SUSTAINABILITY VICTORIA – ASSESSMENT OF VICTORIA'S BIOGAS POTENTIAL

December 2021

EXECUTIVE SUMMARY

Context and objectives

In February 2020, the Victorian Government announced the $10 million waste to energy support package as part of the *Recycling Victoria: A new economy* 10-year action plan to reform Victoria's waste and recycling system. Amongst other targets, this action plan aims to halve the volume of organic waste going to landfill by 2030. In line with this target, anaerobic digestion is considered a priority for investment in waste to energy infrastructure by the Victorian Government (this will be informed by the proposed Waste to Energy Framework, which is currently under development).

In light of this funding announcement as well as the pending closure of the W2E Infrastructure Fund, Sustainability Victoria has engaged Enea Consulting to complete a project that evaluates the two rounds of funding and investigates the landscape for future investment in anaerobic digestion in Victoria. This project (titled *W2E Infrastructure Fund Evaluation and Sector Development*) comprises three main phases, each with its own objective:

1. **W2E Infrastructure Fund evaluation:** Evaluate how the W2E Infrastructure Fund was delivered by measuring performance against program objectives
2. **Estimate of Victoria's biogas potential:** Analyse and expand the Australian Biomass for Bioenergy Assessment (ABBA) project biomass data and provide an estimate of Victoria's (anaerobic digestion) biogas potential
3. **Government measures and interventions:** Investigate global measures and intervention strategies that facilitate anaerobic digestion infrastructure development and provide recommendations for Victoria.

This estimation report encompasses the second phase of the project. The findings of this estimation will inform Phase 3 of the overall project, specifically the recommendations for Sustainability Victoria and the Victorian Government to support investment in infrastructure for anaerobic digestion.

Method and data sources

A funnel approach was used to estimate the potential of Victoria's anaerobic digestion biogas industry (see Figure 1). This report estimates Victoria's:

- **Theoretical biogas potential:** according to the maximum amount of organic residues that can be considered available for anaerobic digestion biogas production based on current organic residue production levels. Only organic residues considered available from the ABBA (Australian Biomass for Bioenergy Assessment) project have been included in this analysis. This includes organic residues from the agricultural, food processing, construction & demolition (C&D), forestry, tertiary services[1] and municipal sector with no high value competing use (see Appendix 2 - for a full list of organic residues considered).
- **Recoverable biogas potential:** based on the proportion of organic residues that are suitable to anerobic digestion and available after considering non-energy competing uses and capture constraints[2]. Both high and low recovery rate scenarios were analysed producing a recoverable biogas potential.

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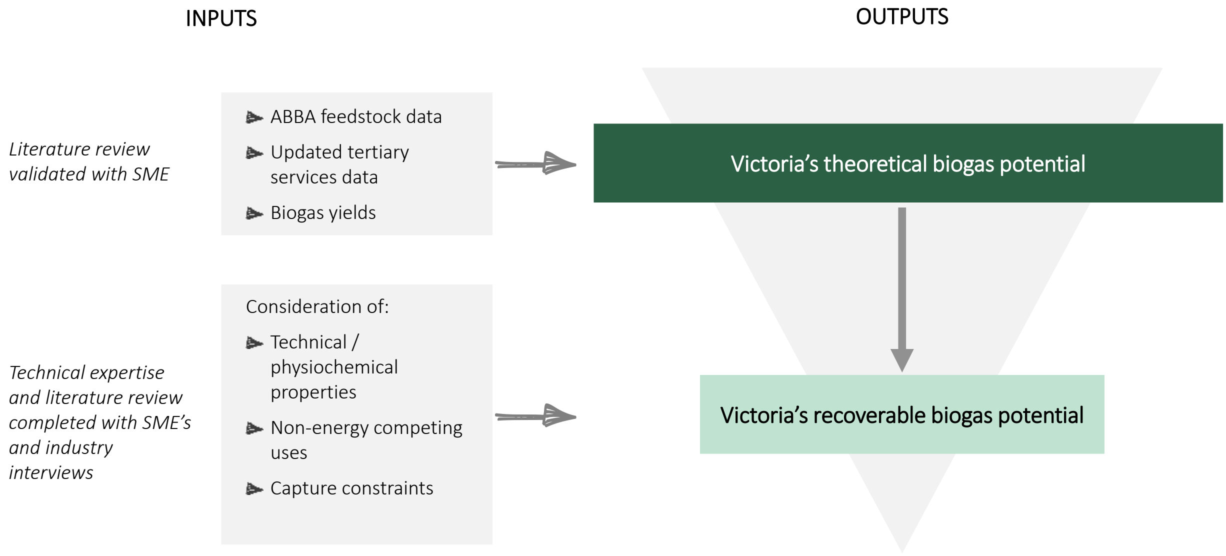
[1] ABBA data on tertiary services organic residues was updated as part of this study (see Section 2.1).

[2] Capture constraints accounts for separation of organic residues, concentration of anaerobically digestible material in the waste stream and logistics of recovery. It does not account for economically recoverable feedstocks or other technical considerations (such as nutrient balance or opportunities for co-digestion).

Figure 1 - Methodology used for assessing Victoria's theoretical and recoverable biogas potential



Key findings

Victoria's theoretical biogas potential is estimated to be 80.6 PJ per year (Figure 2). This represents 37% of the 214 PJ of gas consumed annually in Victoria.

Of this 80.6 PJ per year:

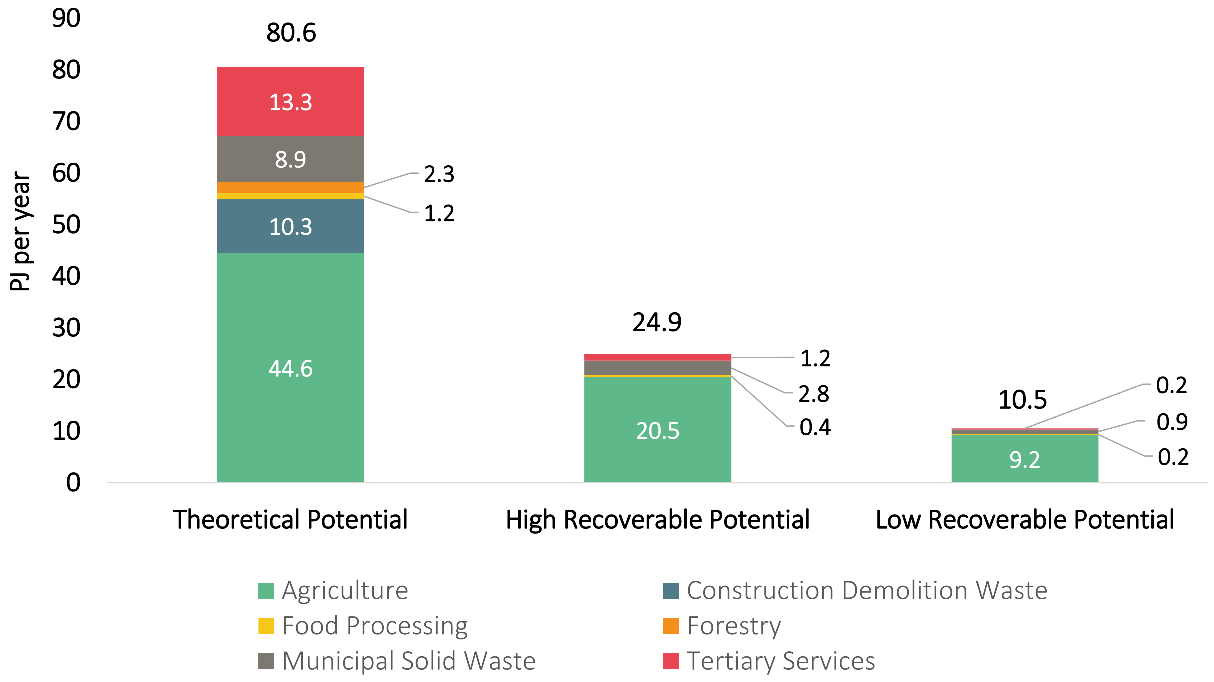
- Agriculture is the sector with the largest potential in Victoria (55% of total theoretical potential). Within this sector, cereal and cropping residues make up 85% of the opportunity.
- The tertiary services sector (including food waste) contributes 17% of Victoria's theoretical biogas potential with retail trade paper and cardboards contributing 26% of this opportunity.
- C&D organic residues account for 13% of the potential which is composed of timber (52% of C&D biogas potential) and garden organics (48% of C&D biogas potential).

