Australian Government
Department of Agriculture

AUSTRALIAN Pork™

A Review of Australian Regulations and Standards for the Handling and Treatment of Biogas

Final Report
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Disclaimer

This report has been prepared in accordance with good professional practice and all reasonable steps have been taken by Prime Consulting International (Australia) Pty Ltd to ensure that the information contained in this report is accurate. However, those considering installing an on-farm biogas plant should seek appropriate independent advice from the office of the gas regulator and environment protection authority in their state.

Scope

This literature review collates the various state and territory Acts, Regulations and Policies that apply to the on-farm production and use of biogas. It is intended that this review will act as an important umbrella document for other related research activities such as the exploration and development of improved management strategies and technologies to enhance the waste management systems currently being used in the pork industry.

The key objectives of this review are to complete:

1. A literature review on the current state and territory legislative requirements with respects to on-farm biogas generation and use; and

2. A literature review on current international practice with respects to on-farm biogas generation and use.

The environmental legislation considered in this review only covers the actual on-farm biogas installation and associated equipment. The scope of this review does not cover environmental legislation that encompasses licensing requirements for the piggery operation or other non-biogas related activities such as waste management.

Furthermore, whilst not covered in the scope of this review, compliance with state and territory occupational health and safety legislation obviously must be included as part of the planning process when considering installing an on-farm biogas plant.

1.0 Executive Summary

Biogas is generated when bacteria degrade biological material in the absence of oxygen, in a process known as anaerobic digestion. Evidence suggests that biogas has been used for centuries, with reports indicating that biogas was used for heating bath water in Assyria early in the 10th century B.C. and anaerobic digestion possibly having been applied to covered sewage tanks in ancient China as far back as 2000–3000 years ago.

In addition to the use of biogas as a sustainable energy source, interest in anaerobic digestion and in particular biogas capture has been traditionally driven by environmental outcomes. In the majority of cases in Europe, a financial grant ranging from 20-40% of the capital cost has been provided through Government assistance programs to reduce the financial burden of debt servicing. The United Kingdom and North America are developing their respective biogas industries with mainly farm-based systems and a small number of larger centralised plants. The Government from each country provides some form of support to develop the local biogas industry through a variety of funding schemes and legislation.

Conversely, Australia has a low population density, large land mass and a warm to hot climate. To establish a centralised digestion plant in Australia that is economically successful will be challenging. The long distances between significant sources of organic waste will result in high transport costs to and from the plant. To be economic the plant would also have to have a demand for the heat generated that either offsets costs or provides a sales return. Apart from the spot price electricity market and the renewable energy certificates (RECs) system, there is no incentive to sell electricity that is generated from a renewable energy source on the Australian market.

In Australia, the capture and use of biogas is a relatively new trend, which understandably is being led by the intensive livestock industries, which followed the development of landfill gas and biogas capture from sewage plants. Farm-scale systems eliminate transport costs and potentially the heat generated can be used on farm to provide heat to a pig-breeding. Most importantly for smaller farms, the cost of installing a farm based tank digestion system is likely to be prohibitive and a covered anaerobic lagoon with gas flaring or energy recovery is a more practical option.

Australian Pork Ltd commissioned this review as a result of increasing interest in biogas capture and use from within the pig production industry. The industry currently does not have a 'handbook' on biogas regulations and standards available to producers. Furthermore, experience from early adopters indicates that there is a wide variation between the states and territories on how biogas production is currently being regulated.

Accordingly, this review details the various regulations and standards for biogas production and use across Australia. The review also covers a selection of international regulations and standards to enable comparison. Ultimately, this review should commence the process of developing a national standard for on-farm biogas generation and consumption.

Principally, biogas is a mixture of methane (CH_4) and carbon dioxide (CO_2). As a rule of thumb, typically biogas would consist of 70% methane and 30% carbon dioxide. However, there are a number of other gases and water, in very small quantities, that make up the final composition of biogas. Biogas can be used for heating, to produce electricity or used in replacement of traditional petroleum based fuels to drive equipment, thus allowing farmers to take advantage of new markets for traditional waste products.

In Australia, the Gas Technical Regulators Committee (GTRC), an association of Government Departments, is responsible for the safe use of gas. The Committee includes representatives from every state and territory in Australia and New Zealand. However, the reality of the situation is that each state and territory within Australia (as well as New Zealand) has its own legislation in the form of Acts, Regulations and Policies that underpin gas safety. The end result is that there are differences in gas safety regulation and combined with difficulties in establishing contact with the correct person in the right department, this often leads to confusion and/or conflicting advice with respects to biogas.

Published Australian Standards set out the minimum safety requirements and current industry practice. Where referred to in legislation, these standards become law and must be complied with. The Australian Standards of relevance to on-farm biogas installations are:

- AS 1375 – Industrial Fuel Fired Appliances Code
- AS 2885 – Pipelines—Gas and liquid petroleum
- AS 3814 – Industrial and Commercial Gas-fired Appliances
- AS 4041 – Pressure Piping
- AS 4130 – Polyethylene (PE) pipes for pressure applications
- AS 5601 – Gas Installations

In New South Wales, Northern Territory, Queensland Tasmania and Victoria the legislation covers installations and appliances using any fuel gas, but in the other states legislation only covers installations and appliances that use gas from a commercial network. Regardless, where a flare is installed and is using a LPG pilot light, gas would be regulated by gas safety legislation in all states.

As with gas safety, each state and territory has its own legislation regarding air quality and emissions and fortunately all states have clear policy guidelines on air quality and emissions; albeit accurately determining emission levels is subjective and potentially expensive. Furthermore, farm-scale biogas production plants do not trigger any licensing requirements and the conversion of methane to carbon dioxide in the gas burning process is regarded favourably.

However, rising energy costs and the growing consciousness of biogas as a readily available alternative energy source, combined with the inexpensive nature of covered pond-based installations, have rapidly spawned a new industry in recent times and gas regulators across the world appear to have been left behind.

The overall result is a current state of confusion. Biogas is not specifically mentioned in any current legislation, which makes the task of determining the applicability of regulations more difficult combined with conflicting information regarding regulations for industrial and gas supply chain networks versus other non-networked gas requirements.

In some cases government officials did not know what legislation applied (if any) to on-farm biogas installations. Whilst with some state and territory departments, numerous and repeated phone calls and emails were needed to secure an appropriate response.

There are examples of old and most likely outdated draft policies being used as guidance documents as well as drafts referring to repealed legislation. Furthermore, departmental websites are not being updated in a timely manner and therefore providing incorrect information. With one state, the responsible department was been incorrectly listed.

It is clear that, in the absence of legislation which specifically deals with biogas production, use and safety, regulators in Australia (except in New South Wales) have chosen two distinct paths:

1. Default to petroleum and/or high pressure gas based legislation; or

2. Leave biogas production unregulated (apart from the compliance with Australian Standards).

Neither regulatory path provides a satisfactory outcome as leaving biogas installations unregulated provides an opportunity for shortcuts to be taken and potentially leaves operators at risk of harm. While the highly regulated regime applied to petroleum gas production (and associated networks) is far too prescriptive and burdens on-farm production sites with comparably high compliance costs. Simply applying current (hydrocarbon-based fuel gas) regulations to on-farm biogas systems without addressing the specific risks of the smaller systems is unreasonable, and results in onerous, costly and inappropriate over regulation of on-farm biogas systems. Furthermore, confusion over applicable regulations, the associated costs and over regulation may lead to a lack of uptake of a potentially economically viable and environmentally beneficial proposition for many producers.

