Dairy Shed Effluent and Biogas – Frequently Asked Questions

Background:

The continued rise in power costs and roll out of the Carbon Farming Initiative have been two of the main drivers behind a jump in interest in generating renewable energy from methane in biogas. Given the global concern about greenhouse gas emissions, it would seem that projects that capture and use biogas are a win-win opportunity. However, there are a number of issues that you should consider before committing your time and energy to investigating a biogas project for your farm.

The most frequently asked questions about capturing and using biogas have been collated below. When considering the answers, please bear in mind that this is an immature industry with a need for more research and development; what is not feasible now may become so in the future so watch this space. Also be aware that it is difficult to answer questions generalising about the economic feasibility of biogas projects. Many of the factors that impact the payback period are site specific so infrastructure costs and returns may not be accurate without investing a significant amount of time and money in planning.

Scenario Descriptions

To help with a discussion of the issues, three scenario's will be considered; a medium to large sized grazing based dairy farm, a large dairy with 'hybrid' feeding system where a significant portion of the diet is fed on a feedpad, and a larger intensive dairy farm where cows are housed and most of the manure is collected.

The 400 cow grazing herd is larger than average but reasonably common within the industry; most of the cow's intake is from grazed pasture so typically only 10% to 15% of the manure excreted by the cow lands on the concrete around the dairy to be washed into the effluent system.

The 700 cow herd with 'hybrid' feeding system receives supplementary feed on a (washed) feedpad. The time on concrete varies with season but can be 8 to 12 hours per day over the hotter third of the year and the proportion collected has been set at 25% as an annual average for this scenario.

The 1000 cow 'TMR' herd is fed a total mixed ration in a freestall shed. Most of the manure is excreted onto a surface flushed into the effluent system so it is reasonable to expect 85% of the manure is collected. Note that 6 to 8 times more 'feedstock' is available to produce methane than for a grazing herd of the same size.

FAQ'S:

1. Can I produce bioenergy from my effluent ponds?

Yes - methane is a fuel and when burnt it can produce heat, or electricity, or both. Methane is the main constituent in reticulated natural gas and is present at concentrations in biogas making it suitable for use as an energy source.

The production of methane is a natural process that begins in the gut of the cow and continues in the effluent pond. Micro-organisms decompose the organic portion of manure generating bubbles of 'biogas' that can usually be seen rising to the top of the first pond (where most of the solids settle). Biogas is typically 60 to 65% methane, the remainder being mostly carbon dioxide. As biogas also contains trace amounts of hydrogen sulphide (which gives it a distinctive 'rotten egg' smell) and other odour-causing compounds, capturing and burning biogas also reduces odour emissions.

2. What infrastructure would I need to capture and use methane?

Methane can be captured from an effluent pond by covering it with a gas-tight cover. The edges of the cover are usually trenched into the embankment to secure it and seal against gas loss and air entry. The cover needs to be designed and installed such that rainwater does not pool uncontrolled on top and sink it. Water-filled weight pipes positioned on the cover can be used to channel stormwater to a suitable collection and pump-off point. Emergency gas vents may be needed to release biogas if it is not being extracted and used fast enough.

With the biogas captured, it can then be supplied to a biogas-rated device where it's combusted to produce heat (using a water heater or boiler) or electricity (engine and generator) usually with some additional heat recovery. Alternatively, as methane is a potent greenhouse gas, it may simply be burnt in a flare where it is turned into carbon dioxide. As this carbon dioxide is considered to be 'biogenic' or part of the short-term carbon cycle, it does not count as a greenhouse gas emission.

While it is possible to burn methane in a solar powered, self-sparking flare using only the pressure of the gas building up under the cover, it is more common that an extraction 'blower' or compressor is used to supply the gas device. Be aware that biogas contains impurities such as hydrogen sulphide which can lead to the formation of sulphuric acid and rapidly corrode metal and concrete components. Devices using biogas must therefore be rated for the task or alternatively, the biogas must be 'cleaned' using gas scrubbers. Heat exchangers using copper alloys are particularly susceptible to corrosion. The choice of gas device is complex and any equipment used must conform to gas safety regulations which currently vary from state to state.

Also remember that you would need to check if any other changes to your effluent system are required. For example, it is likely that effluent from a feedpad will introduce waste feed which would float to the surface and form a mat under the cover unless separated from the effluent before entering the pond using some form of mechanical separation.

3. What about the tank type digesters I see in photos from Europe and North America?

Covered anaerobic ponds are a suitable option for capturing biogas on dairy farms in Australia. They are low-tech, robust, and suited to the dilute effluent streams produced by most Australian dairies. However, complete-mix stirred tank reactors or plug-flow digesters are more commonly used in the northern hemisphere where their different approaches to managing manure produce an effluent stream with a higher solids concentration. In a cold climate, the digester usually needs to be heated which is only feasible where the digestible organic material is concentrated in a smaller volume of water. While it is feasible to pre-treat our relatively dilute effluent streams to produce a feed stock with a higher solids concentration suitable for these more efficient engineered digesters, they are more complex and costly systems.