After excluding organic residues that were not suitable to anaerobic digestion and applying low and high recovery rate scenarios (based on non-energy competing uses and capture constraints), Victoria's recoverable biogas potential is estimated to be between 10.5 PJ per year and 24.9 PJ per year. Figure 2 shows the sector and breakdown and Figure 3 shows the regional breakdown of the recoverable potential. This represents 5-12% of Victoria's annual 214 PJ natural gas usage.

From the sector analysis:

- Agricultural recoverable biogas potential is driven by cereal straw and chaff residues which make up 62-74% of the recoverable agricultural biogas potential. The second highest recoverable agricultural organic residue is cattle dairy manure which makes up 15-20% of the agricultural biogas potential.
- MSW recoverable biogas potential is composed of mixed organics and biosolids (municipal wastewater sludge) which make up 38-81% and 19-62% of the MSW recoverable biogas potential.
- Accommodation and food services industry contributes 14-24% of the total tertiary services recoverable biogas potential.

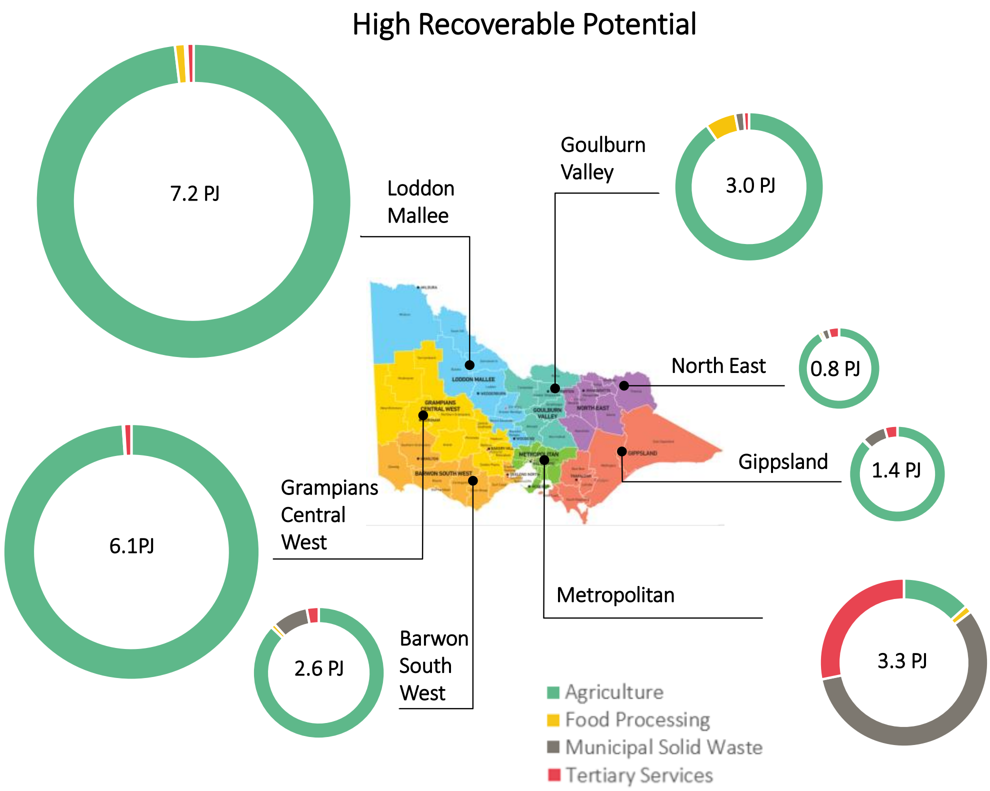
Figure 2 - Sector breakdown of Victoria's recoverable biogas potential from anaerobic digestion



From the regional analysis:

- **Grampians Central West, Loddon Mallee and Goulbourn Valley combined make up 64-66% of Victorian recoverable biogas potential** and are all largely driven by agricultural organic residues, in particular cereal cropping residues.
- The **Metropolitan region accounts for 7-14% of Victorian recoverable biogas potential** and is driven by MSW organics (37-62% of Metropolitan recoverable potential) and Tertiary Service organics (22-26% of Metropolitan recoverable potential).

Figure 3 - Regional breakdown of Victoria's high recoverable biogas potential from anaerobic digestion[3]



The results of this estimation only account for capture constraints and can be further refined through economic modelling. By considering the cost of supplying incremental feedstock volumes to anaerobic digestors and the willingness to pay for this feedstock, the volume of recoverable feedstocks can be determined. However, this present assessment of Victoria's theoretical and recoverable biogas potential represents a first step towards identifying the regions and feedstocks that hold the greatest opportunity for Victoria. This will assist the development and prioritisation of policy mechanisms which focus on the most relevant areas for developing Victoria's biogas industry.

[3] 0.5 PJ of biosolid recoverable potential energy (belonging to the MSW sector) is not displayed on this figure as this data was not available at a regional level. A figure showing the low recoverable biogas potential by region can be found in Section 4.4.

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1 CONTEXT, SCOPE AND OBJECTIVES

1.1 Background

The Australian Biomass for Bioenergy Assessment (ABBA collated data on different types, volumes and locations of biomass residues that may be used for bioenergy (i.e. feedstocks). The ABBA project sought to drive investment in bioenergy by enabling better links between biomass suppliers and end-users. This supports local businesses in maximising the value of organic material that would otherwise be sent to landfill or used for low value applications. The ABBA project was originally funded by ARENA and is now resourced at a state level.

Sustainability Victoria was responsible for producing the Victorian segment of the ABBA project by generating organic residue datasets from primary and secondary productions sectors across Victoria. Organic residue datasets were modelled using Australian Bureau of Statistics (ABS) data, National Pollutant Inventory (NPI) data and data collected through Sustainability Victoria's local government annual surveys. Organic residue datasets are available on the Australian Renewable Energy Mapping Infrastructure (AREMI) platform.

In 2015, Sustainability Victoria's *Infrastructure Gap Analysis* found that government collaboration with the waste and resource recovery industry, waste generators and water authorities was required to support food waste recovery and reduce Victoria's greenhouse gas emissions. In response, the $2.3 million Waste to Energy (W2E) Infrastructure Fund was introduced in July 2016. Since 2016, Sustainability Victoria has delivered two rounds of funding (the second under Sustainability Victoria's Bioenergy Infrastructure Fund, which reallocated over $700k of W2E Infrastructure Fund budget following the withdrawal of a project).