Internationally, it appears that the only standardised resource on biogas safety for agriculture is from Germany. However, the Canadian Standards Association is planning to develop a biogas standard which will focus on the standardisation of biogas generation and utilisation, and Standards New Zealand is also considering a revision of their 1987 Code of Practice for the Production and Use of Biogas.

It would seem that a logical step would be to develop an international approach to on-farm biogas regulations and standards. In doing so, allowances can be made for differences in specific production systems (i.e. digester versus covered pond). At the very least a joint Australia/New Zealand Standard for the on-farm production and use of biogas should be pursued and aligned with the revised Australian Standard 5601 for gas installations.

In the meantime, producers planning to construct a biogas plant on their farm are strongly advised to consult with the appropriate local and state-based regulatory authorities as the first stage in the planning process. This will facilitate their production plant being approved, certified and ultimately able to be commissioned.

2.0 Introduction

Biogas is generated when bacteria degrade biological material in the absence of oxygen, in a process known as anaerobic digestion (Harris, 2010). Volta is generally recognised as putting anaerobic digestion on a scientific footing. He concluded as early as 1776 that the amount of gas that evolves is a function of the amount of decaying vegetation in the sediments from which the gas emerges and that in certain proportions, the gas obtained can become volatile once mixed with air (Marchaim, 1992). However, the high methane content ensures that biogas has an in-built safety feature; it is lighter than air. Accordingly, biogas will rise up into the air and away from equipment and personnel if accidentally released.

Evidence suggests that biogas has been used for centuries with reports indicating that biogas was used for heating bath water in Assyria early in the 10th century B.C. and anaerobic digestion was possibly applied to sewage in ancient China with the 13th-century adventurer Marco Polo reporting that covered sewage tanks were used in China probably as far back as 2000–3000 years ago (He, 2010).

Anaerobic digestion is basically a simple process carried out in a number of steps that can use almost any organic material as a substrate. It occurs in digestive systems, marshes, rubbish dumps, septic tanks and the Arctic Tundra. Conventional anaerobic digestion has been a 'liquid' process, where waste is mixed with water to facilitate digestion, but a 'solid' process is also possible, as occurs in landfill sites (Harris, 2010).

In addition to the use of biogas as a sustainable energy source interest in anaerobic digestion, and in particular biogas capture, has been traditionally driven by environmental outcomes. This is particularly evident in the EU where the European Parliament adopted a non-legislative resolution on sustainable agriculture and biogas and determined a need to review EU legislation in March 2008 (European Parliament, 2008a). The EU resolution was followed shortly by new waste legislation that mandated targets for re-use and recycling of waste by 2020 (European Parliament, 2008b). The European Parliament is now currently debating the need for separate biowaste legislation that would prohibit any biowaste from entering landfill (European Parliament, 2010).

However, in the majority of cases in Europe a financial grant ranging from 20-40% of the capital cost has been provided through Government assistance programs to reduce the financial burden of debt servicing. Furthermore and having observed the progress in Europe, the United Kingdom and North America are developing their respective biogas industries with mainly farm-based systems and a small number of larger centralised plants. The Government from each country provides some form of support to develop the local biogas industry through a variety of funding schemes and legislation (Poad & McGahan, 2010).

Conversely, Australia has a low population density, large land mass and a warm to hot climate. To establish a centralised digestion plant in Australia that is economically successful will be challenging. The long distances between significant sources of organic waste will result in high transport costs to and from the plant. To be economic the plant would also have to have a demand for the heat generated that either offsets costs or provides a sales return. Community heating schemes, which are a convenient heat demand for the European biogas plants do not exist in Australia. Apart from the spot price electricity market and the renewable energy certificates (RECs) system, there is no incentive to sell electricity that is generated from a renewable energy source on the Australian market (Poad & McGahan, 2010).

In Australia, the capture and use of biogas is a relatively new trend, which understandably is being led by the intensive livestock industries, which followed the development of landfill gas and biogas capture from sewage plants.

Farm-scale systems eliminate transport costs and potentially the heat generated can be used on farm to provide heat to a pig-breeding unit. Most importantly for smaller farms, the cost of installing a farm based tank digestion system is likely to be prohibitive and a covered anaerobic lagoon with gas flaring or energy recovery is a more practical option (Poad & McGahan, 2010).

Australian Pork Ltd commissioned this review as a result of increasing interest in biogas capture and use from within the pig production industry. The industry currently does not have a 'handbook' on biogas regulations and standards available to producers. Furthermore, experience from early adopters indicates that there is a wide variation between the states and territories on how biogas production is currently being regulated and therefore there are large differences between states over plant certification requirements.

Accordingly, this review details the various regulations and standards for biogas production and use across Australia. The review also covers a selection of international regulations and standards to enable comparison. Ultimately, this review should commence the process of developing a national standard for on-farm biogas generation and consumption.

3.0 Biogas Composition and Use

3.1 Biogas composition

Because of its energy potential, anaerobic digestion has been studied for decades and the process is now well known (Marcatoa, *et al.* 2009). However, the composition of biogas and the rate of production depend on many factors such as the nature of the organic material, process, temperature and air leakage (Wootton, 2008).

Principally, biogas is a mixture of methane (CH_4) and carbon dioxide (CO_2). As a rule of thumb typically biogas would consist of 70% methane and 30% carbon dioxide. However, there are a number of other gases and water, in very small quantities, that make up the final composition of biogas (refer Table 3.1).

Table 3.1 Biogas composition

Compound	**Chemical Formula**	**Percentage**
Methane	CH_4	40-75%
Carbon Dioxide	CO_2	25-55%
Hydrogen Sulphide	H_2S	50-5000ppm
Ammonia	NH_3	0-1%
Water	H_2O	0-10%
Nitrogen	N_2	0-5%
Oxygen	O_2	0-2%
Hydrogen	H_2	0-1%

Source: Renewable Energy Concepts 2010

3.2 On-farm biogas use

With its physical and chemical properties close to those of natural gas, albeit with a lower methane content, small scale on-farm biogas can be used for heating, to produce electricity or used in replacement of traditional petroleum based fuels to drive equipment (Pipatmanomaia, *et al.* 2009) thus, providing farmers the ability to convert biogas into energy and offset the effects of increasing energy costs.

Ultimately, livestock waste-to-bioenergy treatments have the potential to convert the treatment of livestock waste from a liability or cost component into a profit centre that can:

1. Reduce energy inputs;
2. Reduce reliance on electricity grids;
3. Reduce greenhouse gases; and
4. Potentially diversify farm income through RECs.

4.0 National Gas Standards

4.1 Gas Technical Regulators Committee

In Australia, the Gas Technical Regulators Committee (GTRC), an association of Government Departments, is responsible for the safe use of gas. The Committee includes representatives from every state and territory in Australia and New Zealand. The Committee covers the transportation of gas from the producer through cross country pipelines and distribution networks to the gas appliance (Gas Technical Regulators Committee, 2010a).

