Bioenergy Support Program

Talking Topic 3

Covered lagoons

The Benefits

Covered lagoons capture biogas from manure treatment. Biogas is mostly methane, so it can be used **as a fuel at piggeries** for heating or producing electricity. This **reduces energy costs** and may provide **income** from the **sale of electricity exported to the grid** (See Case Study 1).

Covered lagoons are similar to uncovered manure lagoons, except for an impermeable cover that seals in and captures biogas that is released by the anaerobic decomposition of manure in the lagoon. Most piggery installations imbed the cover in a trench around the perimeter of the lagoon to create a gastight seal (See Figure 1). One piggery in Queensland welded the impermeable cover onto float-pipes to form a floating hood (Figure 2). Access to sludge is simpler with a floating hood arrangement, but the floating hood cover can be more expensive and only captures biogas from the covered portion of the lagoon.

FIGURE 1 Typical bank to bank cover at an Australian piggery

FIGURE 2 Floating hood covered lagoon arrangement at an Australian piggery

The benefits

Capturing and burning of biogas as a fuel also **reduces greenhouse gas emissions and piggery odour** (Insert 1). This may provide additional **income** from the sale of **carbon credits** and **renewable energy credits** (See Talking Topic 6).

Insert 1

Odour reduction

Biogas capture and use as a fuel can substantially reduce piggery odour. For example, Smith et al. (1999) concluded that manure treatment lagoons are the major source of odour at typical Australian piggeries, producing about 75% of all emitted odour. Camp Scott Furphy Pty Ltd (1993) similarly concluded that 82% of odour emissions from a NSW piggery originated from uncovered manure treatment lagoons. Impermeable pond covers capture the odorants together with biogas, and the odorants are destroyed when the biogas is burnt as a fuel. Impermeable lagoon covers can reduce odour emitted by a lagoon by 95% (Stenglein et al., 2011), while floating plastic covers can similarly reduce odour by 60 to 78% (Nicolai et al., 2004).

(Adapted from Skerman and Brown, 2014)

FIGURE An impermeable lagoon cover at a New Zealand piggery. An impermeable cover provides a gas-tight seal that captures biogas and emitted odour. When biogas is burnt in a flare, onsite generator or hotwater system, odorants in the biogas are destroyed.

The benefits

CASE STUDY 1

Real Piggery 2200-sow Farrow-to-Finish NSW

- All conventional flushed sheds
- $980,000 investment
- 2.5-year payback period (paid back fully by July 2015)
- 280 kWe electricity generation with heat recovered for farrowing shed heating
- 60% of electricity produced is exported to the grid ($5,000 per month income)
- About 8,500 tonnes CO_2-e per annum of greenhouse gas emissions prevented (estimate $160,000 per annum income from sale of carbon credits)
- Energy and LPG savings of $15,000 per month
- This site has successfully extracted sludge from their covered lagoons by pumping via sludge extraction pipes

Sludge

Sludge is the inert solids that settle and accumulate in covered lagoons with the treatment of manure. Sludge can be extracted from covered lagoons without removing the impermeable cover. **Sludge has a value as a nutrient source and soil amendment for land application onto crops and pasture.** Soil amendment value is due to improvement in soil structure, probably from the addition of organic matter, not just from nutrients.

To allow time for manure to be properly treated, a covered lagoon has to be sized and operated with an adequate liquid volume (covered lagoons typically operate with a near-constant liquid level). This includes an allowance for sludge solids that accumulate as the manure is treated. Sludge can be intermittently pumped via sludge extraction pipes into a vacuum tanker for spreading using a suitable slurry distribution system (See Case Study 2) or into a drying bay before dry spreading (Birchall, 2013). It should be noted that sludge is thicker and more difficult to pump than water, but a suitable pump can be selected for this application (O'Keefe et al., 2013). Any pumps used near a covered lagoon or biogas system must have an appropriate rating (certification) to operate in the relevant zone or hazardous area where explosive biogas mixtures may be present (See Yap et al. 2015 for guidance).

To reduce floating scum crust layers under the impermeable cover (Figure 3), cereal husks and other large coarse solids can be removed by screening before the manure enters the covered lagoon. This is important because unwanted scum crust can damage a plastic lagoon cover and/or block gas collection piping while reducing the active liquid volume available for manure treatment. Screening manure removes some organic matter, which reduces biogas yield from a covered lagoon, but the biogas yield decrease can be much less than the proportion of organic matter removed by pre-screening (research data available but not shown) and thus pre-screening of manure is encouraged from an operational perspective.

