Methane Reduction Strategies on California Dairies

Introduction

California's dairy industry is very diverse, with farm scales, management systems, landscapes, business structures, and regulatory requirements that vary significantly from region to region. As such, no one strategy for reducing methane emissions associated with manure waste will work for all dairies. CARB's 2015 draft Short-Lived Climate Pollutant Reduction 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."

To illustrate some of the alternative manure management strategies currently in use, the California Climate and Agriculture Network (CalCAN) compiled a series of case studies profiling dairy producers who employ a range of manure management techniques for which there is evidence of reduced methane emissions.

The case studies illustrate various methods for shifting away from flushing manure into stagnant lagoons to one or a combination of the following alternative manure management systems:

- Flush to dry manure management (e.g. scrape or vacuum)
- Flush system with advanced solid separation (e.g. centrifuge or screw press) and composting
- Flush system or scrape system to a pasture-based system
- Compost pack barns

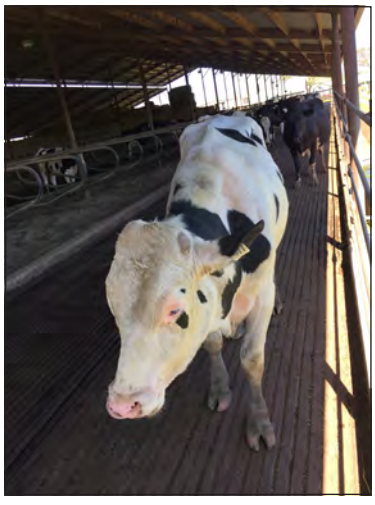
Though each of these case studies is unique and tailored to the opportunities and constraints of each operation, there are some similarities. All of the producers are striving to minimize not only methane emissions but also ammonia and odor. They all integrate some pasturing of cows in their system—to varying degrees depending on their available pasture area and weather conditions—which reduces the amount of manure they must manage near the barns and distributes it across the landscape under aerobic conditions. They are all continuously seeking improvements to their systems. And importantly, the initial capital costs of management practices they use are estimated to be considerably cheaper at a range of approximately $85 to $910 per cow than the installation of anaerobic digesters, which can range from $1,350 to $3,400 per cow.

It is critical, as decisions are made about which manure management practices the State of California will incentivize, that dairy producers are recognized as vital partners and resources in these efforts, and that consideration is given to what climate solutions are feasible, affordable and offer multiple economic, agronomic and environmental benefits. The producers profiled here are among the best examples of valuable and engaged partners.

CalCAN
California Climate & Agriculture Network

www.calclimateag.org

April 2017



Methane Reduction Strategies on California Dairies

Bucher Dairy, Sonoma County

Description of Operation:

Bucher Farms is an organic dairy farm with 600 milking cows near Healdsburg. The farm also consists of 100 dry cows, 700 replacement heifers, and a 40-acre vineyard. The animals graze on over 2,000 acres of land on various ranches. The milk cows have grazing access to 450 acres near the milking and feed barns. Organic dairy rules require that the cows spend a minimum of 120 days per year on pasture; the remaining time, when the ground is too wet or the forage is gone, the cows are under cover in barns or in dry lots near the barns.

Manure Management Approach:

The dairy makes use of a flush system and a series of ponds located on hills above the dairy barns. Water is gravity-fed from the ponds to flush the stalls while the cows are moved out twice daily for milking. The slurry flushes into a concrete tank where it is agitated. It is then pumped under pressure through a screen and a screw auger separator that removes most of the solid material and sends the liquids into another holding pond. That water is pumped back up to the highest pond to recirculate back through the system or is used to irrigate pastures. The solids are dried and composted on site, sometimes mixed with spent bedding, straw or woody material, and sold offsite. In an average year, more than one million pounds of manure is converted to compost.

Benefits to Producer:

- Compost production turns manure into valuable economic product
- Gravity-fed water recirculation system takes advantage of the hilly topography, minimizes water demand and keeps the farm in compliance with water quality regulations
- Minimal land area required for relatively small ponds, an advantage in a county where land costs are significant and land near dairy barns needed for grazing organic milking cows

Challenges, Barriers, and Desired Improvements:

- Equipment is costly (compost turners, spreaders, loaders, dump trucks)
- Ponds produce ammonia which causes odor problems at some times of year and corrosion of metal
- Aeration of ponds could help achieve aerobic conditions that may enhance metabolism of organic material and minimize ammonia off-gassing, but equipment is costly
- Hilly landscape and creek flowing through the property limit the land that can be used for larger ponds or larger compost piles
- Addition of offsite organic material could enhance composting process, but there are sometimes logistical and cost barriers to accessing it

Cost Estimate for System = $250 per cow

$150,000 for equipment (pumps, separator, agitator). Cost of pond construction would be additional and would vary site to site. Bucher Dairy installed their auger ten years ago and it has required little maintenance.