The purpose of the GTRC is to provide benefits to Australian and New Zealand Governments, industry and the public by:

- Promoting safety in all aspects of gas transportation, storage and use;
- Developing and maintaining a consistent regulatory environment and a consistent and common approach between jurisdictions to gas technical and safety activities;
- Benchmarking to identify best practices;
- Sharing information for the purpose of achieving effective and efficient safety and technical regulatory practice covering the gas industry, and
- Providing a forum and discussion group to facilitate reform and harmonisation by implementing consistent approaches and provide a platform for direct peer to peer liaison (Gas Technical Regulators Committee, 2010b).

Of note a new Gas Safety Certification Mark (refer Figure 4.1) will be required to be attached to all new gas appliances from 2012 to allow consumers to know the product is safe to use. This Mark replaces the older stickers from AGA, SAI Global, IAPMO and Global-Mark.

Figure 4.1 New Gas Safety Certification Mark

However, the reality of the situation is that each state and territory within Australia (as well as New Zealand) has its own legislation in the form of Acts, Regulations and Policies that underpin gas safety. The end result is that there are differences in gas safety regulation and these will be highlighted below in the Section 5.

Importantly, differences between state and territory regulations, combined with difficulties in establishing contact with the correct person in the right department, often led to confusion and/or conflicting advice, even when contact was made with the correct person.

4.2 Type A gas appliances

A Type A gas appliance is an appliance which is approved, such as under the Australian Gas Association approval scheme. This generally includes mass-produced domestic and commercial gas appliances (ACT Planning & Land Authority, 2010).

4.3 Type B gas appliances

A Type B gas appliance is an appliance with gas consumption in excess of 10MJ/h for which an Australian Gas Association approval scheme does not exist. This generally includes individually built industrial gas-fired appliances (ACT Planning & Land Authority, 2010). In some states, on-farm biogas installations are likely to be determined to be using a Type B appliance even if they do not exceed the 10MJ/H consumption trigger point requirement *simply* because there is no Australian Gas Association approval scheme for biogas plants.

4.4 Australian Standards

Published standards set out the minimum safety requirements and current industry practice. Where referred to in legislation, these standards become law and must be complied with (Gas Technical Regulators Committee, 2010b).

The Australian Standards of relevance to on-farm biogas installations are:

- AS 1375 – Industrial Fuel Fired Appliances Code
- AS 2885 – Pipelines—Gas and liquid petroleum
- AS 3814 – Industrial and Commercial Gas-fired Appliances
- AS 4041 – Pressure Piping
- AS 4130 – Polyethylene (PE) pipes for pressure applications
- AS 5601 – Gas Installations

Biogas is not specifically mentioned in any of the Standards (in fact most standards refer to or are referring to hydrocarbon fuel gases) and this does lead to ambiguity over whether biogas is captured by the Standard, especially when it is small-scaled farm-based produced. Nevertheless, they remain extremely relevant because every state and territory has an expectation that individual Standards (where applicable) are being met, regardless of whether specific state or territory legislation refers to it or not. Although, further difficulties often arise from trying to determine the relevant sections of the Standards that need to apply to on-farm biogas generation.

Most importantly, some state and territory legislation refers to *specific* Australian Standards, whilst others do not. Accordingly, reviewing local legislation should always be the starting point.

4.4.1 AS 1375 – Industrial Fuel Fired Appliances Code

This standard sets out the safety principles relating to the design, installation, and operation of industrial appliances that involve the combustion of gas or oil, or other fuel in air suspension, or the generation of combustible vapours in such appliances.

4.4.2 AS 2885 – Pipelines—Gas and liquid petroleum

AS 2885 applies to steel pipelines and associated piping and components that are used to transmit single-phase and multi-phase hydrocarbon fluids, such as natural and manufactured gas, liquefied petroleum gas, natural gasoline, crude oil, natural gas liquids and liquid petroleum products.

4.4.3 AS 3814 – Industrial and Commercial Gas-fired Appliances

This Standard provides minimum requirements for the design, construction and safe operation of Type B appliances that use town gas, natural gas, simulated natural gas, liquefied petroleum gas, tempered liquefied petroleum gas or any combination of these gases either together or with other fuels.

4.4.4 AS 4130 – Pressure Piping

This Standard sets out minimum requirements for the materials, design, fabrication, testing, inspection, reports and pre-commissioning of piping subject to internal pressure or external pressure or both. Specific requirements are given for piping constructed of carbon, carbonmanganese, low alloy and high alloy steels, ductile and cast iron, copper, aluminium, nickel, titanium and alloys of these materials.

4.4.5 AS 4130 – Polyethylene (PE) pipes for pressure applications

AS 4130 specifies requirements for polyethylene pipes for the conveyance of fluids under pressure. Such fluids include, but are not restricted to, water, wastewater, slurries, compressed air, and fuel gas. Fuel gas includes natural gas, liquefied petroleum gas (LPG) in the vapour phase and LPG/air mixtures.

4.4.6 AS 5601 – Gas Installations

This Standard sets out requirements for consumer piping, flueing, ventilation and appliance installations which are associated with the use or intended use of fuel gases such as town gas, natural gas, liquefied petroleum gas in the vapour phase, tempered liquefied petroleum gas, simulated natural gas or any similar substance.

The requirements *"cover piping systems from the outlet of—*

a) the consumer billing meter installation; or
b) the first regulator on a fixed gas installation where an LP Gas container is installed on the same site; or
c) the first regulator on site (if no meter is installed) where LP Gas is reticulated from storage off the site;

to the inlet of the appliance".

It should be noted that the Gas Installations Standard has just been completely rewritten. Whilst the new Standard contains major changes, the most relevant change is the specific inclusion of biogas to remove any ambiguity. The final technical draft is now completed and has been signed of by the GTRC, and currently before the technical editors at the Standards Association of Australia. The new Standard will be published before the end of 2010 and there will be road shows throughout the country in 2011 (Patience, 2010).

5.0 State/Territory Gas Safety Regulation

5.1 Overview

As mentioned previously, each state and territory has its own legislation in the form of Acts, Regulations and Policies covering gas installations and gas safety. Where legislation concerning biogas installations could not be found via a literature search or was of an uncertain nature, then phone and email contact was instigated in order to attempt to clarify the position.

Despite a concerted effort, in some cases determining the regulations around biogas could not be ascertained because departmental staff contacted did not know themselves. In noting that most use solar activated ignition systems and therefore not captured by any regulations however, if a LPG pilot light ignition system was used (for example with a flare), then individual state and territory legislation would be applicable and full compliance with the national standards is required by every state and territory regardless.

5.2 New South Wales

In New South Wales, the principal piece of legislation is the Gas Supply Act 1996. The objects of the Act are:

> *"(a) to encourage the development of a competitive market in gas, so as to promote the thermally efficient use of gas and to deliver a safe and reliable supply of gas in compliance with the principles of ecologically sustainable development contained in section 6 (2) of the Protection of the Environment Administration Act 1991,*
>
> *(b) to regulate gas reticulation and gas supply, so as to protect the interests of customers and to promote customer choice in relation to gas supply,*
>
> *(b1) to facilitate the continuity of supply of natural gas to customers, and*
>
> *(c) to promote the safe use of gas."*

Industry and Investment New South Wales is charged under the Act to administer objectives (a), (b) and (b1) above through the Gas Supply (Natural Gas Retail Competition) Regulation 2001and Gas Supply (Safety and Network Management) Regulation 2008. However, these regulations only apply to a gas supply network and therefore do not affect on-farm biogas plants.

