MEAT & LIVESTOCK AUSTRALIA

TIPS & TOOLS

FEEDLOTS

Feasibility of using feedlot manure for biogas production

Beef feedlot manure is a potentially good feedstock for biogas production; however, good manure management is a central issue. Biogas technology can provide the following benefits to lot feeders:

- onsite renewable energy
- effective waste management
- reduced odour and greenhouse gas (GHG) emissions
- improved fertiliser value of manure.

Understanding manure handling practices at Australian feedlots is essential to determine what promotes increases in potential biogas capture.

Key messages

- Feedlot manure readily degrades on the pen surface and the methane potential of the manure decreases significantly. Hence, manure must be harvested frequently (every 30-60 days).
- Feedlot manure is often contaminated with soil, gravel and other physical contaminants. However, good pen design and careful cleaning can minimise contamination.
- Due to the degradation and loss of methane potential that has occurred during stockpiling and composting, this degraded manure cannot be economically used for biogas production. However, the manure stockpile areas are suitable for handling dewatered sludge.
- For most large feedlots, the greatest energy usage is gas to fire the boiler for the steam flaker. Hence, biogas can be used directly as a gas rather than used for electricity generation.
- As energy and cattle costs can vary considerably, the capital cost of the facility must be kept as low as possible. Low-tech solutions should be considered before complex, high-technology solutions.
- Lot feeders are experts in feeding cattle, not operating an industrial facility. The design of the biogas system should not require precision control.
- There are few successful examples of biogas developments using feedlot pen manure. Further research is required to demonstrate the feasibility of low cost, pilot-scale biogas technology (such as covered anaerobic lagoons) in Australia.

Biogas and anaerobic digestion technology

Biogas is produced by anaerobic digestion (AD) of organic materials and consists of 55-80% methane (CH_4) and 15-45% carbon dioxide (CO_2) as well as small gas components, such as water vapour, hydrogen sulphide and nitrogen. AD is a multi-step biological process that involves a range of different types of microorganisms that have specific requirements such as pH, temperature and nutrients. The process remains quite steady once a stable microbial community is formed and the operating conditions are met.

Biogas technology does not have to be complex and difficult to operate. The most common technologies for on-farm AD are engineered, heated and continuously stirred tank reactors, or ambient temperature, unmixed covered anaerobic lagoons (see Table1)[1].

Table 1 : Attributes of continuously stirred tank reactors and covered anaerobic lagoons

	Continuously stirred tank reactors	Covered Anaerobic Lagoons
Construction	Concrete or steel tank with insulation, heating, mixing and plastic membrane roof	Earthen lagoon with plastic cover (and plastic liner where required).
Substrate dry matter (DM)concentration	>4%	>5%
Operating temperature	Heated: 35–39^{0}C (mesophilic) or 55^{0}C (thermophilic).	Varies with ambient temperature (15–35^{0}C).
Advantages	Applicable to a wide range of materials, shorter treatment time, small size, standard designs, applicable for use in all climates.	Lower cost construction using local resources, lower operation and maintenance requirement, no heat demand, tolerant of shock loads, cover also provides biogas storage.
Disadvantages	Higher construction and operation costs including heat demand, requires skilled operation.	Large size, suitable only for liquid organic materials and temperate to warm climates.

[1]Modified from Dairy Australia Fact Sheet. Source: http://frds.dairyaustralia.com.au/wp-content/uploads/2013/05/FINAL_Biogas-technology_A4-report-summary.pdf

Figure 1: Covered Anaerobic Lagoon (CAL)

Figure 2: Simple concrete anaerobic digester

Feedlot manure as a feedstock for biogas

Some key terms

Biomethane Potential (BMP): The volume of methane gas produced during anaerobic digestion of a given feedstock, expressed as litres/kg volatile solids.

Volatile solids (VS): Amount of organic matter in a feedstock.

Total solids (TS): Amount of inorganic and organic matter in feedstock.

Fresh feedlot manure has a biomethane potential (BMP) of between 200 and 300 litres (L) of methane (CH_4) per kg volatile solids (VS). By comparison, swine manure can range from 300-550 L CH_4/kg VS, poultry 350 L CH_4/kg VS and dairy manure 100-250 L CH_4/kg VS. The BMP of stockpile manure can vary depending on age and has been found to produce as little as 13 L CH_4/kg VS.

