3). Furthermore, given their yet-unproven track record in California, anaerobic digesters should not be seen as a panacea; instead they should make up one part of a diversified strategy to reduce agricultural methane emissions while maximizing co-benefits.

Rather than diversifying the mix of dairy methane reduction strategies, however, the *Draft Strategy* seems to double down on the state's previous policies, even promoting a proposal to invest half a billion dollars in dairy digester infrastructure over a five-year period.[8] Despite the *Draft Strategy's* repeated mention of "***avoiding*** or capturing methane from manure at large dairies",[9] CARB emphasizes measures that do only the latter.

Although 29 digesters have been installed in the state since 1989, recent reports indicate that there may now be only 13 California dairies with an operational anaerobic digester.[10] Eleven of these are located at large dairy farms in the Inland Valleys, and two are located at smaller dairies in Marin County.[11] Despite the availability of both federal and state funding for digester construction, numerous policy initiatives to promote these solutions, and the creation of a CARB compliance offset protocol for livestock projects,[12] only a tiny fraction of California's roughly 1,400 dairies currently have working digesters.[13] Of the larger California dairies with 500 or more cows—a herd size that U.S. EPA considers conducive to digester installation—less than two percent currently use an anaerobic digester to handle their methane emissions.[14]

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[7] Draft Strategy, p. 44.

[8] Draft Strategy, pgs. 14 and 46. This funding recommendation, which was created and put forward by dairy industry representatives, is mentioned in CDFA's Recommendations for Short-Lived Climate Pollutants: Agricultural Workgroup Report to CARB on p. 19. Importantly, however, CDFA also notes that "this recommendation should not overshadow the importance of other manure management strategies....On many dairies, other technologies may be the more appropriate emission mitigation strategy and the potential to reduce methane emissions from those strategies is significant."

[9] See Draft Strategy, pgs. ES-7, ES-8, and 39. Emphasis our own.

[10] California Environmental Associates, on behalf of Sustainable Conservation. July 2015. Greenhouse Gas Mitigation Strategies for California Dairies ('Sustainable Conservation Report'), p. 20. Online at: http://www.suscon.org/blog/2015/07/combating-climate-change-dairies-key-in-reducing-methane/

[11] Bartolone, P. Aug. 11, 2015. Manure for some, dollars for others. CALMATTERS.

[12] Some of these efforts are discussed at pp. 40-41 of the Draft Strategy.

[13] Number of dairies taken from CDFA's Dairy: Statistics and Trends Mid-Year Review. Data is for the January-June 2015 period.

[14] U.S. Environmental Protection Agency. Is anaerobic digestion right for your farm? Accessed October 22, 2015. Online at: http://www2.epa.gov/agstar/anaerobic-digestion-right-your-farm

There is very little publicly available information about the lifespan of anaerobic digesters and the level of performance over their lifespan. However, the high attrition rate of digesters installed since 1989 suggests that the public dollars spent on digesters may not be as effective in controlling methane emissions over the long run as initially thought. According to a 2015 report entitled *Greenhouse Gas Mitigation Strategies for California Dairies* (*'Sustainable Conservation Report'*),[15] a number of digesters that received significant public funding are no longer in operation. Many of the digesters installed in California since 1989 have ceased operations because of financial distress, high operational costs, and/or complexity of their operation.[16]

Flushing an alleyway at a dairy in California

Meanwhile, it is apparent that the costs of installing and properly maintaining a dairy digester remain extremely high. The *Sustainable Conservation Report* analyzes recent data on the capital costs of digester installation in California and estimates a cost of $1,350 to $3,400 per cow whose manure is handled by the digester. Although these estimates are derived only from a selection of digester projects, these numbers appear to be significantly higher than what has traditionally been cited in the academic literature—this despite years of policy efforts, research and development to improve the value proposition of these technologies.[17]

In focusing almost exclusively on anaerobic digesters as a dairy methane reduction strategy, both state and federal governments have supported an expectation that, despite large up-front costs, digesters will prove profitable in the long-term. Dairies often plan to rely on income from the production of electricity and/or biogas to defray the high capital costs for digester construction, significant ongoing operating costs, and recurring costs for repairs.