Screw auger separation of liquid and solids

"Composting my manure turns a liability into an asset as soon it leaves my farm and the trucker drops off a check in the office on his way out."

— John Bucher

CalCAN
California Climate & Agriculture Network

www.calclimateag.org

April 2017

Methane Reduction Strategies on California Dairies

Pete Verburg & Sons Dairy, Stanislaus County

Description of Operation:

The Verburgs have been operating their dairy for 54 years, and milk about 700 head of cows twice daily. They produce oats and corn on about 216 acres. They have been using their current manure management system for about 20 years.

Manure Management Approach:

Each lane is flushed during milking. The flush water is gravity-fed to a receiving pit where it travels through two solids separators made of stainless steel mesh that are organized in series. Most solid separator systems use only one; this system removes a larger amount of solids, close to 50 percent. A revolving paddle on the surface of the pit removes the solids trapped behind each screen and dumps them onto a nearby concrete slab. During summer, the solids are moved to windrows to compost, which is turned about every five days. The composted manure is usually used as bedding in free stalls or is sometimes applied to fields.

The wastewater is pumped through a series of three large lagoons below the separators, which facilitates the breakdown of remaining organic matter. In spring, the lagoons bloom with phototrophic purple sulfur bacteria that are responsible for much of the digestion. The water in the last lagoon is used for irrigating crops, applying to compost windrows to maintain the optimal moisture level, and for flushing lanes in the barn.

Benefits to Producer:

- Use of three large lagoons (three times more storage than required) improves water quality, reduces clogging of valves in irrigation system, and prevents excess nutrient loads on fields
- Using two separators removes more solids, which maximizes amount of compost produced and minimizes nutrient load in lagoons
- Final wastewater product is pathogen-free, safer for recycling in barn and on fields; creates healthier environment for animals and workers
- Use of composted manure reduces bacteria and pathogens in bedding; fly populations are low

Challenges, Barriers, and Desired Improvements:

- P• Need sufficient land for the larger lagoon area, a slab for solids piles, and for compost windrows
- Have to manage the windrows to assure optimal compost conditions (e.g., moisture, temperature, oxygen) make high quality compost

Cost Estimate for System = $570 per cow

$200,000 for concrete pits and two separators; cost of lagoon construction and plumbing and electrical will vary widely but the total project could cost $400,000

"With this system, I get peace of mind and don't have to worry about emergencies, like my pond overflowing or the technology breaking down. I don't know why more people don't do something like this."

— Pete Verburg

CalCAN
California Climate & Agriculture Network

www.calclimateag.org

April 2017

Methane Reduction Strategies on California Dairies

Prins Dairy, Stanislaus County

Description of Operation:

Prins Dairy, operating since 1971, is a 600-cow operation using a combination of grazing and free stall housing. They have 185 acres of grazed pasture and another 185 acres planted in corn and wheat for silage.

Manure Management Approach:

The dairy has been using its current manure management system since 1999, refining it and improving it continually. Manure is flushed from free stall barns using recycled water through a fine screen separator. The solids are composted and the liquid is moved into ponds. The ponds are inverted 24 hours a day by vortex circulation with Circul8 Systems™ that exposes naturally occurring photosynthetic purple sulfur bacteria to sunlight so they can digest the organic material in a three-pond system. The ponds are more diluted compared to typical stagnant lagoons to ensure the best translucent habitat possible for the beneficial bacteria. A USDA study of microorganisms in the Prins lagoon water found no Archaea (the only microorganisms that produce methane).

