# Market Analysis of Opportunities in Australia for Anaerobic Digestion Deployment

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# 1 Goulburn Bioenergy Project and ARENA Advancing Renewables Program

ReNu Energy's Goulburn Bioenergy Project is supported by ARENA under the Advancing Renewables Program.

The project aligns with the goals of the Advancing Renewables Program Outcomes which includes:

- Increasing the value delivered by biogas renewable energy
  - Anaerobic digestion and biogas production deliver high value renewable energy converting waste into electricity, leading to more sustainable agribusiness;
  - The Goulburn Bioenergy Project will demonstrate dual fuelling utilising both biogas and mains gas for the purpose of minimising grid electricity consumption and charges, further increasing the value derived from renewable energy.
- Improving the commercial readiness of biogas renewable energy
  - Biogas projects are considered best practice in Australia but not always implemented;
  - Developed as a Build-Own-Operate-Maintain model (BOOM), ReNu Energy will sell power to the abattoir under a power purchase agreement (PPA). This will save the abattoir electricity costs whilst freeing up capital for the business. ReNu Energy's BOOM model provides customers with an innovative implementation structure thus increasing the commercial readiness of biogas renewable energy;
  - Through improving the commercial readiness of biogas renewable energy the Goulburn Bioenergy Project will increase confidence with owners of other facilities.
- Reducing barriers to biogas derived renewable uptake
  - The Goulburn Bioenergy Project will successfully demonstrate the ability to dual fuel a biogas engine with both biogas and mains gas;
  - This will provide significant energy independence as the mains gas will provide redundancy to the primary biogas fuel source and the bioenergy with mains gas will be able to supply the abattoir with its power needs in the event of a grid outage;
  - This is of significant interest to the Food Processing Industry and wider agribusiness as they are commonly located in fringe of grid network locations.
- Reducing the cost of biogas energy
  - The Goulburn Bioenergy Project will drive down costs by technical learnings, improvements in efficiency of design and construction and building supply chain confidence;
  - With a limited number of projects installed in Australia there is significant potential to deliver cost improvements, technology efficiencies and operational efficiencies.
- Improve access to debt and equity funding
  - The Goulburn Bioenergy Project will demonstrate commercial application of biogas to energy technology;

  - The Goulburn Bioenergy Project will demonstrate that projects can be built with a BOOM model under a Power Purchase Agreement;
  - This will increase confidence of investors and provide better access to debt and equity funding;
  - This will drive down the cost of biogas projects for end users.

ReNu Energy has invested significantly to develop the biogas industry in Australia. The industry is poised for robust growth, with projects such as the Goulburn Bioenergy Project, helping to catalyse and accelerate development in the sector.

# 2 Anaerobic Digestion and Biogas to Energy Target Markets

ReNu Energy is targeting the commercial agribusiness market with anaerobic digestion and biogas to energy solutions to:

- Produce renewable energy from agricultural waste;
- Improve the agribusiness waste water management;
- Reduce the agribusiness environmental footprint;
- Reduce the agribusiness greenhouse gas emissions;
- Produce on-site energy; and
- Improve economic sustainability of the agribusiness.

Target agribusinesses include abattoirs, food processors, dairies, piggeries, egg farms, chicken broiler farms and feedlots. Each of these sectors is at varying degrees of maturity with regards to utilisation of anaerobic digestion technology and production of biogas. Nonetheless there are overarching drivers that will see increasing use of anaerobic digestion and biogas production in each of these sectors. These include:

- Agricultural production including export is a strongly growing industry in Australia;
- Increasing commercialisation and corporatisation of the agribusiness industry is seeing the size and scale of agribusiness operations continue to increase to service the growing demand
  - The increasing size and scale of the agribusiness operations makes anaerobic digestion and biogas production increasingly attractive and increasingly economic as a standalone proposition;
- Environmental regulations at the Federal, State and Local Government level continue to drive agribusinesses, in particular greenfields developments and brownfield expansions to adopt best industry practice which includes anaerobic digestion and biogas production;
- Cost of power and cost of grid connection in remote and regional areas continues to be a primary concern for agribusinesses, driving these businesses towards on-site power production options;
- Agribusiness is a significant source of greenhouse gas emissions. A challenge to date has been the measurement of greenhouse gas emissions in certain agribusiness activities. From ongoing industry research the understanding and ability to measure greenhouse gas emissions is enabling businesses to improve their industry practices and consider the next step to reduce their greenhouse gas emissions and adopt best practice such as anaerobic digestion and biogas production; and
- The value adding practice of turning post anaerobic digestion “digestate” into higher value commercial products, i.e. retail packaged fertiliser / potting mix, is an emerging market. As more facilities

incorporate anaerobic digestion into their processes, this will open up the product distribution channels and enable the industry to adopt packaging digestate into retail fertiliser.

# 3 Benefits of Anaerobic Digestion and Biogas Cogeneration

Anaerobic digestion and biogas cogeneration provides significant benefits including producing renewable energy from agricultural waste, improving waste water management, reducing greenhouse gas emissions, improving energy / electricity supply security and improving the economic sustainability of agribusiness operations.

In order to assess the market opportunity for anaerobic digestion deployment in Australia, it is important to have an understanding of the financial benefits of anaerobic digestion and biogas cogeneration. To illustrate the potential economic benefits the various benefits from an "ideal" waste stream have been outlined in Table 1. A waste stream would be ideal if it:

- Possesses low contamination with non-organic material
  - This makes the waste easier to handle and easier to digest
- Qualifies under an Emissions Reduction Fund methodology to create Australian Carbon Credit Units
  - Examples include the Alternative Waste Treatment Methodology[1], Destruction of methane generated from manure in piggeries[2], Domestic, Commercial and Industrial Wastewater[3], Destruction of methane generated from dairy manure in covered anaerobic ponds[4]
- Waste that would otherwise go to landfill
  - Waste going to landfill will incur gate fees and state based waste levies
- The energy produced from the biogas can be used on site as thermal energy (eg a biogas boiler at an abattoir) or as electrical energy (eg biogas generator at a piggery)
  - A biogas boiler will displace energy costs, either coal, natural gas or liquid petroleum gas (LPG)
  - A biogas generator will displace grid electricity costs
    - A biogas generator will also produce renewable energy certificates in the form of Large-scale Generation Certificates (LGC)
- There is an accessible market to utilise the digestate as fertiliser

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[1] Federal Register of Legislative Instruments F2015L00060, Carbon Credits (Carbon Farming Initiative—Alternative Waste Treatment) Methodology Determination 2015, https://www.legislation.gov.au/Details/F2015L00060

[2] Federal Register of Legislative Instruments F2015C00574, Carbon Credits (Carbon Farming Initiative) (Destruction of Methane Generated from Manure in Piggeries—1.1) Methodology Determination 2013, https://www.legislation.gov.au/Series/F2013L00856

[3] Federal Register of Legislative Instruments F2015C00575, Carbon Credits (Carbon Farming Initiative—Domestic, Commercial and Industrial Wastewater) Methodology Determination 2015, https://www.legislation.gov.au/Details/F2015C00575/

[4] Federal Register of Legislative Instruments F2015C00573, Carbon Credits (Carbon Farming Initiative) (Destruction of Methane Generated from Dairy Manure in Covered Anaerobic Ponds) Methodology Determination 2012, https://www.legislation.gov.au/Details/F2015C00573/

**Table 1 Total benefit of anaerobic digestion from 1 tonne of "ideal" mixed waste – NSW Metropolitan**

| Item | Value | Benefit | Comment / Source |
|---|---|---|---|
| **1 tonne mixed organic waste** | 1 | | |
| **m3 biogas/tonne** | 110 | | SEAI[5] |
| **% methane** | 55% | | SEAI[6] |
| **MJ/m$^3$** | 35.8 | | Dairy Australia[7] |
| **MJ/tonne** | 2,166 | | MJ/tonne = m3 biogas/tonne * % methane * MJ/m3 |
| **kWh per MJ** | 0.2778 | | Constant |
| **kWh_thermal/tonne** | 602 | | kWh_thermal/tonne = MJ/tonne * kWh/MJ |
| **electrical conversion efficiency** | 38% | | Assumption |
| **kWh_electrical/tonne** | 229 | | kWh_electrical/tonne = kWh_thermal/tonne * electrical conversion efficiency |
| **auxiliary consumption** | 5% | | Assumption |
| **Net kWh_electrical/tonne** | 217 | | Net kWh_electrical/tonne = kWh_electrical/tonne * (1 - auxiliary consumption) |
| **Value of electricity** | $0.150 /kWh | | Assumption |
| **Electricity Benefit per Tonne** | | $32.6 /tonne | Electricity Benefit per Tonne = Net kWh_electrical/tonne * Value of electricity |
| | | | |
| **LGC Value** | $80 /LGC | | Mercari[8] |

[5] Sustainable Energy Authority of Ireland, Gas Yields Table, http://statistics.seai.ie/Renewables/Bioenergy/Bioenergy_Technologies/Anaerobic_Digestion/The_Process_and_Techniques_of_Anaerobic_Digestion/Gas_Yields_Table.pdf

[6] Sustainable Energy Authority of Ireland, Gas Yields Table, http://statistics.seai.ie/Renewables/Bioenergy/Bioenergy_Technologies/Anaerobic_Digestion/The_Process_and_Techniques_of_Anaerobic_Digestion/Gas_Yields_Table.pdf

[7] UNEP Working Group for Cleaner Production, Eco-efficiency for Australian dairy processors, Fact sheet 5: Biogas, 2004, http://www.ecoefficiency.com.au/Portals/56/factsheets/foodprocess/dairy/ecodairy_fs5.pdf

[8] Mercari Pty Ltd, Mercari operates regulated electronic market places and swaps execution facilities for over the counter (OTC) derivatives and certificates. Mercari holds both an Australian Market Licence and an Australian Financial Services Licence, http://lgc.mercari.com.au/

| | | | |
|---|---|---|---|
| **LGC/kWh** | 0.001 | | Clean Energy Regulator[9] |
| **LGC Value per kWh** | $0.080 /kWh | | LGC Value per kWh = LGC Value * LGC/kWh |
| **LGC Benefit per Tonne** | | $17.4 /tonne | LGC Benefit per Tonne = Net kWh_electrical/tonne * LGC Value per kWh |
| | | | |
| **Specific Energy of Methane (GJ/tonne)** | 55.52 | | IEA Energy Statistics Manual[10] |
| **Tonnes of Methane Destroyed (tonnes $CH_4$ / tonne waste)** | 0.039 | | Tonnes of Methane Destroyed = (MJ/tonne_waste / 1000) / Specific Energy of Methane |
| **Methane Global Warming Potential** | 25 x | | Clean Energy Regulator[11] |
| **Carbon Dioxide Equivalent Mitigated ($tCO_2e$ / tonne waste)** | 0.975 | | Carbon dioxide equivalent mitigated = Tonnes of methane destroyed * Methane global warming potential |
| **Australian Carbon Credit Unit Value** | $12 /$tCO_2e$ | | Clean Energy Regulator[12] |
| **Value of Methane Destroyed** | | $11.7 /tonne | Value of Methane Destroyed = Carbon Dioxide Equivalent Mitigated * Australian Carbon Credit Value |
| | | | |
| **Avoided Waste Levy (NSW Metro)** | | $138.2 /tonne | NSW EPA[13] |
| | | | |
| **Net waste delivery savings** | | $0.0 /tonne | Assumed cost of waste collection and delivery to landfill is similar to cost of waste collection and delivery to anaerobic digestion site |