But there may be flaws with this assumption of long-term profitability. Digester operation can be unreliable with unexpected costs. A 2013 analysis examined the economic feasibility of operating dairy digesters to produce heat and power in California. Using data gathered from a number of systems, the analysis focused on the key indicator of net income as a measure of success. Two of the dairies studied incurred major capital expenditures when the digesters' engines had to be replaced well before the end of their expected 20-year lifetime. Only one dairy (out of six) had positive net income, without grant support, over a 20-year payback period. This dairy had some atypical characteristics that contributed to its successful financial picture. It operated an on-farm cheese plant that replaced expensive propane heating with captured heat from the digester engine. Because of its high power demand, it was able to receive valuable 'retail rate' credits for the electricity produced. Importantly, its management team also treated the digester as an enterprise in and of itself. In other cases, digesters were not built to optimize a revenue stream because the operator did not fully understand the complexities of a potential revenue stream built on utility rates and/or net metering contracts.[18]

[15] California Environmental Associates, on behalf of Sustainable Conservation. July 2015. Greenhouse Gas Mitigation Strategies for California Dairies

[16] Sustainable Conservation Report, p. 20

[17] Sustainable Conservation Report, pp. 22-3

[18] Hurley, S. and M. Summers. March 2013. An Economic Analysis of Six Dairy Digester Systems in California, Volume 2. California Energy Commission Report CEC-500-2014-001-V2

This suggests a pressing need to further reduce financial and operational risks of digester investment, both for the state and for growers (see Recommendation #2). But it should also serve as a caution against investing too heavily in a practice that has only seen long-term success in a limited number of California cases—at least before the barriers to that success have been more fully overcome.

Another challenge posed by too great a focus on incentivizing dairy digesters is that, rather than avoiding methane generation altogether, these technologies can actually create incentives to generate methane from manure. The more methane that is produced then converted to electricity or biogas, the higher the revenue for the digester operator. Especially in light of the aforementioned financial strains that digester investment can bring about, this is a potential perverse incentive that must be addressed. Conversely, this can also pose challenges to long-term digester profitability, as herd sizes (and hence methane generation) can drop significantly amidst a volatile dairy market.

Digester technologies also come with unnecessary emissions risks, some of which are not adequately understood. With the large amounts of methane being generated, even a relatively small percentage of fugitive or 'unintended' methane releases from the system could be significant. These systems may be considerable sources of unintended methane emissions if they are not adequately designed or operated to destroy the methane they generate. One study of fugitive methane emissions from a manure digester estimated that an average of 3.1 percent of the methane produced escaped the digester system during normal operations but also noted that when methane flaring occurred, fugitive methane emissions jumped to above 30 percent of the total methane production.[19]

In addition, the amount of emissions resulting from the land application of residual solids from large anaerobic digesters is poorly understood. This use of effluent is known to generate GHG emissions but there has been no sufficient examination or estimation of the extent of GHG emissions generated by California dairies through this practice.[20]

Overall, the state has failed to adequately acknowledge alternatives to large confined dairy systems, especially dairies that avoid generating large quantities of methane through the aerobic decomposition of wastes on pasture land. Some of these dairies also use lagoons and methane digesters, but on a smaller scale, and there is great potential to promote manure handling systems that reduce the degree of anaerobic decomposition through dry scraping, vacuuming or solid separation techniques (see Recommendations #4 and #5).

CARB's development of an SLCP Strategy is an opportunity to diversify and expand the breadth of the state's agricultural methane reduction efforts. Challenges and roadblocks to wider adoption of these other practices remain, as well, but beginning SLCP efforts with a too-limited approach comes with inadvisable risks. Management practices that have been put on the back burner in years past should be brought to the fore, more fully researched, and incentivized to meet the *SLCP Concept Paper's* criteria for strategies that are "based on a whole-system perspective…taking into account the lifecycle of emissions, energy and water use, economics, animal health/welfare, soil health, and water quality."[21]

Recommendation #1. Diversify the SLCP Strategy beyond a focus on funding anaerobic digestion systems and reconsider digester strategies to ensure long-term benefits of public investment.

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[19] Flesch, T.K., R.L. Desjardins and D. Worth. 2011. Fugitive methane emissions from an agricultural biodigester. Biomass and Bioenergy (35):3927-3935

[20] Veigh, T., L. Olander and B. Murray. 2014. Greenhouse Gas Mitigation Opportunities in California Agriculture: Science and Economic Summary. Nicholas Institute Report NIGGMOCA R 1; p. 12

[21] Concept Paper, p. 21

B. Third-Party Ownership and Operation: Reducing investment risks

Current and future digester incentive programs should directly address the significant risks and demands of digester ownership and operation, which can contribute to the failures to achieve long-term benefits of public investment in digesters discussed above. Improved forms of simple, accessible third-party ownership arrangements and leases could be an effective means of shifting these risks and burdens from the dairy farmer to other parties, thereby reducing the risks of state investment in the technology. Funding guidelines should also increase the impact of state investments by expanding opportunities for medium-scale dairies, recognizing the higher barrier to entry faced by these operations.

