Agro-industrial waste: The importance of matching technology with feedstock

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Value of Biogas East, Toronto, Canada

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Synopsis

1. Overview of biogas developments in Australia
2. Waste management practices and influence on quantity and quality of feedstock
    1. Piggeries
    2. Dairy
    3. Milk processing
    4. Beef feedlots
    5. Red Meat Processing
3. Biogas recovery technologies and future opportunities

Overview of biogas developments in Australia

- Biogas capture more common in municipal waste treatment industry
  Most sites employ cogeneration (electrical power and heat) units
- Intensive livestock industries in Australia have been slow to adopt biogas technology
  - Relatively inexpensive alternative energy sources
  - Relatively high cost and lack of proven technology suitable for Australian production systems
  - Absence of Government incentives, in comparison to other countries
- Covered anaerobic lagoons are the preferred technology to treat livestock waste and waste water from food processing plants

Covered anaerobic lagoon (CAL)
Rendering plant, Beaudesert, Queensland

[© USQ/CAE, Peter Harris]

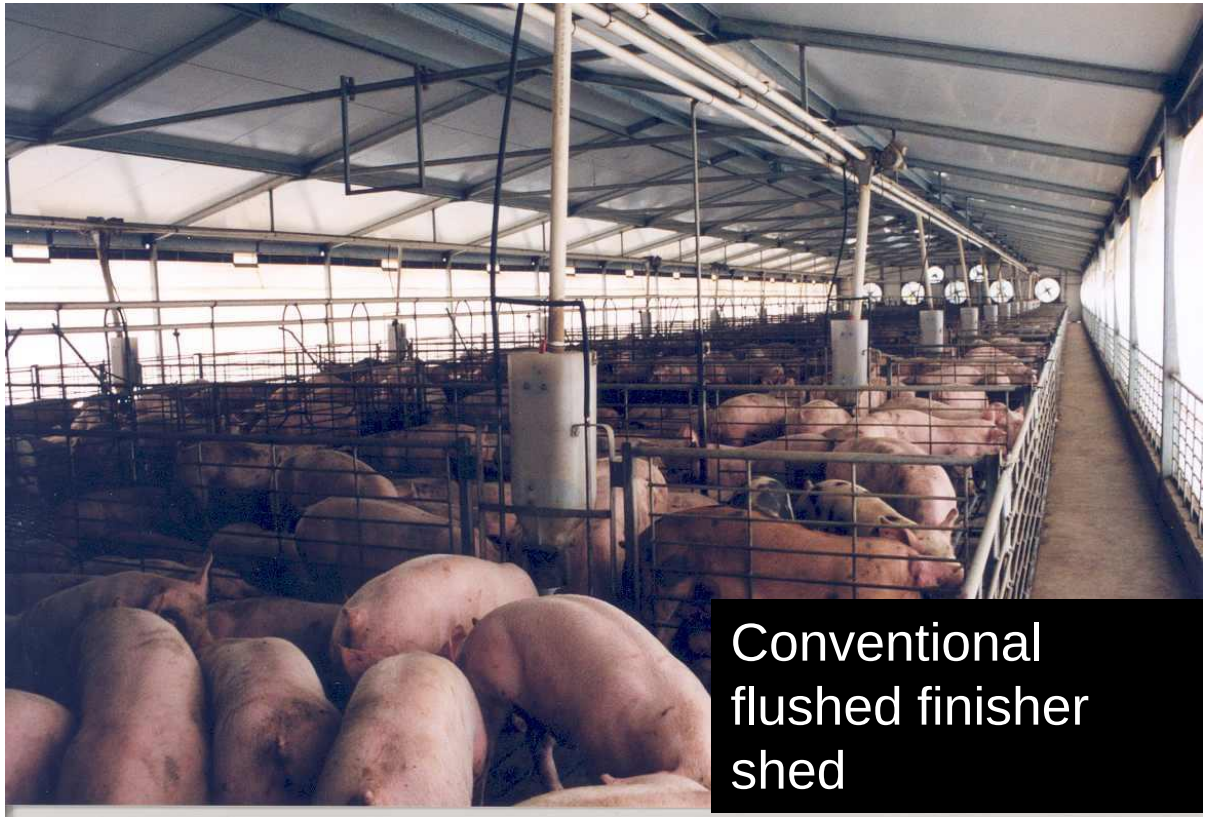
Waste Management practices

- Large quantities of solid and liquid waste generated by Australian agro-industrial sector
  - Piggeries
  - Dairies
  - Milk processing
  - Beef Feedlots
  - Red meat processing

- Waste management is diverse with each industry varying type, composition, collection methods and handling

Piggeries

Conventional flushed grower shed



Conventional flushed finisher shed

Photos courtesy RIRDC Australian Methane to Markets in Agriculture (AM2MA) Research, Skerman 2008

Photo courtesy RIRDC Australian Methane to Markets in Agriculture (AM2MA) Research, Skerman 2008