Table 2 provides a measure of BMP values of various manure types from a single feedlot with corresponding volatile solids.

The varying volatile solids can be due to either prolonged manure breakdown, mixing of manure with soil or a combination of both. To ensure maximum methane production a number of factors need to be considered when harvesting manure, such as:

- **Age:** Feedlot manure readily degrades on the pen surface and the BMP of the manure decreases significantly. Manure must therefore be harvested frequently and loaded into the digester quickly.
- **Contaminants:** Feedlot manure is often contaminated with soil, gravel and other physical contaminants.

Table 2: BMP values and corresponding volatile solid of various manure types

Manure type	Manure age (days)	Volatile solids (as a percentage of total solids)	Biomethane potential (L CH_4/kg volatile solids)
Fresh manure	0	87.9	218
Pen surface manure	30 to 60	77.2	173
Pen cleaned manure	30 to 60	75.2	135
Stockpile manure	Greater than 60	42.2	13

Feedlot manure management

Ensuring the capture of manure before significant degradation occurs and the minimisation of contamination during pen cleaning is the most effective but may not be the most viable approach given the necessity of dramatic change in feedlot manure management and increased maintenance costs. Pen cleaning without the removal of the compacted manure interface layer will reduce the amount of soil and other non-degradable materials in the harvested manure.

Figure 3: Pen cleaning while retaining a compacted manure interface layer

Figure 4: Pen cleaning with a front-end loader where the interface is removed exposing clay base

Biogas system design options

Current feedlot manure management in solid form offers little opportunity for current digester designs. Aside from slatted floor feedlots in the United States, there are few successful examples of biogas developments using feedlot pen manure from traditional open air earthen feedlots.

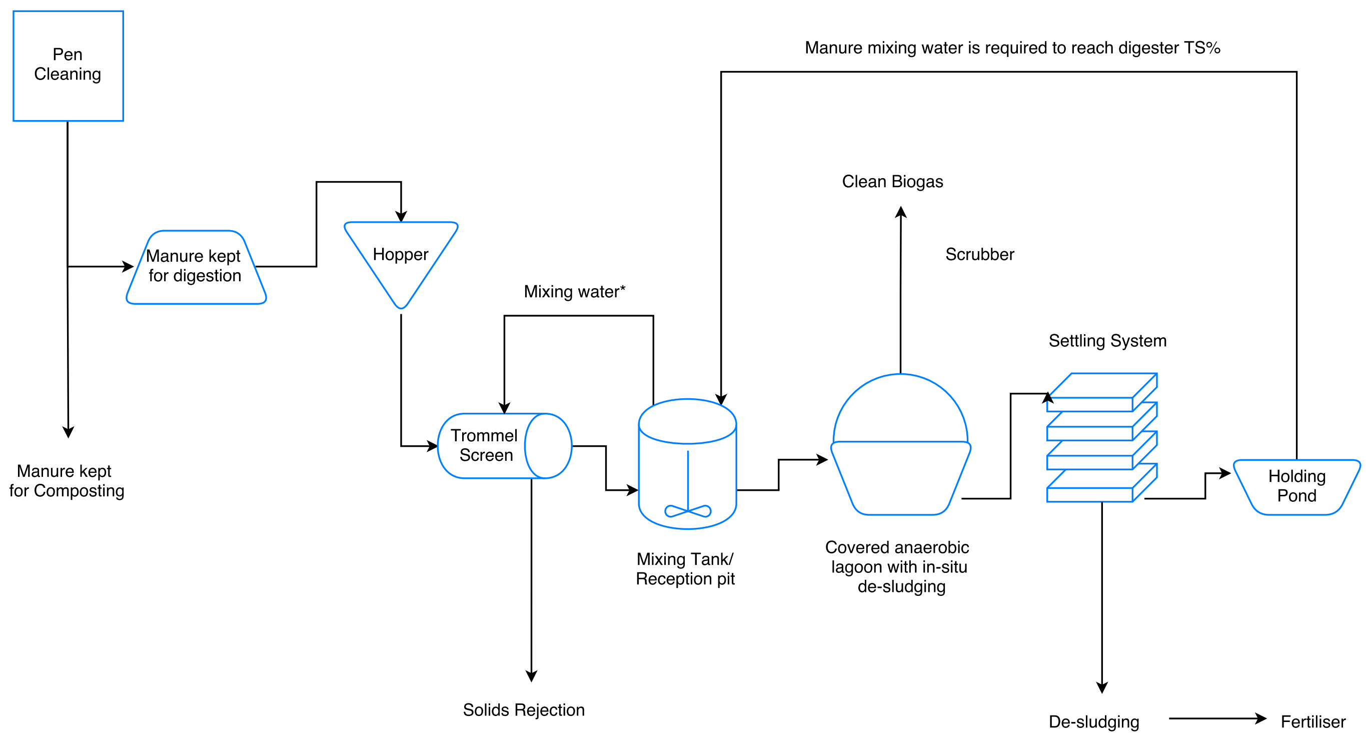
The following flow chart provides some key elements of a biogas system potentially suitable for handling feedlot manure for use as a single substrate for biogas production.