Most grants and other public funding measures require the owner of the digester to assume significant financial risk if the digester fails. But many dairy operators do not want to assume that level of risk. In addition, they may not have the time, the expertise, or the interest needed to properly maintain and operate the digester. Adding the role of renewable energy generator to the list of tasks already burdening a dairy operator is often less desirable. Furthermore, a lack of expertise in the technology may result in less-than-optimal financial benefit to the grower or even a failure to operate the equipment with maximum efficiency.[22]

In an ideal third-party ownership arrangement, the dairy operator would remain responsible for providing an adequate supply of waste but could be freed from paying the capital costs of a digester, as well as most of the expertise and time demands of digester operation and maintenance.[23]

Third party ownership models typically require:

- A lease or arrangement for the land on which the facility sits, between the dairy farm owner and a third party owner of the digester system.
- A manure supply agreement between the dairy farmer and the digester owner.
- Performance guarantees from the digester operator and manufacturer for the period of time the digester will operate.
- Revenue agreements, which are often preferred by third party owners. The agreements would cover potential sources of revenue for the digester (e.g., electricity production, fiber for animal bedding), tipping fees for waste disposed of in the digester and environmental credits available from the state.[24]

One legal model for this arrangement is the use of a power purchase agreement (PPA), an arrangement that has been widely used for solar photovoltaic systems. Under a PPA, the dairy digester can be owned and installed by a third party who sites the digester on the dairy property. In return for the access to the land and the use of the dairy's resources to produce the energy, the owner/operator provides electricity to the dairy at a significantly lower cost than local utilities.[25]

Another arrangement is a lease in which either the dairy operator or a third party owns the digester. If the dairy operator owns the digester, the lease may provide that the lessee or a third party operates and maintains the digester. If a third party owns the digester, the farmer is usually provided with electricity for the dairy operation. The digester owner and dairy farmer also agree on the division of the monetary benefits of digester power that is provided to an electric grid and the benefits of tax depreciation on the digester. Generally, the lease is structured so that the dairy bears

[22] Hurley and Summers, 2013

[23] New York State Energy Research and Development Authority. May 2014. Anaerobic Digester Business Model and Financing Options for Dairy Farms in New York State. Final Report. Report No. 14-30

[24] Ibid.

[25] Ibid.

the risk of loss of the digester services from delays in constructing the digester or mechanical failure of the digester.[26]

Any state-funded incentives for digesters should be structured so that dairies can access these and other improved financial arrangements that reduce the risk of digester attrition, thereby making state investment in digesters a less risky public investment. The state may want to pursue agreements with third-party digester operators who receive public investments that require operation of the digester for a set period of time—for example, the state could require 20 years of guaranteed digester operation in exchange for public subsidy.

Recommendation #2. To maximize the benefits of public investment, focus on digester strategies that support long-term operation of at least 20 years. Pursue projects and funding structures that shift digester operation and maintenance away from individual dairy producers to third-party operators that can provide performance guarantees on state-subsidized digesters. Ensure that California dairies benefit from a non-regulatory approach, which addresses GHG emissions and reduces financial risk, while providing compensation for the use of their manure waste.

C. Co-Digestion: Increasing opportunities and maximizing efficiencies

The anaerobic digestion of dairy waste with additional organic waste streams, known as 'co-digestion', can significantly increase the energy produced and provide additional operational benefits. In some geographic regions with large concentrations of dairies, multiple operations could contribute manure to be co-digested along with other organic waste streams that are increasingly diverted from landfills under the state's SLCP and waste reduction strategies. Co-digestion could also reduce the risk of state investment by developing digester models with multiple diverse stakeholders, increased flexibility in operating needs, and more secure ownership structures.

Compost made from manure and other organic solids

California could look to multi-benefit co-digestion facilities in other states as an example.[27] One successful dairy-based co-digestion model in Pennsylvania includes the use of dairy waste, community food waste, poultry manure and other animal waste. In addition to tipping fees, this project creates additional revenue from the sale of carbon credits, fertilizer and animal bedding.[28] At another example in Michigan, two on-farm facilities co-digest manure with liquid food residuals from nearby food processors. A third-party company, Casella Organics, owns the digesters, bears the responsibility for their operation and maintenance, and even delivers the liquid food residuals to the dairies. The co-digested material is ultimately processed into a stabilized liquid fertilizer and stored until it is used by the dairy and neighboring farms, replacing both synthetic fertilizer products and traditional raw manure spreading. The biogas produced by the digesters is used to power a small combined heat and power unit that provides electricity and heat to the farm's buildings, and surplus electricity is distributed through the power grid. Food processors who recycle their residuals at the digester may also qualify for credits on their utility bill.[29]

[26] Ibid.

[27] U.S. EPA's AgStar Database features some case studies of successful co-digesters. Online at: http://www2.epa.gov/agstar

[28] USDA, EPA and Department of Energy, Biogas Opportunities Roadmap: Voluntary Actions to Reduce Methane Emissions and Increase Energy Independence (Aug. 2014).