[9] Clean Energy Regulator, http://www.cleanenergyregulator.gov.au/RET/Scheme-participants-and-industry/Power-stations/Large-scale-generation-certificates/Large-scale-generation-certificate-eligibility-formula

[10] International Energy Agency (IEA), Energy Statistics Manual, 2005, https://www.iea.org/publications/freepublications/publication/energy-statistics-manual.html

[11] Clean Energy Regulator, Global warming potentials, May 2016, http://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism/Baselines/Reported-baseline/global-warming-potentials

[12] Clean Energy Regulator, Auction Results, April 2017, http://www.cleanenergyregulator.gov.au/ERF/Auctions-results

[13] NSW EPA, the NSW Environment Protection Authority (EPA) is the primary environmental regulator for New South Wales, http://www.epa.nsw.gov.au/wasteregulation/waste-levy.htm

| | | | |
|---|---|---|---|
| | | | |
| **Volatile Solids Ratio (% Totals Solids)** | 90% | | For food waste<br>Institute for Agrobiotechnology Tulln[14] |
| **Biodegradation Rate** | 50% | | This is dependent on retention time, which is dependent on the size of the covered anaerobic lagoon.<br>This is a typical biodegradation rate for food waste or manure anaerobic digestion (Eastern Research Group, Inc. )[15] |
| **Covered Anaerobic Lagoon Solids Destruction** | 45% | | Covered Anaerobic Lagoon Solids Destruction = Volatile Solids Ratio * Biodegradation Rate |
| **Organic Garden Products Produced (tonnes garden products / tonne waste)** | 0.55 | | Organic Garden Products Produced = Tonnes of Waste * (1 – Covered Anaerobic Lagoon Solids Destruction) |
| **Retail value of packaged organic garden products per tonne garden products** | $200.0 /tonne garden products | | Sustainability Victoria[16] |
| **Retail value of packaged organic garden products per tonne of waste** | | $110.0 /tonne waste | |
| | | | |
| **Total Benefit per Tonne** | | $310 /tonne | Total Benefit per Tonne = Electricity Benefit per Tonne + LGC Benefit per Tonne + Value of Methane Destroyed + Avoided Waste Levy + Net waste delivery savings |

[14] Steffen, R.; Szolar, O. and Braun, R., Institute for Agrobiotechnology Tulln, University of Agricultural Sciences Vienna, Feedstocks for Anaerobic Digestion, 1998, http://www.agrienvarchive.ca/bioenergy/download/feedstocks_AD.pdf

[15] John H. Martin, Jr., Eastern Research Group, Inc., An Evaluation of a Mesophilic, Modified Plug Flow Anaerobic Digester For Dairy Cattle Manure, 2005, www.dvoinc.com/documents/gordondale_report_final.pdf

[16] Sustainability Victoria, Case study: Energy from waste helps Berrybank Farm bring home the bacon, November 2015, http://www.sustainability.vic.gov.au/-/media/resources/documents/services-and-advice/business/investment-facilitation/written-case-studies/investment-case-study---berrybank-farm---december-2015.pdf?la=en

# 4 Capital Cost of Anaerobic Digestion and Biogas Cogeneration

In order to assess the market opportunity for anaerobic digestion deployment in Australia, it is important to have an understanding on the capital investment required.

A credible capital cost of covered anaerobic lagoon and biogas cogeneration systems has been published by Meat and Livestock Australia Limited[17]. The capital cost of an anaerobic lagoon is dependent on the volume of waste water that needs to be processed. The size of a covered anaerobic lagoon is a function of the throughput of waste water and the required retention time to digest the organic loading in the waste water. The retention time will be dependent on the type of waste water, eg abattoir, piggery effluent etc.

The volume of biogas produced is dependent on the waste water throughput and the organic loading.

Although the Meat and Livestock Australia Limited capital cost estimates are targeted to abattoir applications, the figures are broadly applicable to all covered anaerobic lagoon and biogas cogeneration applications.

[17] Report prepared by GHD Pty Ltd for Meat and Livestock Australia Limited and Australian Meat Processor Corporation, Covered Anaerobic Lagoons, July 2012, https://www.mla.com.au/download/finalreports?itemId=1879

**Table 2 Capital cost of CAL system items (comparison by meat processing plant size)** [18, 19]

| Item | Small Plant | Low-Medium Plant | High-Medium Plant | Large Plant |
|---|---|---|---|---|
| **General design criteria and potential energy production** | | | | |
| Nominal wastewater flow, kL/d | 500 kL/d | 1,500 kL/d | 4,300 kL/d | 7,000 ML/d |
| Size of CAL, ML | 7.5 ML | 22 ML | 60 ML | 90 ML |
| Biogas production, $m^3$/d | 500 $m^3$ / d | 1,600 $m^3$ / d | 3,400 $m^3$ / d | 7,300 $m^3$ / d |
| Cogen – elec output<br>- Exhaust heat | 40 kW<br>30 kW | 135 kW<br>90 kW | 280 kW<br>180 kW | 600 kW<br>385 kW |
| **Generic Costs** | | | | |
| Anaerobic lagoon excavation, cut and fill | $ 250,000 | $ 380, 000 | $ 750,000 | $ 1,500,000 |
| Lagoon liner | $ 80,000 | $ 150,000 | $ 300,000 | $ 520,000 |
| Inlet and out structures | $ 20,000 | $ 20,000 | $ 35,000 | $ 40,000 |
| CAL cover | $ 150,000 | $ 200,000 | $400,000 | $ 600,000 |
| Electrical generator | $ 250,000 | $ 365,000 | $720,000 | $ 1,000,000 |
| Biogas Flare | $ 100,000 | $ 100,000 | $ 150,000 | $ 140,000 |
| Sulphide Scrubber | $ 20,000 | $ 20,000 | $ 30,000 | $ 40,000 |
| Ancillaries, pipework & installation | $ 380,000 | $670,000 | $1,320,000 | $1,950,000 |
| Sub-total | $1,250,000 | $ 1,905,000 | $ 3,705,000 | $ 8,790,000 |
| Contingencies, design, engineering (30%) | $ 375,000 | $ 560,000 | $ 1,111,500 | $ 1,745,000 |
| **Total** | **$ 1,625,000** | **$ 2,430,000** | **$ 4,816,500** | **$ 7,535,000** |

[18] Report prepared by GHD Pty Ltd for Meat and Livestock Australia Limited and Australian Meat Processor Corporation, Covered Anaerobic Lagoons, July 2012, https://www.mla.com.au/download/finalreports?itemId=1879

[19] Report prepared by CSIRO for Meat and Livestock Australia Limited and Australian Meat Processor Corporation, The use of abattoir waste heat for absorption refrigeration, March 2010, https://www.mla.com.au/download/finalreports?itemId=1855

# 5 Agribusiness is a growing industry

## 5.1 Production

Over the 5 years from 2009/10 to 2015/16 livestock meat and livestock products has grown from $39.6 billion dollars in value to $56.0 billion dollars in value.

This has been driven by both domestic consumption growth as well as export growth.

**Table 3 Livestock Meat and Products Production[20]**

| | 2009/10 Value | 2015/16 Value |
|---|---|---|
| **LIVESTOCK MEAT** | **$m** | **$m** |
| Cattle and calves | | $13,087 |
| Sheep and lambs | | $3,239 |
| Pigs | | $1,353 |
| Poultry | | $2,748 |
| Other livestock | | $195 |
| *Total livestock meat* | $12,700 | $20,622 |
| | | |
| **LIVESTOCK PRODUCTS** | | |
| Wool | | $2,965 |
| Milk | | $4,282 |
| Eggs | | $783 |
| *Total livestock products* | $5,700 | $8,030 |
| | | |
| **Total Livestock** | $39,600 | $55,994 |

## 5.2 Exports

### 5.2.1 Meat Exports

Over the years from 2010/11 to 2015/16, meat exports have grown from 1,383,529 tonnes to 1,788,527 tonnes with significant growth of exports into China, USA and Eastern Europe.

[20] Australian Bureau of Statistics, Catalogue Number 7503.0 - Value of Agricultural Commodities Produced, Australia, 2015-16, Australian Bureau of Statistics, Catalogue Number 7503.0 - Value of Agricultural Commodities Produced, Australia, 2009-10, http://www.abs.gov.au/ausstats/abs@.nsf/mf/7503.0

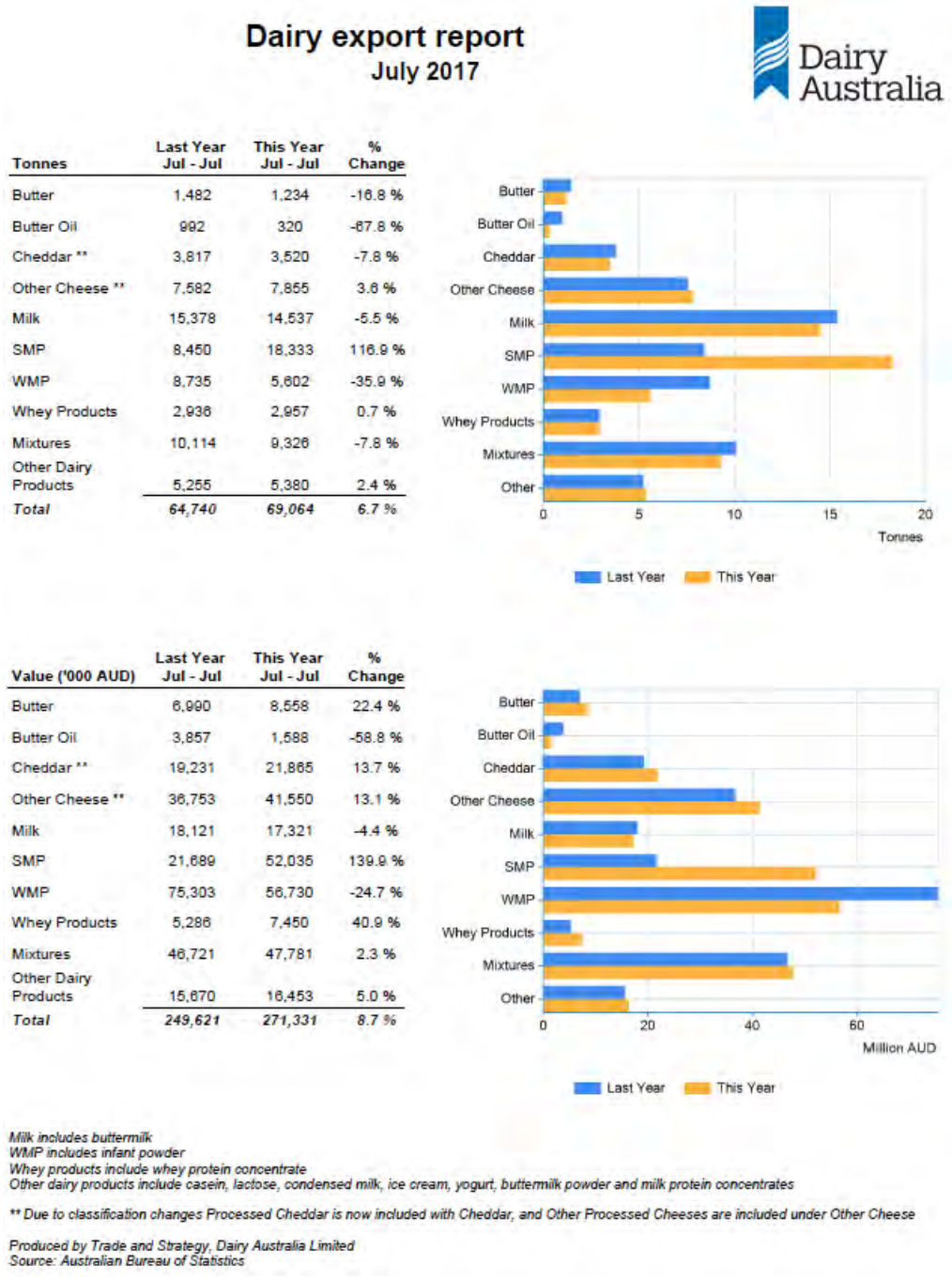
**Table 4 Meat Exports**[21]