The Gas Supply Amendment Regulation 2010 changed the responsibly for objective (c) from the WorkCover Authority of New South Wales to New South Wales Fair Trading on 3 September 2010. The 2010 Regulation also repealed the Dangerous Goods (Gas Installations) Regulation 1998 and amended the Gas Supply (Consumer Safety) Regulation 2004 to include gas installations. The transfer of responsibility to New South Wales Fair Trading does seem odd, but given it only occurred very recently, more time is needed before comment on the appropriateness of the transfer can be made.

Furthermore, the recent change has led to conflicting information being provided. The WorkCover Authority of New South Wales' website has not been updated and reports that WorkCover is still administering the Dangerous Goods (Gas Installations) Regulation 1998 (WorkCover Authority of New South Wales, 2010).

While the above is not helpful and regardless of the fact that biogas is not specifically mentioned in the amended Regulation, *Part 6 – Gas installations (not supplied from a gas network)* is the relevant section to consult to ensure the correct testing and certification requirements are completed, as biogas installations that operate under 200 kPa are captured by amended the Gas Supply (Consumer Safety) Regulation 2004 (Bushel 2010).

5.3 Northern Territory

In the Northern Territory gas safety is covered under the Dangerous Goods Act 2009 and Dangerous Goods Regulations 2010. NT WorkSafe, the administrative and regulatory arm of the Northern Territory Work Health Authority, is responsible for the Territory-wide regulation of occupational health and safety, dangerous goods, electrical safety, and rehabilitation and workers' compensation.

On-farm biogas production is covered under the Dangerous Goods Act 2009 and Dangerous Goods Regulations 2010. The applicable legislation is Part 3 of the Regulations *'Class 2 dangerous goods (gases)'*. Furthermore, the general licensing requirements for the manufacture and storage of dangerous goods, is covered in Section 3 and 4, respectively of the Regulations (Currington, 2010).

5.4 Queensland

Biogas production and safety in Queensland is regulated under the Petroleum and Gas (Production and Safety) Act 2004. The purpose of this Act is to facilitate and regulate the carrying out of responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel gas industry. It specifically *'regulates and promotes the safety of persons in relation to an operating plant'*.

On-farm biogas production and use is classified as an 'operating plant' under the Act and therefore regulated in Queensland under the Act and the Petroleum and Gas (Production and Safety) Regulation 2004[1], which imposes a higher level of compliance than, arguably, is required for an on-farm biogas installation.

The Petroleum and Gas Inspectorate within the Department of Employment, Economic Development & Innovation is Queensland's competent authority and should be consulted directly before commencing any work on a biogas production plant.

There is a two-stage approval and certification process in Queensland. The Department has a guideline which outlines the process required. The *Gas Work Authorisation (Industrial Appliances) - Guideline to apply for and conduct work under a Gas work authorisation (industrial appliances)* can be downloaded from the Department's website. In addition an *Application for a Gas Work Authorisation* will need to be downloaded, completed and the applicable fee paid.

Finally the *SafeOP for petroleum and gas – Self-audit tool for compliance with legislative requirements* will needed to be downloaded and completed before certification can be provided.

[1] The 2004 Regulation was significantly amended on 30 June 2010 and accordingly it is critical to ensure a recent copy of the Regulation is obtained.

5.5 South Australia

South Australia's principal legislation is the Gas Act 1997. The objects of this Act are—

"(a) to promote efficiency and competition in the gas supply industry;

(b) to promote the establishment and maintenance of a safe and efficient system of gas distribution and supply;

(c) to establish and enforce proper standards of safety, reliability and quality in the gas supply industry;

(d) to establish and enforce proper safety and technical standards for gas installations and appliances; and

(e) to protect the interests of consumers of gas."

Whilst safety and technical issues involving gas installations are covered under Part 4 of the Gas Regulations 1997, neither the Act nor Regulations are applicable to an on-farm biogas facility in South Australia, unless a LPG pilot light is being used (Patience, 2010).

5.6 Tasmania

The applicable legislation in Tasmania is the Gas Act 2000 and Gas (Safety) Regulations 2002. Specifically, a Safety Management Plan pursuant to Sec 77 of the Gas Act 2000 and Regulation 46 (d & g) of the Gas Safety Regulations 2002 is required for an on-farm biogas installation.

The Office of the Director of Gas Safety within the Office of Workplace Standards which is part of the Department of Justice administers the Act and Regulations and should be contacted before commencing a biogas installation. The Office has a *Guideline for the preparation of a submission for the acceptance of Gas Installation (major) "safety management plan"*. Although this document is still in draft, proponents are advised to review this guideline at the earliest opportunity.

5.7 Victoria

As with other states, Victoria has a Gas Safety Act 1997. The main purpose of the Gas Safety Act is to make provision for the safe conveyance, sale, supply, measurement, control and use of gas and to generally regulate gas safety.

In February 2008, the Gas Safety (Gas installation) Regulations 2008 came into effect. The objectives of these Regulations are—

"(a) to provide for standards for gasfitting work;

(b) to provide for the procedures relating to the acceptance of appliances and gas installations; and

(c) to make provision generally in relation to the safety of gas appliances, gas installations and work on gas appliances and installations."

A number of changes were made from the previous regulations and in particular, to the acceptance by Energy Safe Victoria (ESV) of complex gas installations and Type B appliances (Energy Safety Victoria, 2010a). Accordingly, ESV is now the competent authority charged with administering the

Act and Regulations and should be contacted before commencing any work on a biogas production plant. Importantly, it should be noted that that where biogas is simply being captured and vented to the air, ESV jurisdiction does not apply.

ESV's jurisdiction applies when a biogas plant is capturing the gas and then piping it to either a Type B appliance or another farm process, (e.g. for heating sheds). For Type B installations that are providing heating and electricity, the gasfitting line to that appliance (or appliances) would be a 'complex gas installation' and the first step in the process is the requirement for a licensed gasfitter to submit a Start Work Notice to ESV at least 48 hours before commencing the job (Cannizzo, 2010).

The entire eight-step process for obtaining authorisation and certification is detailed in *Schedules 7, 8, 9, 10 and 11* of the 2008 Regulations and documented on ESV's website, as are the relevant *Gas Installation Application Forms*. Nevertheless, the key points to note when installing a Type B appliance and/or a complex gas installation are:

1. Ensure that all relevant information has been supplied at least a month before gas is required.

2. Ensure that the information has been accepted before gas is required for commissioning.

3. Ensure a Gasfitting Notice has been submitted at least 48 hours prior to commissioning.

4. At least seven days before hand over of the appliance to the customer/user is required ensure that an appointment has been made with an OGS inspector for a specific date prior to the handover to witness any tests.

5. Ensure that any relevant tests have been or can be witnessed by the OGS inspector.

6. When accepted by the OGS, an appliance will have an acceptance label allocated. This must be attached to the appliance before handing over to the customer/user.

7. Any installation of a Type B appliance is a "complex gas installation". Gasfitting Notices must be provided for both the consumer piping installation and the appliance.

8. Special conditions apply for steel welding work, fusion jointing of polyethylene pipe, hot tapping and installation work over 200kPa gas pressure (Energy Safe Victoria, 2010b).