In some cases, larger dairies may generate a sufficient amount of manure to make offsite transfer economical. At the Pixley Biogas anaerobic digestion facility in California, an offsite digester uses solid and liquid waste from a nearby dairy, the Four J Farm Dairy, mixed with food waste to generate energy for the Calgren Renewable Fuels ethanol plant. Manure is pumped daily from the dairy farm through a pipe to the offsite digester. In return for the manure, the dairy receives digested solids to use as bedding and digested effluent to apply as fertilizer. The California Energy Commission provided $4.6 million in grant funding for the mile-long manure delivery pipe, which saved on operating costs of trucking the manure as well as potential air emissions from the trucks. Food waste is trucked to the digester from area food processors, renderers and grease-trap pumping services. In addition, waste heat from the ethanol plant heats the digester and pasteurizes the liquid manure that is used as fertilizer.[30]

Diversified dairies with value-added operations such as cheese production and other processed food enterprises can also benefit from co-digestion of wastes on-site. The Straus Family Creamery in Marin County co-digests wastewater from its creamery with manure from its dairy cattle operation. This reduces runoff and allows the wastewater to be treated and stored, then reused to flush the milking barn and free-stall barn.[31]

Mixing and matching waste streams in one digester can be challenging, and more research may be needed to find the best combinations and pre-treatment for mixed waste streams. Nevertheless, co-digesters do provide an opportunity to increase the amount of energy from a digester and help address the issue of dealing with multiple waste streams that may not be economically feasible to deal with separately or individually. Co-digesters could also reduce financial risks by building in flexibility and piloting more stable ownership models.

Recommendation #3. Provide adequate incentives for co-digestion projects that offer the dual benefits of reduced methane emissions from dairy manure and landfills.

D. Dry Manure Management: An economical multi-benefit approach to methane reductions

The time is right to support the adoption of and conversion to dry manure handling systems, such as scrape and vacuum systems, as well as managed dry composting systems. These aerobic dry handling systems, unlike anaerobic wet handling systems, to large extent avoid generating the significant amounts of methane that must be confined and destroyed.

As CDFA's *Agricultural Workgroup Report* notes, "methane emissions can be dramatically reduced – perhaps by more than 90 percent – when dry systems are used."[32] A recent meta-analysis of field-scale data on manure management practices determined that, while liquid manure storage systems had the greatest per-head methane emissions, dry systems had among the lowest.[33] Other research

[29] Casella Organics, 'Anaerobic Digestion'. Online at: http://casellaorganics.com/services/anaerobic-digestion

[30] A description of the Calgren biodigester is available at Dan Emerson, Digester Biogas Heats Up Ethanol Plant, 56 Biocycle 46 (June 2015). Note that Assembly Bill No. 1104 (2014) extended an existing exemption in the California Environmental Quality Act to this digester. The exemption was expanded to include a biogas pipeline located in Fresno, Kern, Kings, or Tulare County that is used to transport biogas derived from anaerobic digestion of dairy animal waste. California Public Resources Code § 21080.23.5.

[31] See Kresge, L. and K. Mamen. January 2009. Strauss Family Creamery in California Water Stewards: Innovative On-farm Water Management Practices, pp. 19-29

[32] CDFA. June 2015. Recommendations for Short-Lived Climate Pollutants: An Agricultural Workgroup Report for the California Air Resources Board and California Department of Food and Agriculture ('Agricultural Workgroup Report'), p. 13. Online at: http://www.cdfa.ca.gov/EnvironmentalStewardship/pdfs/slcp-reommendations.pdf

[33] Owen, J.J. and W.L. Silver. 2015. Greenhouse gas emissions from dairy manure management: a review of field-based studies. Global Change Biology 21:550-565

suggests that in some circumstances, cows for which 80 to 90 percent of manure waste is handled in dry management-based organic dairy systems emit less overall methane than those in conventional liquid-based systems, “regardless of how methane losses are reported (per kg milk, per day, per lactation, or over a [cow’s] lifetime)”.[34] Although more California dairies rely on anaerobic lagoons than their counterparts in almost any other U.S. state,[35] many dairies in Glenn and Tulare counties already handle a portion of their manure through dry management systems.[36] This suggests that dry management systems can be economically viable, and that broader adoption of dry practices may be feasible with the right incentives and research in place.

The expense of using dry systems can be a concern,[37] although no California studies have fully examined the total costs and benefits of these options as compared to liquid-based methods of manure management. The infrastructure and maintenance costs of a dry system will vary depending upon a variety of factors, but capital costs will generally be lower than those of an anaerobic digester. Given the poor track record of digester technologies in the state (as discussed above), dry management systems could prove to be a more reliable option for state investment in some circumstances.