In 2020, the development of a $10 million waste to energy support package was announced as part of the *Recycling Victoria: A new economy* 10-year action plan to reform Victoria's waste and recycling system. This action plan intends to reduce the amount of waste sent to landfill and contribute to the Victorian Government's target of net zero emissions by 2050 by reducing emissions in the waste sector.

More specifically, *Recycling Victoria: A new economy* aims to reduce the volume of organic waste going to landfill by 50 per cent and provide household Food Organics Garden Organics (FOGO) collection services by 2030. The Victorian Government has highlighted that biological waste to energy treatments such as anaerobic digestion (to generate biogas) will be critical to achieving greater recovery of organic wastes. Thus, anaerobic digestion is considered a priority for investment in waste to energy infrastructure by the Victorian Government.

1.2 Project objectives and scope

Pending the closure of the W2E Infrastructure Fund and in light of the most recent funding announcements, Sustainability Victoria is seeking an overview of anaerobic digestion within the waste to energy sector. To inform the development of the new $10 million package, Sustainability Victoria has engaged Enea Consulting to evaluate the W2E Infrastructure Fund and investigate the landscape for future investment.

The project comprises three main phases, each with its own objectives (see Table 1-1). This report encompasses Phase 2 of the project.

Table 1-1 – Summary of project phases and objectives

#	Phase	Objective
1	W2E Infrastructure Fund evaluation (completed)	Evaluate how the W2E Infrastructure Fund was delivered by measuring performance against program objectives

#	Phase	Objective
2	Estimate of Victoria’s biogas potential (this report)	Analyse and expand the Australian Biomass for Bioenergy Assessment (ABBA) project biomass data and provide an estimate of Victoria’s biogas potential
3	Government measures and interventions	Investigate global measures and intervention strategies that facilitate anaerobic digestion infrastructure and provide recommendations for Victoria

1.3 Objectives of this report

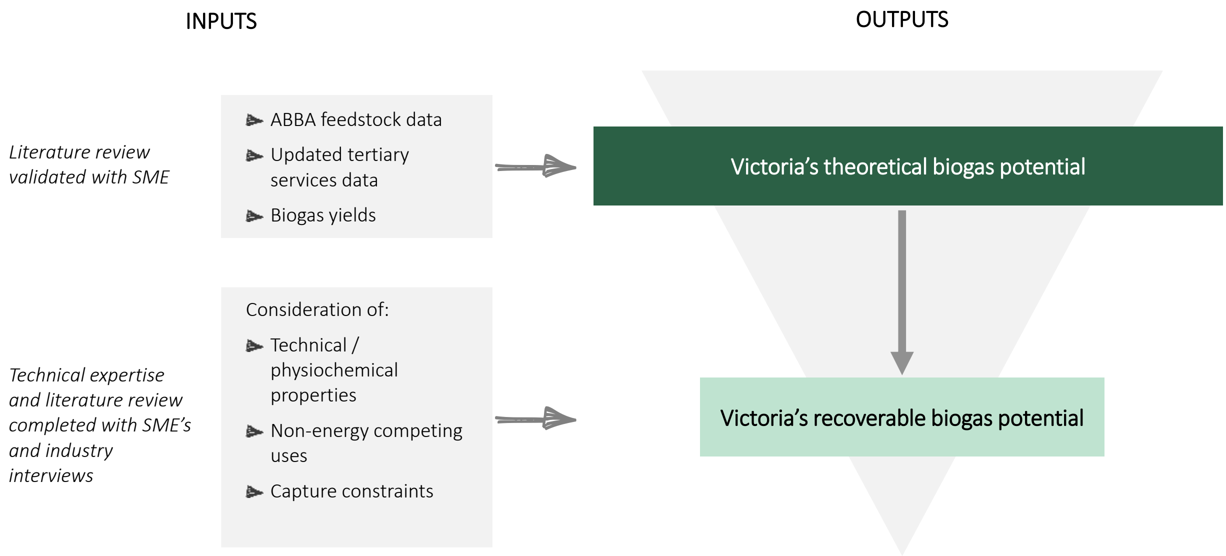
The objective of the second phase of the project was to estimate Victoria’s biogas potential in terms of annual energy production. This phase of the project paid particular attention to the portion organic residues that are recoverable with consideration for non-energy competing uses and capture constraints (see Section 0). This report details the key findings from this analysis.

2 ANALYSIS METHODOLOGY

A funnel approach was used to estimate the potential of Victoria's biogas industry (see Figure 2-1). This chapter outlines the methodology used to estimate Victoria's:

- **Theoretical biogas potential:** according to the maximum amount of organic residues that can be considered available for anaerobic digestion biogas production based on current organic residue production levels (Section 2.1). All organic residues from the ABBA (Australian Biomass for Bioenergy Assessment) project have been included in the anaerobic digestion biogas potential even if they require significant pre-treatment or are better suited to other waste to energy technologies. This includes organic residues from the agricultural, food processing, construction & demolition (C&D), forestry, tertiary services and municipal sector with no high value competing use (see Appendix 1 for a full list of organic residues considered).
- **Recoverable biogas potential:** based on the proportion of organic residue that is suitable to anerobic digestion and is available depending on non-energy competing uses and capture constraints (Section 0). Both high and low recovery rate scenarios were analysed producing a recoverable biogas potential.

Figure 2-1– Methodology to estimate Victoria's recoverable biogas potential



2.1 Estimate of Victoria's theoretical biogas potential

Victoria's theoretical biogas potential combines Victoria's feedstock potential with biogas yields.

2.1.1 Feedstock potential

The ABBA project data was leveraged to estimate Victoria's feedstock potential (see Appendix 1 for a complete list of organic residues). Overall, the 63 organic residues considered in the ABBA project can be allocated into six sectors (see Table 2-1).

Table 2-1 – Sectors and examples of organic residues[4]

#	Sector	Organic residue examples
1	Agriculture	Cropping residues Livestock manure Fruit and vegetable culls
2	Forestry	Harvest residues Wood processing residues
3	Food processing	Meat processing residues Dairy manufacturing residues Fruit processing residues
4	Tertiary services	Wholesale and retail trade organics Professional services organics Accommodation and food services organics
5	Municipal solid waste (MSW)	Organics Paper and cardboard Biosolids
6	Construction and demolition (C&D) waste	Garden organics Timber waste

Opportunities to update and improve the ABBA project data for organic residues within the tertiary services sector were identified. The ABBA project modelled these organic residues using the waste generation per full time equivalent employee (FTEE) reported in the SRU 2013[5] and employment data based on relevant Australian and New Zealand Standard Industry Classification (ANZSIC) divisions[6]. Improvements on the tertiary service sector organic residue calculation are outlined below:

- Review of the tertiary services organic residues revealed that the ABBA project used the SRU 2013 report for the waste generation rates per FTEE which were determined through site surveys of waste generators. These waste generators reported numbers being sent to landfill or recycling, which is in wet tonnes. There is no evidence in the report of a moisture content being applied to determine dry tonnes, which is the basis for all other ABBA feedstocks. This was accounted for in this report by applying an appropriate moisture content to the tertiary services organic residues.
- In addition, the Blue Environment 2018 report[7] was used to update the SRU 2013 waste generation per FTEE where applicable. Appendix 1 lists the waste generation rates applied to each of the organic residues within the tertiary services sector.
- Finally, the latest employment data reported by the Australian Bureau of Statistics (ABS) for each ANZSIC division was used to scale each of the tertiary services organic residues to the size of Victoria's industry.