Deep litter shed – commonly used to house weaner and grower pigs

Deep litter grower/finisher shed

Photos courtesy RIRDC Australian Methane to Markets in Agriculture (AM2MA) Research, Skerman 2008

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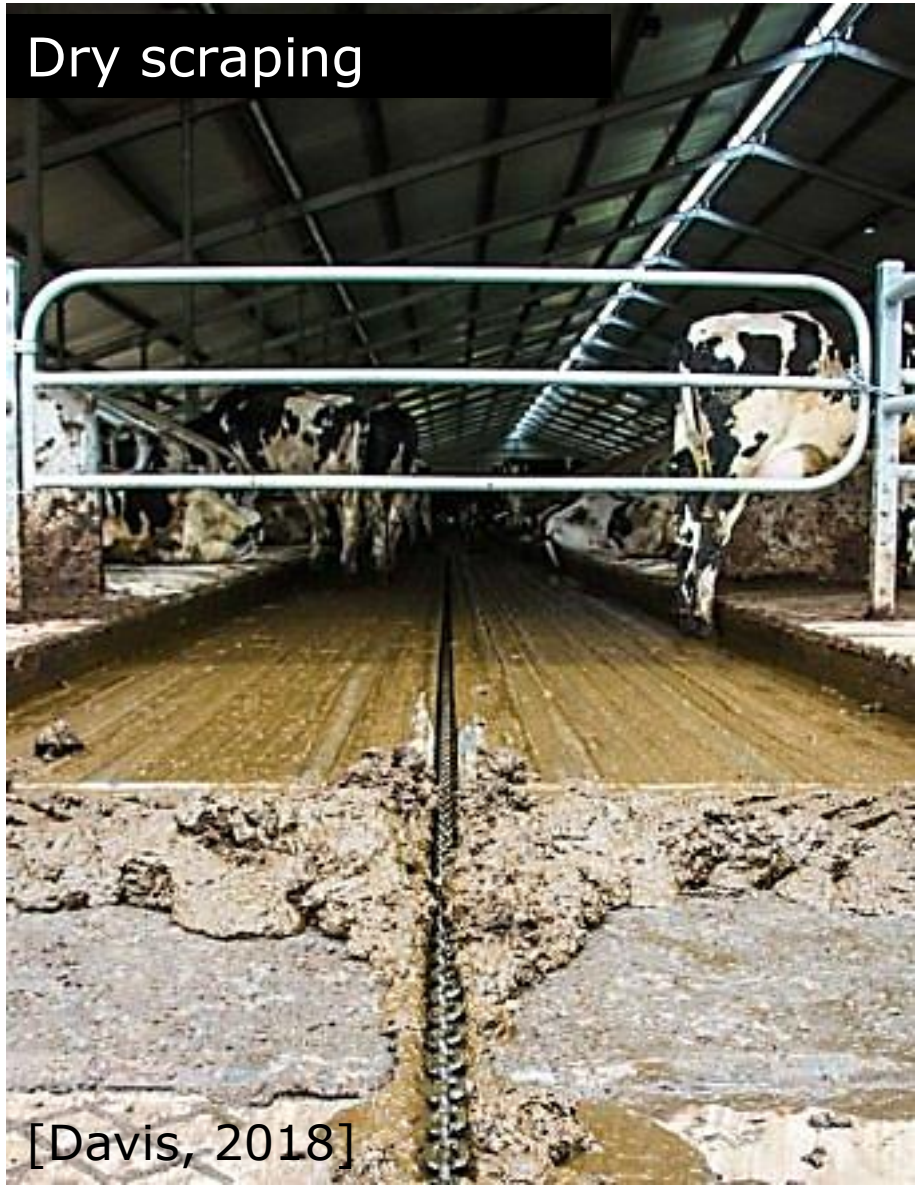
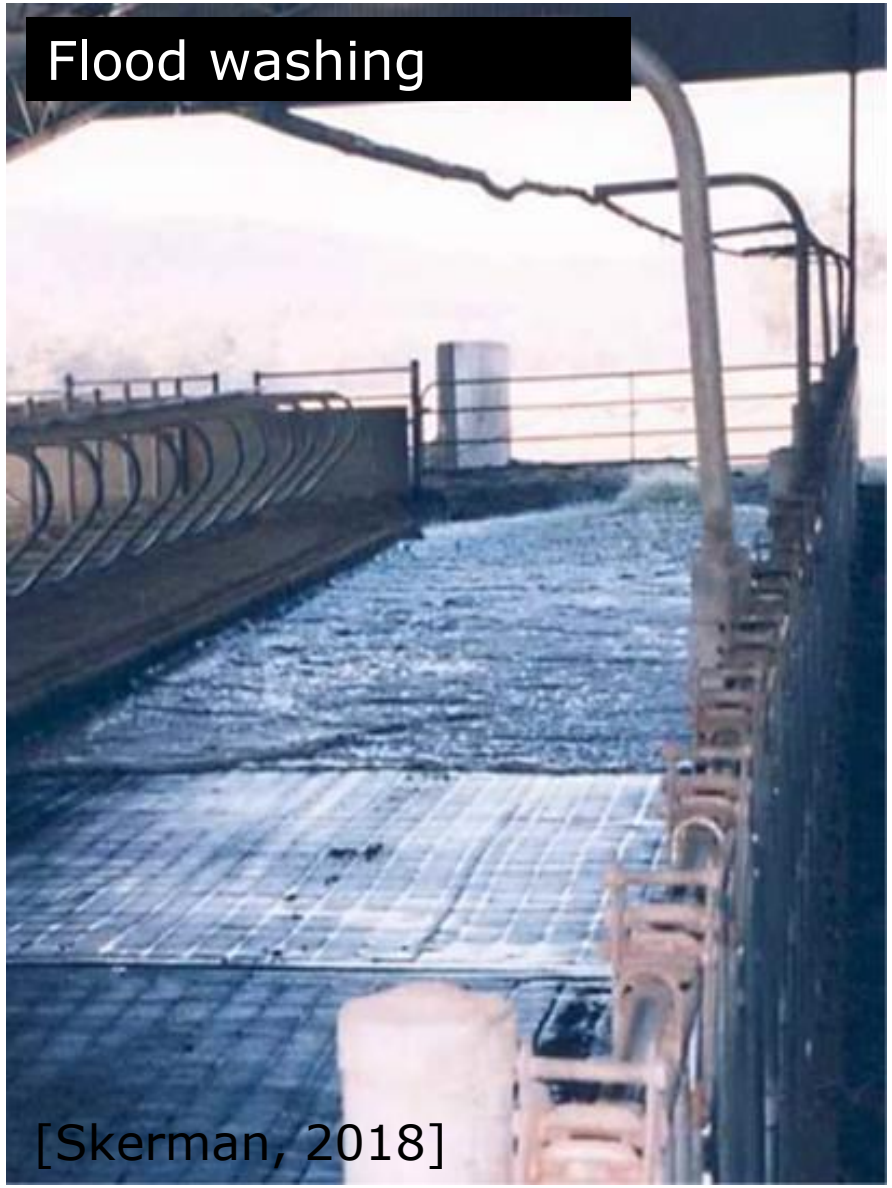
Dairies