ESV also has *Draft Landfill / Biogas Flare Systems Guidelines* to assist with the design of landfill and biogas flare safety and control systems, in order to ensure compliance with a number of safety features that are considered as minimum requirements. The guideline covers the following important aspects of the landfill or biogas, under the following headings:

- Design, Construction And Operation Of The Gathering System
- Design, Construction And Operation Of The Gas Treatment Facility
- Design, Construction And Operation Gas Flare System and
- Operating And Maintenance Of The Overall Facility (Energy Safe Victoria, 2005)

It should be noted however that the Guideline was written in 2005 and still remains as a draft. Furthermore, ESV refers applicants to the schedules under the old Safety (Gas Installations) Regulations 1999, which were repealed by the more recent Gas Safety (Gas installation) Regulations 2008. Nevertheless, the Guideline is a useful resource and should be referred to when planning an on-farm biogas installation in Victoria.

5.8 Western Australia

In Western Australia the applicable Act is the Gas Standards Act 1972. This Act sets out the standards of purity, pressure and safety of gas supplied, the inspection of gas installations, the regulation of the practice of gasfitting (including licensing), the approval of gas appliances and extensive regulation-making powers. The subordinate legislation is the Gas Standards (Gasfitting and Consumer Gas installations) Regulations 1999. Gas installation work is principally regulated by the 1999 Regulations, which provides for licensing of gas fitters and authorisation holders (Department of Commerce, 2010).

There are no regulations where an owner/operator produces and consumes biogas on the same site. However, should the gas be consumed on a different location from where it was produced (e.g. piped to a neighbouring farm) then the gas installation would need to be certified in accordance with the 1999 Regulations (Robertson, 2010).

6.0 State/Territory Environmental Protection

6.1 National

As outlined in the Scope, the environmental legislation considered in this review only covers the actual on-farm biogas installation and associated equipment. The scope of this review does not cover environmental legislation that encompasses licensing requirements for the piggery operation or other non-biogas related activities such as waste management.

Australian Pork Ltd recently published the second edition of the National Environmental Guidelines for Piggeries, which covers the regulations and reporting requirements for gaseous emissions from piggeries. While greenhouse gas emissions from agriculture are currently excluded from any national reporting requirement, reducing agricultural emissions will assist Australia to meet its national emissions reduction targets (Department of Climate Change and Energy Efficiency, 2010). Regardless of agriculture's exclusion, the Australian pig industry is taking a proactive approach to improve its environmental credentials and reduce its carbon footprint. It is for that reason biogas capture and utilisation, or conversion to carbon dioxide (via flaring) has a significant role to play.

As with gas safety, each state and territory of Australia has its own legislation, polices, codes of practice and guidelines regarding air quality and emissions. An activity that has a potentially significant environmental impact will be regulated and usually by the respective environmental protection authority.

6.2 New South Wales

The Protection of the Environment Operations Act 1997 is the key piece of legislation in New South Wales. The subordinate legislation, the Protection of the Environment Operations (Clean Air) Regulation 2010 is set to repeal the current Protection of the Environment Operations (Clean Air) Regulation 2002 soon. The Department for Environment, Climate Change and Water administers the Act and Regulations.

Pertinent to the flaring of biogas is Part 4 of the Regulation which covers the *Emission of Air Impurities from Activities and Plant*. Furthermore, the relevant standards of concentration for emissions from both new and existing flares, afterburners and vapour recovery units are specified in Schedule 2 of the Regulation. However, for flares this is limited to particulate emissions from flares with a larger capacity than those most likely to be installed on farms.

6.3 Northern Territory

Natural Resources, Environment, The Arts and Sport (NRETAS) is the Northern Territory's competent authority charged with administering the Waste Management and Pollution Control Act 2009. Whilst NRETAS does issue licences to regulate activities under Schedule 2 of the Act, on-farm biogas emissions are not included.

6.4 Queensland

Air quality and emissions are covered under the Environment Protection Act 1994 and Environmental Protection Regulation 2008 in Queensland is administered by the Department for Environment and Resource Management.

Licences are required for any "Environmentally Relevant Activity" (ERA) listed in the Regulation. For biogas flaring, a fuel burning licence is required for all equipment with a fuel burning capacity of 500

kg/h or more, as per ERA 15 in this regulation (Department for Environment and Resource Management, 2010).

For installations not requiring a licence, the general intention of the Environmental Protection Act is to be complied with and all reasonable practicable measures taken to prevent environmental harm.

6.5 South Australia

In South Australia, case the Environment Protection Act 1993 and Environment Protection Regulations 2009 are the relevant pieces of legislation. The Environmental Protection Authority in South Australia is charged with administering the respective legislation.

As with other states, the Act lists prescribed activities that require a licence. The Fuel Burning licence, which has a threshold limit of 5 MW of heat output from the burning process, is applicable to biogas flares, however, the maximum heat output from a 600SCMH[2] biogas flare (the largest size commonly used on farms) is 4.4MW (Wootton, 2008).

For installations with no licence requirement, flaring must still comply with the air quality impact assessment requirements included in *EPA 386/06 Air quality impact assessment- using design ground level pollutant concentrations (DGLCs)*. The assessment provides advice and criteria for proponents of new developments that may emit pollutants into the atmosphere.

EPA 386/06 requires that the combustion process adequately disperses nitrous oxide and other pollutants that may be detrimental to human health, and may be applied differently depending on the proximity to residential areas.

Wootton (2008) highlighted in their report that this assessment criteria creates two potential problems for flare installations:

1. Either good judgement or expensive plume dispersion modelling is required to determine if the quantity of pollutants emitted from the flare will disperse adequately; and

2. It is difficult to establish the quantity of pollutants emitted from open flares, and therefore even more difficult to determine if they will disperse adequately.

The author also raised their concerns with Environmental Protection Authority in South Australia, which acknowledged that further work or guidelines were required to make the criteria workable for small, low cost installations. The obvious risk being that with no other applicable policy the EPA may default to their existing industrial requirements which will be not commensurate with the risks.

6.6 Tasmania

Tasmania's legislation includes the Environmental Management and Pollution Control Act 1994 and Environment Protection Policy (Air Quality) 2004, both of which are administered by the Environmental Protection Authority within the Department of Primary Industries, Parks, Water and Environment.

Schedule 2 of the Act lists 'Level 2 Activities', which require a licence. Specifically, Part 7(a) covers any process or combination of processes involving the use of fuel burning equipment or incineration

[2] Standard Cubic Metres per Hour

and where the equipment alone or in aggregate is capable of burning combustible matter at a rate of one tonne or more per hour. However importantly, Wootton (2008), noted that 600SCMH of biogas was equivalent to 284kg/h of methane.

In addition, compliance with the Environment Protection Policy (Air Quality) 2004 is required. Schedule 1 of the Policy specifies 'in-stack concentrations that would normally be expected to be achievable using accepted modern technology'.

6.7 Victoria

In Victoria, the applicable legislation is the Environment Protection Act 1970, the Environment Protection (Scheduled Premises and Exemptions) Regulations 2007 and the State Environment Protection Policy (SEPP) (Air Quality Management). Environment Protection Authority (EPA) Victoria administers the respective legislation.

The Air Quality Management SEPP establishes the framework for managing emissions into the air environment in Victoria from all sources of air pollutants, so that the air quality objectives outlined in the Ambient Air Quality SEPP are met. The management framework and attainment program for protection of the air environment contained in SEPP (Air Quality Management) address not only ambient (or regional) air quality, but also the management of particular sources (for example, industry, motor vehicles and open burning) and local air quality impacts, including air toxics, odorous pollutants, greenhouse gases and ozone depleting substances. (Environment Protection Authority Victoria, 2010)

EPA Victoria was unsuccessfully contacted several times in order to clarify the application of the Air Quality Management SEPP on biogas plants. However, Wootton (2008) noted in their report that any applicable licence or recommendation is very specific, and the regional EPA Victoria office and local council should be consulted in the first instance.