Some larger piggeries are instead using stirred in-ground lagoon technology (http://www.rcmdigesters.com/rcm-technology/heated-stirred-lined/), where sludge is kept suspended by intermittent mixing. These stirred in-ground lagoons can be more expensive to construct and may need heating for the manure to be adequately treated, but sludge accumulation is reduced and biogas production can be more consistent when the lagoon contents are heated.

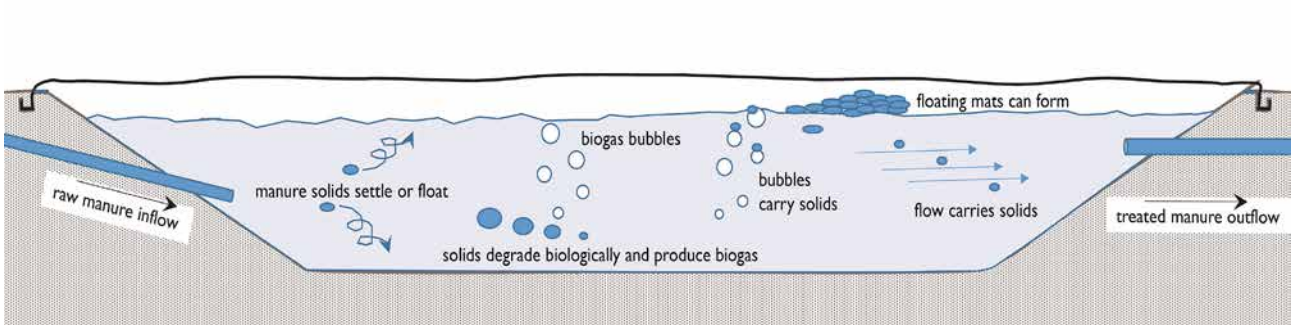

FIGURE 3 Solids can accumulate as sludge and scum in a covered lagoon.

CASE STUDY 2

Real Piggery 2,000 sow Farrow-to-Finish VIC

- Conventional flushed sheds
- $900,000 investment. Anticipate a further $800,000 of investment to be completely energy self-sufficient.
- $240,000 to date from sale of carbon credits
- 54 kWe biogas power generation installed, with an additional 200 kWe planned for installation. Heat is being recovered from biogas generator engines for weaner shed heating.
- Estimate can use biogas to displace 633,366 kWh per annum electricity and 44,744 L per annum of LPG, potentially worth $390,000 per annum.
- Successfully extracts sludge via HDPE sludge extraction pipes with a vacuum tanker (about yearly), and spreads the sludge as a slurry on crop-land using a tined sludge direct-injection implement.*
- Three sludge extraction pipes protrude through the pond bank (under the cover trench) on each long edge of the covered lagoon, offset so that sludge can be extracted at various locations along the lagoon length.

** Several other slurry distribution options are available which can similarly minimize odour and nitrogen volatilisation.*

Managing Stormwater

The impermeable plastic cover has to be flexible enough to accommodate movement but also rigid enough to minimise stormwater pooling.

High Density Polyethylene (HDPE) is the most common cover material at Australian piggeries. A cover supplier can recommend appropriate materials and cover design for particular installations.

Excessive pooling of stormwater can damage the impermeable plastic cover on the lagoon (See Figure 4). **Water-filled ballast pipes** typically guide stormwater into a collection sump, from where it can be pumped off the cover (See Case Study 3). The ballast pipes can be secured onto the cover with welded band-sleaves made of the same material as the cover. The ballast pipes also reposition biogas under the cover into more manageable smaller pockets. The placement of ballasts should therefore consider prevailing wind-direction, and may include a large central member with smaller lateral members, depending on the size and geometry of the lagoon.

Stormwater run-off from the edges of a bank-to-bank cover can cause severe erosion (See Case Study 3). The lagoon bank must be protected. Unkept vegetation can increase the risk of damage to the plastic cover by rodents or fire (See Figure 4) and, because biogas is flammable, mowing may not be safe in close vicinity to the cover. A fence near the cover can allow stock to safely graze and maintain vegetation.

FIGURE 4 Stormwater and related management with covered lagoons at Australian piggeries. (Left) Unwanted, a biogas whaleback trapped by a rim of stormwater; (Right) Wanted, a fire break with regularly maintained vegetation around the lagoon perimeter prevented a bush fire from progressing up to the cover before it was extinguished.

