# Five Piggery Biogas Capture and Energy Generation Feasibility Studies

**Report prepared for the**

**Co-operative Research Centre for an Internationally Competitive Pork Industry**

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# Executive Summary

The Pork CRC is currently involved in research that will develop commercially viable effluent management systems for pig production that significantly reduce the net carbon footprint of piggeries. In particular, the research program will establish pork production systems that are carbon neutral through novel research such as the development of anaerobic digestion techniques. The research program will transform the Australian pig industry by specifically addressing critical environmental and economic issues that confront its sustainability.

This project involved the technical and economic feasibility assessment of capturing, destroying and/or using captured biogas as an energy source at existing piggery operations. There may also be other drivers for piggeries to capture and destroy biogas, such as for odour reduction. The assessments cover five different piggeries, with large variations in size, design and operation. This meant that the assessments provided a range of energy requirements and biogas capture potential. Four of the piggeries are located in Australia (two in South Australia and two in Western Australia) and one in New Zealand Piggery.

The findings from this research indicate that there is potential for capturing and utilising biogas to minimise piggeries' reliance on electricity from the grid and / or imported fuels such as diesel and liquefied petroleum gas (LPG). The five case studies have all been shown to be economically feasible, with each piggery having short payback periods between 1.8 and 7.2 years and delivering a substantial positive return on investment over a 10-year project life.

Biogas feasibility may vary for specific piggeries. It is thus recommended that interested producers carry out more site specific investigations to identify whether biogas technology is right for them.

# Table of Contents

# 1. Introduction

The Pork CRC is currently involved in research that will develop commercially viable effluent management systems for pig production that significantly reduce the net carbon footprint of piggeries. In particular, the research program will establish pork production systems that are carbon neutral through novel research, such as the development of anaerobic digestion techniques. The research program will transform the Australian pig industry by specifically addressing critical environmental and economic issues that confront its sustainability.

The Carbon-Neutral Pork Production program specifically involves highly innovative research to maximise methane production from effluent ponds, so that collection and use of gas is economically viable. Alternative approaches to waste management will also be studied to develop solid-waste pork production systems that mitigate carbon outputs.

Currently, the majority of effluent treatment systems at Australian piggeries are uncovered anaerobic ponds. Previous research by Wiedemann et al. (2010) identified that the largest single emission source from pig production was from the anaerobic effluent treatment system, where methane ($CH_4$) is produced as the effluent breaks down in an anaerobic (without oxygen) environment.

This emission source can be mitigated and/or used by capturing the methane in a covered anaerobic pond (CAP) system and destroying it. The CAP system involves installing a geo-membrane cover, such as high density polyethylene (HDPE), low density polyethylene (LDPE) or polypropylene (PP) on an existing or purpose-built anaerobic pond. Methane is highly volatile and can be burnt with a flare, or can be used to generate heat and/or electricity in a generator or a combined heat and power (CHP) unit. Figure 1 shows an example of a biogas hot water system and heated tiles from Grantham piggery. Photos were supplied by Alan Skerman (DAFF, Qld).

Provided the methane is destroyed, the overall GHG emissions from the piggery will be reduced regardless of whether a flare or generator is used. The Department of Climate Change and Energy Efficiency (DCCEE 2011) developed a methodology under the Carbon Farming Initiative (CFI) for the destruction of methane generated from manure in piggeries. "Methodology for the destruction of methane generated from manure in piggeries". This methodology includes trapping the biogas produced by the digestion of the piggery effluent in anaerobic lagoons and the combustion of the methane component of the gas. Figure 2 shows a typical covered anaerobic pond (CAP) in Australia.

This project involves the technical and economic feasibility assessment of capturing, destroying and/or using captured biogas as an energy source at existing piggery operations. The individual assessments cover five piggeries, with a range of energy requirements and biogas capture potential. Four of the piggeries are located in Australia (two in South Australia and two in Western Australia) and one in New Zealand Piggery.

**FIGURE 1 – BIOGAS HOT WATER SYSTEM AND HEATED TILES AT GRANTHAM PIGGERY (PHOTOS COURTESY OF ALAN SKERMAN, DAFF QLD)**

**FIGURE 2 – COVERED ANAEROBIC POND (CAP) IN AUSTRALIA**

## 2. Methodology

The project was divided into a staged assessment for each piggery, which provided the operators with advice on: initial investigations regarding layout of the system; the most appropriate anaerobic digestion technology; biogas use and conditioning; digestate management; and financial modelling of the most appropriate biogas use options.