Feedlots

[Skerman, 2018]

Box scraper

[Watts and McCabe, 2015]

Front end loader

Red Meat processing

CRITICAL REVIEWS IN ENVIRONMENTAL SCIENCE AND TECHNOLOGY
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Toward profitable and sustainable bioresource management in the Australian red meat processing industry: A critical review and illustrative case study

Bernadette K. McCabe [a], Peter Harris[a], Diogenes L. Antille[a,b], Thomas Schmidt[a], Seonmi Lee[a], Andrew Hill[a], and Craig Baillie[a]

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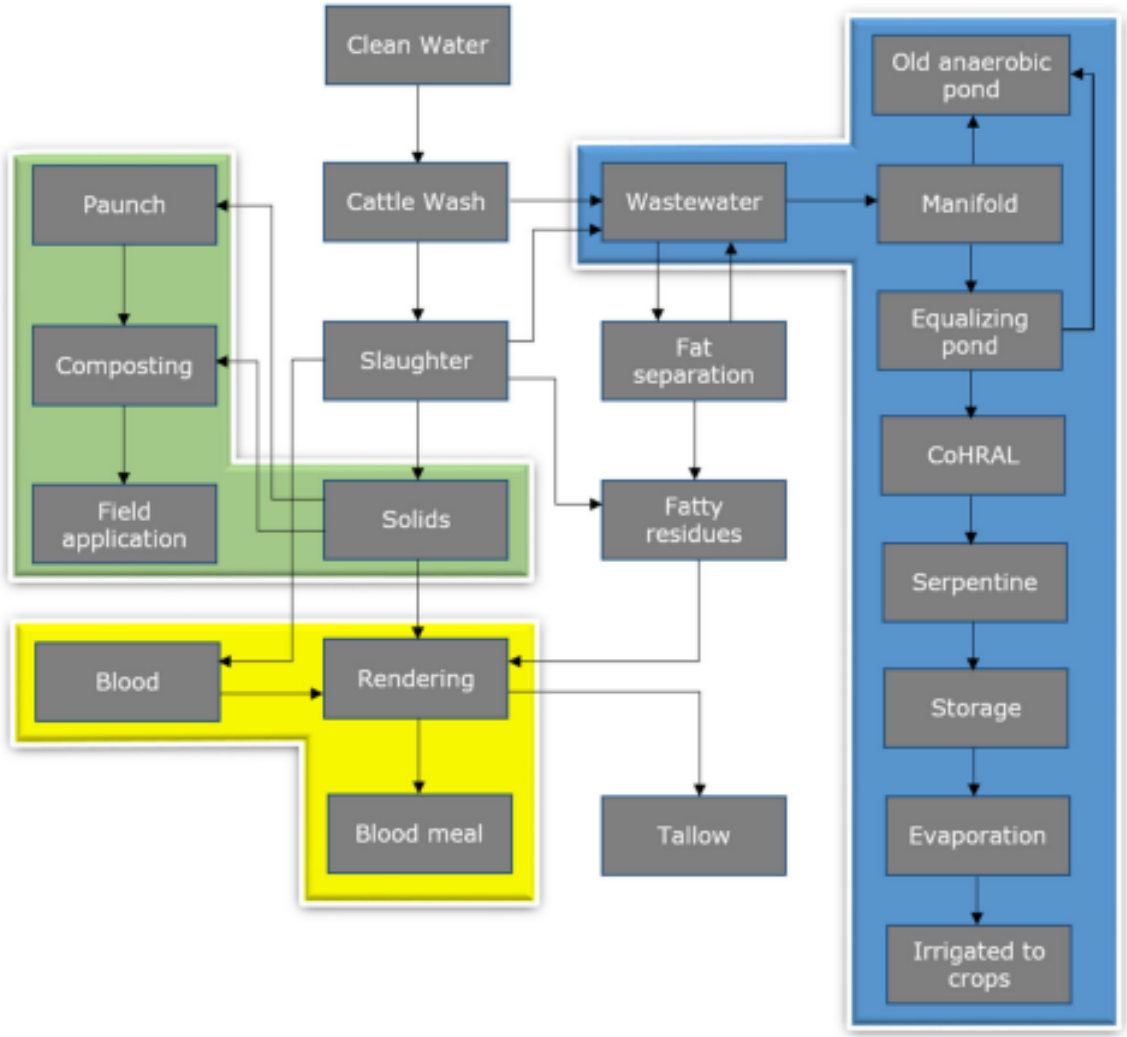