6.8 Western Australia

The Environmental Protection Act 1986 and the Environmental Protection Regulations 1987 are administered by the Environmental Protection Authority. Category 67, Schedule 1 of the Regulations classifies fuel burning on premises on which gaseous, liquid or solid fuel is burnt in a boiler for the supply of steam or in power generation equipment as a prescribed act. It applies to 500 kilograms or more per hour (fuel with a sulphur content of 0.25% or more) or in aggregate 2000 kilograms or more per hour (fuel with a sulphur content of less than 0.25%). Accordingly, farm-scale plants do not meet the threshold criteria.

Western Australia is proposing the implementation of an Air Quality Environmental Protection Policy in order to bring into state-wide affect the existing standards and goals of the National Environment Protection Measure (NEPM). The NEPM currently establishes standards for six pollutants commonly found in ambient air and sets a goal of compliance with its standards by July 2008 (Environmental Protection Authority, 2010). However, the *Air Quality Environmental Protection Policy* was first drafted in 2001 and is still unfortunately in development.

7.0 International Standards

7.1 Canada

The Canadian Standards Association has a Code for Digester Gas and Landfill Gas Installations, which specifies construction and installation standards. However, it is primarily designed for sewage treatment and landfill gas and does not cover on-farm biogas (Canadian Standards Association, 2010).

Regardless, it would appear that Ontario leads the way as far as regulating the handling and use of on-farm biogas in Canada is concerned. Ontario has in place regulations that regulate the utilisation of biogas through the Gaseous Fuels Regulation 2001 and requires gas piping to be installed by a certified installer working for a Technical Safety Standards Authority (TSSA) approved company. Compliance with the Boilers and Pressure Vessels Regulations 2001 is also required.

As far as emissions are concerned, a Certificate of Approval under Part V of the Environmental Protection Act 1990 is required when co-digesting off-farm materials with low volumes of farm materials and not operating under the Nutrient Management Act 2002 (Sauvé, 2010).

Sauvé (2010) also reports that the Canadian Standards Association is planning to develop a biogas standard which will focus on the standardisation of biogas generation and utilisation. The new standard will use:

- The B105 Digester and Landfill Gas Code;
- The B146 National Gas and Propane Code;
- Translated German Agricultural Biogas Safety Rules, and
- Experience from Ontario biogas industry.

In addition, the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) has developed a Biogas Operators' Course which is delivered by the International Biogas and Bioenergy Center of Expertise (IBBK) based in Germany. A reference manual has also been developed by OMAFRA. Further, a one-day classroom or e-learning course on biogas safety for operators' course material will be completed by end of 2010 (Sauvé, 2010).

Finally, farmers need to establish a farm emergency plan that includes:

- Emergency responsibilities of individuals working on the farm;
- An emergency contact list;
- A copy of the plan, including the farm's location, kept by the telephone;
- What to do in case of spills, fire, power outages and other emergencies; and
- Kept somewhere visible (entrance of farm or near digester) (Sauvé, 2010).

7.2 Germany

The only standardised resource on biogas safety for agriculture is from Germany. The current version was published in 2008 by the German Agricultural Occupational Health and Safety Agency (Sauvé, 2010).

The Code was jointly developed by the German Agricultural Occupational Health and Safety Agency and the German Biogas Association and sets out the requirements for construction and operation of on-farm biogas systems (Sauvé, 2010).

Sauvé (2010) highlights that the German Code specifies the rules for agricultural biogas systems operating below 1.5 psi (0.1 bar) and provides information for:

- Engineering design firms;
- Contractors;
- Operators and employees, and
- Insurance companies.

7.3 New Zealand

In New Zealand there is a Code of Practice for the Production and Use of Biogas, Farm Scale Operation, which has been the recognised national standard since 1987. The Standard is in two parts:

1. Production of Biogas; and
2. Uses of Biogas.

The objective of Part 1 is to provide information to enable planning, design and construction of a farm scale biogas plant, and to assist in safe and efficient operation of the plant (Standards Association of New Zealand, 1987a). This standard details information around biogas production using a digester rather than a covered pond. Part 2 of the standard provides information on the utilisation of the biogas produced by the plant (Standards Association of New Zealand, 1987b).

In response to an international initiative around developing biogas standards, Standards New Zealand is currently considering a revision of the current standard. A tiered system of production has been discussed, which would acknowledge differences between the capital intensive, European style plants and the farm-scale covered pond type systems (McGruddy, 2010).

In New Zealand, biogas production comes under the control of the Gas Act 1982 and the Plumbers Gasfitters and Drainlayers Act 1976 (now superseded by the Plumbers Gasfitters and Drainlayers Act 2006) (Standards Association of New Zealand, 1987a).

Gas Safety is regulated by the Gas (Safety and Measurement) Regulations 2010 and the recognised competent authority is Energy Safety, within the Ministry of Economic Development. The Regulations cover general gas safety, and approval and certification of gas installations.

Emissions in New Zealand are regulated under the National Environmental Standards for Air Quality 2004 and administered by the Ministry for the Environment. Importantly, the standards are to be reviewed with the proposed amendments being publicly notified on 10 June 2010 (Ministry for the Environment, 2010).

7.4 United States

As with Australia, each state has its own legislation, polices, codes of practice and guidelines regarding gas safety and air quality and collating each individual states' legislation would comprise an entire report all of its own.

That said, a literature search could not find any specific regulations relating to biogas in the United States. However, a *Biogas Utilization Handbook* was published in 1998 by the Environment, Health and

Safety Division within the Georgia Tech Research Institute for the United States Department of Energy. It is an extremely large and comprehensive document and includes biogas safety and use amongst many other aspects involved with the production and use of industrially produced biogas (Walsh *et al.*, 1988) and provides a useful reference for those wishing to install a small scale farm based system.

8.0 Conclusion

As highlighted in the introduction, the capture and use of biogas is a relatively new trend which has taken off extraordinarily quickly. Whilst farm uptake of biogas systems has been strongest in Europe to date, interest is accelerating rapidly in Britain, North America, Australia and New Zealand. A clear example of this rapid uptake can be found in the province of Ontario, Canada where twenty five on-farm biogas plants have been commissioned over the past twelve months (Sauvé, 2010).

The initial desire to capture biogas has principally been driven by a convergence of new environmental policy directives and fortunately all Australian states have clear policy guidelines on air quality and emissions; albeit accurately determining emission levels is subjective and potentially expensive. Furthermore, farm-scale biogas production plants do not trigger any licensing requirements and the conversion of methane to carbon dioxide is regarded favourably.

However, rising energy costs and the growing consciousness of biogas as a readily available alternative energy source, combined with the inexpensive nature of covered pond-based installations, have rapidly spawned a new industry in recent times and gas regulators across the world appear to have been left behind.

The overall result is a current state of confusion. Biogas is not specifically mentioned in any current legislation, which makes the task of determining the applicability of regulations more difficult combined with conflicting information regarding regulations for industrial and gas supply chain networks versus other non-networked gas requirements.

