Methane from effluent ponds

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% CH₄ with most of the remainder CO₂

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 260 operating digesters on livestock farms (May 2015); 206 of those on dairies including 26 covered lagoons.

Digesters 101

- Source: USEPA AgSTAR

Covered anaerobic pond

- Source: USEPA AgSTAR
Which technology?

- Covered anaerobic ponds “appear to represent the best option for commercial on-farm biogas capture and use” in Aust. (low tech, robust, suited to dilute effluent).

Uptake in Australia

- Pigs: 1 engineered (complete mix) digester and 6 covered pond projects (7% Aust pork production ~ 180,000 SPU’s) 2014 data
- Dairy: 0 covered anaerobic ponds.

Rivalea, Corowa NSW – 2 sites have biogas projects

- 14ML covered anaerobic lagoon at Bungowannah.
- 6,000 sow ‘breeder only’ piggery 2012
- 42ML covered anaerobic lagoon at Corowa.
- 5,000 sow ‘farrow to finish’ piggery’ 2012
- 13,000 t/y CO2‐e mitigated – replace LPG hot water heating

Abattoir – 2.8ks from lagoon

Rivalea piggery and abattoir complex
Differences between pigs and dairy

1) Amount of Volatile Solids (VS) produced as the feedstock.

- 1 Standard Pig Unit (SPU) represents 90 kg VS/yr (an average size grower pig)
- 100 sow, farrow to finish = 1260 SPU and ~110,000 kg VS/yr.
- Typical dairy cow excretes 1200-1800 kg VS/lactation but only 10-15% collected (120-270 kg VS).
- 1 dairy cow (grazing) equivalent to 1.3 - 3 SPU.

Rivalea, Corowa NSW – 2 sites have biogas projects

A 42ML covered anaerobic lagoon at Corowa.
A 5,000 sow ‘farrow to finish’ piggery 2012
= 20,000 to 45,000 cows (grazing herd)

Rivalea, Corowa NSW – 2 sites have biogas projects

A 14ML covered anaerobic lagoon at Bungowannah.
A 6,000 sow ‘breeder only’ piggery 2012
= 4,000 to 9,000 cows (grazing herd)

Differences between pigs and dairy (cont.)

- Intensive vs. extensive
  - Typical dairy 300 cows, majority of diet directly grazed with manure excreted in paddock, remaining ~10-15% collected. Equivalent to 400 – 900 SPU.
  - Intensive dairy, 1000 cows in freestall fed total mixed ration (TMR), ~60-90% collected. Equivalent to 10,000 – 18,000 SPU.
- 1 dairy cow (intensively housed) equivalent to 10 - 18 SPU

Rivalea, Corowa NSW – 2 sites have biogas projects

A 14ML covered anaerobic lagoon at Bungowannah.
A 6,000 cow ‘breeder only’ piggery 2012
= 4,000 to 6,000 cows (grazing herd)
+ 700 to 1,200 cows (freestall)

Rivalea, Corowa NSW – 2 sites have biogas projects

A 42ML covered anaerobic lagoon at Corowa.
A 5,000 cow ‘farrow to finish’ piggery 2012
= 20,000 to 45,000 cows (grazing herd)
+ 3,500 to 6,000 cows (freestall)
Differences between pigs and dairy (cont.)

2) Degradability of excreted VS greater for pigs compared to dairy (monogastric vs. ruminant, differing diets)

- $B_o$ is maximum methane producing capacity. Default given by IPCC:
  - $B_o$ pigs = 0.46 m³/kg VS
  - $B_o$ dairy = 0.24 m³/kg VS

Relevant ERF methods

- Destruction of methane generated from dairy manure in covered anaerobic ponds
- Destruction of methane from piggeries using engineered biodigesters
- Destruction of methane generated from manure in piggeries
- Destruction of methane generated from manure in piggeries

Common elements:
- covering ponds to prevent the release of methane (or diversion to engineered digester)
- collecting the emitted methane, and
- combusting the methane to convert it to carbon dioxide and water.

Requirements of methods

- Ponds comply with industry guidelines; pond depth > 2m (pig) or VSLR > 50 g/m³ (dairy)
- Only animal manure & normal waste feed & bedding may be digested
- Frequent sparking flare or monitoring of flaring system
- Record keeping: animal no's, time on yard, diet, etc

Baseline vs. measured emissions

- Estimate baseline if project did not occur (tonnes CO₂-e)
- Tiered approach to calculating VS entering pond (DGAS, PigBal)
- Calculate net abatement: measured quantity of methane emissions avoided minus emissions from operating the project
- Cannot claim a quantity of methane destroyed higher than baseline

Data collection

- Measurement subject to quality controls. For example, measurement of quantity of methane emissions destroyed:
  - Instrument operates with an accuracy of +/- 5%
  - Field checked for accuracy within 2 months of end of reporting period
  - Re-calibrated at lesser of manufacturer’s recommended interval or every 5 years

Project costs & viability

- ERF reverse auction - min project size 2,000 t/y CO₂-e mitigated
- 400 sow farrow to finish piggery (4000 SPU) may mitigate 2,000 t/y CO₂-e
  - At present, projects are not economically feasible under about 4-5,000 t/y CO₂-e mitigated. However, this may reduce as smaller and cheaper equipment becomes available.
- 5,000 - 12,000 cow grazing herd may mitigate 4,000 t/y CO₂-e
- 800 - 1,500 cow fully intensive herd may mitigate 4,000 t/y CO₂-e
  - Under the ERF, projects are unlikely to be feasible for flaring methane only. Projects will have to generate electricity, CHP or tri-generation.
  - Energy cost rises will dictate project uptake in the future.
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 kWh-e)
- 1 cow excreting 5.4 kg COD/d (NZ data), 15% collected, 50% destroyed
  = 0.1 kg CH₄/cow.d
  = 1.4 kWh-e/cow.d (NOTE only 25-30% of that is potential electrical output, or ~0.35 kWh/cow.d)
- 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 80°C, 2.3 L/d, COP 0.98) = 0.19 kWh/cow.d
- So energy budget looks positive, but need to consider system cost!

Capital costs (USA AgSTAR program)

Cost energy of energy produced?

- 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

Resources

- Approved ERF methods
- Dairy Shed Effluent and Biogas – Frequently Asked Questions
- Is biogas technology right for Australian dairy farms?