The methodology is described as follows:

**Stage 1 – Site Visit and data collection:**

This stage investigated the overall feasibility of a biogas system at the piggery and identify the most appropriate biogas use options and their financial attractiveness. Site visits were conducted at five conventional piggeries and included:

1. Pre site visit data acquisition with the collation of records on electricity and heat consumption, effluent flow and quality, existing waste management system key performance figures, feed composition and feed use.
2. Site visit and discussion of options and issues on-site, including drivers for the biogas system, regulations and problems, on-site data gathering of distances between major infrastructure e.g. distance between anaerobic pond and energy production equipment or sheds, distance to nearest electrical transformer, determination of ownership of nearby power infrastructure for resale of electricity to grid, discussion of potential collaboration options and plans for future farm expansions/modifications etc.
3. Recommendation for further information gathering (e.g. rules around connecting generators to local networks, effluent nutrient analysis etc.)

**Stage 2 – Modelling:**

Operational data collected from relevant pig production activities at each piggery were used as part of the feasibility study to model the potential methane output from each site. This stage included:

1. Modelling of expected biogas production and potential energy production, and estimation of most appropriate digester pond layout (e.g. retrofit vs. new, single vs. multiple ponds).
2. Financial modelling of the most appropriate biogas uses, including approximate costs of equipment and identification of likely legal / safety implications.
3. Investigations into maximising co-benefits of the system, e.g. GHG abatement, nutrient use/disposal, energy security etc.

**Stage 3 – Reports and presentation:**

Individual reports were prepared for the five individual participating piggeries. The reports included: data collected for the site (methane production, energy generation potential and energy use), assessment of the sites options, preliminary design of best-bet options, capital and operating costs of system, a cost benefit analysis, conclusions and recommendations.

In addition, to these reports, a presentation was prepared that explains the findings of the individual assessments and discussion on the implications.

## 3. Outcomes

The primary outcomes of the project were five individual biogas feasibility reports for the participating piggeries. In addition, a Powerpoint presentation has been prepared that presents the major findings and implications for each of the assessments - http://porkcrc.com.au/wp-content/uploads/2013/08/BEA-27-June-2013-Tait-Biogas-Pig-Industry.pdf

A summary of the production, housing and effluent management systems at the five piggeries are as follows:

***Piggery 1***

Piggery 1 is a multi-site farm located in South Australia. The piggery operates a multi-site farrow-to-finish facility with breeder, weaner and grower units. Total sow numbers are just over 1500. The breeder unit accommodates 500 of the sows on straw, while 1000 of the sows are housed in conventional effluent-based sheds. All weaners (3-11 weeks) are also housed on straw. The manure produced as the deep litter piggeries was not included in the assessment. The grow-out pigs (11-22 weeks) are housed in three separate conventional piggeries. All three grower units, plus the breeder site combined operates at approximately 11 892 SPU contributing to anaerobic ponds. The grower and breeder sheds utilise a pull plug system with the plugs pulled usually every one to two weeks on average. Piggery 1 has its own feedmill which is located at the breeder site. Piggery 1 has been operating for a number of years and the existing anaerobic ponds on site have never been de-sludged during their lifetimes.

***Piggery 2***

Piggery 2 operates a grow-out facility with pigs aged from 11 to 22 weeks and is located in South Australia. The site takes progeny from two 600 sow breeder units. Every two to three weeks, 1200 pigs enter the site, while about 1200 pigs leave the site over the same time frame, giving an average pig number of approximately 4300. The site operates at approximately 5112 SPU. Pig accommodation consists of tunnel ventilated conventional sheds with five long drains. The sheds utilise a pull plug system, with the plugs pulled usually every three weeks on average. Some flushing is also undertaken in the sheds. Piggery 2 has been operating for approximately seven years and has an existing anaerobic pond on site which has never been de-sludged during the lifetime of the piggery.