Benefits to Producer:

- Fertilizer to improve soil health is produced in two forms: compost from the separated solids, and plant-available fertigation water that is biologically alive and nutrient-rich (anaerobic systems lose most of their nitrogen as ammonia and sulfur as hydrogen sulfide)
- Improved crop yields without need for commercial fertilizer
- Lower levels of odor and VOC, H2S, and NH3 emissions from ponds
- Less rusting within facility due to significant reduction of corrosive gas
- Better hoof health and cow health because disease-causing pathogens do not survive in a properly circulated ponds; eliminates need for copper sulfate foot baths which is toxic to lagoons, soil, plants and animals
- Eliminates stagnant water in lagoons that can create mosquito habitat
- Flush alleys are not slick, and are safer for cows and workers

Challenges, Barriers, and Desired Improvements:

- This system works best under a high rate of dilution which requires more fresh water and greater pond capacity than conventional stagnant lagoons
- Requires land for compost production and nearby cropland to apply irrigated fertigation liquids
- Some electrical energy will be required, though it is very low

Cost Estimate for System = $625 per cow

For an 800-cow dairy, the estimated cost of installing the circulators is $200,000. The lagoon size would likely need to be increased at a cost of $250,000, and the current lagoon system clean-out would cost $50,000. Kevin, as an experienced user, estimates his costs are 1/10 to 1/4 that of a digester with easier maintenance.

Aeration of manure lagoons with Circul8 Systems

Ponds populated with purple sulfur bacteria

"This is really a simple system that is all about working with nature and not against it. Nature will win!"

— Kevin Prins

CalCAN
California Climate & Agriculture Network

www.calclimateag.org

April 2017

Methane Reduction Strategies on California Dairies

Gillian's Dairy, Sonoma County

Description of Operation:

Gillian's Dairy has been operating for 20 years and has always been pasture-based, achieving organic certification in 2006. They now have a herd of 220 head on 280 acres at the dairy, and they rent another 700 acres nearby for hay, sheep and young dairy stock.

Manure Management Approach:

Like many on the North Coast, the dairy was located many years ago near a creek. When the Mahrts started their operation, all of the manure ran into one pond that had insufficient capacity for an all-liquid system and would have caused water quality issues. Instead, they started composting the manure inside the cow barns during the winter when the cows were not on pasture, a system called "compost pack barns," more common on midwestern dairies. Research in the Netherlands suggests that this approach may lower methane emissions (see: http://dx.doi.org/10.18174/393409).

In the fall, the barn is prepared by laying down one to two feet of rice hulls or sawdust. With a rototiller, the bedding is turned daily and sawdust or rice hulls are added as needed (once or twice weekly) to maintain an aerobic environment and to provide a carbon source. In spring when the cows are on pasture fulltime, the composting manure is emptied and left for another year, and it is then spread on pastures and hay fields.

Benefits to Producer:

- Composting in the barns keeps the compost covered and dry and prevents it from becoming anaerobic and hard to manage
- Compost serves as a valuable soil amendment for hay crop and pastures (it contains more nitrogen than waste from a manure lagoon)
- Keeps the dairy in compliance with water quality regulations; minimal ammonia emissions
- Bedding material under cows improves hoof and leg health and may lead to longer-lived stock

Challenges, Barriers, and Desired Improvements:

- Turning the piles daily is labor-intensive; during wet winters, more management is needed since cows are indoors more of the time
- Rice hulls as bedding, though inexpensive, contain a lot of silica and take time to break down; finding an affordable alternative is challenging
- Would like to retrofit barn with a forced air system that vacuums air from underneath the bedding. This would mean less labor and fuel to turn the piles, and he could install a moisture trap and air quality monitoring equipment to manage the system

Cost Estimate for System = $910 per cow

The forced air retrofit would cost approximately $100,000. To build a new barn with air circulation would cost about $200,000.

Garry aerating composting manure after animals have been moved out to pasture

Bedding and composting manure is 1-2 feet deep

"When talking about liquid slurry systems, my dad used to say 'You take one gallon of manure, add nine gallons of water, and you get 10 gallons of shit.'"

— Garry Mahrt

CalCAN
California Climate & Agriculture Network

www.calclimateag.org

April 2017

Methane Reduction Strategies on California Dairies

Bordessa Family Farms, Sonoma County

Description of Operation:

Bordessa Family Farms owns and operates two organic dairy farms with a total of 700 milking cows in western Sonoma County. The farm has about 1,000 acres of pasture and rents an additional 1,300 acres nearby. Jarrid is a fifth generation California dairy farmer.