Figure 3. Schematic of process flow of solid and liquid waste (McCabe et al., 2018).

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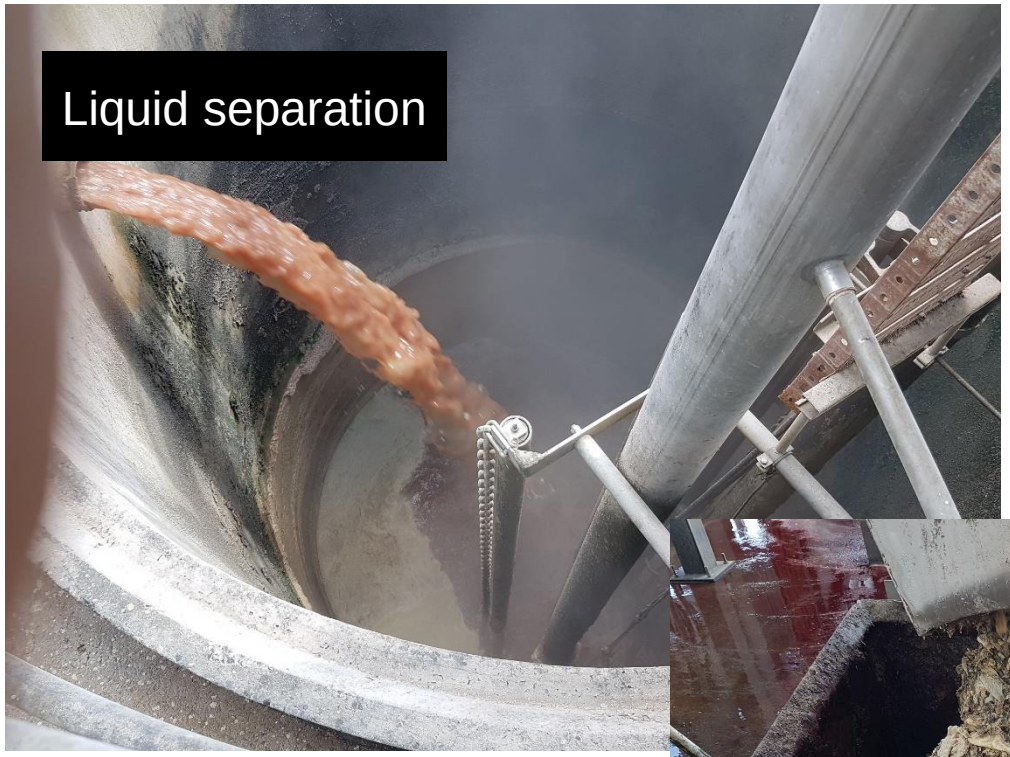
Liquid separation



Fat separation

Solid separation

[© USQ/CAE, Peter Harris]

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Land application of composted paunch

[© USQ/CAE, Dio Antille]

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TECHNICAL NOTE:

AN INVESTIGATION INTO THE FERTILIZER POTENTIAL OF SLAUGHTERHOUSE CATTLE PAUNCH

D. L. Antille, B. K. McCabe, W. Van Der Spek, C. P. Baillie

ABSTRACT. *In Australia, recycling of paunch waste to farmland has been suggested as a cost-effective and practicable environmental option, but little is known about its agronomic value. Experimental work was undertaken to assess potential risks due to weed seed contamination, determine the agronomic response of ryegrass (*Lolium perenne *L.) to soil incorporation of paunch, and investigate short-term greenhouse gas (GHG) emissions. Five types of paunch with compost ages between 2 and 16 weeks were compared with urea (46% N) and applied at field equivalent rates of 0 (control), 150, and 300 kg ha^{-1} N. The risk of weed contamination from paunch applied to soil appeared to be negligible; however, techniques that enable seed viability to be determined may be required to fully discard such risk. Average dry matter yield with paunch was ~30% higher than untreated grass, but ~35% lower than with urea. Dry matter yield in paunch-treated grass was between 2500 and 3250 kg ha^{-1} over five cuts conducted at 25-day intervals. Paunch N responses were between 1.12 and 3.25 kg DM kg^{-1} N depending on compost age, but lower than with urea N (~6.5 kg DM kg^{-1} N). Nitrogen use efficiency of paunch ranged between 3% and 20%, compared to about 35% with urea. Nitrogen fertilizer replacement value (NFRV) of paunch was highest in the 6-week-old compost (~60%) and ranged between 20% and 55% across all other organic materials. Short-term N_2O emissions were similar ($p > 0.05$) with both mineral and organic amendments; however, CH_4 emissions were higher ($p < 0.05$) from paunch compared with urea-treated soil. Overall, there appears to be potential for paunch-derived products to be used as a source of C and nutrients in crop production. Industry quality specifications for compost are available, but they need to be expanded to incorporate guidelines relevant to paunch. There is a requirement for the value proposition to industry to be determined, including reduced cost of paunch disposal via gate fees.*

Biogas recovery

Anaerobic ponds are an economical method for treating manure effluent from intensive livestock industries and high strength waste water such as the effluent generated by the meat processing industry.

The benefits are the production of stable, odour-free sludge that can be used as a fertiliser and the production of biogas for energy production.

The major adverse issues with anaerobic ponds are odour generation and uncontrolled release of methane and carbon dioxide to the atmosphere. Installing a geomembrane cover, fixed or floating, over anaerobic ponds reduces odour release and permits the capture of methane rich gas.