### *Piggery 3*

Piggery 3 is a 1200 sow multiplier unit (predominately breeding operation) located in Western Australia. The majority of the weaner pigs are removed from the site every two weeks and grown out by a contract grower, with approximately 380 weaned pigs (24 days of age) and approximately 380 pigs one week post weaning (31 days of age) removed from the site fortnightly. This leaves approximately 100 pigs per week to be grown out to finishing age (approximately 24 weeks). The current operating capacity is 4646 SPU. The Piggery 3 operators plan to expand the operation by doubling the number of sows onsite to 2400, with all weaned pigs from the additional 1200 sows removed from the site to be grown out by a contract grower. This will take the operating capacity to 7089SPU. Pig accommodation consists of conventional sheds with flush drains. The piggery utilises on-farm bores to supply drinking and cleaning water. The sheds are flushed with recycled water from the pond system. The operator's have recently constructed a 10.1 ML purpose built anaerobic pond, with the view to it been operated as a covered anaerobic pond.

### *Piggery 4*

Piggery 4 is a 720 sow farrow to finish piggery located in Western Australia. Pigs are weaned onto straw and remain there until 18 weeks of age. Heavy bacon pigs are then housed back in the conventional piggery until finishing age, which is approximately 23 weeks. This is equivalent to 4353 SPU housed in conventional flushed sheds. The operator's plan to expand by the operation by 500 sows as a breeder unit only (pigs to 4 weeks of age). This would result in a total equivalent to 5399 SPU housed in conventional flushed sheds. Pig accommodation consists of conventional sheds with flush drains, where heating occurs through the use of electric heat lamps. Accommodation also includes deep litter sheds, however the manure from these sheds was not included in the assessment. Pigs are kept on straw from 4 weeks of age to 18 weeks of age respectively. All breeding stock, piglets and 1800 bacon pigs are always kept on slats. There is an existing anaerobic pond on site, with an estimated volume of approximately 7.4 ML.

### *Piggery 5*

Piggery 5 is a farrow-to-finish piggery located near Auckland in New Zealand. The piggery operates 600 sows in a farrow-to-finish operation, with 26 piglets produced per sow/year. This is equivalent to 6975 SPU. Pig accommodation consists of conventional sheds, with pull plugs and flush drains. Approximately 75% of the piggery operates on a pull plug system, while the remaining 25% use a direct flush system. The piggery uses four ponds in series, plus one emergency storage pond. The final effluent discharge is by land irrigation on 120 ha of dairy pasture. Piggery 5 is keen to improve environmental performance as part of an ongoing rebuild of the piggery. Odour emissions from the site are an issue with neighbours, and the piggery is keen on implementing practical options for the reduction of odour emissions from the site.

***The main outcomes of the five studies are as follows:***

*Piggery 1*

A combined heat and power (CHP) unit was deemed the most effective method of using biogas to minimise the piggery's reliance on electricity from the grid and imported fuels such as diesel and liquefied petroleum gas (LPG). Due to the multi-site layout of Piggery 1, it is not feasible to capture and utilise all the potential energy from all possible sites to offset the entire Piggery 1 energy consumption. This is due to the large distances that exist between the sites and the difficulty, cost and administrative effort associated with pumping effluent and / or biogas over these distances, and particularly under public roads, although this has been done before at other piggeries in Australia. As the breeder site accounts for 72% of electricity and 100% of LPG and diesel consumption at Piggery 1, it was decided to examine offsetting energy usage at this site only using biogas.

Two CAP and CHP systems, namely purpose built short sludge retention CAPs and retro-fitted longer sludge retention CAPs, were examined for the following scenarios:

- Scenario 1 - Replacing the energy consumption at the breeder site with the biogas captured and utilised with the CAP and CHP system at the breeder site.
- Scenario 2 - Replacing the energy consumption at the breeder site with the biogas captured and utilised with the CAP and CHP system at the breeder site. This system will be supplemented with biogas captured at the nearest grower unit, which will be piped to the breeder site via a 2" polyethylene pipeline.

It is likely that a staged approach would be the best option for Piggery 1. Scenario 1, replacing the energy consumption at the breeder site with the energy captured and utilised from the retro-fitted long sludge retention CAP and CHP system at the breeder site would be the recommended first stage. This option would allow the offset of approximately 84% and 89% of diesel and LPG consumption respectively at the breeder site, at a lower capital investment when compared against Scenario 2. Scenario 1 has an estimated **payback period** of just over **4.2 years** and an estimated **return on investment** over ten years of **198%.** However, it should be noted that no electricity is offset in Scenario 1.