| AUS Meat Exports | 2010/11 Tonnes | 2015/16 Tonnes |
|---|---|---|
| Beef and Veal | 937,298 | 1,165,974 |
| Buffalo | 0 | 20 |
| Mutton | 86,222 | 143,915 |
| Lamb | 156,523 | 240,609 |
| Goat | 25,853 | 28,322 |
| Pork | 21,351 | 23,011 |
| Fancy Meat | 156,283 | 186,677 |
| Total | 1,383,529 | 1,788,527 |

### 5.2.2 Dairy Exports

Both volume and value of dairy exports continues to grow. The value of dairy exports has increased in volume to 69,064 tonnes, and in value from $271.3 million.

[21] Department of Agriculture and Water Resources - Total Meat Exports By State of Production, Fiscal YTD to June 2016 -- Tonnes Shipped Weight, Monday, July 4, 2016, Department of Agriculture and Water Resources - Total Meat Exports By State of Production, Fiscal YTD to June 2011 -- Tonnes Shipped Weight, Friday, July 1, 2011, http://www.agriculture.gov.au/export/from-australia/quota/red-meat/statistics



Dairy export report
July 2017

Dairy Australia

| Tonnes | Last Year Jul - Jul | This Year Jul - Jul | % Change |
|---|---|---|---|
| Butter | 1,482 | 1,234 | -16.8 % |
| Butter Oil | 992 | 320 | -67.8 % |
| Cheddar ** | 3,817 | 3,520 | -7.8 % |
| Other Cheese ** | 7,582 | 7,855 | 3.6 % |
| Milk | 15,378 | 14,537 | -5.5 % |
| SMP | 8,450 | 18,333 | 116.9 % |
| WMP | 8,735 | 5,602 | -35.9 % |
| Whey Products | 2,936 | 2,957 | 0.7 % |
| Mixtures | 10,114 | 9,326 | -7.8 % |
| Other Dairy Products | 5,255 | 5,380 | 2.4 % |
| *Total* | *64,740* | *69,064* | *6.7 %* |



| Value ('000 AUD) | Last Year Jul - Jul | This Year Jul - Jul | % Change |
|---|---|---|---|
| Butter | 6,990 | 8,558 | 22.4 % |
| Butter Oil | 3,857 | 1,588 | -58.8 % |
| Cheddar ** | 19,231 | 21,865 | 13.7 % |
| Other Cheese ** | 36,753 | 41,550 | 13.1 % |
| Milk | 18,121 | 17,321 | -4.4 % |
| SMP | 21,689 | 52,035 | 139.9 % |
| WMP | 75,303 | 56,730 | -24.7 % |
| Whey Products | 5,286 | 7,450 | 40.9 % |
| Mixtures | 46,721 | 47,781 | 2.3 % |
| Other Dairy Products | 15,670 | 16,453 | 5.0 % |
| *Total* | *249,621* | *271,331* | *8.7 %* |



*Milk includes buttermilk*
*WMP includes infant powder*
*Whey products include whey protein concentrate*
*Other dairy products include casein, lactose, condensed milk, ice cream, yogurt, buttermilk powder and milk protein concentrates*

*** Due to classification changes Processed Cheddar is now included with Cheddar, and Other Processed Cheeses are included under Other Cheese*

*Produced by Trade and Strategy, Dairy Australia Limited*
*Source: Australian Bureau of Statistics*

**Figure 1 Dairy Exports July 2017[22]**

[22] Dairy Australia, Dairy export report, July 2017, https://www.dairyaustralia.com.au/industry/exports-and-trade/latest-export-statistics

# 6 Existing Anaerobic Digesters and Biogas in Australia

## 6.1 Australia Biogas Country Report

IEA Bioenergy is an organisation set up in 1978 by the International Energy Agency (IEA) with the aim of improving cooperation and information exchange between countries that have national programmes in bioenergy research, development and deployment[23]. As part of the IEA Bioenergy Task 37, Australia provides an Australia Biogas Country Report to the IEA[24].

Based on a survey of industry participants, the Australia Biogas Country Report estimated there is ~1,442 GWh pa of energy produced from biogas in Australia.

**Table 5 Status of biogas production in Australia (data from 2016)**

| Substrate / Plant type | Estimated Number of plants | Number of plants from survey | Potential Production (GWh/year)* |
|---|---|---|---|
| Sewage sludge (WWTP) | 52 | 22 | 221 |
| Biowaste | 5 | 3 | 15 |
| Agriculture | 22 | 9 | 27 |
| Industrial | 34 | 12 | 39 |
| Landfill | 129** | - | 1,140** |
| **Total** | **242** | **46** | **1,442** |

* Calculated from the estimated electricity production and an assumed efficiency of 35% with 70% methane content in biogas.
** From 2006 Sustainable Power Plant Register, Australian Business Council for Sustainable Energy

## 6.2 List of Existing Anaerobic Digesters in Australia

There are several compilations (all incomplete) cataloguing existing anaerobic digesters in Australia. These include:

- Rural Industries Research & Development Corporation[25];
- National Centre for Engineering in Agriculture, University of Southern Queensland[26]; and

[23] IEA Bioenergy, http://www.ieabioenergy.com/
[24] Associate Professor Bernadette McCabe, Australian National Team Leader for IEA Bioenergy Task 37 Energy from Biogas, http://www.bioenergyaustralia.org/pages/iea-bioenergy-.html
[25] Rural Industries Research & Development Corporation, Biomass Producer Bioenergy Information for Australia's Primary Industries, http://biomassproducer.com.au/projects/
[26] National Centre for Engineering in Agriculture, University of Southern Queensland, Survey for Australian Biogas Facilities, http://biogas.nceastg.usq.edu.au/biogas/#/map

- Bioenergy Australia has also identified a list of Anaerobic Digestion Plants in Australia[27], though this list has not been produced by Bioenergy Australia, nonetheless it is the more comprehensive of the catalogues produced to date[28].

Based on a review of these various sources, ReNu Energy has compiled the list of existing anaerobic digesters in Australia as shown in Table 6.

**Table 6 List of Existing Anaerobic Digesters in Australia**

| # | Anaerobic Digester | Category | Owner / Operator | Feedstock | Source |
|---|---|---|---|---|---|
| 1 | Pittsworth, QLD | Agriculture | Darling Downs Eggs/ RL Adams Ltd | Chicken manure | http://www.cleanenergyfinancecorp.com.au/our-investments/case-studies/egg-producer-turns-waste-into-energy.aspx |
| 2 | Leongatha, VIC | Agriculture | Murray Goulbourn | Food Processing Waste | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| 3 | Netherby, SA | Agriculture | Urrbrae Agricultural High School | Pig and Cow Manure | https://australianpork.infoservices.com.au/items/2011-2206-REPORT |
| 4 | Bears Lagoon, VIC | Agriculture | George Weston Foods Limited | Pig manure | http://www.rdv.vic.gov.au/__data/assets/pdf_file/0019/209260/WEEP-Evaluation-SED-Summary-20140114.pdf |
| 5 | Berrybank, VIC | Agriculture | Charles IFE BerryBank Farm | Pig manure | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| 6 | Grantham, QLD | Agriculture | QLD Natural Pork Holdings | Pig manure | http://biomassproducer.com.au/projects |
| 7 | Lundavra Biogas - Agricultural Waste - QLD | Agriculture | Enviropower Investments Pty Ltd as Trustee for JB and KB Cameron Superannuation Fund | Pig manure | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| 8 | Mindarra, WA | Agriculture | Kamarah Piggery | Pig manure | http://biomassproducer.com.au/projects |
| 9 | Strathane Agricultural Waste - QLD | Agriculture | Cefn R & D Pty Ltd | Pig manure | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| 10 | Warra, QLD | Agriculture | Sunpork Farms | Pig manure | http://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/Emissions%20Reduction%20Fund%20Register.xlsx |
| 11 | Yarrawalla, VIC | Agriculture | Kia-Ora | Pig Manure | http://biomassproducer.com.au/project/kia-ora-piggery-poo-heats-and-powers-the-site-with-some-to-spare/#.Wcx6NrKx270 |

[27] Bioenergy Australia, Biogas Reports in Australia, AD Plants in Australia, http://www.bioenergyaustralia.org/pages/biogas-reports-in-australia.html
[28] https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4