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Piggeries

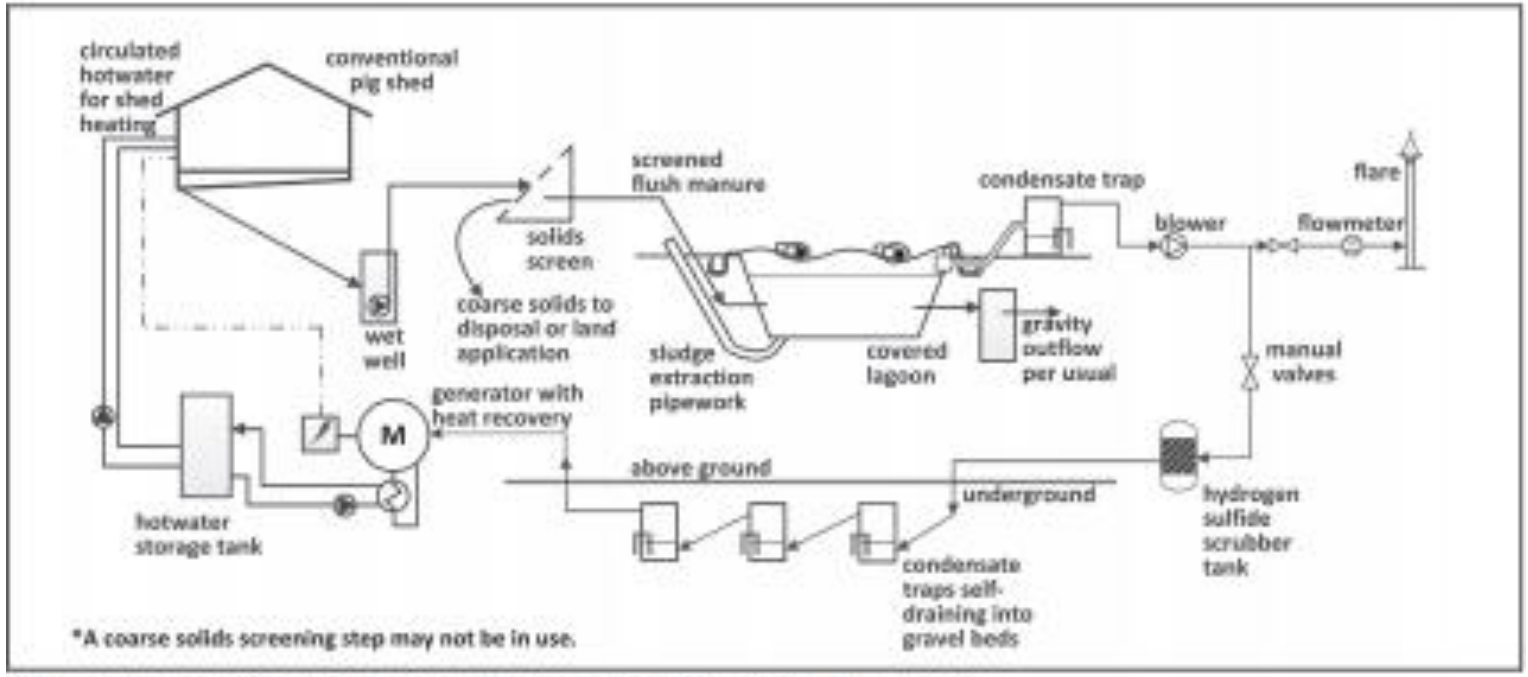
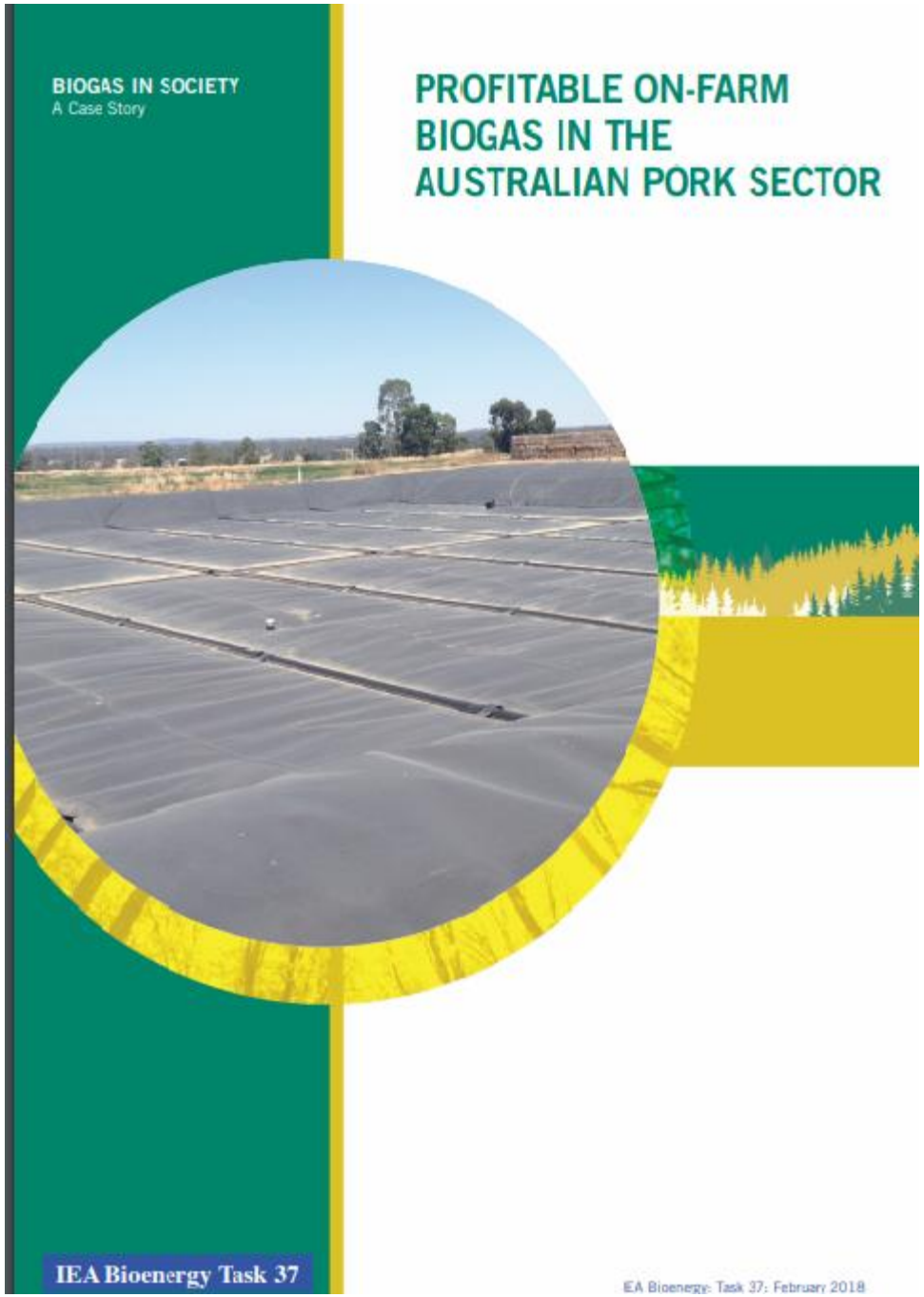