[4] All organic residue volumes were used directly from ABBA, except for the tertiary services sectors which were updated as per Section 2.1.1.

[5] The SRU 2013 *Waste flows in the Victorian commercial and industrial sector* report was prepared for Sustainability Victoria. It reports waste generation rates per FTEE for each ANZSIC industry division based on desktop review and primary data collection through site surveys.

[6] The ANZSIC system classifies entities into industry divisions based on their main business function. Each industry division is further divided into subdivisions.

[7] The Blue Environment 2018 *Food waste in hospitality* report was prepared for Sustainability Victoria. It reports on how food waste is generated by the hospitality sector in the City of Melbourne based on desktop review and onsite assessments of hospitality businesses.

2.1.2 Biogas yields

Biogas yields for each organic residue was gathered through desktop review of relevant literature and validated with subject matter experts (SMEs). A full list of SMEs is available in Appendix 4. Victoria's theoretical biogas potential was estimated using the formula in Figure 2-2.

Figure 2-2 – Calculation of Victoria's theoretical biogas potential

2.1.3 Potential for improvement

There are several areas for improvement that would reduce the uncertainty of the results obtained in this assessment. Limitations of this study include the accuracy of data used, lack of recent available data and use of only secondary data:

- The Arcadis 2018 report[8] assessed the accuracy of the organic residues estimated as part of the ABBA project. Each organic residue's accuracy was ranked either low, medium or high depending on the granularity of production data and specificity of the waste generation rate applied. Most organic residues were classified highly accurate.
- No primary data on organic residue volumes was collected (through either site surveys or consultation) to improve organic residues classified either low or medium accuracy. This was outside the scope of this project.
- Where possible the SRU 2013 waste generation rates were updated using the Blue Environment 2018 report. The remaining SRU 2013 waste generation rates may be outdated.
- The biogas yields applied to each organic residue were not obtained from direct measurement of anaerobic digestion of organic residue samples. Instead, biogas yields were collected through desktop review of academic papers and industry reports. In particular, the academic papers have been peer reviewed. As stated in Section 2.1.2, final biogas yields used were validated with SMEs.

2.2 Estimate of Victoria's recoverable biogas potential

Victoria's recoverable biogas potential adjusts Victoria's theoretical potential according to each organic residue's suitability to anaerobic digestion and the extent to which the feedstock is recoverable based on non-energy competing uses and capture constraints.

2.2.1 Suitability to anaerobic digestion

Firstly, it was considered whether an organic residue is technically suitable to anaerobic digestion. Anaerobic digestion converts organic substrates into methane, carbon dioxide, bacterial biomass and digestate through a series of biochemical reactions carried out by microorganisms in the absence of oxygen.

[8] The Arcadis 2018 *Biomass Technical Report* details the methodologies used to calculate the quantities of Victorian biomass reported through the ABBA project. It details the assumptions and methodologies behind each organic residue, provides an overview and assesses the accuracy of the results.

There are several factors that affect the ability of the microorganisms to carry out these biochemical reactions, particularly the chemical composition of the substrate. Substrates with high cellulosic content are more readily anaerobically degradable whereas substrates with high lignin content are not. Substrates with high lignin content can be anaerobically digested with significant pre-treatment but are typically more suitable to other waste to energy technologies such as pyrolysis or incineration. Additionally, the ratio of nutrients (such as the carbon to nitrogen ratio) can be either too high or low for anaerobic microorganisms, although this can be solved through co-digestion of complimentary substrates.

The main physical property that determines a substrate's suitability to anaerobic digestion is the moisture content. Dry substrates may be suitable to a number of waste to energy technologies including pyrolysis and pyro-gasification in addition to dry or high solids anaerobic digestion. Combustion-based processes (such as incineration) become less efficient if a substrate has a high moisture content because a portion of energy produced is absorbed by the water. Substrates such as slurry or wastewater are most suitable to anaerobic digestion because the chemical energy is separated from water in the form of methane.

Thus, substrates may be suitable to either dry or wet anerobic digestion depending on their moisture and lignin content as well as their ability to be recycled. Substrates that were deemed not suitable to anaerobic digestion were removed from further analysis (Table 2-2). It should be noted that these excluded substrates may be appropriate for other waste to energy technologies such as gasification and incineration.

Based on the considerations above and consultation with subject matter experts, Table 2-2 shows the Victorian organic residues deemed suitable and unsuitable for anaerobic digestion. Unsuitable organic residues were excluded from further analysis.

Table 2-2 – List of organic residues assessed as unsuitable for anaerobic digestion

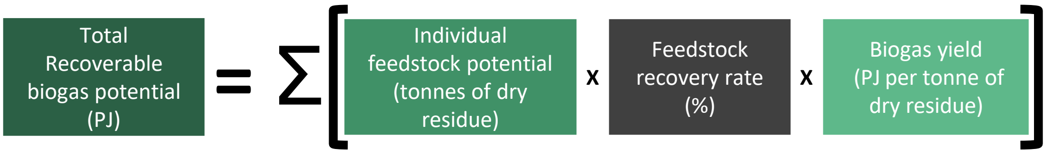
Sector	Organic residues unsuitable for anaerobic digestion	Rationale
Forestry	Harvest residues Wood processing residues	High lignin content
Food processing	Almond processing residues	High lignin content
Tertiary services	Paper and cardboard	More suited to recycling
MSW	Paper and cardboard	More suited to recycling
C&D waste	Timber Garden organics	High lignin content

2.2.2 Recovery rates

Of the organic residues deemed suitable for anaerobic digestion, recovery rates were applied to estimate Victoria's recoverable biogas potential. The ABBA project already excludes organic residues that are currently being used for higher value purposes. For example, this includes stubble left behind after cereal crop harvest to maintain soil cover and prevent soil erosion. From this starting point of what the ABBA project considered potentially available for bioenergy uses, the portion of each organic residue that can be considered recoverable was quantified through recovery rates with input from industry and academic stakeholders. Non-energy competing uses and capture constraints (see Appendix 1 for definitions) were considered in this assessment.

Victoria's recoverable biogas potential was estimated using the formula in Figure 2-2. Each recovery rate reduces the theoretical potential of its corresponding organic residue.

Figure 2-2 – Calculation of Victoria's recoverable biogas potential



2.2.3 Potential for improvement

The assessment carried out in this study does not include economic considerations such as the profitability of operating anaerobic digestors using certain feedstocks. A more robust estimation of Victoria's recoverable biogas potential would be achieved by economic modelling to consider the cost of supplying incremental feedstock volumes to anaerobic digestors. Willingness to pay for these feedstocks, based on competing feedstock uses and biogas substitutes, would determine the portion of feedstocks that could be recovered. However, this level of assessment was out of scope for this project.

As a proxy, data on Australian organic waste disposal destinations (e.g. landfill and composting) by different industries were used to estimate potential recovery rates with the input of subject matter experts (see consulted organisations in Appendix 4). When direct data was not available for Australia, overseas recovery rates of organic feedstocks for anaerobic digestion were analysed and adapted to Victoria with subject matter expert input.