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|---|---|---|---|---|---|
| **12** | Young, NSW | Agriculture | Windridge Farms | Pig manure | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| **13** | Young, NSW | Agriculture | Blantyre Farms | Pig manure | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| **14** | Corowa, NSW | Agriculture | Riverlea | Pig manure / Abattoir | http://www.cleanenergyregulator.gov.au/ERF/Pages/Emissions%20Reduction%20Fund%20project%20and%20contract%20registers/Project%20register/ERF-Project-Detailed-View.aspx?ListId=%7B7F242924-BF02-45EE-A289-1ABCC954E9CE%7D&ItemID=266 |
| **15** | Colac, VIC | Agriculture | Barwon Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **16** | Camellia, NSW | Biowaste | Earthpower Technologies | Municipal and commerical organic wastes | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| **17** | Janadakot, WA | Biowaste | Richgro | Municipal and commerical organic wastes | http://www.cleanenergyfinancecorp.com.au/our-investments/case-studies/converting-waste-to-energy.aspx |
| **18** | Shenton Park, WA | Biowaste | Western Metropolitan Regional Council | Municipal and commerical organic wastes | http://www.anaeco.com/index.php?option=com_frontpage&Itemid=1 |
| **19** | Spring Farm, NSW | Biowaste | Global Renewables / SITA | Municipal and commerical organic wastes | http://www.sita.com.au/facilities/arrt-facilities/spring-farm-advanced-resource-recovery-facility |
| **20** | Beaudesert, QLD | Industry | A J Bush and Sons | Abbatoir wastewater | http://www.cleanenergyfinancecorp.com.au/our-investments/case-studies/renderer-maximises-biogas-resources.aspx |
| **21** | Beenleigh, NSW | Industry | Teys Australia | Abbatoir wastewater | http://www.ampc.com.au/site/assets/media/Factsheets/Climate-Change-Environment-Water-Waste-Energy-Sustainability/Combating-climate-change.pdf and http://www.beefcentral.com/processing/teys-tr-in-latest-round-of-carbon-abatement-grants/ |
| **22** | Bromelton, QLD | Industry | AJ Bush & Sons | Abbatoir wastewater | http://www.business.gov.au/grants-and-assistance/closed-programs/CleanTechnology/CleanTechnologyInvestment/Pages/CTIP-Grantee.aspx# |
| **23** | Dinmore, QLD | Industry | JBS Australia | Abbatoir wastewater | http://www.cleanenergyfinancecorp.com.au/our-investments/case-studies/biogas-replaces-natural-gas-for-meat-processor.aspx |
| **24** | Hazelmere, WA | Industry | Talloman | Abbatoir wastewater | http://www.craigmostyn.com.au/rendering-protein/talloman/ and McNicholl 2014 Bioenergy Australia Conference |
| **25** | Inverell, NSW | Industry | Bindaree Beef | Abbatoir wastewater | http://www.mitchelhanlon.com.au/sites/default/files/content/13060_bindaree_beef_-_pea_final.pdf |

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|---|---|---|---|---|---|
| **26** | Kilcoy, QLD | Industry | Kilcoy Pastoral Company | Abbatoir wastewater | http://www.cleanenergyfinancecorp.com.au/media/76321/cefc-factsheet_agriculture-and-agribusiness_lr.pdf |
| **27** | King Island, TAS | Industry | JBS Australia | Abbatoir wastewater | http://www.ampc.com.au/resources/presentations2012/the-study-into-the-king-island-covered-anaerobic-lagoon-project and McNicholl 2014 Bioenergy Australia Conference |
| **28** | Longford, Tas | Industry | JBS Australia | Abbatoir wastewater | McNicholl 2014 Bioenergy Australia Conference |
| **29** | Murray Bridge, SA | Industry | Thomas Food | Abbatoir wastewater | http://www.beefcentral.com/processing/tfi-commits-30m-to-murray-bridge-biogas-project-plant-upgrade/ |
| **30** | Oakey, QLD | Industry | Nippon Meat Packers | Abbatoir wastewater | http://www.beefcentral.com/processing/self-funded-oakey-methane-project-looks-to-slash-millions-off-energy-bill/ and McNicholl 2014 Bioenergy Australia Conference |
| **31** | Rivestone, NSW | Industry | AJ Bush & Sons | Abbatoir wastewater | http://www.business.gov.au/grants-and-assistance/closed-programs/CleanTechnology/CleanTechnologyInvestment/Pages/CTIP-Grantee.aspx# |
| **32** | Rockhampton, NSW | Industry | Teys Australia | Abbatoir wastewater | http://www.ampc.com.au/site/assets/media/Factsheets/Climate-Change-Environment-Water-Waste-Energy-Sustainability/Combating-climate-change.pdf and http://www.beefcentral.com/processing/teys-tr-in-latest-round-of-carbon-abatement-grants/ |
| **33** | Singleton, NSW | Industry | Throsby Meats | Abbatoir wastewater | http://www.ampc.com.au/site/assets/media/Climate-Change/Wastewater-Research/Anaerobic-pond-material-vulnerability.pdf and McNicholl 2014 Bioenergy Australia Conference |
| **34** | Tamworth, NSW | Industry | Teys Australia | Abbatoir wastewater | http://www.beefcentral.com/processing/teys-tr-in-latest-round-of-carbon-abatement-grants/ |
| **35** | Wagga, NSW | Industry | Teys Australia | Abbatoir wastewater | http://www.beefcentral.com/processing/teys-tr-in-latest-round-of-carbon-abatement-grants/ |
| **36** | Windsor, NSW | Industry | Camilleri | Abbatoir wastewater | McNicholl 2014 Bioenergy Australia Conference |
| **37** | Maryvale, VIC | Industry | Australian Paper | Black Liquor | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| **38** | Tumut, NSW | Industry | Visy | Black Liquor + Energy Crops | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| **39** | Melbourne, VIC | Industry | Federation Square | Commerical Food Waste | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **40** | Allansford, VIC | Industry | Warrnambol Cheese and Butter | Food Processing Waste | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **41** | Nowra, NSW | Industry | Shoalhaven Starches | Food Processing Waste | http://www.manildra.com.au/community/article/environmentally_responsible/ |

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|---|---|---|---|---|---|
| **42** | Wendouree, VIC | Industry | McCains Ballarat | Food Processing Waste | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **43** | Yandina, QLD | Industry | Buderim Ginger | Food processing Waste | http://www.business.gov.au/grants-and-assistance/closed-programs/CleanTechnology/CleanTechnologyInvestment/Pages/CTIP-Grantee.aspx# |
| **44** | Ipswich, QLD | Industry | Trisco Foods | Food Waste | http://biomassproducer.com.au/project/pilot-trisco-foods-turn-sweet-scraps-into-power/#.Wcxc4LKx270 |
| **45** | Coolaroo, VIC | Industry | Visy | MSW paper pulp | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| **46** | Beresfield, NSW | Industry | Baiada | Poultry | http://biomassproducer.com.au/project/baiada-poultry-eases-costs-with-onsite-biogas-production/#.Wcxez7Kx270 |
| **47** | Bairnsdale, VIC | Water Utility | East Gippsland Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **48** | Bangholme, VIC | Water Utility | Melbourne Water Corporation | Sewage Sludge | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| **49** | Bateau Bay, NSW | Water Utility | Wyong Shire Council | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **50** | Beaudesert, QLD | Water Utility | Urban Utilities | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **51** | Bolivar, SA | Water Utility | SA Water | Sewage Sludge | http://www.sawater.com.au/sawater/education/ourwastewatersystems/wastewater+treatment+process.htm |
| **52** | Bondi, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/energy-management/index.htm |
| **53** | Bundaberg, QLD | Water Utility | Bundaberg Regional Council | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **54** | Cessnock, NSW | Water Utility | Hunter Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **55** | Christies Beach, SA | Water Utility | SA Water | Sewage Sludge | http://www.sawater.com.au/sawater/education/ourwastewatersystems/wastewater+treatment+process.htm |
| **56** | Contarf, QLD | Water Utility | Unity Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **57** | Coombahbah, QLD | Water Utility | City of Gold Coast | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **58** | Craigie, WA | Water Utility | Water Corporation (WA) | Sewage Sludge | https://www.watercorporation.com.au/-/media/files/residential/water%20supply%20and%20services/wastewater/beenyup-wwtp-brochure.pdf |
| **59** | Cronulla, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/energy-management/index.htm |

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|---|---|---|---|---|---|
| **60** | Elanora, QLD | Water Utility | City of Gold Coast | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **61** | Gatton, QLD | Water Utility | Urban Utilities | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **62** | Glenelg, SA | Water Utility | SA Water | Sewage Sludge | http://www.sawater.com.au/sawater/education/ourwastewatersystems/wastewater+treatment+process.htm |
| **63** | Hamilton, VIC | Water Utility | Wannon Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **64** | Hobart, Tas | Water Utility | TasWater | Sewage Sludge | http://ecogeneration.com.au/news/macquarie_point_wastewater_treatment_plant_cogeneration_project/002090/ |
| **65** | Hornsby Heights, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/current-projects/improving-our-wastewater-system/west-camden-waterrecycling-plant/index.htm |
| **66** | Kawana, QLD | Water Utility | Unity Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **67** | Kincumber, NSW | Water Utility | Gosford City Council | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **68** | Leongatha, VIC | Water Utility | South Gippsland Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **69** | Malabar, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/energy-management/index.htm |
| **70** | Maroochydore, QLD | Water Utility | Unity Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **71** | Melton, VIC | Water Utility | Western Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **72** | Mooroopna, VIC | Water Utility | Goulburn Valley Water | Sewage Sludge | http://www.gvwater.vic.gov.au/communications/publications/images/Annual_Report_2007-08_Water_Environment.pdf |
| **73** | Mt Martha, VIC | Water Utility | South East Water | Sewage Sludge | http://southeastwater.com.au/CurrentProjects/Projects/Pages/MtMarthaSTPUpgrades.aspx |
| **74** | Munster, WA | Water Utility | Water Corporation (WA) | Sewage Sludge | https://www.watercorporation.com.au/-/media/files/residential/water%20supply%20and%20services/wastewater/woodman-point-wwtp-brochure.pdf |
| **75** | Narrambla, NSW | Water Utility | Orange City Council | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **76** | Norah, NSW | Water Utility | Wyong Shire Council | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **77** | North Head, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/energy-management/index.htm |
| **78** | North Rockhampton, QLD | Water Utility | Rockhampton Regional Council | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |

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|---|---|---|---|---|---|
| **79** | Pinkenba, QLD | Water Utility | Urban Utilities | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **80** | Riverstone, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/current-projects/improving-our-wastewater-system/west-camden-waterrecycling-plant/index.htm |
| **81** | Rocklea, QLD | Water Utility | Urban Utilities | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **82** | Shepparton, VIC | Water Utility | Goulburn Valley Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **83** | Tatura, VIC | Water Utility | Goulburn Valley Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **84** | Warriewood, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/energy-management/index.htm |
| **85** | Werribee, VIC | Water Utility | AGL Energy Sales | Sewage Sludge | https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml?recType=LGC |
| **86** | West Camden, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/current-projects/improving-our-wastewater-system/west-camden-waterrecycling-plant/index.htm |
| **87** | West Camden, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/current-projects/improving-our-wastewater-system/west-camden-waterrecycling-plant/index.htm |
| **88** | West Hornsby, NSW | Water Utility | Sydney Water Corporation | Sewage Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/current-projects/improving-our-wastewater-system/west-camden-waterrecycling-plant/index.htm |
| **89** | Woodford, QLD | Water Utility | Unity Water | Sewage Sludge | https://batchgeo.com/map/2fb1cc9f27a39cb7b37562b95c32bcf4 |
| **90** | Glenfield, NSW | Water Utility | Sydney Water Corporation | Water Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/energy-management/index.htm |
| **91** | Liverpool, NSW | Water Utility | Sydney Water Corporation | Water Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/energy-management/index.htm |
| **92** | Wollongong, NSW | Water Utility | Sydney Water Corporation | Water Sludge | http://www.sydneywater.com.au/SW/water-the-environment/what-we-re-doing/energy-management/index.htm |

# 7 Increasing Size and Scale of Agribusinesses in Australia

Increasing commercialisation and corporatisation of the agribusiness industry is seeing the size and scale of agribusiness operations continue to increase to service the growing demand most economically and efficiently.

