Eco-efficiency for Australian dairy processors

Fact sheet 5: Biogas

What is biogas?

Biogas is a methane-rich combustible gas created by the anaerobic (without air) digestion of organic material. Dairy processing waste streams suitable for anaerobic digestion include high-strength effluent streams generated from CIP rinses, or waste whey or lactose streams from cheese production. The composition of biogas varies according to the feedstock and the operation of the digester. The typical composition is shown in Table 1. Biogas can be used to generate electricity or to supplement the fuel requirements of a processing plant.

When burned, a cubic metre of biogas yields about 377 MJ of heat energy for every 1% of methane composition (e.g. biogas composed of 65% methane yields 24 506 MJ/m3).[1]

Table 1: Composition of biogas[2]

Component	Content % (v/v)
methane	52–95
carbon dioxide	10–50
hydrogen sulphide	0.001–2
hydrogen	0.01–2
nitrogen	0.1–4
oxygen	0.02–6.5
argon	0.001
carbon monoxide	0.001–2
ammonia	trace
organics	trace

What are the components of a biogas system?

A biogas system consists of:

- a constant, reliable source of effluent to be digested
- an anaerobic digester with an airtight impermeable cover to trap the gas
- treated effluent storage facility
- a gas surge or storage tank
- a gas handling and use system
- a flare for burning unused gas.

Gas handling and use

A gas handling system consists of piping, a gas pump or blower, a gas meter, pressure regulator and condensate drains. Gas is drawn out from the digester via collection pipes under a slight vacuum. A meter monitors the flow rate and a regulator releases excess pressure from beneath the cover.

When is it economically viable to recover and utilise biogas?

The installation of an anaerobic digester and utilisation of biogas can provide a good return on investment (2–4 years) if the infrastructure for utilising the biogas already exists (e.g. an existing gas-fired boiler that requires only a small additional capital expenditure); where there is a high cost for heating fuel (e.g. LPG); and where the company can make substantial savings from the reduced cost of effluent disposal due to the lower organic loads. The publication *The potential for generating energy from wet waste streams in NSW* (SEDA 1999) provides some useful information on the utilisation of biogas, and details six case studies where the economic viability has been examined. Table 2 gives an example of methane and energy yields from anaerobic digestion for an ice-cream plant in Minto, New South Wales.

Table 2: Sample methane and energy yields from biogas digestion for an ice-cream factory, NSW[2]

	Low-rate digestion of effluent (lagoon digester)
Material available for digestion	3060 kg COD/day
Organic load available	0.34 kg COD/m^3/day
Methane conversion rate	0.352 m^3/kg COD removed
Organic removal rate	70%
Methane yield	754 m^3 CH_4/day
Energy yield	27 000 MJ/day
Equivalent natural gas cost	$324/day @ $12/GJ

1 USEPA, *A manual for developing biogas systems at commercial farms in the US*, AgStar handbook,1997.

2 UNEP Working Group for Cleaner Production, NSW, *The potential for generating energy from wet waste streams in NSW*, Sustainable Energy Development Authority, Sydney, 1999.

What are the challenges in capturing and using biogas?

- Dairy plants experience large fluctuations in the rate of flow and strength of effluent, which affects their capacity to produce biogas.
- It is a challenge to estimate the amount of energy generated by a system and size the gas-handling and utilisation systems to suit.
- Hydrogen sulfide and other chemicals in biogas can corrode boiler tubes and may need to be removed before use.
- Warm biogas cools as it travels through pipes, condensing water vapour, which must be removed by condensate traps.
- Operators need the training, skill and time to keep the system operating effectively.

Anaerobic digester at Warrnambool

In 1993 Warrnambool Cheese and Butter installed an anaerobic digester at the Warrnambool plant, with the facility to recover biogas for use as a fuel source in the boilers. The project was only moderately successful, because of problems encountered in maintaining a constant gas supply pressure to the boilers, and the presence of moisture in the gas. Biogas was not refined in any way, which caused excessive corrosion in the boiler combustion chamber. The use of the biogas was suspended in July 2003 pending further investigation and improvements to the operation. The biogas could potentially provide 80–100% of the energy requirements for the production of hot water at the site and save $290 000/yr.

Utilisation of biogas

The upflow anaerobic sludge-bed (UASB) effluent treatment system at Golden Circle in Brisbane produces usable biogas as one of its by-products. The effluent system treats wastewater from fruit and vegetable processing. The biogas is collected in the UASB reactors and compressed, and pumped to a gas-fired boiler to supplement the existing coal-fired boilers. Golden Circle collects and burns approximately 2.5 million m^3 of biogas per year, saving $100 000/yr in coal costs. This will improve further when the company's gas storage capacity is increased.[3]

Anaerobic digester with cover for biogas capture — Warrnambool Cheese and Butter, Allansford

Methane and energy generation — useful calculations

The following calculations can be used to estimate methane yield and potential energy savings.

Maximum yield (m^3/day) = Load of COD to digester (kg/day) × COD removal rate (%) × 0.352 m^3 CH_4/kg COD removed

Energy available (MJ/day) = quantity of methane (m^3/day) × heating value of methane (35.8 MJ/m^3)

3 UNEP Working Group for Cleaner Production, *Eco-efficiency toolkit for the Queensland food processing industry*, 2004.

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For further information see the *Eco-efficiency for the Dairy Processing Industry Manual*, August 2004
or contact the UNEP Working Group for Cleaner Production: phone 07 3365 1432, email p.prasad@uq.edu.au
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