In some cases government officials did not know what legislation applied (if any) to on-farm biogas installations. Whilst with some state and territory departments, numerous and repeated phone calls and emails were needed to secure an appropriate response.

There are examples of old and mostly likely outdated draft policies being used as guidance documents as well as drafts referring to repealed legislation. Furthermore, departmental websites are not being updated in a timely manner and therefore providing incorrect information. With one state, the responsible department was been incorrectly listed.

It is clear that, in the absence of legislation which specifically deals with biogas production, use and safety, regulators in Australia have chosen two distinct paths:

1. Default to petroleum and/or high pressure gas based legislation; or

2. Leave biogas production unregulated (apart from the compliance with Australian Standards).

Neither regulatory path provides a satisfactory outcome as leaving biogas installations unregulated provides an opportunity for shortcuts to be taken and potentially leaves operators at risk of harm. While the highly regulated regime applied to petroleum gas production (and associated networks) is far too prescriptive and burdens on-farm production sites with comparably high compliance costs. Simply applying current (hydrocarbon-based fuel gas) regulations to on-farm biogas systems without addressing the specific risks of the smaller systems is unreasonable, and results in onerous, costly and inappropriate over regulation of on-farm biogas systems. Furthermore, confusion over applicable regulations, the associated costs and over regulation may lead to a lack of uptake of a potentially economically viable and environmentally beneficial proposition for many producers.

Australian regulators are not alone. Their international peers are also struggling to determine appropriate biogas production and safety regulations. This has culminated in the first ever international conference on *Biogas Production - Safety and Regulation* which is being convened by the European Virtual Institute for Integrated Risk Management on 24 November 2010 in Paris, France (European Virtual Institute for Integrated Risk Management, 2010).

Germany is currently the only country that has a specific regulatory environment for biogas production and use, but it is based around the use of a capital intensive digester. Equally, New Zealand has a gazetted Code for on-farm biogas production and use, but it too is also based around a digester and was written in 1987.

Standards New Zealand recognises that the current Code is outdated and a more contemporary Code which reflects the current low-cost, covered-pond systems is needed. Similarly, the Canadian Standards Association is also in the planning process for the development of a biogas standard. It would seem that a logical step would be to develop an international approach to biogas regulations and standards. In doing so, allowances can be made for differences in specific production systems (i.e. digester verses covered pond). At the very least a joint Australia/New Zealand Standard for the on-farm production and use of biogas should be pursued and aligned with the revised Australian Standard 5601 for gas installations.

In the meantime, producers planning to construct a biogas plant on their farm are strongly advised to consult with the appropriate local and state-based regulatory authorities as the first stage in the planning process. This will facilitate their production plant being approved, certified and ultimately able to be commissioned.

9.0 References

ACT Planning & Land Authority. 2010. Gas Appliance Worker Accreditation. Viewed 21 October 2010.
<http://www.actpla.act.gov.au/__data/assets/pdf_file/0004/2011/gas-awa.pdf>

Bushel. M. 2010. Port Macquarie Office of New South Wales Fair Trading. Personal Communication. 26 October 2010.

Canadian Standards Association. 2010. Code for Digester Gas and Landfill Gas Installations. Viewed 25 October 2010.
<http://www.shopcsa.ca/onlinestore/GetCatalogItemDetails.asp?mat=2411318>

Cannizzo, I. 2010. Manager, Complex Gas Appliance Safety, Energy Safe Victoria. Personal Communication. 14 October 2010.

Currington, J. 2010. Senior WorkSafe Officer, NT WorkSafe. Personal Communication. 5 November 2010.

Department of Climate Change and Energy Efficiency. 2010. Agricultural Emissions. Viewed 25 October 2010.
<http://www.climatechange.gov.au/government/initiatives/cprs/who-affected/agriculture/agricultural-emissions.aspx>

Department of Commerce. 2010. Standards and Legislation. Viewed 25 October 2010. <http://www.docep.wa.gov.au/energysafety/Content/Regulation/Standards_and_legislation/Standards_and_legislation.htm>

Department for Environment and Resource Management. 2010. ERA 15. Viewed 25 October 2010.
< http://www.derm.qld.gov.au/services_resources/item_details.php?item_id=34294>

Energy Safe Victoria. 2005. Landfill / Biogas Flare Systems Guidelines. Viewed 11 October 2010. <http://www.esv.vic.gov.au/ForGasProfessionals/TechnicalinfosheetsforGasFitters/GuidesanddatasheetsTypeBAppliancesandComplexGasInstallations/LandfillGasBiogas/tabid/366/Default.aspx>

Energy Safe Victoria. 2010a. The Gas Safety (Gas Installation) Regulations 2008. Viewed 11 October 2010.
<http://www.esv.vic.gov.au/ForGasProfessionals/NewGasApplicationGuide/TheGasSafetyGasInstallationRegulations2008/tabid/436/Default.aspx>

Energy Safe Victoria. 2010b. Acceptance Procedure for Type B Appliances and Complex Installations. Viewed 11 October 2010.
<http://www.esv.vic.gov.au/ForGasProfessionals/TechnicalinfosheetsforGasFitters/GuidesanddatasheetsTypeBAppliancesandComplexGasInstallations/AcceptanceProcedureforTypeBAppliances/tabid/353/Default.aspx>

Environmental Protection Authority. 2010. Developing a Statewide Air Quality Environmental Protection Policy. Viewed 13 October 2010.
<http://www.epa.wa.gov.au/article.asp?ID=1070&area=Policies&CID=20&Category=Environmental+Protection+Policies+%28EPP%29>

Environment Protection Authority Victoria. 2010. State Environment Protection Policy (Air Quality Management). Viewed 13 October 2010.
<http://www.epa.vic.gov.au/about_us/legislation/air.asp#sepp_ambient_air>

European Parliament. 2008a. INI/2007/2107 Sustainable agriculture and biogas: a need for review of EU-legislation. Viewed 1 October 2010
<http://www.europarl.europa.eu/oeil/file.jsp?id=5484572>

European Parliament. 2008b. MEPs give green light for new EU waste legislation with binding 2020 targets. Viewed 1 October 2010.
<http://www.europarl.europa.eu/sides/getDoc.do?language=EN&type=IM-PRESS&reference=20080616IPR31745>

European Parliament. 2010. Call for bio-waste directive, with mandatory separate collection. Viewed 1 October 2010.
<http://www.europarl.europa.eu/en/pressroom/content/20100705IPR77803>

European Virtual Institute for Integrated Risk Management. 2010. Biogas Production - Safety and Regulation Agenda. Viewed 1 October 2010.
<http://www.eu-vri.eu/filedown.aspx?file=6846 >

Gas Technical Regulators Committee. 2010a. Home Page. Viewed 14 October 2010 <http://www.gtrc.gov.au/>

Gas Technical Regulators Committee. 2010b. About the Organisation. Viewed 14 October 2010. < http://www.gtrc.gov.au/about/>

Harris, P. 2010. An introduction to biogas, viewed 21 September 2010. <http://www.adelaide.edu.au/biogas/basic/ >

He, P-J. 2010. Anaerobic digestion: An intriguing long history in China. *Waste Management*, 30(4): 549-550.

Marcatoa, C-E., Mohtarb, R., Revela, J-C., Pouechc, P., Hafidid, M. & Guiresse. M. 2009. Impact of anaerobic digestion on organic matter quality in pig slurry. *International Biodeterioration & Biodegradation*, 63(3): 260-266.