The increasing size and scale of the agribusiness operations makes anaerobic digestion and biogas production increasingly attractive and increasingly economic as a standalone proposition.

- Dairies
  - 1979/80 = 1,880,000 cows / 21,994 registered farms
  - 2014/15 = 1,740,000 cows / 6,128 registered farms[29]
- Piggeries
  - The numbers of pig producers has reduced from ~50,000 in 1960 to ~1,000 in 2012
  - The number of sows and gilts has remained relatively stable, 2,137,921 as at June 2012[30]
- Egg Farms
  - 22.049 million pullets & layers as at December 2010 / 309 egg farms as at June 2009
  - 25.688 million pullets & layers as at December 2015 / 252 egg farms as at June 2014[31]
- Chicken Broiler Farms
  - The chicken meat industry has grown from ~300 million birds produced in 1990 to ~600 million birds produced in 2016[32]
- Cattle feed lots
  - Cattle on feed has increased from ~400,000 head in 1995 to ~1,000,000 head in 2017[33]

# 8 Australia is an Immature Biogas Market

Due to different regulatory markets and incentive programs, other international jurisdictions' biogas markets are significantly more developed than Australia.

There is significant potential for biogas to make a contribution to Australia's renewable energy ambitions, greenhouse gas reduction targets and increase energy security by providing dispatchable renewable energy at distributed locations.

[29] Dairy Australia, Australian Dairy Industry In Focus 2016, https://www.dairyaustralia.com.au/-/media/dairyaustralia/documents/about-dairy-australia/key-publications/2016-in-focus.ashx?la=en&hash=663613D9E790F02D90D825E6C842C31BCB3F40D0
[30] Australian Pork Limited, Australian Pig Annual 2012-2013, http://auspigannual.realviewdigital.com/#folio=11
[31] Australian Eggs Limited, https://www.aecl.org/
[32] Australian Chicken Meat Federation Inc., ACMF is the peak coordinating body for participants in the chicken meat industries in Australia, http://www.chicken.org.au/files/_system/Image/Graphs/Chicken%20Meat%20Production%20-%20detailed.jpg?Production=Production
[33] Australian Lot Feeders' Association, ALFA / MLA Feedlot Survey, Jan - Mar 2017 http://www.feedlots.com.au/industry/quarterly-survey

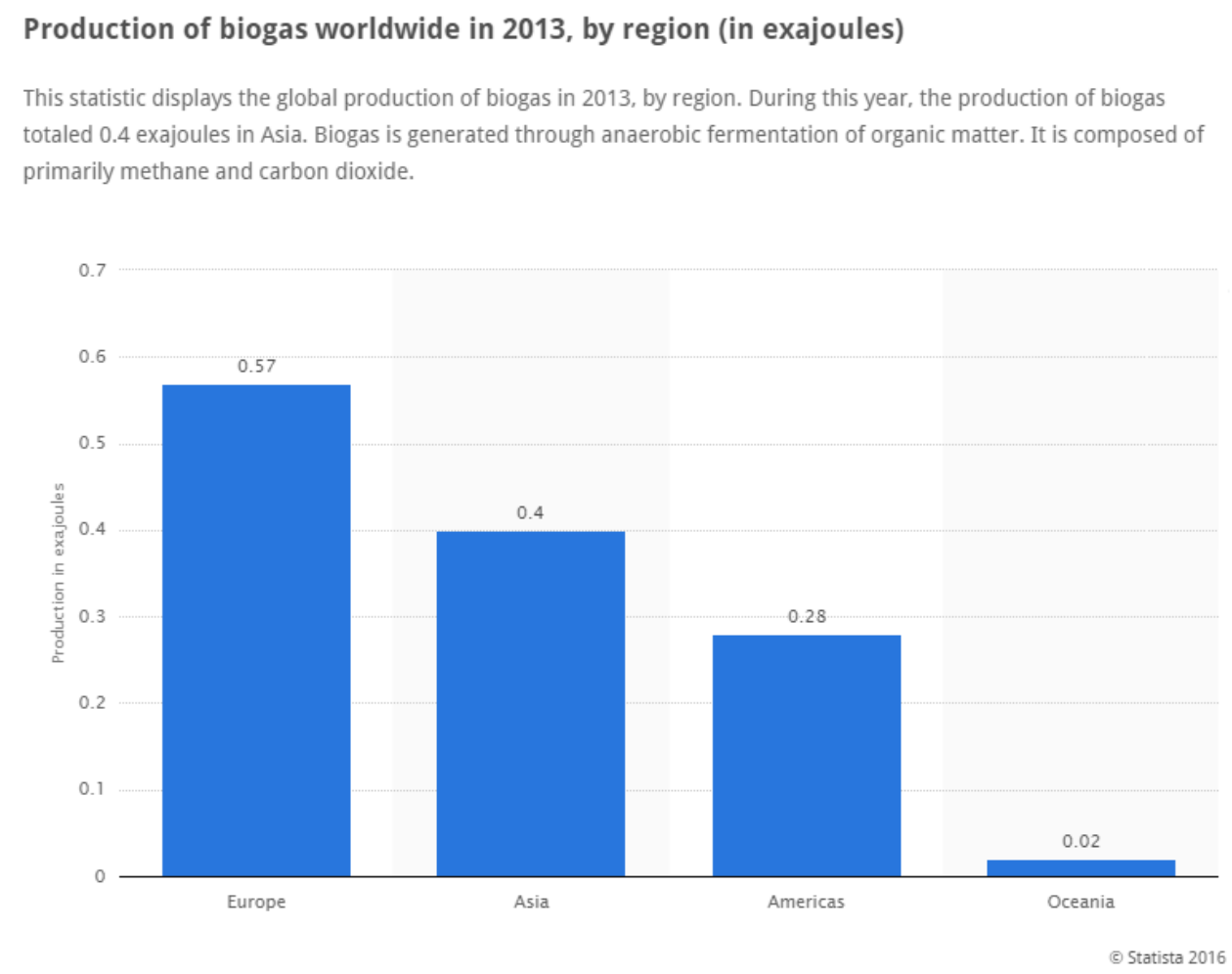



**Figure 2 Production of biogas worldwide[34]**

# 9 Digestate for Fertiliser

The value adding practice of turning post anaerobic digestion "digestate" into higher value commercial products, i.e. retail packaged fertiliser / potting mix, is an emerging market.

The Berrybank Piggery in Victoria, supported by Federal and State Government grants, has successfully incorporated packaging of digestate for retail fertiliser / potting mix[35].

[34] Statista Inc., https://www.statista.com/statistics/481828/biogas-production-worldwide-by-region/
[35] Sustainability Victoria, Case study: Energy from waste helps Berrybank Farm bring home the bacon, November 2015, http://www.sustainability.vic.gov.au/-/media/resources/documents/services-and-advice/business/investment-facilitation/written-case-studies/investment-case-study---berrybank-farm---december-2015.pdf?la=en

In the USA digester by-product is now being stocked by Walmart and garden supply outlets[36].

As more facilities incorporate anaerobic digestion into their processes, this will open up the product distribution channels and enable the industry to adopt packaging digestate into retail fertiliser.

# 10 Potential Australian Biogas Market Size – By Target Industry

## 10.1 Abattoirs

There has been multiple (~18) covered anaerobic lagoons deployed at various abattoirs (Table 6). Government programs have helped enable the deployment of anaerobic digestion in abattoirs and food processors as best practice adoption. Several abattoir based projects were enabled through the Clean Technology Innovation Program[37].

Opportunities in the abattoir space will be driven by new abattoirs (driven by the growth in meat exports), upgrading of existing uncovered ponds as the existing ponds reach the end of their design life, and solutions for smaller abattoirs as the cost of energy and cost of carbon rises and anaerobic digestion technology improves.

There are 129 abattoirs on the AUS-MEAT Accreditation Listing[38].

Of the 129, approximately 10 are large scale (export accredited, daily kill greater than 400 cattle per day / 2,000 sheep per day), 30 medium scale (export accredited, daily kill less than 400 cattle per day / 2,000 sheep per day) and 90 small scale (domestic supply only). Based on this distribution, the total market opportunity for biogas in abattoirs is estimated at ~40 projects (all the large plus half the medium) and ~$160 million value.

**Table 7 Estimated number and distribution (by size) of abattoirs in Australia**

| Size | Facilities | Viability of Anaerobic Digestion and Biogas | |
|---|---|---|---|
| Small | 89 | Economically sub scale | |
| Medium | 30 | Economically sufficient scale | |
| Large | 10 | Economically sufficient scale | |
| | | | |
| | | Value per opportunity[39,40] | $4.0 million |
| | | Total Market Opportunity $ | $160 million |

[36] Waste360, http://www.waste360.com/anaerobic-digestion/wisconsin-firm-converts-waste-soil-replacement
[37] Department of Industry, Innovation and Science, Clean Technology Investment Program, Delivered by AusIndustry, https://www.business.gov.au/~/media/Business/CTInvesProg/Clean-technology-investment-program-grant-recipients-XLSX.ashx?la=en
[38] AUS-MEAT Accreditation Listing, https://www.ausmeat.com.au/docs/AUS-MEAT%20Accreditation%20Listing.pdf
[39] ReNu Energy estimate
[40] Meat and Livestock Australia Limited, Covered Anaerobic Lagoons Meat Industry Applications

## 10.2 Food Processing

Food processing targets for biogas include meat renderers, milk and dairy processors, pre-made meal preparers and frozen food packagers etc.

There are ~76 rendering operations who are members of the Australian Renders Association Inc[41]. Most renderers are co-located with abattoirs, with ~15 utilising anaerobic digestion on site. Other rendering sites utilise open ponds as part of their waste water treatment. These sites with only open ponds are primary targets for anaerobic digestion as they expand and upgrade their waste water treatment systems.

The organics in the milk and dairy processing waste water is highly valuable to the milk and dairy processors. Hence they are strongly incentivised to reclaim the organics in their waste water. This make biogas projects somewhat challenging, as there is risk of biogas production from anaerobic digestion being reduced due to site efficiency improvements.

Anaerobic digestion for packaged meal preparers, chip manufacturers etc is primarily driven by regulation (i.e. regulation of release of water used into trade waste) as they are generally located in industrial parks. Note facilities like breweries typically have anaerobic digestion (UASB style), though typically they do not produce enough biogas to be commercially attractive (e.g. the Carlton United brewery at Yatala flares their biogas).

**Table 8 Estimated market opportunity for food processing industry anaerobic digestion**

| Facilities | Value per Opportunity | Total Market Opportunity $ |
|---|---|---|
| 20[42] | $5.0 m | $100.0 m |

## 10.3 Piggeries

There has been multiple (~10) covered anaerobic lagoons deployed at various piggeries (Table 6). The implementation of these projects has been driven by a variety of factors including reliability of grid electricity at fringe of grid locations, and diesel replacement.