Figure 3: A schematic overview of a covered lagoon biogas set-up at a piggery



http://task37.ieabioenergy.com/case-stories.html

Dairy

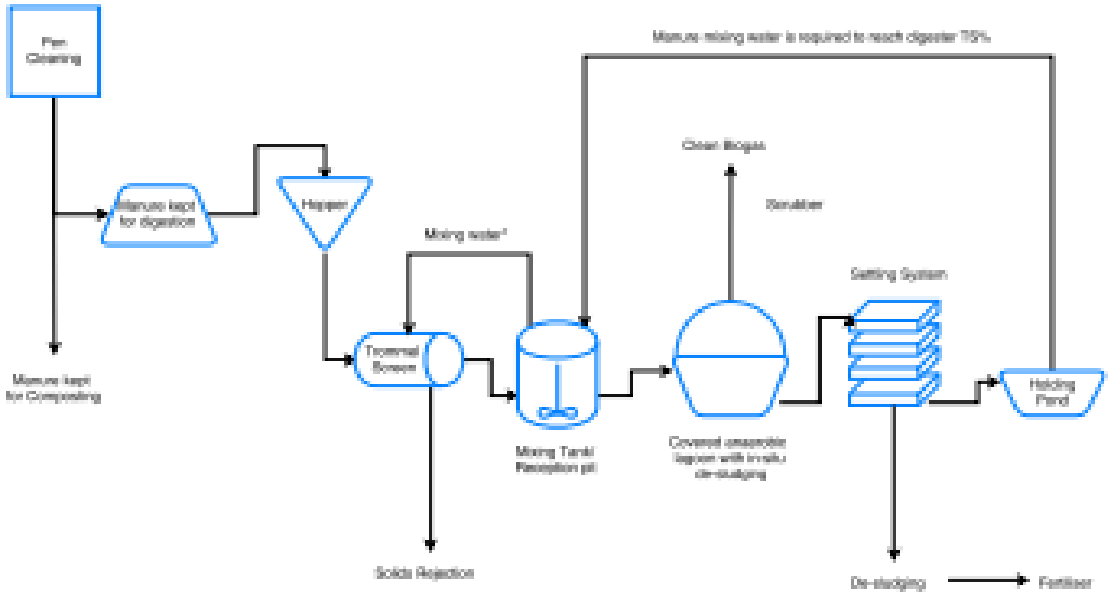
- Intensification of industry providing improved scope for biogas system development
- Commonly use anaerobic pond effluent treatment systems
- Currently limited adoption of biogas technology

Photos courtesy RIRDC Australian Methane to Markets in Agriculture (AM2MA) Research

Feedlots

https://www.mla.com.au/globalassets/mla-corporate/research-and-development/documents/presentations/tipstools_feasibility_052017.pdf

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.

Is biogas technology right for my feedlot?

Before making this decision 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.

TIPS & TOOLS

FEEDLOTS

Feasibility of using feedlot manure for biogas production

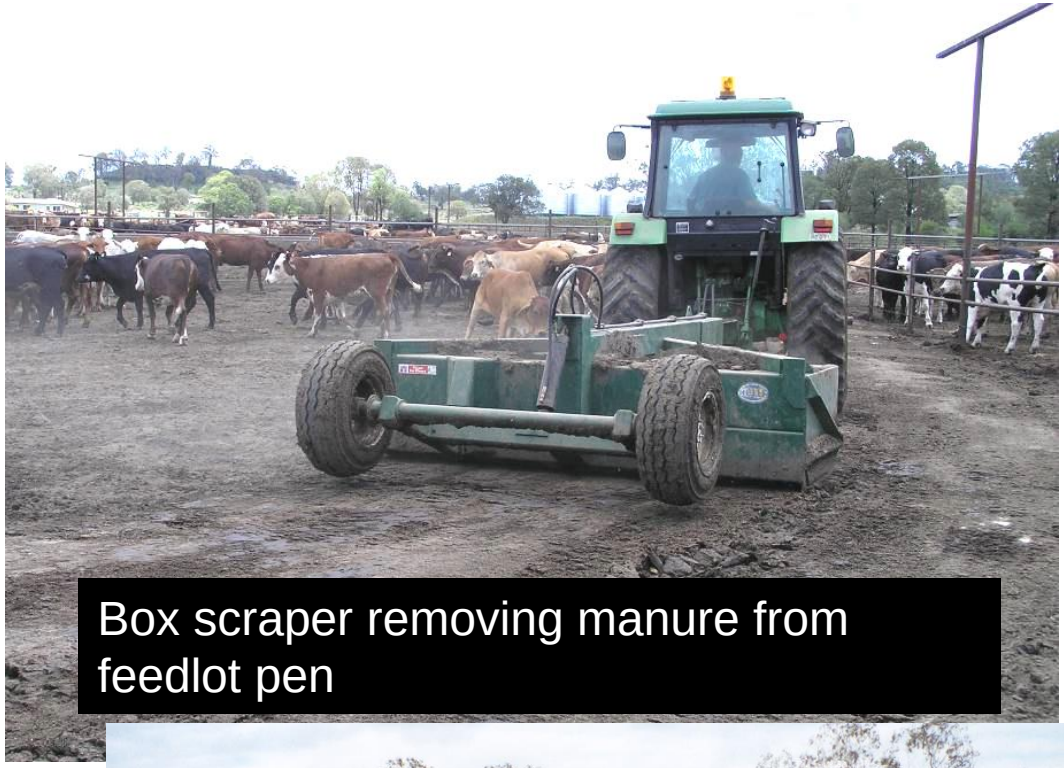
Beef feedlot manure is a potentially good feedstock for biogas production; however, good manure management is a central issue. Biogas technology can provide the following benefits to lot feeders:

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

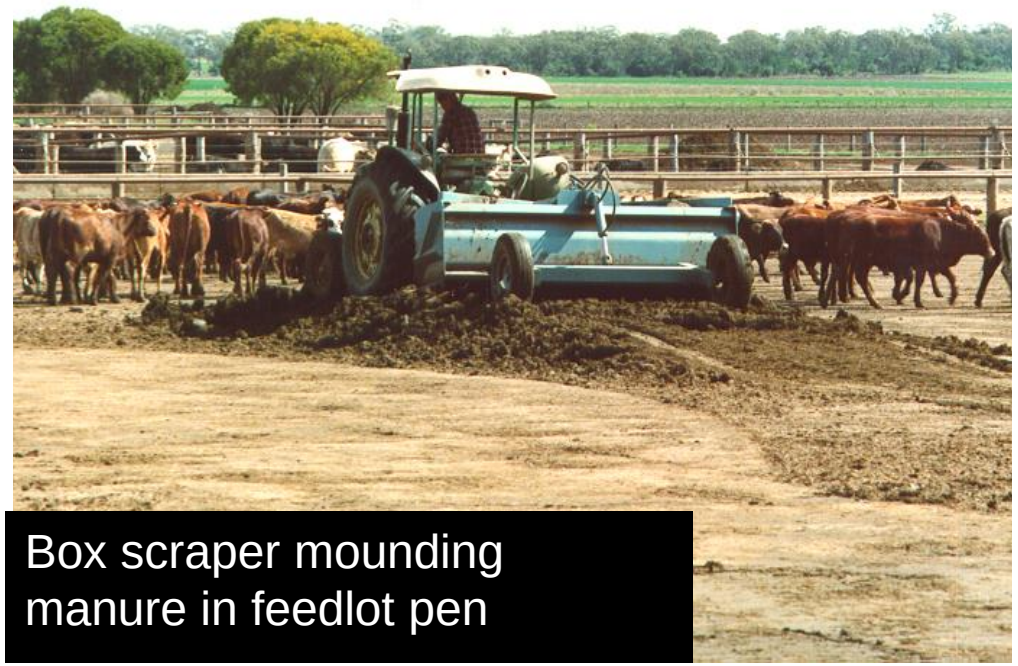
Understanding manure handling practices at Australian feedlots is essential to determine what promotes increases in potential biogas capture.

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.



Box scraper removing manure from feedlot pen



Box scraper mounding manure in feedlot pen

Specialised compost turning machinery operating at a feedlot

[Skerman, 2018]

Red meat processing

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Impact of technology on feedstock: CAL vs CSTR

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Investigating the impact of seasonal temperature variation on biogas production from covered anaerobic lagoons treating slaughterhouse wastewater using lab scale studies

Thomas Schmidt, Peter Harris, Seonmi Lee, Bernadette K. McCabe*

Centre for Agricultural Engineering, University of Southern Queensland, Toowoomba, QLD, Australia

- Investigated effects of optimal mesophilic conditions and stirring
- Reduced temperature from 38°C to 25 °C
- 30% reduction in biogas production at a temperature of 31°C
- Decrease to 25.5°C, with an increase of the organic loading rate caused up to 80% difference in gas production and negatively influenced process stability
- Natural gas consumption could be offset with biogas to reduce yearly expenditure of natural gas by up to 25.4% if lagoons are operated under optimal mesophilic conditions

Waste aggregation opportunities

- Opportunities for waste aggregation and industry benefit through co-digestion are under-explored in Australia
- Distance and the transporting of waste is a major challenge to co-digestion
- Programs including the Australian Renewable Energy Mapping Infrastructure (AREMI), Australian Biomass for Bioenergy Assessment (ABBA) and Rural R & D for Profit "Waste to Profits" aim to deliver tools to assess co-digestion
- New digester technologies and pre-treatment developments are aiming to improve the cost-effectiveness

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Australian Government
Department of Agriculture, Water and the Environment

Thankyou

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