Windrows of compost on a dairy farm in California

The *Agricultural Workgroup Report* highlights that dry solids can be used as an income stream through the production of saleable compost products, which aligns well with the *Draft Strategy’s* proposal to significantly boost compost markets and infrastructure. Converting to composted manure systems could significantly reduce methane and nitrous oxide emissions,[38] as well as lower the risk of pathogen contamination and alleviate food safety concerns.[39] Furthermore, the wider use of manure-derived compost as a soil amendment could increase carbon sequestration.[40]

Well-developed markets for compost and soil amendments, such as those envisioned in the draft SLCP Strategy, can offset costs and even make dry manure management a profitable enterprise. By recognizing the potential of dry systems to contribute a supply of high-quality compost to the market, the SLCP Strategy can help to develop these practices as a viable option for more dairy operations. The SLCP Strategy should propose comprehensive ways to overcome any logistical and regulatory obstacles to on-dairy composting of manure wastes, in addition to clearing the path for large-scale compost facilities. Complementary efforts like CDFA’s Healthy Soils Initiative will help to more fully value the multiple benefits of these products, making them a greater value proposition for dairies to pursue.

Broader adoption of solid separation technologies could also be an effective strategy, according to

[34] Benbrook, C., C. Carman, E.A. Clark, C. Daley, W. Fulwider, M. Hansen, C. Leifert, K. Martens, L. Paine, L. Petkwitz, G. Jodarski, F. Thicke, J. Velez, and G. Wegner. November 2010. A Dairy Farm’s Footprint: Evaluating the Impacts of Conventional and Organic Farming Systems. The Organic Center, p. 30

[35] Owen and Silver 2015, pp. 561-2

[36] Meyer, D., P.L. Price, H.A. Rossow, N. Silva-del-Rio, B.M. Karle, P.H. Robinson, E.J. DePeters, and J.G. Fadel. 2011. Survey of dairy housing and manure management practices in California. Journal of Dairy Science 4744-4750. The survey found that “only scraping” was used at 37.5% of Glenn dairies and 20% of Tulare dairies, while an additional 18.8% of Glenn dairies and 44.7% of Tulare dairies used both “flushing and scraping.”

[37] Agricultural Workgroup Report, p. 13

[38] Pattey, E., M.K. Trzcinski and R.L. Desjardins. 2005. Quantifying the reduction of greenhouse gas emission as a result of composting dairy and beef cattle manure. Nutrient Cycling in Agroecosystems, pp. 173-187.

[39] Agricultural Workgroup Report, p. 14

[40] Ryals, R., M.D. Harman, W.J. Parton, M.S. DeLonge, and W.L. Silver. 2015. Long-term climate change mitigation potential with organic matter management on grasslands. Ecological Applications 25(2):531-545

the *Agricultural Workgroup Report*. Devices such as weeping walls and double-screened mechanical separators, which can efficiently remove a portion of solids from being broken down by methanogens in the lagoon, could be adopted fairly easily at many California dairies and would likely avoid significant methane emissions. Solid separation technologies are currently in place at most large dairy farms in Glenn and Tulare Counties,[41] although their enhanced and expanded use—with methane reduction as a key objective—could provide models for other dairies. Again, cost is a potential concern (although they are far less capital-intensive than digesters[42]), but well-designed incentives could help to overcome this obstacle.[43]

However, the *Draft Strategy* does not adequately acknowledge the significant potential of these practices and technologies. Dry systems and solid separation practices could be incentivized in a relatively economical manner and, when done right, may help avoid some of the thorny water and soil contamination challenges associated with liquid manure management systems.[44] Dry manure management should play a prominent role in the mix of strategies that the state encourages dairies to adopt, particularly at new and expanded operations.

While more effort is needed to identify the best ways to widely promote dry management solutions, this should not exclude these practices from CARB's SLCP Strategy or limit the potential share of public investment they might receive. To meet CARB's ambitious targets, the dairy industry will need access to multiple methane reduction opportunities, none of which will be 'one-size-fits-all.'[45]

To that end, we support the *Agricultural Workgroup Report's* recommendations[46] that CARB and relevant agencies should:

- Investigate the cost per metric ton of GHG reduction for the most efficient solid separation technologies...and for conversion to dry manure management systems and develop incentive programs for these technologies;
- Avoid and remove any unnecessary regulatory barriers to composting of dairy manure and digestate; and
- Examine trade-offs in methane production potential, regulatory burdens and market considerations between on-farm composting and centralized composting facilities.

To this list we would add the need for an improved understanding and valuation of the environmental and economic co-benefits of dry manure handling systems. This information could inform the development of incentives for the adoption of dry manure management.