The piggery industry group, Australian Pork Limited, has been instrumental in developing best practice guidelines, fact sheets and checklists to assist operators to adopt biogas and bioenergy[43]. Relative to dairies, egg farms, chicken broilers and beef cattle, the transition from the conventional waste / waste water treatment practices used by the piggery industry to best practice anaerobic digestion and biogas capture is a relatively modest transition which has assisted early adoption of best practice in the industry.

The opportunities in the piggery space will be driven by greenfield piggery development and brownfield piggery expansion where environmental regulation is moving towards requiring anaerobic digestion and biogas capture in line with best practice.

[41] Australian Renderers Association Inc Membership Listing, http://ausrenderers.com.au/index.php/downloads/category/15-membership
[42] ReNu Energy estimate
[43] Australian Pork Limited, the producer owned organisation supporting and promoting the Australian pork industry, http://australianpork.com.au/industry-focus/environment/renewable-energy-biogas/

There are ~1,900 piggeries in Australia[44]. It is estimated that ~20 to 30 facilities are of sufficient scale for a purely economic biogas project (i.e. not for development approvals or environmental approvals). At a typical piggery project size of ~$4 million per project, this equates to a potential market size of ~$100 million.

**Table 9 Estimated number and distribution (by size) of piggeries in Australia**

| | Sows | Midpoint | Total Pigs | Facilities | Viability of Anaerobic Digestion and Biogas |
|---|---|---|---|---|---|
| Small scale | 1-49 | 25 | 10,480 | 1,063 | Economically sub scale |
| Small Commercial | 50 -99 | 75 | 11,849 | 163 | Economically sub scale |
| Medium Commercial | 100 – 499 | 300 | 69,880 | 277 | Economically sub scale |
| Large | 500 – 999 | 750 | 58,343 | 82 | Economically sub scale |
| | 1,000 + | na | 1,987,369 | 324 | |
| | ReNu assumed lower distribution 1000 + | 2,225 | 667,369 | 300 | Economically sub scale |
| | ReNu assumed upper distribution 1000 + | 55,000 | 1,320,000 | 24 | Economically sufficient scale |
| | | | | Value per Opportunity | $4.0 m |
| | | | | Total Market Opportunity $ | $96.0 m |

## 10.4 Dairies

There are only 2 covered ponds on dairy farms in Australia[45]. There has been lower deployment of anaerobic digestion solutions on dairy farms for a number of reasons. The primary reason is that the majority of dairies in Australia are pasture based dairies rather than shedded dairies. Manure collection is a matter of standard practice for shedded dairies, whilst manure is not collected at pasture based dairies, and collection is logistically difficult. Secondarily, the volatile solids ratio for cow manure is lower (compared to pig manure). Following the USA lead, it is expected that there will be a shift towards shedded dairies with larger herd sizes in the future.

There are approximately 6,128 registered dairy farms in Australia. Approximately 333 of the 6,128 dairy farms are in categorised as large scale by Dairy Australia (> 700 head).

[44] Australian Pork Limited, Australian Pig Annual 2012-2013, http://auspigannual.realviewdigital.com/
[45] AgSystems Design, Energy from biogas – bright future or big headache, DfT Professional Development, 26 October 2010, http://www.murraydairy.com.au/_literature_97343/Biogas_-_Headache_or_Bright_Future

**Table 10 Estimated number and distribution (by size) of dairies in Australia (2014-15) – Adapted from Dairy Australia, Dairy Industry In Focus 2016[46]**

| Herd Size | <150 | 150-300 | 301-500 | 501-700 | >700 | All Sizes |
|---|---|---|---|---|---|---|
| | Farms by State | | | | | |
| VIC | 632 | 2,146 | 812 | 330 | 206 | 4,126 |
| NSW | 218 | 310 | 106 | 35 | 35 | 704 |
| Subtropical | 152 | 224 | 63 | 0 | 9 | 448 |
| Dairy SA | 63 | 118 | 40 | 18 | 13 | 252 |
| West | 26 | 63 | 42 | 13 | 13 | 157 |
| Tas | 61 | 185 | 119 | 18 | 57 | 440 |
| Australia | 1,151 | 3,068 | 1,183 | 396 | 330 | 6,128 |
| | | | | | | |
| Average Herd Size* | 50 | 200 | 367 | 567 | 1,090 | |
| Total Head | 57,575 | 613,597 | 434,056 | 224,670 | 359,384 | 1,689,252** |

* Assumes the average herd size in each grouping in skewed towards the lower end of the group

** Australian Dairy Industry In Focus 2016 reported 1,689,000 head in 2014-15

**Table 11 List of Shedded Dairies in Australia (note this list are those known to ReNu Energy and is not comprehensive)**

| Dairy | Location | Head | Reference |
|---|---|---|---|
| Lemontree Dairy | Darling Downs, QLD | ~1,000 | http://www.lemontreedairy.com.au/ |
| Riverina Dairy | Corowa, NSW | ~2,000 | http://www.riverinadairy.com/index.php |
| Trigg | Bungaree, VIC | ~500 | http://adf.farmonline.com.au/news/magazine/equipment-and-technology/general/ballarat-freestall-barn-on-show/2700383.aspx |
| Wright | Allora, QLD | ~250 | http://www.daviesway.com.au/products/dairy_installations/free-stall-barn-installations/wright-s-256-cow-free-stall-barn.aspx |
| Nilma | Gippsland, VIC | ~300 | http://www.stockandland.com.au/story/3560224/free-stall-sheds-work/ |
| Leppington Pastoral | Bringelly, NSW | ~2,000 | http://www.lpcmilk.com/ |
| Moxey Farms | Gooloogong, NSW | ~7,000 | http://www.theland.com.au/story/4642957/moxey-farms-adds-one-more/ |
| McNamara Dairying | Irrewillipe, VIC | ~1,000 | http://www.farmweekly.com.au/news/agriculture/cattle/dairy/cow-from-colac-vic-makes-the-grade/1400689.aspx |
| Glen Goulburn Dairy | Coomboona, VIC | ~1,600 | http://www.coomboona.com/our-history/ |

[46] Dairy Australia, Dairy Industry In Focus 2016

For the medium term outlook, ReNu assesses there is / will be approximately 10 dairy anaerobic digestion and biogas projects. As the shedded dairy operation skews to the very large size operations, the projects will typically be larger in size. Hence ReNu has estimated a typically dairy project at ~$6 million in

**Table 12 Estimated market opportunity for shedded dairy anaerobic digestion**

| Facilities | Average Herd Size | Head | |
|---|---|---|---|
| 10 | 3,000 | 30,000 | Economically sufficient scale (Note no ACCU's) |
| | | Value per Opportunity | $6.0 m |
| | | Total Market Opportunity $ | $60.0 m |

## 10.5 Egg Farms

There is currently 1 existing anaerobic digestion facility on an egg farm, which was supported by the Clean Technology Food and Foundries Innovation Program[47].

It is expected opportunities in the egg farm industry will grow as measurement of greenhouse gas emissions from egg farming practices are better understood. Currently anaerobic digestion of chicken manure does not qualify under the Emissions Reduction Fund for the creation of Australian Carbon Credit Units. This is because the release of greenhouse gases from chicken manure is not well understood.

Raw chicken manure directly spread on soil will not release material amounts of greenhouse gases as it lacks the bacteria to cause the breakdown of the organic materials and release of methane, the carbon in the chicken manure is released to the environment primarily as carbon dioxide as opposed to methane (with methane having a much greater global warming potential).

Composted chicken manure will release material amounts of greenhouse gases as during the composting process, which includes mixing the new chicken manure with other organics and composted/broken down chicken manure, bacteria is introduced to the chicken manure hence accelerating the composting of the chicken manure, but also releasing methane.

Further work is required, which may lead to the development of an Emission Reduction Fund methodology for egg farm projects (where the standard practice is to send chicken manure to compost). This will enhance the economic viability of egg farm anaerobic digestion projects and open up the market opportunity.

There are 252 egg farms in Australia housing 25 million birds[48]. ReNu Energy estimates there is currently ~25 egg layer facilities that would be of sufficient scale for a biogas project. Note egg layer facilities are generally co-located with egg washeries to provide the water, though it is estimated a proportion of the ten won't be co-located with egg washeries and hence may not have access to a water supply for anaerobic digestion. With continued growth in the industry, in the medium term ReNu Energy expects there will be ~20 potential opportunities for anaerobic digestion and biogas in the egg farm industry.

[47] Rural Industries Reasearch & Development Corporation, Poultry manure to power in the Darling Downs, December 2014, http://biomassproducer.com.au/case_study/poultry-manure-to-power-in-the-darling-downs/#.V-3UXvn5i70

[48] Australian Egg Corporation Limited (AECL), Australian egg industry overview – December 2015, https://www.aecl.org/dmsdocument/523

**Table 13 Estimated number and distribution (by size) of egg farms in Australia (2015) – Adapted from AECL Australian egg industry overview**

| Size | Midpoint | Facilities | Birds | | |
|---|---|---|---|---|---|
| < 100,000 | 31,411 | 197 | 6,188,000 | Economically sub scale | |
| 100,000 - 300,000 | 200,000 | 30 | 6,000,000 | Economically sub scale | |
| 300,000 - 500,000 | 400,000 | 15 | 6,000,000 | Economically sufficient scale (Note no ACCU's) | |
| 500,000 - 1,000,000 | 750,000 | 10 | 7,500,000 | Economically sufficient scale (Note no ACCU's) | |
| Total | | 252 | 25,688,000 | | |
| | | | | Potential opportunities | ~20 |
| | | | | Value per Opportunity | $5.0 m |
| | | | | Total Market Opportunity $ | $100.0 m |

## 10.6 Chicken Broiler Farms (Poultry)

Currently there are no anaerobic digestion projects deployed at broiler operations. Similar to egg farms, broiler operations do not currently qualify under the Emissions Reduction Fund for the creation of Australian Carbon Credit Units. Based on latest research it is expected that in the near term an Emission Reduction Fund methodology for broiler projects will be developed. This will enhance the economic viability of broiler farm anaerobic digestion projects and open up the market opportunity.

There are ~500 million birds produced each year. Typically, meat chicken growing is contracted out, with around 800 contract growers producing 80 per cent of Australia's meat chickens[49]. The 500 million bird annual production equates to a bird population of ~70 million at any time. This is significantly more birds than the population of egg layers.

Anaerobic digestion for broiler farms is currently challenging due to broiler farms not having a qualifying ERF methodology. Broiler farms often also have limited access to water for anaerobic digestion. Due to the limited access to water, it is considered more likely that anaerobic digestion for chicken broiler farms will be tank style digesters rather than covered anaerobic lagoons. ReNu Energy estimates that in the medium term the opportunity in the chicken broiler farm industry for anaerobic digestion and covered anaerobic lagoons is in the order of 20 projects and $100 million.