Once this system is operational, upgrading to Scenario 2 could be further explored, with replacement of the current energy use at the breeder site with biogas captured from the retro-fitted long sludge retention CAP at the breeder site, as well as biogas captured at the nearest grower unit. The implementation of this second stage would allow the offset of 100% of LPG consumption as well as 98% of its electricity and diesel consumption at the breeder site, with a likely small shortfall occurring in the winter months of July and August. A staged approach is recommended as it has less initial capital investment when compared against Scenario 2 as a stand-alone option, and allows for any teething problems with the first installation to be addressed. Progression on to Scenario 2 can then enable the breeder site to become almost 100% energy self-sufficient without making much equipment redundant. Scenario 2 as a stand-alone option has an estimated **payback period** of just over **4.4 years** and an estimated **return on investment** over ten years of **182%.**

### *Piggery 2*

The most viable option for Piggery 2 was found to be utilising the methane generated on site to produce electricity using the existing long sludge retention pond. This is due to the very low costs for earthworks associated with this option. The **payback period** for this option is **8.45 years** and the **return on investment** is **7.6%** respectively. It should be noted that the cost of desludging the existing anaerobic pond was not included as part of this study.

The possibility of exporting excess electricity to the grid was also examined. The economic feasibility was found to increase when the added expense and revenue associated with electricity export was included with the **payback period** decreasing to **5.6 years** for the retro-fitted long sludge retention CAP respectively. Discussions with local line companies to gauge whether they are willing to collaborate on such a scheme are essential before this option for additional revenue can be considered.

A simple CAP and flare system was also examined for both a purpose built short sludge retention CAP and retro-fitted long sludge retention CAP respectively as part of this study. A simple CAP and flare system is economically feasible for the retro-fitted long sludge retention pond with a **ROI of 20%** and a **payback period** of just over **7 years**. However, it should be noted that the economic feasibility of this option would rely completely on the revenue associated with Australian carbon credit units and it provides no energy to offset current energy use at the piggery. A simple CAP and flare system was found to not be economically feasible for a purpose built short sludge retention CAP with a **payback period** of over **13 years**.

### *Piggery 3*

Piggery 3 has recently constructed a 10.1 ML purpose built anaerobic pond, with the view to it being operated as a covered anaerobic pond. It should be noted that the costs associated with the purpose built pond were not included as work had been completed before the commencement of this study. This proposed CAP system was examined for the following scenarios:

- Scenario 1 - CAP and flare - capturing and flaring the potential biogas generated from the existing piggery effluent stream in the proposed CAP system. It should be noted that the economic feasibility of this option would rely completely on the revenue associated with Australian carbon credit units and it provides no energy to offset current energy use at the piggery.
- Scenario 2 - CAP and boiler (existing) – capturing the potential biogas generated from the existing piggery effluent stream in the proposed CAP system and utilising it through a boiler and hot water system to offset current LPG usage.
- Scenario 3 - CAP and boiler (expanded) – capturing the potential biogas generated from the existing piggery effluent stream in the proposed CAP system and utilising it through a boiler and hot water system to offset predicted LPG usage for the proposed expanded operation.

- Scenario 4 - CAP and flare (screen) - capturing and flaring the potential biogas generated from the existing piggery effluent stream in the proposed CAP system with a static rundown screen. However, it should be noted that the economic feasibility of this option would rely completely on the revenue associated with Australian carbon credit units and it provides no energy to offset current energy use at the piggery.
- Scenario 5 - CAP and boiler (existing) (screen) – capturing the potential biogas generated from the existing piggery effluent stream in the proposed CAP system with a static rundown screen and utilising it through a boiler and hot water system to offset current LPG usage.
- Scenario 6 - CAP and boiler (expanded) (screen) – capturing the potential biogas generated from the existing piggery effluent stream in the proposed CAP system with a static rundown screen and utilising it through a boiler and hot water system to offset predicted LPG usage for the proposed expanded operation.
- Scenario 7 - CAP and CHP (screen) – capturing the potential biogas generated from the existing and expanded piggery effluent streams in the proposed CAP system with a static rundown screen and utilising it through a CHP unit and hot water system to offset predicted LPG and electricity usage for the proposed expanded operation.

All of the scenarios, apart from Scenario 4, were estimated to be economically feasible with low payback periods, high returns on investments and high cumulative net profits after 10 years of operation.