In particular, we note that dry manure handling systems are relatively low-tech; compared to liquid handling systems, they rely more heavily on labor for moving and properly storing (and composting) manure, and therefore offer a potential job creation co-benefit. However, both the *Agricultural Workgroup Report* and the *Sustainable Conservation Report* cite increased labor costs as a primary obstacle to converting to dry manure management systems, suggesting that these systems are less feasible to incentivize because of this. Both reports suggest a preference for retrofitting of liquid handling infrastructure over dry manure handling systems *in part because dry manure handling systems require more labor.*[47]

Dairies have received considerable public funding for the purchase of infrastructure and equipment

[41] Meyer et. al., 2011
[42] Sustainable Conservation Report, p. 8
[43] Agricultural Workgroup Report, p. 12
[44] Draft Strategy, p. 11
[45] Sustainable Conservation Report, p. 9; Agricultural Workgroup Report, p. 10
[46] Agricultural Workgroup Report, p. 2
[47] See the Agricultural Workgroup Report, pp. 13-14; and Sustainable Conservation Report, pgs. 51, 53, and 54.

designed to reduce the negative impacts of liquid waste handling systems. A bias toward supporting handling systems with high equipment costs but low farm-level labor requirements could be considered at odds with the *Draft Strategy's* own objective to "[support] jobs and economic growth" in the most disadvantaged parts of the state, particularly the Central Valley.[48] While the *Draft Strategy* suggests that an infrastructure-focused investment approach would create many temporary construction jobs and some permanent employment opportunities, it is unclear whether these jobs would accrue in the agricultural communities where they are needed most.

This is a crucial consideration, as California counties with concentrations of large dairies also have relatively high unemployment levels. The county with the highest number of cows in confined dairy operations is Tulare County. As of August 2015, Tulare also has a 10.9 percent unemployment rate—the second-highest in California. Other counties with high concentrations of dairy cows include Merced County (9.5 percent unemployment) and Stanislaus County (8.4 percent). These stand in contrast to the statewide average unadjusted unemployment rate of 6.1 percent.[49]

CARB seeks to ensure that public funds are used in a way that best improves the economic welfare of our most disadvantaged communities. One of the best ways to achieve this laudable goal is to provide employment. The comparatively high labor requirements of dry manure management systems should not be seen as an obstacle; rather, providing greater permanent employment opportunities in agricultural communities should be considered a clear co-benefit.

Recommendation #4. Develop dry manure management incentives that result in economical methane reductions, job creation, and provide other co-benefits such as compost production.

E. Pasture-Based Dairying Practices: Create opportunities for 'mixed' dairy systems

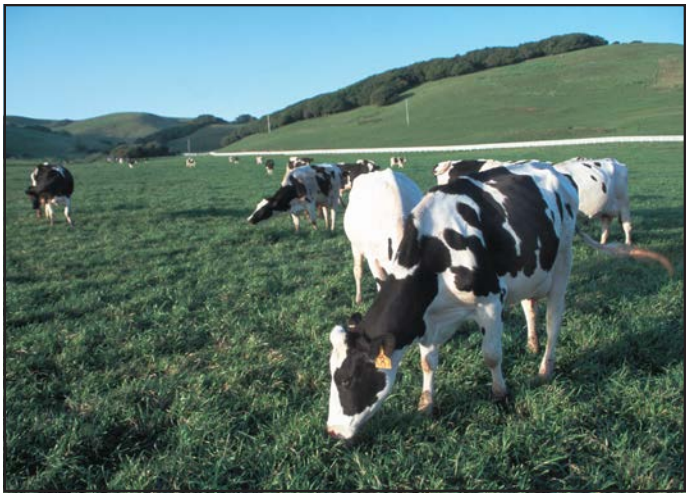
Numerous successful pasture-based dairy practices can provide an alternative and a complement to flush-based, confined animal dairy systems. In well-managed pasture systems, cow manure decomposes aerobically along with plant material, reducing the amount of methane generated. The carbon from these materials is sequestered in the soil. Increased soil carbon not only results in lower net GHG emissions from the farming system but also results in healthier, more productive soil.[50] There is potential for the state to incentivize greater pasturing of dairy cows across the industry, and even within some large confinement operations, in ways that reduce manure-related methane emissions and maximize co-benefits.