[49] Australian Chicken Meat Federation (ACMF) Inc, The Australian Chicken Meat Industry: An Industry in Profile, 2011, http://www.chicken.org.au/industryprofile/downloads/the_australian_chicken_meat_industry_an_industry_in_profile.pdf

**Table 14 Estimated number and distribution (by size) of chicken broiler farms in Australia – Adapted from ACMF Australian Chicken Meat Industry Profile**

| Size | Midpoint | Facilities | Birds |
|---|---|---|---|
| < 10,000 | 5,833 | 1,200 | 7,000,000 |
| 10,000 - 100,000 | 50,000 | 600 | 30,000,000 |
| 100,000 - 200,000 | 150,000 | 180 | 27,000,000 |
| > 200,000 | 300,000 | 20 | 6,000,000 |
| Total | | 2,000 | 70,000,000 |
| | | Potential opportunities | ~20 |
| | | Value per Opportunity | $5.0 m |
| | | Total Market Opportunity $ | $100.0 m |

## 10.7 Cattle Feed Lots

Currently there are no anaerobic digestion projects deployed at cattle feed lots in Australia. This is due to existing feed lot design where it is difficult to collect manure for the purpose of biogas production and due to the variability in head count at the feedlot.

Internationally, eg the USA, it is common practice to utilise a feedlot design which incorporates collection of manure and the production of biogas. An example is BioTownAg[50] in Indiana, USA where the waste from ~4,500 beef cattle plus ~800 pigs, is utilised to produce ~2.5 MWe.

The largest single site feedlot in Australia houses up to ~56,000 head at any time[51]. This compares to a large shedded dairy which houses ~5,000 head. Thus there is a large potential market in the feed lot sector.

The feed lot industry is currently developing new feed lot designs and operational practices to take advantage of the biogas potential. The Australian Government Rural Industries Research and Development Corporation have also been evaluating the biogas production for cattle feed lots[52]. This will open up this market opportunity in the longer term.

## 10.8 Mixed Waste Anaerobic Digestion

Anaerobic digestion of mixed waste has the added benefit of avoiding landfilling waste and the costs associated. There is significant investment required with regards to waste handling and logistics in order to access the benefits.
The Jandakot Bioenergy Plant operated by Richgro in Western Australia is an example of a mixed waste facility[53]. For a total capital spend $8 million, the Jandakot facility processes 35,000- 50,000 tonne per annum of food waste at the anaerobic digestion plant at Richgro Garden Products. The Jandakot Bioenergy

[50] BiotownAg, http://biotownag.com/
[51] Beef Central, http://www.beefcentral.com/top-25-lotfeeders-list/
[52] Rural Industries Research and Development Corporation, Feedlot Waste, http://biomassproducer.com.au/producing-biomass/biomass-types/animal-waste/feedlot-waste/#case
[53] Joseph Oliver, Biogass Renewables Pty Ltd, Jandakot Bioenergy Plant, Commercially-viable bioenergy from foodwaste: an Australian success story at Richgro Garden Products, November 2015, https://arena.gov.au/assets/2015/11/Jandakot-Bioenergy-Plant.pdf

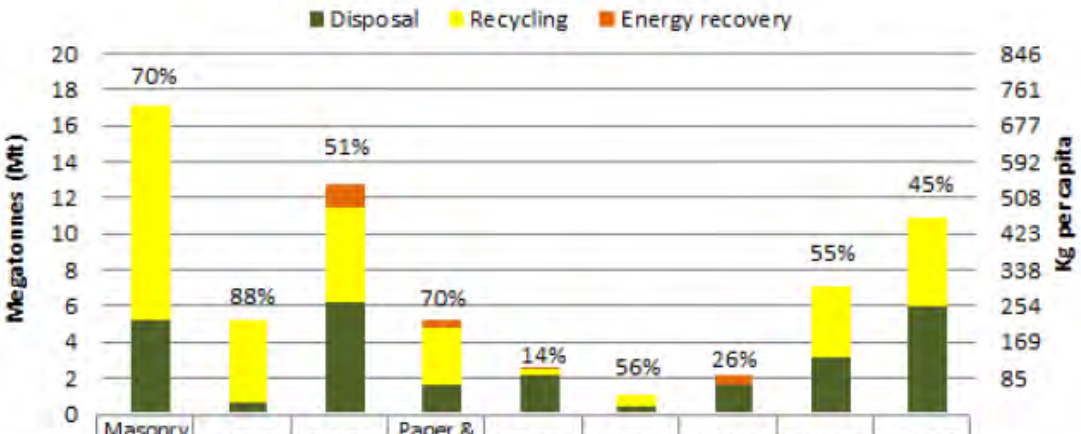
Plant is designed to produce over 2 $MW_e$ capacity electricity, with 1.7 $MW_e$ exported to the grid, and up to 2.2 $MW_{th}$ heat for utilization. The facility also produces up to 100$m^3$ of liquid biofertiliser at 6% dry solids;

The potential for mixed waste anaerobic digestion is greatest in NSW due to the relatively high waste levy (compared to other states). As shown in **Error! Reference source not found.**, it can be seen the majority o f benefit from a mixed waste anaerobic digestion project is accrued from the avoided waste levy and the value adding to higher value end products (i.e. garden products).

As identified in the Australian National Waste Report 2016[54], there are 13 million tonnes of organics waste produced nationally. Of this 5.2 million tonnes is recycled and 1.4 million tonnes is utilised in energy recovery, leaving 6.2 million tonnes currently being disposed.

ReNu Energy estimates that ~10% of the 6.2 million tonnes could be utilised for energy recovery through anaerobic digestion, i.e. ~0.6 million tonnes. This is equivalent to about 20 projects of a similar scale to the Richgro Jandakot facility. At an approximate capital cost of $10 million per project this indicates a market size of approximately $200 million.

[54] Randell Environmental Consulting, Prepared for Department of the Environment and Energy, Australian National Waste Report 2016, http://www.environment.gov.au/system/files/resources/d075c9bc-45b3-4ac0-a8f2-6494c7d1fa0d/files/national-waste-report-2016.pdf




| | Masonry mat. | Metals | Organics | Paper & c'board | Plastics | Glass | Other | Hazwaste | Fly ash |
|---|---|---|---|---|---|---|---|---|---|
| Generation (kg/cap) | 726 | 219 | 542 | 223 | 107 | 45 | 91 | 298 | 460 |
| Generation (Mt) | 17 | 5.2 | 13 | 5.3 | 2.5 | 1.1 | 2.1 | 7.0 | 11 |
| En recovery (Mt) | | | 1.4 | 0.5 | 0.02 | | 0.5 | 0.0 | |
| Recycling (Mt) | 12.0 | 4.6 | 5.2 | 3.2 | 0.3 | 0.6 | 0.1 | 3.9 | 4.9 |
| Disposal (Mt) | 5.2 | 0.6 | 6.2 | 1.6 | 2.2 | 0.5 | 1.6 | 3.2 | 5.9 |

*'Masonry mat.' means masonry material; 'c'board' means cardboard; 'Hazwaste' means hazardous waste; 'En recovery' means energy recovery. The stated percentages are the resource recovery rates = (energy recovery + recycling) / generation.*

**Figure 3 Waste generation by fate and material category, Australia 2014-15 (Australian National Waste Report)[55]**

# 11 Geographic Considerations

There are several different aspects to consider when considering how geography affects a project. These include:

- Climate
  - Like the human stomach, anaerobic digestion works better in warmer climates (i.e. approximately body temperature) with more stable temperatures, in particular cold temperatures are undesirable;
  - The impacts of cold temperatures can be mitigated through heating of the digester, e.g. using waste heat from biogas engines, or using insulated covers;
- Wind
  - The cover for a covered anaerobic lagoon will be subject to wind loadings which will impact the amount of ballast required to weight the cover down

[55] Randell Environmental Consulting, Prepared for Department of the Environment and Energy, Australian National Waste Report 2016, http://www.environment.gov.au/system/files/resources/d075c9bc-45b3-4ac0-a8f2-6494c7d1fa0d/files/national-waste-report-2016.pdf

- Geotechnical
  - The key geotechnical consideration is the level of the water table
  - The level of the water table will impact the maximum depth of a lagoon
  - The soil and rock conditions will also impact the maximum slope of the lagoon walls, and whether the liner of the lagoon will require any protection (e.g. through the use of geotextile fabric to prevent rock shards tearing a plastic liner)
- Feedstock availability
  - This is especially a consideration for mixed waste digestion, which can often be seasonal
  - Due to cost of logistics, feedstock need to be within a reasonable radius
- Water availability
  - Many feedstocks will require additional water to be added to the feedstock prior to anaerobic digestion, e.g. chicken manure, hence the availability of water is a key consideration
- Soil conditions for irrigation
  - The soil conditions will impact whether digestate (i.e. the “sludge” post anaerobic digestion and subsequent treatment) can be irrigated to land
  - The digestate will contain nitrogen, phosphorous and potassium
  - In general these elements are beneficial to agriculture, but too much of any or all of these elements can have negative impacts on agricultural productivity
- Water, road and easement crossings
  - Often for general site amenity, in particular relating to odour, anaerobic digesters are physically separated from primary site operations
  - Physical separation can also be driven by geotechnical and site space considerations, or due to some land on site having higher value (e.g. being more agriculturally productive land) and some land having lower value
  - This can introduce considerations such as effluent pipes, gas pipes, electric cables and/or access roads needing to cross creeks, roads or other easements which can impact development approvals and project cost
- Regional cost of energy
  - Although there is a “National Electricity Market” encompassing New South Wales, Queensland, South Australia, Tasmania and Victoria, there remains significantly different wholesale costs of electricity in the different state and territory jurisdictions
  - The financial year average wholesale energy prices for financial year 2015/16 and 2016/17 are shown in Table 15
  - The wholesale cost of energy is a key component (along with network and distribution charges) of end user electricity bills which is a key consideration when assessing an anaerobic digestion and biogas for electricity project

**Table 15 National Electricity Market Wholesale Prices 2015/16 and 2016/17[56]**

| YEAR | NSW | QLD | SA | TAS | VIC |
|---|---|---|---|---|---|
| FY16 | $51.60 /MWh | $59.99 /MWh | $61.67 /MWh | $102.70 /MWh | $46.14 /MWh |
| FY17 | $81.22 /MWh | $93.12 /MWh | $108.66 /MWh | $75.40 /MWh | $66.58 /MWh |

- Regional network and distribution charges
  - Along with the wholesale cost of energy, the network and distribution charges are a key component of end user electricity bills
  - Network and distribution charges vary significantly from jurisdiction to jurisdiction
  - A list of electricity distribution and network companies is shown in Table 16
  - There are typically three key components of network and distribution charges, network energy costs (charged in units of $/kWh), network demand costs (charged in units of $/kVA) and fixed charges (charged in units of $ per day)
  - These network charges can also be separated into different time periods, e.g. peak, off-peak and shoulder periods
  - Subject to Australian Energy Regulator determination of network electricity pricing proposals[57], the electricity and distribution network companies have flexibility to
    - Set the pricing mix for network energy charges, network demand charges and fixed charges
    - Define what is a peak period, what is an off-peak period and what is a shoulder period
    - Set the pricing mix for peak, off-peak and shoulder periods
    - Define summer months / winter months or high demand months / low demand months
    - Set the pricing mix for summer months / winter months etc
    - Set different usage thresholds such that different network tariffs structures apply above and below the threshold
  - To illustrate the widely varying network tariff regimes, for a “large user”
    - In the Energex network a large user might be on network tariff CAC-NTC4500 (Connection Asset Customer connected to an 11 kV Line)[58]
      - Network Fixed Charge = “Site specific prices are confidential”
      - Network Demand Charge = $12.567 /kVA/month
      - Network Usage Peak = $0.00421 /kWh