It was concluded that Scenario 3 was the most viable scenario for Piggery 3, with a low **payback period** of **1.8 years** and a high **return on investment** of **597%.** The scenario also has a **cumulative net profit** after 10 years of **$1 185 706**.

However, if a screen is required, it is likely that a staged approach is the best option to implement at Piggery 3. Scenario 6, CAP and boiler (expanded) (screen), would be a good first step in this staged approach. Once the system is operational, the possibility of upgrading to Scenario 7, CAP and CHP (screen), can then be examined. A staged approach is recommended as it has less initial capital investment when compared against Scenario 7 as a stand-alone option and it also allows any teething problems with the first installation to be addressed.

It should be noted that gas cleaning costs were not included with any of the boiler options and this may be required if issues for slagging in the boiler become problematic.

***Piggery 4***

The most viable system for Piggery 4 is to capture and utilise methane generated on-site to produce electricity, using the proposed retro-fitted short sludge retention pond. This system is the most viable for both the current and proposed expanded operation at Piggery 4 due to the lower capital costs associated when it is compared against the purpose built long sludge retention CAP. The retro-fitted short sludge retention CAP was found to have a **payback period** of approximately **5.6 years** and a positive **return on investment** of **108%** over 10 years at the current operational capacity. These results compare favourably against the economic indicators of the purpose built long sludge retention CAP, which has a **payback period** of approximately **6 years** and a **return on investment** of **91.6%.**

Both CAP systems perform better for the expanded operation when compared against the current operation with the **payback period** decreasing to **4.7** and **5.5 years** and the **return on investment** increasing to **151%** and **109%** for the retro-fitted short sludge retention CAP and the proposed new long sludge retention CAP respectively. This increase in performance is due to the increase in VS in the system, however sludge accumulation in the pond would need to be monitored and a screen may be required in the later stages of the long sludge retention CAP project.

### *Piggery 5*

The systems under review at Piggery 5 include two CAP configurations – the first with a new purpose built pond with short sludge retention of one year and the second with the existing pond modified and covered.

It was concluded that both systems would have very similar economic feasibilities, as both systems have identical effluent streams entering them and the initial capital investments associated with each system are similar. The farm manager at Piggery 5 stated his preference to utilise an existing pond on site. Therefore, the retro-fitted longer sludge retention CAP was the only system that was modelled further.

Two options were examined for modifying and covering an existing anaerobic pond on-site. The first option examined the CAP and generator system as a stand-alone system with all costs included. The second option examined the add-on cost of the biogas utilisation equipment on its own. The biogas utilisation equipment costs were examined as an add-on cost separately, as Piggery 5 already plan to cover an existing anaerobic pond to aid in the management of odour emissions. Therefore, the cost associated with modifying and covering the existing pond was excluded for the second option.

It was concluded that a stand-alone CAP and generator system is not economically feasible for Piggery 5. However, if a CAP system is planned or required in order to manage odour emissions, the biogas utilisation equipment as a separate add-on cost is economically feasible with a **return on investment** of **64%** and a **payback period** of **7.2 years**. It should be noted that this scenario does not include the costs associated with the construction of the covered anaerobic pond.

Table 1 shows a summary of the most favourable outcomes from the five feasibility studies.

**Table 1 – Summary of most favourable outcomes from the feasibility studies**

| Piggery | SPU number | Type of piggery | Total capital cost ($) | Payback period (years) | ROI (10 years) (%) |
|---|---|---|---|---|---|
| **Piggery 1** | 11 892 | Multi-site farrow- | 410 935 | 4.2 | 198 |

| | | | | | |
|---|---|---|---|---|---|
| | | to-finish | | | |
| **Piggery 2** | 5112 | Grow-out | 279 448 | 8.45 | 7.6 |
| **Piggery 3** | 7089 (expanded) | Sow multiplier unit | 170 179 | 1.8 | 597 |
| **Piggery 4** | 5399 (expanded) | Farrow-to-finish | 345 636 | 4.7 | 151 |
| **Piggery 5** | 6975 | Farrow-to-finish | 298 319 | 7.2 | 64 |

## 4. Application of Research

The findings from this research indicates that piggeries have the potential to capture and utilise biogas to minimise piggeries' reliance on electricity from the grid and / or imported fuels such as diesel and liquefied petroleum gas (LPG). There is the possibility for the commercialisation of this biogas utilisation system, with the potential for this technology to be adopted by more piggeries.

