Energy from biogas – bright future or big headache?
Energy from biogas

- Methane from anaerobic digestion has been utilised since the late 1800’s.

- There are literally millions of small digesters in developing nations providing low cost energy for lighting and cooking.

- USA had 186 operating digesters on livestock farms (Mar 2012); 153 on dairies including 15 covered lagoons.

- In Australia; 1 complete mix digester and ~6 covered anaerobic ponds for pigs. No covered ponds on dairy farms.
Anaerobic digestion 101

- Anaerobic digestion starts in the rumen (where the easy energy is extracted), continues in the pond
- Methanogens are slow and sensitive – process can suffer upset
- Biogas is typically 60-65% CH$_4$ with most of the remainder CO$_2$
Digesters 101

Source: USEPA AgSTAR
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Which technology?

- Covered anaerobic pond digesters “appear to represent the best option for commercial on-farm biogas capture and use” in Aust. (low tech, robust, suited to dilute effluent).
- However, the best approaches to crust and sludge management have yet to be determined.
Covered anaerobic pond
How much potential energy?

• 1 kg COD produces 0.25 kg CH₄ (or 0.35 m³ at STP)
• 1 kg CH₄ contains 50 MJ energy (~14 kWhₑ)
• 1 cow excreting 5.4 kg COD/d (NZ data), 15% collected, 50% destroyed
  = 0.1 kg CH₄/cow.d
  = 1.4 kWhₑ/cow.d (NOTE only 25-30% of that is potential electrical output, or ~0.35 kWh/cow.d = 0.015 kW/cow)
• Could be 2.4 kWh/cow.d or 0.1 kW/cow under TMR/freestall scenario

• For comparison, approx. electrical energy required for:
  • Milk cooling (17 to 4°C, 20 L/d, COP 2.6) = 0.12 kWh/cow.d
  • Hot water (15 to 85°C, 2.3 L/d, COP 0.98) = 0.19 kWh/cow.d
• So energy budget looks positive, but need to consider system cost!
Typical costs (US AgSTAR program)

Figure 1. Total capital cost of complete mix, plug flow, and covered lagoon AD systems

1 Costs are stated in September 2009 dollars.
Typical costs (US AgSTAR program)

Figure 2. Capital cost per dairy cow for complete mix, plug flow, and covered lagoon AD systems

1 Costs are stated in September 2009 dollars.
Typical costs - Aust?

• Scarce Australian data; feasibility study for 2200 cow freestall dairy; approx. $800K (exc. pond earthworks and heat recovery) comprising:
  • $310K cover ($20/m²)
  • $230K genset (typically allow >$1500/kW)
  • $100K engineering
  • ~$400/cow

• Using USEPA AgSTAR cost at $700/cow for 2000 freestall cows (2.4 kWh/cow.d), a 15 year lifespan and $0.02/kWh O&M
  • $0.05/kWh produced => warrants investigation
Typical costs - Aust?

- Assuming capital cost of $220,000 for 300 cow grazing herd (0.35 kWh/cow.d), a 15 year lifespan and $0.02/kWh O&M
  - $0.40/kWh produced => very expensive power

- At the smaller scale, dairies might concentrate on thermal energy via biogas rated boilers, and adsorption chillers (pending development)
Will the CFI be a ‘game-changer’?
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- With a methane yield (from typical pond, grazing operation) of 0.1 kg CH$_4$/cow.d and carbon credit of $20/t, this is $16.80/cow.yr
- 300 cows (grazing) => $5,000/yr additional benefit
- What’s the audit and reporting costs?
Winter performance is lower

• Need to ensure sufficient gas is produced over winter months to run biogas-reliant equipment (or have backup supply)

• Seasonal loading rates may vary and exacerbate gas yield fluctuation. For e.g. feedpad use increases in summer months.
Sludge management

• Sludge will build up, even with pre-treatment (mechanical screen, trafficable solids trap etc)
• Either remove sludge or design pond to have sludge allowance exceeding life of cover
Crust management?
Other pitfalls?

- Biogas is saturated with water vapour and is corrosive = hard on equipment and instrumentation!
- Distance from site for service calls
- Removing rainwater commonly causes headaches
Can I cover an existing pond?

- Loading rate (higher loading rate = smaller surface area = lower cover cost)
- Hydraulic residence time (min 30 days)
- Depth (minimum 3.5 to 4m)
- Preventing crusting
- Options for sludge removal
Resources:

- Dairying for Tomorrow; on-farm action/tackling specific issues/effluent & nutrients/”Capturing methane for bioenergy”
- Dairying for Tomorrow; tools & guidelines/Effluent and Manure Management Database/Chapter 8.1 ”Production and beneficial use of methane”
- Edgerton 2009 “Bioenergy Commercialisation for Australia’s Dairy industry”, RIRDC Publication No 09/164
- GHD 2008 “Assessment if Methane Capture and Use from the Intensive Livestock Industry” RIRDC Publication No 08/025
- AgSTAR www.epa.gov/agstar/index.html