A study conducted in Pennsylvania confirmed benefits of managed pasture dairy systems compared to confined dairy systems. Total emissions of methane, nitrous oxide and carbon dioxide were about 10 percent lower in the pasture system. Ammonia emissions were also lower because manure from pasture systems did not need to be stored and handled before it was used as fertilizer. Fields that had previously grown cattle feed were converted to perennial grasslands for grazing, with carbon sequestration levels climbing from zero to as high as 3,400 pounds of CO_2e per acre per year.[51]

Although pasture-based management, including managed grazing, may not be appropriate for all dairies to employ, some confinement dairies—even in the Central Valley—could apply practices that

[48] Draft Strategy, p. 4
[49] Data from California Employment Development Department, Report 400C, Monthly Labor Force Data for Counties: Revised Report for August 2015, issued Oct. 16, 2015.
[50] See, e.g., O'Brien, D., J.L. Capper, P.C. Garnsworthy, C. Grainger, and L. Shalloo. 2014. A case study of the carbon footprint of milk from high-performing confinement and grass-based dairy farms. Journal of Dairy Science, 97:1835–1851.
[51] Perry, A. May-June 2011. Putting dairy cows out to pasture: An environmental plus. USDA-ARS Agricultural Research Magazine

lessen the need for manure storage while improving soil and ecosystem health. California should invest in demonstration projects that explore the possibilities for broader adoption of these practices across a more diverse spectrum of the state's dairies. Demonstration projects that bring together dairy producers, researchers and technical experts on pasture operations could lead to more 'mixed systems' dairies that combine a grazing and industrial production system, and which—according to a group of experts in the field—present "much opportunity for the dairy industry to explore."[52]



As with confinement systems, pasture-based dairy systems require training and attention to the proper handling of animal manure and other dairy waste in order to decrease methane emissions from the operation. These dairy systems rely on rotational grazing; carefully managed rotations can achieve relatively rapid breakdown of manure in soil, maximize soil carbon sequestration, and encourage the uptake of nutrients in vegetation. In these systems, carbon is bound to the soil and taken up by vegetation to feed the cattle, rather than being incorporated into methane.[53] Even with 10 to 20% of manure deposited in anaerobic lagoons, organic dairies—which require a pasturing component—could still generate less methane per kg milk, and less methane over a cow's lifetime, than intensive industrial dairy operations.[54] Although pasturing is a required component of organic milk production, conventional operations can also reap benefits from managed grazing practices in the form of improved animal health and nutrition, higher-quality products, healthier soils, and multiple environmental benefits.[55]

Well-designed demonstration projects can challenge perceptions that pasture-based practices are not feasible because of land constraints and other issues. The idea that grazing practices require "significantly more" land overall[56] has been challenged in some cases. For instance, one study found organic dairy farms to require significantly less prime cropland per cow as compared to conventional confined operations that fed cows large quantities of corn and soybeans, with an average per-cow land requirement of 3.8 acres on an organic operation compared to 4.9 acres on high-production conventional farms.[57]

Of course, the feasibility of any methane reduction strategy will depend upon the specific circumstances of the dairy operation as well as regional constraints, such as local regulations, land types, and the amount of time animals can spend outdoors in a given area or climate. But innovative land management strategies, supported through demonstration projects, could explore the relative trade-offs and benefits that come from varying levels of cow pasturing in 'mixed system' dairy operations.

Demonstration projects could also show economically desirable ways for some confinement operations to become more 'mixed'. The incorporation of rotational grazing and pasture-based practices into an existing operation need not be perceived as a threat to a dairy's profit margin.

[52] Von Keyserlingk, M.A.G., N.P. Martin, E. Kebreab, K.F. Knowlton, R.J. Grant, M. Stephenson, C.J. Sniffen, J.P. Harner III, A.D. Wright, and S.I. Smith. 2013. Invited review: Sustainability of the US dairy industry. Journal of Dairy Science, 96(9), 5405-5425

[53] See, e.g., Machmuller, M.B. et al., April 30, 2015. Emerging land use practices rapidly increase soil organic matter. Nature Communications Art. No. 6995

[54] Benbrook et al., 2010, p. 30

[55] For a compilation of relevant research, see the Grassworks Fact Sheets at http://grassworks.org/?110180

[56] Draft Strategy, p. 44

[57] Benbrook et al., 2010, pgs. 5 and 24

On the contrary, grazing systems can be competitive economically[58] and there are already strong markets in California for dairy products that come from pasture-based systems, including organic dairies. Indeed, in 2014, USDA's Market News reported concern that organic dairy supplies were tightening. California became the top organic dairy state in 2008 with the largest number of certified organic milk cows. In 2010, USDA published new rules on pasture requirements for organic milk certification—including the requirement that cows must graze on pasture at least 120 days per year and organic producers must have a plan to manage the pasture as a crop and protect soil and water quality. Demand for organic milk has remained high.[59]

Recommendation #5. Develop demonstration projects for pasture-based dairy practices, bringing together interested dairy operators, technical providers (e.g., USDA NRCS, RCDs, etc.) and university researchers (e.g., UC Davis and Chico State dairy programs, etc.) to create opportunities for 'mixed' dairy systems that incorporate aspects of pasture grazing into their operations.