4. So can I cover an existing pond?

Yes, it is possible to cover an existing pond - provided that:

- It has a volume that allows a 'hydraulic residence time' of between 30 and 60 days,
- Surface crusting is not significant (waste feed or bedding usually forms a floating mat underneath the cover that can block gas collection pipes and emergency vents) or floatable material can be separated and removed, and
- There is some means of desludging the pond before the settled solids reduce the hydraulic residence time to less than 30 days.

The pond should be structurally sound and, if a fixed cover is being considered, have an embankment wide enough to accommodate the fixing trench. If a new pond is being planned, be aware that significant savings can be made in cover costs if the loading rate and pond depth are selected to minimise the surface area.

5. What's a digester system going to cost?

The establishment costs for biogas projects are site-specific; for example the area of the pond to be covered, distance from the pond to the point of biogas use, the type of gas device, and distance to grid and connection requirements all vary from site to site. Unfortunately, as the technology is relatively immature in Australia, there are relatively few 'local' case studies available to inform us about the expected range of establishment costs.

Data from the US EPA's AgSTAR project suggests that the capital costs for covered anaerobic pond systems range from$680 per cow for 2000 head, up to $1570 per cow for 500 head (data in 2009 US dollars based on eight covered pond projects including pond earthworks, engine-generator, design and installation). Note that this comparison is only valid for systems where cows are housed; such systems will have capacities 6 to 8 times larger than for the same sized grazing based herd.

The only dairy project commissioned to date in Australia took place at DemoDAIRY, Terang – a 350 cow grazing operation. Establishment costs were approximately $105,000 in 2009 for cover, flare, plumbing, electrical, and monitoring equipment. Note that this was a research project (higher monitoring equipment costs) and the biogas was burnt in a flare and not used by any other means. The cover was approximately $35,000 or $23/m2.

A NIWA trial at Huntly in New Zealand has established a covered anaerobic pond for a 480 cow herd for approximately NZ$40,000 including cover, flare, plumbing and flow meter. There was a significant labour contribution provided by the proponents that was not costed. These two examples suggest that the establishment costs to cover and flare range from $85-300/cow - but remember that range is for grazing systems where only 10% of the manure is collected.

6. Will the Carbon Farming Initiative provide any incentive?

The Carbon Farming Initiative gives farmers the opportunity to generate extra income from activities that reduce greenhouse gas emissions. The destruction of biogas generated by animal manure via a flare is an activity that is eligible under the CFI and a methodology has already been approved for use by the pig industry. A dairy specific methodology is expected to be in place from 2013.

The methodology is used to estimate baseline emissions that would occur without the pond being covered; that estimate sets the upper limit to how much abatement can be claimed. Using the biogas to produce electricity and/or heat does not make the project ineligible because they result in the methane being destroyed.

Be aware that there are stringent measures in place to ensure that any benefit claimed is genuine and meeting international standards. For these requirements, and for further information, please refer to the CFI Handbook and the proposed dairy methodology in the links to further information.

7. So how much benefit could I expect?

The monetary benefit resulting from the project will vary depending upon how the biogas is used. In order of increasing capital cost, the strategies for utilising biogas on a dairy farm are:

i. Capture and flare the biogas to reduce emissions and claim carbon credits under the Carbon Farming Initiative

ii. Use the biogas to fuel a water heater to offset the energy otherwise required to produce hot water, and flare any excess biogas

iii. Run a combined heat and power (CHP) plant to produce hot water (using heat recovery from the engine jacket and possibly exhaust gases) and electricity to directly offset on-site power consumption, flare any excess biogas

iv. CHP plant exporting any excess electricity to grid

The following table contains an analysis of the potential returns under each of these strategies. It is important to understand the underlying assumptions made and those are stated below.

Scenario:		400 cow herd, grazing	700 cow herd, hybrid	1000 cow herd, TMR
Production	L/lactation	6310	6991	7671
	L/cow.d	20.7	22.9	25.2
Dry Matter Intake[1]	kg/cow.d	18.6	19.8	21.1
Volatile Solids excreted[1]	kg/cow.d	3.8	4.0	4.3
Proportion collected	%	10	25	85
Volatile Solids to pond[2]	kg/d	135	632	3259
Estimated methane yield[3]	m^3 CH_4/d	29	136	704
	t CO_2-e/yr	127	593	3059
Flare only:				
CFI incentive[4]	$/yr	1903	8891	45886
	$/cow.yr	4.76	12.70	45.89
Hot water, flare remainder:				
Hot water electricity offset[5]	$/cow.yr	7.34	7.02	6.82
Combined benefit	$/cow.yr	12.10	19.73	52.71
Combined heat & power:				
Potential electricity yield[6]	kWh/d	83	386	1990
	kW	3	16	83
Purchased electricity offset[7]	$/cow.yr	8.18	21.84	43.99
Electrical export revenue[8]	$/cow.yr	0.00	0.00	16.12
REC value[9]	$/cow.yr	2.20	5.88	21.24
Heat recovery benefit[10]	$/cow.yr	5.03	7.02	6.82
Combined benefit	$/cow.yr	20.18	47.45	134.06