As noted from Section 3 of this report, there are potential benefits to the cost of production with the potential to offset all or a proportion of associated energy consumption with the installation of a biogas capture and utilisation system for the 5 case studies.

At present, biogas capture and utilisation systems are currently been successfully undertaken by other producers across Australia. As CFI compliance and access to the required equipment becomes easier and cheaper, more piggeries across Australia will be able to successfully adopt biogas capture and utilisation technology.

It is advisable that each piggery commission a cost benefit and feasibility analysis before any biogas utilisation system was installed due to the variety of factors that affect both the practical and economic feasibility of such a system as part of their operation.

# 5. Conclusion

The findings from this research indicate that there is potential of capturing and utilising biogas to minimise piggeries' reliance on electricity from the grid and / or imported fuels such as diesel and liquefied petroleum gas (LPG).

The five case studies have all been shown to be economically feasible with each piggery having short payback periods between 1.8 and 7.2 years and delivering a substantial positive return on investment over a 10-year project life. At present, there are also biogas capture and utilisation systems currently been successfully undertaken by other producers across Australia.

The research indicates that biogas capture and utilisation technology can be successfully adopted at piggeries. However, all piggeries are different and care should be taken when interpreting these results. Each piggery would require an individual cost benefit and feasibility analysis before any biogas utilisation system was installed due to the variety of factors that affect both the practical and economic feasibility of such a system. These factors include but are not limited to piggery size and energy demand and cost. There may however be other drivers for piggeries to capture and destroy biogas, such as for odour reduction.

# 6. Limitations/Risks

The research indicates that biogas capture and utilisation technology can be successfully adopted at piggeries. This research is supported by producers who have successfully adopted biogas and capture technology at piggeries across Australia. However, all piggeries are different and care should be taken when interpreting these results and it is advisable that piggeries undertake individual cost benefit and feasibility studies before any biogas utilisation system was installed due to the variety of factors.

The other risk for piggery operators is a reduction in potential revenue from an operation. Electricity prices will certainly continue to increase, thus the revenue (offset of grid electricity) from this stream will continue to increase. However, economic assessments should be undertaken with the scenario of a relatively conservative or even no income from carbon offsets in case this revenue stream is reduced or disappears in the future.

Costs for scrubber media are considered to be uncertain at this stage but may be substantial. The cost of scrubber media can have a dramatic effect on the feasibilities of a biogas utilisation project. The Pork CRC has commissioned further research to address scrubber media costs in a separate project developing low-cost alternatives to commercially supplied scrubbing media.

There is also uncertainty involved with the reconstruction costs associated with retro-fitting and covering existing anaerobic ponds for use in biogas utilisation projects. These costs can vary greatly and can also have dramatic effects on the feasibilities of biogas utilisation projects.

It should be noted that each piggery would require an individual cost benefit and feasibility analysis before any biogas utilisation system was installed due to the variety of factors that affect both the practical and economic feasibility of such a system. The feasibility of installing a biogas utilisation system can depend on factors such as:

- size of piggery (number of SPU)
- type of piggery (breeder or grower with more potential biogas generated at grower units as compared against breeder and weaner units)
- effluent management system (pull plug or flushing – some organic matter is degraded in a pull plug system prior to exiting the sheds, which leads to a loss of biogas potential compared to an identical piggery with direct flush system)
- feed ration
- site layout (whether or not the piggery is a multi-site operation)
- energy demands and whether there is a feedmill on site
- energy cost
- type of electricity supply (3-phase power gives the potential to sell excess electricity generated from biogas capture back to the grid)
- location (different states have different legislative requirements)
- government incentives.

The above list is just a summary and does not include all factors that may affect the practical and economic feasibility of installing a biogas utilisation system at piggeries. Therefore, before such a system can be adopted, it is imperative that an individual feasibility analysis is undertaken at the piggery.

## 7. Recommendations

This work showed that biogas use at piggeries can be highly feasible and beneficial to pork production. To facilitate uptake across the Australian and New Zealand piggery industries, it is recommended that:

- more farms assess biogas feasibility for their respective operations;
- that the benefits and opportunities be more widely marketed through existing communication pathways;
- that the projects assessed in this work be further progressed to refine the cost estimates and project scope; and
- that industry bodies work with producers to identify and secure suitable capital funding to further boost biogas projects.

## 8. References


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