[56] Australian Energy Market Operator, Average Prices - Historical, http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data-dashboard#average-price-table
[57] Australian Energy Regulator, Networks & Pipelines, Determinations & Access Arrangements, Pricing proposals & tariffs, https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/pricing-proposals-tariffs
[58] Energex, SCS and ACS prices, 1July 2017 to 30 June 2018, https://www.energex.com.au/home/our-services/pricing-And-tariffs/business-customers/pricing-publications

  - Network Usage Off Peak = $0.00421 /kWh
  - Peak = 7am – 11pm Monday to Friday
  - Off peak = All other times
- In the Essential Energy network, a large user might be on network tariff BLND3AO (LV TOU Demand 3 Rate)[59]
  - Network Fixed Charge = $14.3064 /day
  - Network Demand Charge Peak = $9.7278 /kVA/month
  - Network Demand Charge Shoulder = $8.8013 /kVA/month
  - Network Demand Charge Off Peak = $2.1175 /kVA/month
  - Network Energy Charge Peak = $0.037065 /kWh
  - Network Energy Charge Shoulder = $0.034187 /kWh
  - Network Energy Charge Off Peak = $0.022104 /kWh
  - Peak = 7am - 9am and 5pm - 8pm on weekdays
  - Shoulder = 9am - 5pm and 8pm - 10pm on weekdays
  - Off peak = All other times
- In the SA Power Networks network, a large user might be on network tariff BD (Large Business LV Tariff Class Business Monthly Actual kVA Demand)[60]
  - Network Fixed Charge = $0.3460 /day
  - Network Demand Charge Year Shoulder 12 months = $0.2048 /kVA/day (= $6.144 /kVA/month assuming 30 days in a month)
  - Network Demand Charge Summer Peak 5 months = $0.4126 /kVA/day (= $12.378 /kVA/month assuming 30 days in a month)
  - Network Energy = $0.0497 /kWh
  - Shoulder demand (12 months) applies to the monthly workday maximum kVA demand (measured over a half hour interval) between 12:00 and 16:00 hours local time, for each month of the year
  - Summer peak demand is an additional peak demand price which applies during the peak period (November to March) between 16:00 and 21:00 hours local time, on workdays
- From the 3 examples above it can be seen

[59] Essential Energy, Network Price List and Explanatory Notes, https://www.essentialenergy.com.au/asset/cms/pdf/electricitynetwork/PriceListAndExplanatoryNotes2017-18.pdf

[60] SA Power Networks, Network Tariff & Negotiated Services, Manual No. 18, August 2017, https://www.sapowernetworks.com.au/public/download.jsp?id=65467

  - the Network Energy Charge ranges from less than 1 c/kWh (Energex) to almost 5 c/kWh (SA Power Networks)
  - the Network Fixed Charge ranges from less than $1 /day (SA Power Networks) to approximately $14 /day (Essential Energy)
  - the Network Demand Charges rates are not directly comparable as they are defined so differently

- Network Connection
  - A biogas project will typically be required to submit a connection application with the network operator as a Negotiated Connection
  - Although all the network operators are regulated by the Australian Energy Regulator and their frameworks for Negotiated Connections are approved by the Australian Energy Regulator, each network operator has their own process, own information requirements and own technical standards for Negotiation Connection Applications
  - As a simple example the threshold for being categorised as a Negotiated Connection can vary across the different network jurisdictions
  - For example in the Energex network, an Embedded Generator, e.g. solar panels, thermal or wind generation systems, with a capacity of 5 kW (or 5 kVA) or more will be categorised as a Negotiated Connection[61]
  - In the Essential Energy network, an Embedded Generator with ≤ 30 kW system with augmentation to the LV network will be a Standard Connection Service[62]

[61] Energex, Model Standing Offers, https://www.energex.com.au/home/our-services/connections/model-standing-offers
[62] Essential Energy, Connection offers and contracts, https://www.essentialenergy.com.au/content/connection-offers-and-contracts

**Table 16 Electricity distribution network companies**

| Electricity Distribution Network | State |
|---|---|
| ActewAGL | ACT |
| Ausgrid | NSW |
| Ausnet Services | VIC |
| Citipower | VIC |
| Endeavour Energy | NSW |
| Energex | QLD |
| Ergon Energy | QLD |
| Essential Energy | NSW |
| Jemena | VIC |
| Power and Water Corporation | NT |
| Powercor | VIC |
| SA Power Networks | SA |
| TasNetworks | TAS |
| United Energy | VIC |
| Western Power | WA |

# 12 Deployment Models

There are two main deployments models. The first, which is the traditional approach, is owner operated. The second, is the Build-Own-Operate-Maintain (BOOM) model.

ReNu Energy's Build-Own-Operate-Maintain (BOOM) contracts allows our customer freedom to focus on core business.

ReNu Energy offers long-term, full-service contracts with BOOM contracts, designed to put our customers in control of their business by allowing ReNu Energy to assist our customers with their plant's daily anaerobic digestion and biogas operations. ReNu Energy makes a life cycle commitment with BOOM to ensure that a high performing anaerobic digestion and biogas system is provided to our customers plant operations.

Choosing a BOOM service contract means that our customers are free to focus on their company's core activities and are better able to utilize business capital. The BOOM model allows businesses to benefit from long-term reliability, predictable economics, and an optimised anaerobic digestion and biogas system. This makes a BOOM agreement an ideal solution for many customers.

When compared to the traditional approach to anaerobic digestion and biogas, BOOM provides many advantages. In the traditional approach, customers invest capital in non-core business assets. In the traditional model, customers bear the responsibility of developing a conceptual design, paying for site audits, hiring an engineering, procurement and construction firm, issuing requests for proposals, evaluating bids, installing the equipment, and operating and maintaining it. In the traditional model, the customer assumes all risk for budget over-runs, schedule delays, operational upsets and maintenance.

# 13 Barriers to Uptake

Each anaerobic digestion and biogas project is relatively bespoke. There are several challenges which can create a barrier to uptake. These include but are not limited to:

- As previously identified, some waste sources currently have approved methodologies for the creation of carbon abatement units enabling participation in the Emissions Reduction Fund, whilst other waste sources do not
  - Developing approved methodologies across the spectrum will remove one of the barriers to uptake;
- Some sites are high energy users, e.g. an abattoir with their refrigeration loads, whilst others are smaller energy users, e.g. a piggery
  - For the business case it is preferable that the site is a high energy user and that as much as possible of the biogas is utilised on site / “behind-the-meter”;
- For smaller energy users such as a piggery, the revenue stream from exporting surplus energy can be a significant factor in the business case
  - There are two hurdles to clear with regards to monetising surplus energy through export to the National Electricity Market or Wholesale Electricity Market (WA), firstly obtaining approval from the network operator, then secondly reaching agreement with a retailer to be paid for the export;
- Different network and distribution areas have a different approach to distributed generation, in particular with regards to export of surplus electricity
  - If on site electricity load is relatively low, such as at a piggery, relative to the potential biogas electrical production, this can lead to a significant potential for export of surplus electricity;
  - Different network distribution areas have different levels of requirements in order to be able to export surplus electricity as well as different connection application processes and timelines;
- In the case of mixed waste anaerobic digestion, a project proponent needs to consider the fact that some state jurisdictions have landfill levies and thus incentivise the avoidance, whilst other state jurisdictions do not;
- Age of existing site infrastructure
  - Often the existing site infrastructure, such as transformers, and main switch boards etc, can be relatively old;
  - This can both be a potential benefit to the business case for a project to progress, in that capital is required to be spent regardless, or a potential detriment to the business case for a project to progress, in that a project can potentially “bring forward” the requirement to upgrade existing infrastructure;
- Multi-faceted business cases
  - The business case for anaerobic digestion and biogas is multi-faceted which can make it relatively complex;
  - The business case generally is to replace a “dumb but simple compliance asset”, i.e. an open pond for the purpose of reducing organic loading in waste water, with a “smart value adding asset”, i.e. a covered anaerobic lagoon plus biogas generation (or biogas boiler);

  - In order to make the business case, the project proponent needs to understand their energy requirements, their cost of energy, renewable energy certificates, carbon credit units, capital costs and operating costs, plus the associated compliance obligations in particular with regards to carbon credit units and operating gas equipment;

- Heat or electricity
  - Similar to the challenges of the multi-faceted business case, the decision regarding heat or electricity can also be relatively complex;
  - This applies to sites such as abattoirs and rendering plants who have a large demand for high grade heat;
  - In order to assess whether biogas is best used for heat or electricity, the answer will depend on factors such as, is the alternative source of high grade heat coal or natural gas or a different source, what is the cost of the alternative heat source, what is the cost of grid electricity, does the peak / off peak and energy / demand / fixed cost charging regime for grid electricity impact the analysis, what is the reliability of supply of the site's grid electricity versus what is the reliability of supply of the site's heat supply, is there a different compliance regime for biogas for heat versus biogas for electricity, is there a different approvals regime for biogas for heat versus biogas for electricity;
- Dealing with waste is at the end of the value chain
  - One challenge to overcome with regards to accelerating uptake of anaerobic digestion and biogas is that upgrading to best practice waste management is often not a top-level priority for an operation in a competitive business environment;
  - Waste and waste water management is literally at the end of the production process at site and is often considered primarily from a compliance perspective as opposed to a value adding perspective;
  - As the economic case for anaerobic digestion and biogas continues to become more compelling, this barrier is continually being overcome;
  - ReNu Energy's Build-Own-Operate-Maintain business model enables a customer to benefit from ReNu Energy's expertise, allowing the customer to focus on their core business and upgrade from "compliance" to "value adding" at zero capital cost.

# 14 Potential Australian Biogas Market Size - Summary

Filtering the market based on commercial scale and taking into account brownfield expansion and greenfield development, ReNu Energy estimates the potential biogas market in Australia at ~$800 million.

**Table 17 ReNu Energy estimate of potential biogas market size**

| Sector | Potential Projects | Value |
|---|---|---|
| Abattoirs | ~40 | $160 m |
| Food Processing | ~20 | $100 m |
| Dairy Farms | ~10 | $60 m |
| Piggeries | ~24 | $96 m |
| Egg Layers | ~20 (Post ERF methodology) | $100 m |
| Broiler Farms | ~20 (Post ERF methodology) | $100 m |
| Beef and Sheep Feedlots | Longer Term | Longer Term |
| Mixed Waste Facilities | ~20 | $200m |
| Total | | ~$816 m |

# 15 References / Bibliography

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