While different recovery rates were tailored to different sectors and feedstocks, to further improve the accuracy of the recoverable biogas potential estimate, recovery rates could also be tailored to specific regions and geographic locations. For example, different regions have their own agricultural practices which would affect recovery rates such as Goulburn Valley having a greater need for recycling organic residues than other regions due to low rainfall which would decrease recovery rates. However, the annual burning of crop stubble in Barwon Southwest and Grampians Central West regions or not needing to sew back crop stubble after periods of high rainfall would result in higher recovery rates.

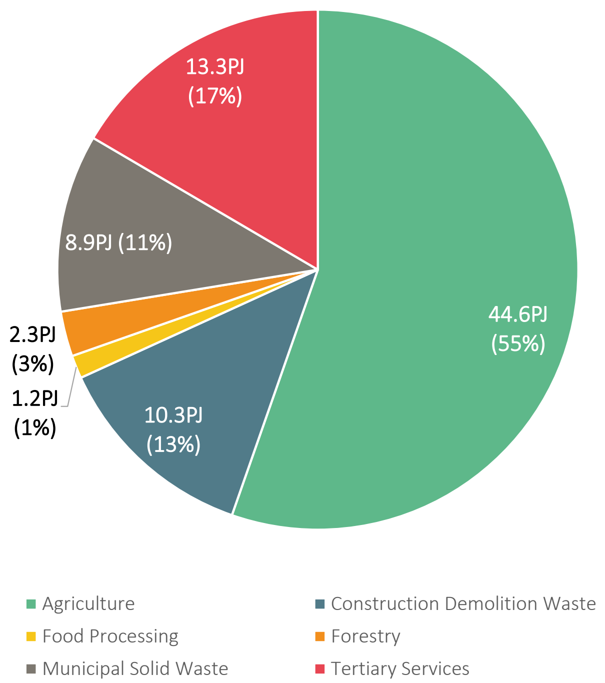
3 VICTORIA'S THEORETICAL BIOGAS POTENTIAL

The Victorian theoretical biogas potential analysis assumes all organic residues considered are used to generate biogas through anaerobic digestion only (for a full list of organic residues see Appendix 1). Without considering any limits to feedstock recovery, this total is meant to indicate the upper limits of what is theoretically available to Victoria in terms of biogas production from anaerobic digestion, based on currently existing organic residues. This chapter breaks down the theoretical potential by sector (Section 3.1) and region (Section 3.2) in Victoria.

3.1 Estimate of Victoria's theoretical biogas potential by sector

Victoria's theoretical potential is estimated to be 80.6 PJ per year (see Figure 3-1). This represents 37% of Victoria's annual natural gas usage of 214 PJ in 2020.

Figure 3-1 – Sector breakdown of Victoria's theoretical biogas potential (80.6 PJ per year)



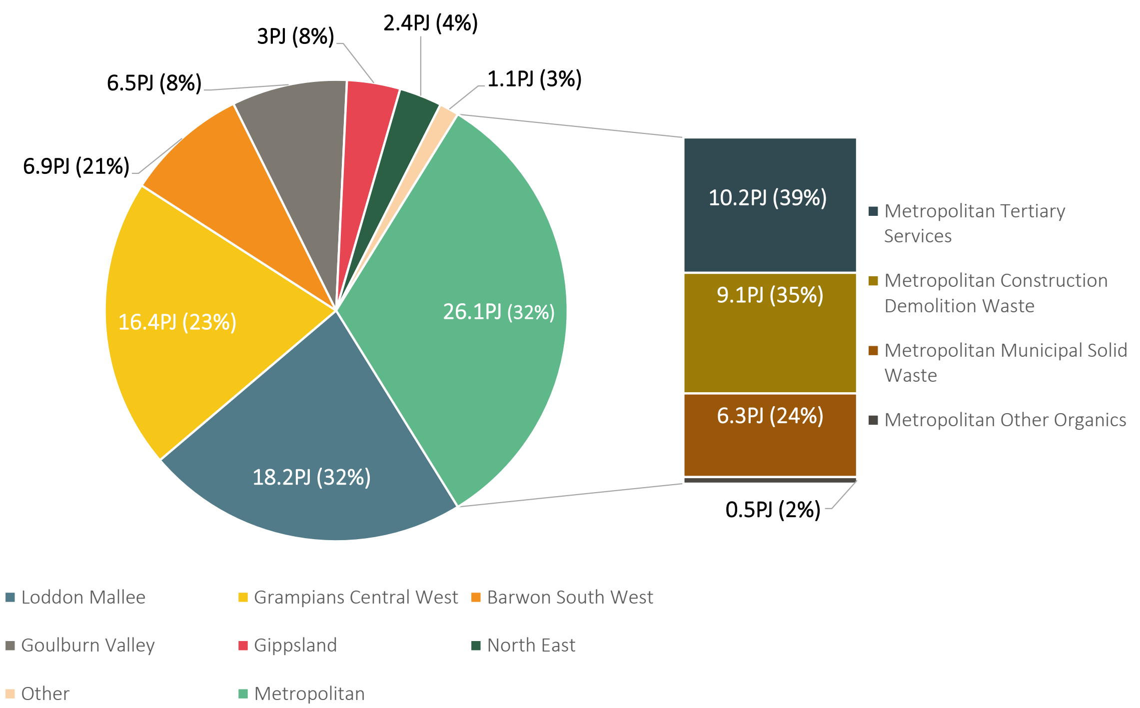
Of the 80.6 PJ per year:

- 55% is derived from agricultural residues. This is largely driven by cereal and cropping residues (straw and chaff), which make up 85% of Victoria's theoretical biogas potential from agricultural organic residues.
- Tertiary services account for 17% of Victoria's theoretical biogas potential with the highest contributors being paper and cardboard waste from retail trade and organics from the accommodation and food services industry which make up 26% and 11% of the tertiary service's total biogas potential
- 13% is derived from C&D waste. C&D organic waste is composed of garden organics and timber, which make up 42% and 58% of Victoria's theoretical biogas potential from C&D Waste, respectively.
- 11% is derived from MSW. This includes mixed organics, paper, cardboard and biosolids from wastewater treatment.
- The remaining sectors, forestry and food processing, together account for less than 5% of Victoria's theoretical biogas potential.

3.2 Estimate of Victoria's theoretical biogas potential by region

While agricultural residues make up the majority of the theoretical biogas potential, these organic residues are distributed across multiple regions. When quantifying the biogas opportunity by region, most of the biogas opportunity lies within the Metropolitan region. It contains 32% of Victoria's theoretical biogas potential with little agricultural potential. The regional breakdown of Victoria's theoretical biogas potential is shown in Figure 3-2.

Figure 3-2 – Geographic breakdown of Victoria's theoretical biogas potential (80.6 PJ per year)[9]



[9] 1.1 PJ of municipal biosolids from wastewater treatment has not been included in the regional breakdown (shown in the 'Other' category) as this data was not available at an LGA or regional level

The Metropolitan theoretical biogas potential makes up the majority of Victoria's theoretical biogas potential as shown in Figure 3-2. This is largely driven by Tertiary services waste, C&D waste and MSW.

- Tertiary Services mixed organics, paper and cardboard makes up 39% of the Metropolitan biogas potential with Retail Trade, Accommodation and Food Services together making up 42% of the Tertiary Services biogas potential.
- C&D garden organics and timber make up 35% of the Metropolitan biogas potential and MSW organics, paper and cardboard account for 24% of the Metropolitan theoretical biogas potential.
- All other organic residues account for less than 2% of this region's theoretical biogas potential.