Manure Management Approach:

Approximately 10 years ago, the dairy installed three cement pits to receive manure flushed from the milking barns with recycled water. The slurried manure is held in one of the three pits until it full, which is enough to hold the manure accumulated during milking and in the one or two months each winter when the cows cannot be pastured due to rain. At the end of each pit is a "weeping wall," a screen of wooden slats through which solids are separated as the water moves through the screen, pressurized by gravity. As more solids collect, greater filtration occurs since the solids themselves act as a filter. The liquid is recycled either back through the barn for flushing or is used to fertigate pasture. The solids are dried, composted and used on pasture to enhance soil health and add fertility. Spent bedding is mixed with into the compost piles, and sometimes purchased chicken manure for additional nitrogen.

Benefits to Producer:

- Labor costs for spreading the dry manure are lower than for liquid manure because it spreads more easily, they can move larger loads, and there is no odor like there is when spreading liquid manure
- Compost makes excellent fertilizer and produces better forage
- Minimal odor in the pits once the solids and liquids are separated and the solids are dried

Challenges, Barriers, and Desired Improvements:

- Ponds produce ammonia which causes odor problems at some times of year and corrosion of metal
- Interested in experimenting with a relatively simple and expensive technology used in the manure pits called a SludgehammerTM, a submerged air diffuser with a dimpled surface that encourages the growth and dispersion of beneficial bacteria to digest the organic material that can cause odors and emissions of ammonia, methane and other harmful volatile organic compounds
- Interested in addition of humic acids to compost piles to improve compost quality

Cost Estimate for System = $86 per cow

Ten years ago, the farm spent approximately $50,000 for the cement pits and $10,000 for the flush pump system. Very little maintenance has been required since.

Weeping wall solid separator

Gravity-fed channels from barn to three flush pits

"It seems to me that having cows on pasture as much as possible is better for the environment since they are spreading their own manure and fertilizing the soil rather than piling it up in one place."

— Jarrid Bordessa

CalCAN
California Climate & Agriculture Network

www.calclimateag.org

April 2017

Methane Reduction Strategies on California Dairies

Lafranchi Dairy, Marin County

Description of Operation:

The Lafranchi Dairy is a family dairy in the Nicasio Valley, Marin County. The Lafranchi's have been ranching on the land since the early 1900's. They own 1,500 acres, 900 of which are certified organic, including the dairy and loafing barns. During wet season 400+ cows are kept in the loafing barn up to 24 hours a day. In spring and summer they are let out to pasture and spend 4-5 hours a day in the milking barn. The dairy houses West Marin Compost (WMC) a public-private operation that leases land from the dairy. WMC was established in 2011 to produce a high-quality compost, help manage the nutrient load from the dairy, and to serve West Marin County's need to manage equestrian and green waste streams. Compost produced is used by the dairy for pasture and range application, as bedding for the cows and sold to the regional community for landscaping and agricultural purposes. WMC recently provided all the compost used for USDA-NRCS field trials to evaluate the impact of compost application on grazed grasslands across California.

Manure Management Approach:

Between 12,000 and 13,500 gallons of manure is produced each day and managed by a water flush system. Combined water used for flushing the barns with manure-heavy effluent is sent to one of two static picket dam separators, where the water drains by gravity to the dairy lagoon. The remaining manure solids are moved from the separator to an 80x80 cement pad where they are mixed with green waste and equestrian manure. This mixture is then moved to windrows on the compost pad. Water from the lagoon is used for initial moistening of the windrows as needed, reducing water volume in the pond and allowing the nutrients in the water to be incorporated into the compost and stabilized through the thermophilic composting process.

Proposed Manure Management Strategy

Once manure has been combined with water in the flush system, it is difficult to fully separate the solids, and the water produced after separation is nutrient-rich. The Lafranchi dairy and West Marin Compost would like to switch to a dry scape system. This would require infrastructure changes in the loafing and milking barns, and a new pump to send the manure to the picket separators. This would significantly reduce the volume of water and solids in the lagoon and hence the quantity of methane produced. Changing the system to a dry scape operation would have multiple benefits including:

- Reduction of methane derived from storing anaerobic liquid manure in an open pond
- Overall reduction of volume of water in the pond by an estimated 70-80%
- Nutrient management benefits
- Facilitation of compost production

Co-Benefits:

The current lagoon is permitted under the existing Dairy General Order. However, it does not currently comply with the permeability requirements in the Water Board General Order for Composting Operations. Switching to a dry scape system and using the existing static picket separator and cement pad would further reduce overall water in the pond and decrease the nutrient load in the water.

Cost Estimate for System = $1,250 - $1,875 per cow

Switching to a dry scape system, integrated with the compost operation, is estimated to cost $500,000 - $750,000.

written by Calla Rose Ostrander, California Carbon Project