CASE STUDY 3

Same piggery as CASE STUDY 2 – Focus on Stormwater management

- Partially above-ground covered lagoons to achieve hydraulic fall towards secondary storage dams. Gravitational delivery of treated effluent to secondary storage dams.
- Severe issues with lagoon bank integrity. Tunnelling erosion through embankment possibly exacerbated by dispersive clay soil, and/or inadequate compaction or moisture control during construction.
- 14” rainfall area, which is moderate, but significant bank wash issues.
- Fencing and growing vegetation to protect bank (note irrigation sprinkler near fence). The fence around the cover allows stock to graze the bank to keep the vegetation under control.
- Run-off originates from inflation of the cover for biogas storage, with only a central ballast pipe dividing the lagoon in half along its length, with half the rain falling on the cover and running off onto the bank.

Biogas Collection

Biogas can be stored for short periods under the impermeable cover above the lagoon liquid surface, so that the biogas can be used when it is most needed or during high electricity tariff periods. However, excessively inflated covers may age prematurely. Biogas is collected via perforated pipes or perforated flat panels on the perimeter bank under the impermeable cover (Figure 5).

The biogas collection pipework is positioned or shaped to allow condensing moisture to drain back into the lagoon or into an outside moisture collection drum (See Talking Topic 4).

Emergency vents should allow safe venting of biogas when needed (See Talking Topic 2). A flare can be a safe venting option and also reduces odour if the vented biogas is burnt (Yap et al. 2015).

FIGURE 5 Biogas collection pipework under the cover at Australian piggeries, which can be either slotted pipes with burs removed, or more commonly perforated HDPE flat panels. The perforated panel HDPE has been preferred because it is easily secured and does not move or roll with movement of the cover.

Lagoon Sizing and Installation

The principles of lagoon sizing are similar for covered and uncovered lagoons, as per industry guidelines (Tucker and Tait, 2015; Tucker et al. 2010).

This means that industry-standard sizing tools, such as PigBal, are also used for covered lagoons. For a covered lagoon, a deeper narrower shape can minimize the lagoon surface area to be covered, reduce cover costs and provide easier access for pumping of sludge. Covered lagoons have been smaller than uncovered lagoons designed by the Rational Design Standard (RDS) (Barth, 1985), because covered lagoons may appropriately treat higher organic loading rates. It is sensible to size a bank-to-bank covered lagoon (See Case Study 4) with a width which is a multiple of the standard sheet width of the roll of cover plastic. It is generally preferred to position covered lagoons below pig sheds and secondary storage lagoons below covered lagoons, because liquid flow by gravity is usually simpler.

It is advisable to talk to the supplier-installer of the impermeable cover before the actual pond is constructed (earthworks). This can help resolve preferred design features such as the required width of the pond top berm to allow safe installation of the cover, for better construction to be sure the edges are straight and firm.

Note that it can be unpleasant and unsafe to install a cover on an active manure-filled lagoon, so the cover installer may request that the lagoon be left dormant for a period of time prior to the cover installation, or may ask that the lagoon be pre-filled with fresh water. Also, a supplier may prefer to install the cover during cooler months to prevent unwanted stresses on the cover because of thermal contraction.

AN IMPORTANT SAFETY REMINDER

Biogas is dangerous if not handled correctly. Biogas can be explosive and extremely toxic (See Talking Topic 2). The *Code of Practice for On-farm Biogas Production and Use at Piggeries* (Yap et al., 2015) presents practical ways to safely handle biogas.

FIGURE 6 It is preferred for pipework to protrude through the pond bank (right), because then pipes and joints do NOT move up and down when the cover becomes inflated to store biogas. When biogas pipework is connected directly to the cover (left), the joint with the cover can fail prematurely, which is unwanted. Similarly, excessive movement along other cover joints and pipe joints can impose unwanted stresses and increase the potential for premature failure.

CASE STUDY 4

Real Piggery 5500 sow Breeder Unit NSW

- Conventional flushed sheds
- Burns biogas in a flare for odour control
- Sequence of photos showing installation of a 2 mm thick HDPE cover in a perimeter trench.

FIGURE Progressive installation of cover at the piggery

Other Talking Topics

Talking Topic 1
Collecting the biogas benefits of pig manure

Talking Topic 2
Biogas Safety – the essentials

Talking Topic 3
Covered lagoons
This present document

Talking Topic 4
Cleaning piggery biogas

Talking Topic 5
Using piggery biogas

Talking Topic 6
Reducing the carbon footprint of a piggery

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