Both Loddon Mallee and Grampians Central West (accounting for 23% and 21% of Victoria's theoretical biogas potential, respectively as shown in Figure 3-2 are largely driven by cereal cropping residues (straw and chaff). These organic residues account for 87% of the biogas potential of Loddon Mallee's and 81% of Grampians Central West's theoretical biogas potential.

While the theoretical biogas potential provides insight to the overall anaerobic digestion opportunity in Victoria, it is limited by two factors:

- Not all organic residues are suitable for anaerobic digestion
- Not all feedstocks can practically be recovered due to range of reasons including non-energy competing uses and capture constraints.

Thus, the recoverable biogas potential was assessed in Section 4 to provide a more realistically achievable figure for the anaerobic digestion opportunity in Victoria.

4 VICTORIA'S RECOVERABLE BIOGAS POTENTIAL

The Victorian recoverable biogas potential assessment includes only feedstocks suitable for anaerobic digestion and takes into account recovery rates based on non-energy competing uses and capture constraints of feedstocks (for a full list of recovery rates see Appendix 3). This chapter shows the findings of the recovery rates (Section 4.1) and breaks down the recoverable biogas potential by sector (section 4.2), feedstock (Section 4.3) and region (Section 4.4) in Victoria.

4.1 Recovery rate findings

Different sectors face different challenges in recovering feedstocks for anaerobic digestion. For example, MSW waste is more likely to face contamination issues compared to agricultural feedstock or food processing waste which is less likely to be contaminated with waste unsuitable for anaerobic digestion. High and low recovery rates were considered for several feedstocks based on assumptions on their non-energy competing uses and capture constraints.

A sector overview of the feedstocks investigated, and main considerations used for determining recovery rates are shown in Table 4-1 (see Appendix 2 for a complete list of recovery rates used for each feedstock). An example of the competing uses for straw and chaff and MSW organics is shown in Figure 4-1 and Figure 4-2 for the high and low recovery rate scenarios.

Table 4-1 – Main considerations used to develop recovery rates[10]

Sector	Suitable feedstocks for anaerobic digestion	Low recovery rate	Consideration for low recovery rates	High recovery rate	Considerations for high recovery rate
Agriculture	Cropping residues	15%	➢ Several non-energy competing uses are considered for straw and chaff including requirements for land application / cover, animal bedding and animal feed. The portion allocated to anaerobic digestion is reduced to provide feed for animals. ➢ The use of straw and chaff for other waste to energy technologies is not accounted for in this recovery rate.	40%	➢ Non-energy competing uses considered include land application / cover and animal feed. In this scenario, straw is not used for animal bedding. ➢ The use of straw and chaff for other waste to energy technologies are not accounted for in this recovery rate.
	Livestock manure	60%	➢ Only livestock slurry and manure from intensive operations (e.g. from feeding and milking sheds) are considered. Consequently, this feedstock is concentrated and uncontaminated. ➢ This scenario takes into account the competing use of this feedstock for land application.	100%	➢ In this scenario, it is assumed that all livestock manure from intensive operations (e.g. from feeding and milking sheds) is used for anaerobic digestion, and that digestate from this feedstock and grazing livestock waste is used for land application instead.
	Fruit and vegetable culls	100%	➢ Fruit and vegetable biomass that can be used for economic uses (such as juice or jams) are already	100%	Same as low recovery rate.

[10] Recovery rates represent an average across Victoria, with high and low scenarios used to capture the range of different practises used in different regions.

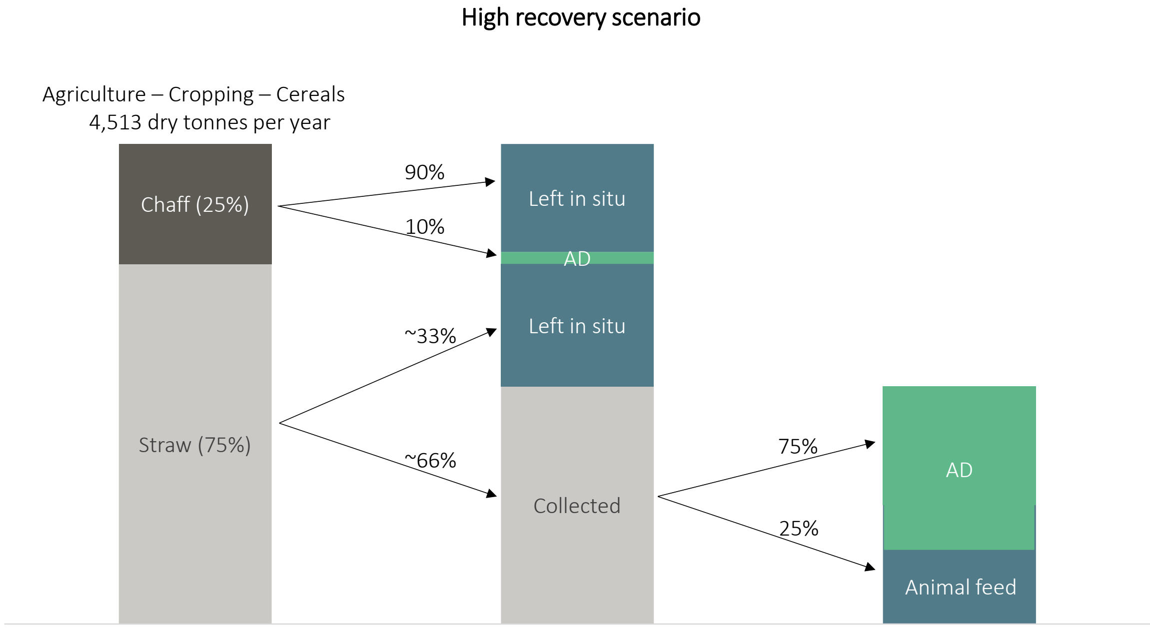
Sector	Suitable feedstocks for anaerobic digestion	Low recovery rate	Consideration for low recovery rates	High recovery rate	Considerations for high recovery rate
			excluded from the organic residue volume figure. Since the only fruit and vegetable biomass in this feedstock is from crop culls (such as from poor weather events), a recovery rate of 100% is assumed.		
Forestry	No suitable organic residues for anaerobic digestion due to high lignin content in the wood harvest and wood processing residues (see Table 2-2).				
Food processing	Meat processing residues Fruit processing residues Wine manufacturing residues	50%	➢ Currently, organics from food processing goes to either composting or landfill. In this scenario, all the food processing waste going to composting has been considered recoverable since digestate produced after biogas production can still be composted. However, this will have implications with current composting operations which have agreements to currently take organic residues. ➢ No organics sent to landfill are recovered in the low recovery scenario.	84%	➢ In the higher recovery scenario, in addition to the recovery of organics sent to composting, 80% of the organics from food processing sent to landfill is assumed recoverable based on overseas examples.
	Meat processing wastewater Dairy processing wastewater	70%	➢ Because wastewater is both generated and already collected onsite, there are less logistical barriers in	70%	➢ Same as low recovery rate.