Central to this system is the use of a covered anaerobic lagoon which has been identified as a suitable technology for feedlots.

Based on existing manure management on feedlots the following should be considered when designing a feedlot biogas system:

- For most large feedlots, the greatest energy usage is gas to fire the boiler for the steam flaker. Hence, biogas can be used directly as a gas rather than used for electricity generation. This reduces the cost and complexity of handling the biogas.
- Feedlots already use large machinery for manure and feed management (front-end loaders, box scrapers, body trucks, vibrating or rotating screens). The biogas system should be designed to use existing equipment.
- Currently, the nutrients in manure are a saleable resource at feedlots. The biogas system should ensure that key nutrients (N, P and K) can still be used as organic fertiliser.
- As feedlots are always located on large areas of land with good separation from neighbours, land area constraints do not apply. A small foot print for the facility is unnecessary.
- All feedlots have a holding pond which captures contaminated runoff from the pen area. This can provide a water source for the biogas plant that already contains some organic matter.

Figure 5: Flow chart incorporating key elements of a proposed biogas system suitable for feedlots



*Mixing water is used as a water jet to remove debris from Trommel screen and further break up manure before entry mixing tank.

Techno-economic feasibility

The following is a simple techno-economic feasibility for a 10,000 SCU using pen surface manure that is less than 60 days old (BMP 170 L CH_4/ kg VS at a VS of 76%). It shows that the methane required for steam flaking is similar to the amount of methane produced from a 42 ML covered anaerobic lagoon.

- The following assumptions have been made:
- Grain consumption of 23,500 tonnes/year
- Requires thermal energy of 285 MJ/T grain for steam flaker which is equivalent to about 6,700,00 0 MJ/yr
- The equivalent methane requirements for feedlot grain processing is 195,000 m^3 CH_4/yr
- Maximum methane production from covered anaerobic lagoon is 230,000 m^3 CH_4/yr

Is biogas technology right for my feedlot?

Before making this decsion there are 5 key points to consider:

✓ **Location:** Feedlots need to be in a low-rainfall and/or summer-dominant rainfall zone to maximise the availability of dry manure.

✓ **Pen surface**: Feedlots need to have well-design and constructed smooth pen surfaces and manure is harvested with little gravel.

✓ **Harvesting:** Ability to frequently harvest manure with minimal soil, gravel and other physical contaminants.

✓ **Water supply:** Sufficient water is required to ensure manure feedstock mixing consistency

✓ **Biogas utilisation:** Ideally feedlots should have a steam flaker and boiler system to use the biogas in the most economical way.

Key Contacts:

Dr. Bernadette McCabe
University of Southern Queensland
Email: bernadette.mccabe@usq.edu.au

Dr. Joseph McMeniman
Feedlot Project Manager
Email: jmcmeniman@mla.com.au

Level 1, 40 Mount Street,
North Sydney NSW 2060
P: 02 9463 9333 I F: 02 9463 9393
www.mla.com.au

MEAT & LIVESTOCK AUSTRALIA