F. Enteric Fermentation: The other piece of the pie chart

According to CARB's 2013 GHG Inventory, livestock enteric fermentation accounts for 29 percent of methane emissions in the state.[60] The *Draft Strategy* proposes to extend the national dairy industry's own voluntary goal for reducing these emissions, which would amount to a 25 percent reduction by 2030 based on current levels.[61]

As the state supports research into enteric strategies, these studies should take a full life-cycle analysis of potential supplements and feeding practices to ensure that these strategies do not harm the health of cows, produce environmental harms or threaten public health.

Studies should be designed to produce relevant results for diverse operation types, including biologically-based and organic systems. The potential benefits of soil health on feed quality, livestock methanogen production, net GHG emissions, and milk and meat quality should be considered, in conjunction with CDFA's Healthy Soils Initiative.

One dietary supplement for reducing enteric fermentation currently under study is particularly appropriate for California—the use of grape marc or pomace as feed supplement for both dairy cows and beef cows. Feeding studies have shown that inclusion in the cow's diet of grape pomace—the skins, seeds, stalks and stems that remain after grapes have been pressed to make wine—can significantly reduce enteric methane production.[62] For California's wineries, this byproduct of winemaking is usually sold for further processing or composted. The use of wine industry pomace by the dairy industry as a feeding supplement to reduce enteric methane emissions could be a positive development for both agricultural sectors.

Another line of research to reduce enteric methane production focuses on whole diet manipulation to devise feeding regimes that decrease methane production. Researchers are examining more complex diets as a means of reducing enteric fermentation.[63] Well-managed grazing systems with a diversity of plant types could be an ideal system for providing this more diverse diet. Grazing

[58] Von Keyserlingk, et al., 2013
[59] Green, C. and W. McBride. Q1 2015. Consumer Demand for Organic Milk Continues to Expand – Can the U.S. Dairy Sector Catch Up? Choices.
[60] California Air Resources Board, Current GHG inventory (2013).
[61] Draft Strategy, p. ES-8
[62] Moate., P.J. Aug. 2014. Grape marc reduced methane emissions when fed to dairy cows. 97 Journal of Dairy Science 573-87
[63] Knoell, A.L. et al., 2015. Effect of Diet on the Rumen Microbial Community Composition of Growing Cattle and the Role It Plays in Methane Emissions. Nebraska Beef Cattle Reports: Paper No. 86

regimes can ensure that the cows graze on a diversity of plants while also allowing for decomposition of manure in ways that maximize carbon sequestration. Future research should be designed to determine how these systems can provide a more diverse diet with additional nutrients and forages that are easier for cattle to digest and improve livestock health while reducing methanogens.

Recommendation #6: Support research and demonstration on strategies that reduce emissions from enteric fermentation. Include strategies that are relevant for organic and pasture-based systems because they maximize environmental co-benefits.

Conclusion

With the implementation of its Short-Lived Climate Pollutant Strategy, the State of California has an opportunity to support a vibrant, diverse, and resilient dairy industry that can tackle the challenges of the 21st century.

Setting ambitious and comprehensive methane reduction goals is just the beginning; it also matters how we get there. There will be no one-size-fits-all solution. Rather, locally-relevant strategies that maximize economic, environmental, and community co-benefits will likely prove to be the most successful over the coming decades.

Technological fixes are often the most appealing strategy. They often do not require changes to the underlying system that creates the need for them in the first place. However, in the case of anaerobic digesters operated by dairy producers, the state runs the risk of expensive public investment that may not deliver the kind of reductions desired. Such a strategy may further exacerbate economic strain on an already financially volatile industry.

Instead of creating risks and liabilities for dairy operators, successful SLCP strategies will generate new opportunities, encourage transformation, and foster innovation. We must not shy away from alternative approaches that meet the needs of individual producers—whether considering a dry manure strategy, improved composting facilities, developing a pasture system for replacement heifers, or a co-digester run on manure and other feedstocks. Operations of all types and scales should feel empowered, not constrained, by a collective mission to slash the concentrations of harmful climate forcers in our atmosphere.

Above all, dairies should see the state as a vital partner in these efforts. Such efforts will require the state to consider how incentives create long-lasting changes that meet a diversity of goals. Highlighting co-benefits in policy documents is one thing; actualizing state incentives to achieve co-benefits is quite another. It is challenging. But we have the right mix of state agencies, industry leaders, advocates and researchers to work creatively together to make the SLCP Strategy achieve multiple benefits for our communities.

The list of issues facing California dairies is long and complex. A diverse and flexible SLCP roadmap can have the additional benefit of bringing long-term sustainability to the state's dairy farms, while bolstering the status of California as a national dairy leader. ■