Sector	Suitable feedstocks for anaerobic digestion	Low recovery rate	Consideration for low recovery rates	High recovery rate	Considerations for high recovery rate
			capturing this feedstock. However, a portion of wastewater may not be recoverable due to contamination (such as from washing chemicals) and may be too dilute for recovery.		
Tertiary services	C&I organic residues	6%	➢ Currently, organic waste (composed of food organics and garden organics) from tertiary services and MSW are sent to either composting or landfill. Only food organics is assumed recoverable for anaerobic digestion due to the unsuitability of high lignin woody waste in garden organics for digestion. The 12% food organics[11] (based on NSW organic waste audits) from total organics currently sent to composting is assumed to be recovered in this scenario.	34%	➢ In this scenario, in addition to the food organics from composting being recovered, 70% of the organics sent to landfill, for MSW and tertiary services respectively, are assumed to be recovered for anaerobic digestion, as this has been achieved overseas.
Municipal solid waste (MSW)	Organics	6%		42%	➢ In this recovery scenario, in addition to the food organics from composting being recovered, 60% of the organics sent to landfill, for MSW and tertiary services respectively, are assumed to be recovered for anaerobic digestion, as this has been achieved overseas.

[11] The Mach 2020 *Analysis of NSW Kerbside Green Lid Audit Data Report* shows the composition of food organics and garden organics under various collection configurations (sized bins and collection frequencies).

Sector	Suitable feedstocks for anaerobic digestion	Low recovery rate	Consideration for low recovery rates	High recovery rate	Considerations for high recovery rate
	Biosolids (wastewater treatment sludge)	50%	This recovery rate takes into account the competing use of biosolids for land application and soil conditioner.	50%	Same as low recovery rate.
Construction and demolition (C&D) waste	No suitable organic residues for anaerobic digestion due to the high lignin content in the timber and garden organics residues (see Table 2-2).				

Figure 4-1 – High and low recovery rate considerations of cereal straw and chaff (state average)



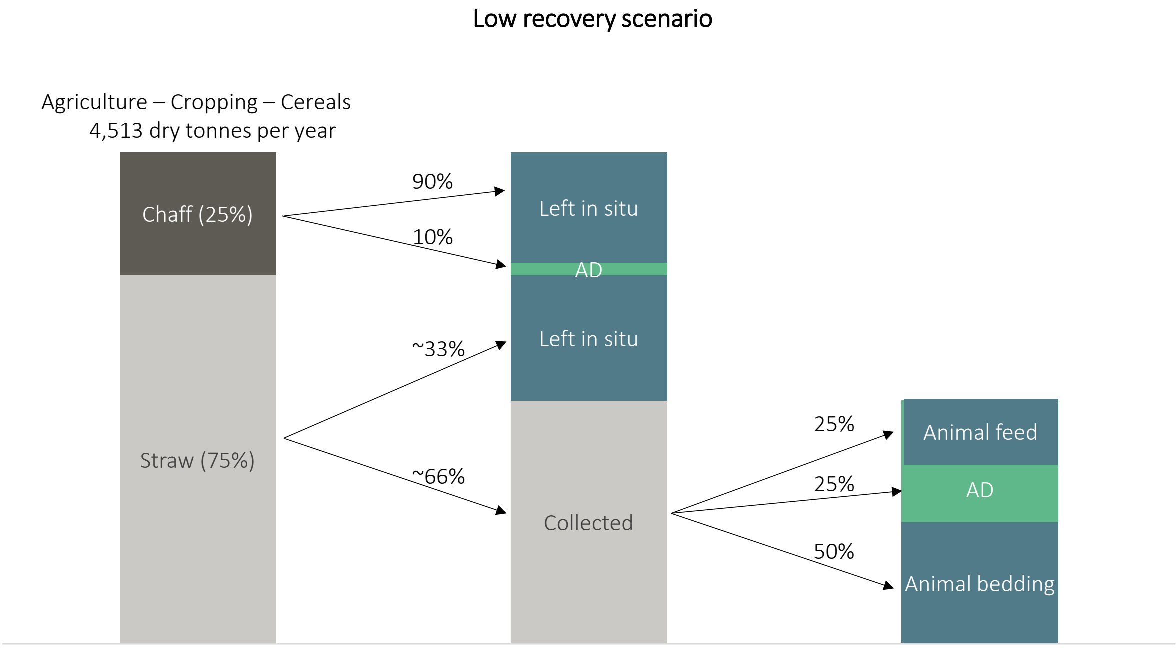
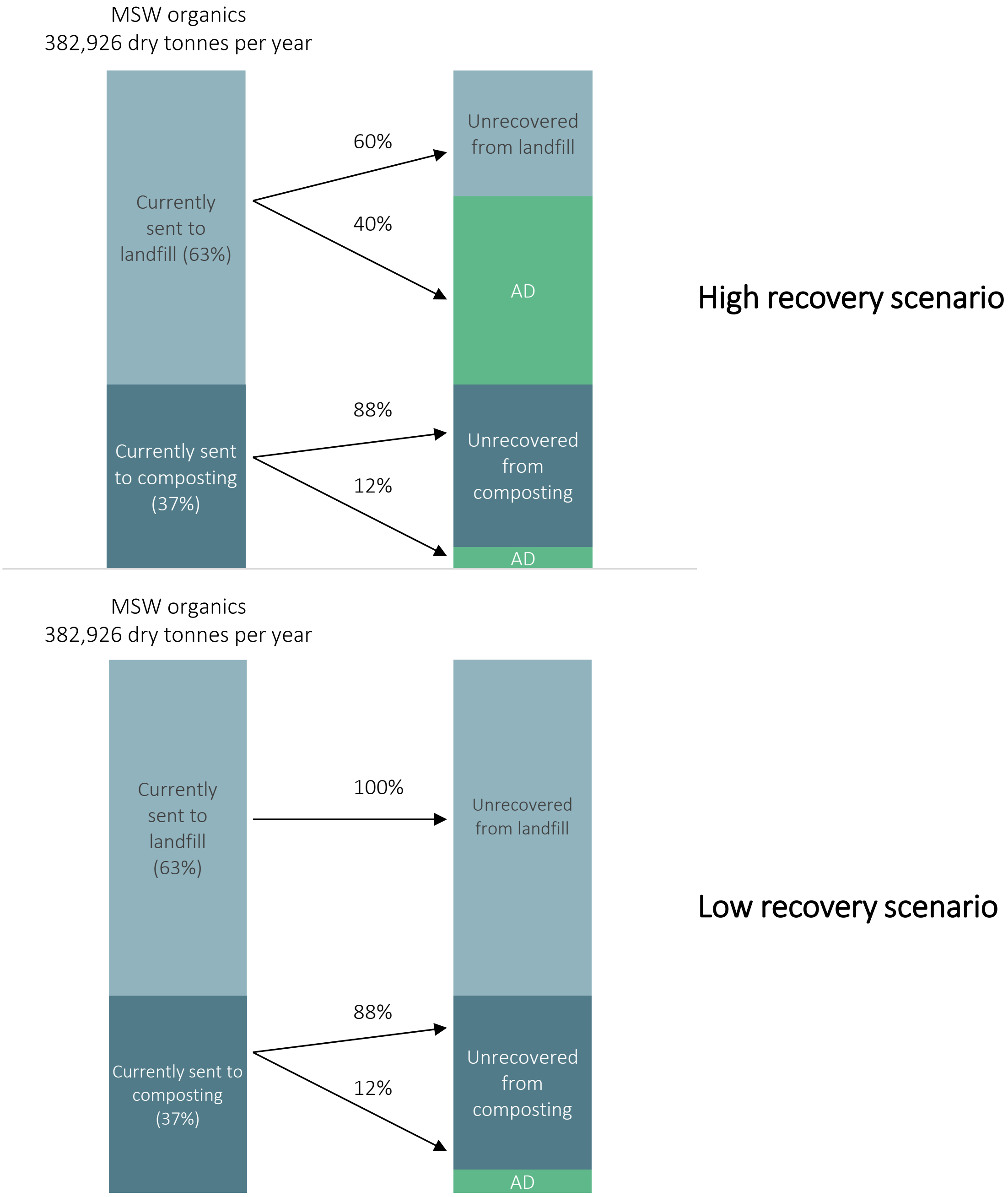