Notes:

1. Calculated using DGAS
2. After allowing 10% VS removal by screen
3. Calculated using CFI methodology – 'baseline emissions'
4. Carbon price @ $15/t CO2-e, price will vary, benefit excludes energy used to capture and combust biogas
5. Electricity cost for water heating @ $0.10/kWh off-peak, offset limited to estimated hot water requirement
6. Electrical generation efficiency @ 30%
7. On-site consumption estimated @ 44 kWh/kL, electricity cost averages @ $0.15/kWh, $0.02/kWh O&M cost
8. Export @ $0.08/kWh under Victorian standard feed-in tariff (100 kW limit), $0.02/kWh O&M cost
9. Renewable Energy Certificates valued @ $35/MWh, price will vary
10. Engine jacket heat recovery only (0.8 kWh/kWh)

The following general points can be made considering the estimated benefits and the information available on establishment costs:

- While the carbon farming initiative does provide an incentive to capture and burn methane, the payback based on the CFI alone is not currently attractive for a grazing based dairy. While deeper ponds, better volume to area ratios and dilution of infrastructure costs mean that economies of scale do apply, even adopting a low-end establishment cost of $85/cow results in a simple payback period exceeding 15 years.
- Bear in mind that this analysis has not accurately costed the compliance and audit/reporting costs that would be incurred by participating in the CFI. However, they will be significant and likely to absorb much of the incentive paid to a small to medium sized grazing based dairy.
- Biogas can be used to offset the dairy's hot water needs. More case studies are needed but using the 480 cow Huntly, NZ dairy as an example, (where a biogas rated water heater is planned for an estimated additional $12,000 over the 'flare only' scenario), the simple payback period could be reduced from 18 to 9 years.
- Most grazing based dairies do not generate enough feedstock to produce electricity at scale that is practically or economically feasible. It would be much less expensive to produce the same amount of power using solar (photovoltaic) panels.
- Increasing the 'time on concrete' means that more methane will be captured per cow. As the amount of methane captured increases, so does the number of options available for utilising it. The 1000 cow TMR herd has the potential to produce electricity at a scale that is practical and warrants a detailed cost-benefit analysis. Using US EPA AgSTAR establishment costs of $1030/cow (for 1000 housed cows) suggests a simple payback period of 8 years.
- More detailed information on establishment costs for systems suited to those dairies with hybrid feeding systems is needed before any conclusions can be made about which strategies, if any, are economically feasible.

Be aware that over the winter months, biogas production typically drops as the rate of biological activity in the pond slows. It would be unwise to commit to using a biogas device if there was any possibility of insufficient or unreliable gas supply. Farms that are seasonal producers (low numbers of cows in milk over winter) would have an additional restriction on methane production at that time. Planning a biogas use strategy will also be made more difficult for farms with a hybrid feeding system where cows spend more time on concrete over the summer months increasing the peak in biogas production.

8. Methane is potentially explosive - how do I manage that risk?

Methane is odourless and colourless and is flammable when mixed with air at 5 to 15% by volume. While methane is lighter than air and will disperse upon release, other constituents in biogas such as carbon dioxide (an asphyxiant) and hydrogen sulphide (highly toxic to humans and animals) are heavier than air and will collect in confined spaces. Any areas where biogas is handled should be well ventilated to disperse fugitive gases. Any electrical equipment within the area will need to conform to hazardous area requirements. An assessment of all safety risks will be required and site-specific risk control measures will be needed.

Biogas blower and flow meter. Photo courtesy of GWF Bears Lagoon Piggery

Covered anaerobic pond. Photo courtesy of DemoDAIRY

Covered anaerobic pond and candlestick flare. Photo courtesy of NIWA

Candlestick flare. Photo courtesy of NIWA

9. Where can I go for further information?

Dairy Australia, 2008. Effluent and Manure Management Database for the Australian Dairy Industry, Chapter 8.1 – Production and beneficial use of methane. http://www.dairyingfortomorrow.com/index.php?id=48

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Davidson, A. 2009. A Review of Australian Regulations and Standards for the Handling and Treatment of Biogas. Australian Pork Limited Report 2010/1013.333

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Olliff, R., Sheba, L., and Barber, L. 2012 Creating Energy from Effluent. RIRDC Publication No. 12-032 https://rirdc.infoservices.com.au/items/12-032

Sunraysia TAFE. Fundamentals of Commercial Biogas Production and Use short course. http://www.sunitafe.edu.au

US EPA, 2011. Common Safety practices for On-Farm Anaerobic Digestion Systems. http://www.epa.gov/agstar/documents/safety_practices.pdf

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