Marchaim, U. 1992. Biogas processes for sustainable development. Food and Agriculture Organization, Rome, Italy. Viewed 1 October 2010.
<http://www.wcasfmra.org/biogas_docs/www.fao.org_docrep.pdf>

McGruddy, E. 2010. Environment Officer for New Zealand Pork, Massey University. Personal Communication. 14 October 2010.
Ministry for the Environment. 2010. National Environmental Standards for Air Quality. Viewed 25 October 2010.
<http://www.mfe.govt.nz/laws/standards/air-quality-standards.html>

Poad, G.D., McGahan, E.M. 2010. *Exploration of the Opportunities to Establish Anaerobic Digestion for the Generation of Biogas*. APL Project No. 2293, Australian Pork Limited, Canberra, Australia.

Patience, B. 2010. Manager Gas Installation and Appliance Safety, Office of the Technical Regulator, Department for Transport, Energy and Infrastructure. Personal Communication. 11 October 2010.

Pipatmanomaia, S., Kaewluana, S. & Vitidsantb, T. 2009. Economic assessment of biogas-to-electricity generation system with H_2S removal by activated carbon in small pig farm. *Applied Energy*, 86(5): 669-674.

Renewable Energy Concepts. 2010. Biogas Composition. Viewed 1 October 2010. <http://www.renewable-energy-concepts.com/biomass-bioenergy/biogas-basics/gas-composition.html>

Robertson, D. 2010. Principal Engineer, Energy Safety WA, Department of Commerce. Personal Communication. 13 October 2010.

Sauvé, T. 2010. Rules and New Developments of On-Farm Biogas Safety. *Proceedings from the 2nd Canadian Farm & Food Biogas Conference*. London, Ontario, March 10 2010.

Standards Association of New Zealand. 1987a. *Code of Practice for the Production and use of Biogas, Farm Scale Operation: Part 1 Production of Biogas*. Publication No. NZS 5228. Wellington, New Zealand.

Standards Association of New Zealand. 1987b. *Code of Practice for the Production and use of Biogas, Farm Scale Operation Part 2 Uses of Biogas*. Publication No. NZS 5228. Wellington, New Zealand.

Walsh, J.L., Ross, C.C., Smith, M.S., Harper, S.R. & Wilkens, W.A. 1998. *Biogas Utilization Handbook*. Environment, Health and Safety Division, Georgia Tech Research Institute. Atlanta, Georgia, United States of America.

Wootton, P. 2008. *Assessment of Australian biogas flaring standards*. Publication No. 08/024. Rural Industries Research and Development Corporation. Canberra, Australia.

WorkCover Authority of New South Wales. 2010. Regulations. Viewed 13 October 2010. <http://www.workcover.nsw.gov.au/lawpolicy/Regulations/Pages/default.aspx>

10.0 Bibliography

Birchell, S. 2010. *Biogas production by covered lagoons: performance data from Bears Lagoon piggery*. Publication No. 10/023. Rural Industries Research and Development Corporation. Canberra, Australia.

Cansino, J.M., Pablo-Romero, M.P., Román, R.& Yñiguez, R. 2010. Tax incentives to promote green electricity: An overview of EU-27 countries. *Energy Policy*, 38: 6000–6008.

Hertle, C. 2008. *Assessment of methane capture and use from the intensive livestock industry*. Publication No. 08/025. Rural Industries Research and Development Corporation. Canberra, Australia.

Holm-Nielsen, J.B., Al Seadi, T. & Oleskowicz-Popiel, P. 2009. The future of anaerobic digestion and biogas utilization. *Bioresource Technology*, 100: 5478–5484.

Kaparaju, P. & Rintala, J. 2011. Mitigation of greenhouse gas emissions by adopting anaerobic digestion technology on dairy, sow and pig farms in Finland. *Renewable Energy*, 36: 31-41.

Magma Pty Ltd. 2008. *Using methane in intensive livestock industries*. Publication No. 08/050. Rural Industries Research and Development Corporation. Canberra, Australia.

Marcato, C-E., Mohtar, R., Revel, J-C., Pouech, P., Hafidi, M., & Guiresse, M. 2009. Impact of anaerobic digestion on organic matter quality in pig slurry. *International Biodeterioration & Biodegradation*, 63: 260–266.

Ravena, R.P.J.M. & Gregersen, H.K. 2007. Biogas plants in Denmark: successes and setbacks. *Renewable and Sustainable Energy Reviews*, 11: 116–132.

Rose, G. 2010. Australian Methane to Markets in Agriculture Program Manager, Rural Industries Research and Development Corporation. Personal Communication. 13 & 14 October 2010.

Schwartz, H. 2010. Director, Biogas Australia Pty Ltd. Personal Communication. 13 October 2010.

Skerman, A. 2010. Principal Environmental Engineer, Department of Employment, Economic Development & Innovation. Personal Communication. 11 & 13 October 2010.

Stucley, C. 2010. *Overview of bioenergy in Australia*. Publication No. 10/078. Rural Industries Research and Development Corporation. Canberra, Australia.

Appendix I – Resource Documents Hyperlinks

New South Wales

Department for Environment, Climate Change and Water – Emission of Air Impurities from Activities and Plant
http://www.environment.nsw.gov.au/resources/air/FAQPOEP4/faqpoeocarpart4.pdf

Queensland

Department of Employment, Economic Development & Innovation – Gas Work Authorisation (Industrial Appliances) – Guideline to apply for and conduct work under a Gas work authorisation (industrial appliances)
http://www.dme.qld.gov.au/zone_files/petroleum_pdf/guideline_gwa_ia.pdf

Department of Employment, Economic Development & Innovation – Application for a Gas Work Authorisation
http://www.dme.qld.gov.au/zone_files/petroleum_pdf/appl_gas_work_auth_ia_sv.pdf

Department of Employment, Economic Development & Innovation – SafeOP for petroleum and gas – Self-audit tool for compliance with legislative requirements
http://www.dme.qld.gov.au/zone_files/petroleum_pdf/safeop.doc

Victoria

Gas Safety (Gas installation) Regulations 2008 – Schedules 7, 8, 9, 10 and 11
http://www.esv.vic.gov.au/ForGasProfessionals/NewGasApplicationGuide/tabid/435/Default.aspx

Energy Safety Victoria – Gas Installation Application Forms
http://www.esv.vic.gov.au/ForGasProfessionals/GasInstallationApplicationForms/tabid/443/Default.aspx

Energy Safety Victoria – Draft Landfill / Biogas Flare Systems Guidelines
http://www.esv.vic.gov.au/Portals/0/Gas%20Professionals/Files/Guides%20and%20datasheets/Type%20B/LandfillandBiogasFlareSystemsGuidelines.pdf

South Australia

Environmental Protection Authority – EPA 386/06 Air quality impact assessment- using design ground level pollutant concentrations (DGLCs)
http://www.epa.sa.gov.au/xstd_files/Air/Guideline/guide_airquality.pdf

Western Australia

Environmental Protection Authority – Air Quality Environmental Protection Policy
http://www.epa.wa.gov.au/docs/1070_EPP_AAQ01.pdf

United States of America

Georgia Tech Research Institute – Biogas Utilization Handbook
http://146.164.33.61/silviocarlos/biogas%2009/Biogas%20Importante/Biogas%20Utilization%20Handbook.pdf