Figure 4-2 – High and low recovery rate considerations of MSW organics



4.2 Estimate of Victoria's recoverable biogas potential

From scenarios explored using high and low recovery rates, the recoverable biogas potential of Victoria is estimated to be between 10.5 PJ and 24.9 PJ per year (Figure 4-3). This represents a 5-12% of Victoria's 2020 natural gas consumption of 214 PJ for comparison. Victoria's recoverable biogas potential is driven by the agricultural sector, with the agricultural recoverable biogas potential estimated to be between 9.5 PJ and 20.5 PJ (Figure 4-4).

Figure 4-3 – Sector breakdown of Victoria's recoverable biogas potential from anaerobic digestion

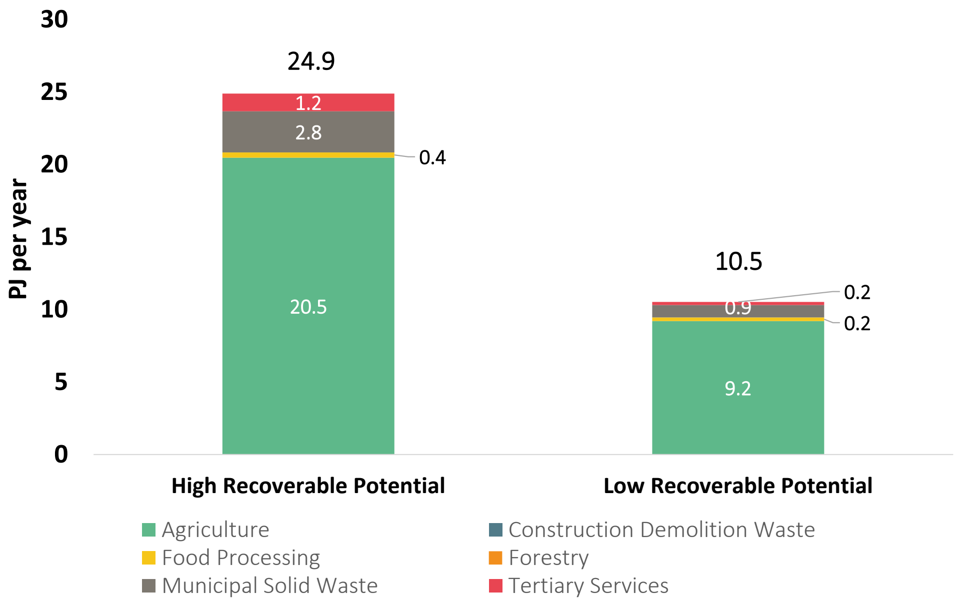
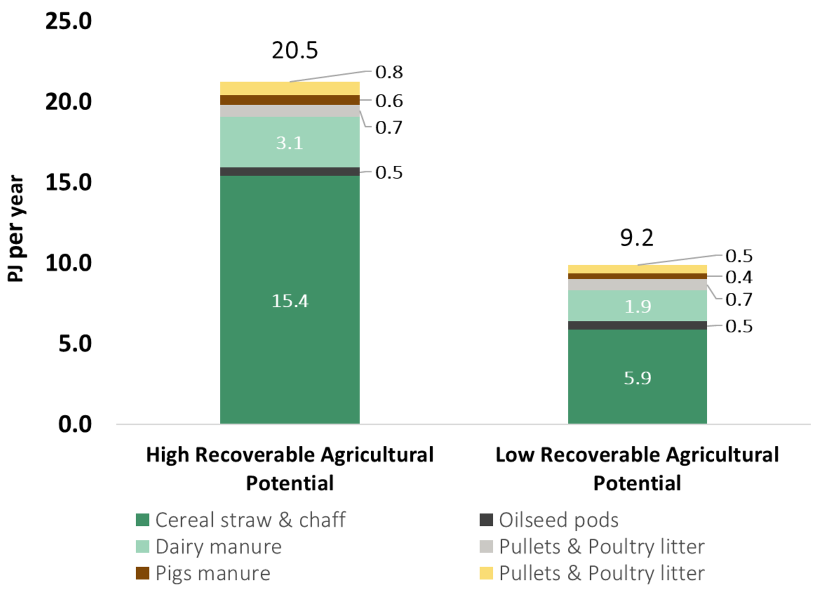


Figure 4-4 – Breakdown of Victoria's agricultural recoverable biogas potential from anaerobic digestion



4.3 Feedstocks with highest recoverable potential for anaerobic digestion

The majority of the recoverable biogas potential comes from agriculture (82-88%) of total recoverable potential) and is driven by cereal straw and chaff residues which make up 62-74% of the recoverable agricultural biogas potential.

Figure 4-4 shows that the cereal straw and chaff make up the majority of the recoverable agricultural biogas potential. Cereal straw and chaff can be anaerobically digested, either by dry digestion by itself or wet digestion when mixed with other feedstocks such as manure and slurry. There are opportunities for co-digestion as multiple agricultural feedstocks may be located on the same farm or nearby.

Cereal residues also have a relatively low water content compared to other feedstocks and as a result they are more cost efficient to transport (due to a higher energy density per weight). This means that excess straw and chaff could potentially be sent to nearby anaerobic digestion units that don't necessarily have to be located onsite (e.g. AD using wastewater which cannot be transported) to increase their biogas production volumes at those sites and achieve better economies of scale.

The second highest recoverable agricultural feedstock is cattle diary manure which makes up 15-20% of the agricultural biogas potential. The total manure, effluent and slurry recoverable biogas potential from all livestock (poultry, pigs and dairy cattle) makes up 22-29% of the agricultural biogas potential.

Animal manure, slurry and effluent feedstocks have high biogas potential but also a high water content. Because of this, they often require anaerobic digestion technologies with a larger space requirement such as anaerobic ponds or lagoons. It should be noted that this recoverable potential primarily focuses on animal waste from intensive farming operations (such as factory farmed pigs or waste from cattle in the milking and feed shed) and manure from livestock grazing on paddocks has been excluded entirely (due to logistical barriers, competing use for land application and contamination of dirt and soil). However, there is scope to increase this figure if manure from cattle feedlots is collected.

MSW organics is the sector with the second highest recoverable biogas potential contributing between 8-11% of Victoria's total recoverable biogas potential.

The food organics feedstocks from MSW is highly suitable to anaerobic digestion. Although this may be mixed with garden organics, these wastes can be separated adequately to remove inappropriate organics such as high lignin woody waste such as in the form of branches. Unfortunately, MSW waste is more likely to be contaminated when compared to other feedstocks (such as from agriculture or directly from food processors). These contaminants may range from being inert and reducing biogas yields to being harmful inhibitors which could adversely affect the operation of anaerobic digestors.

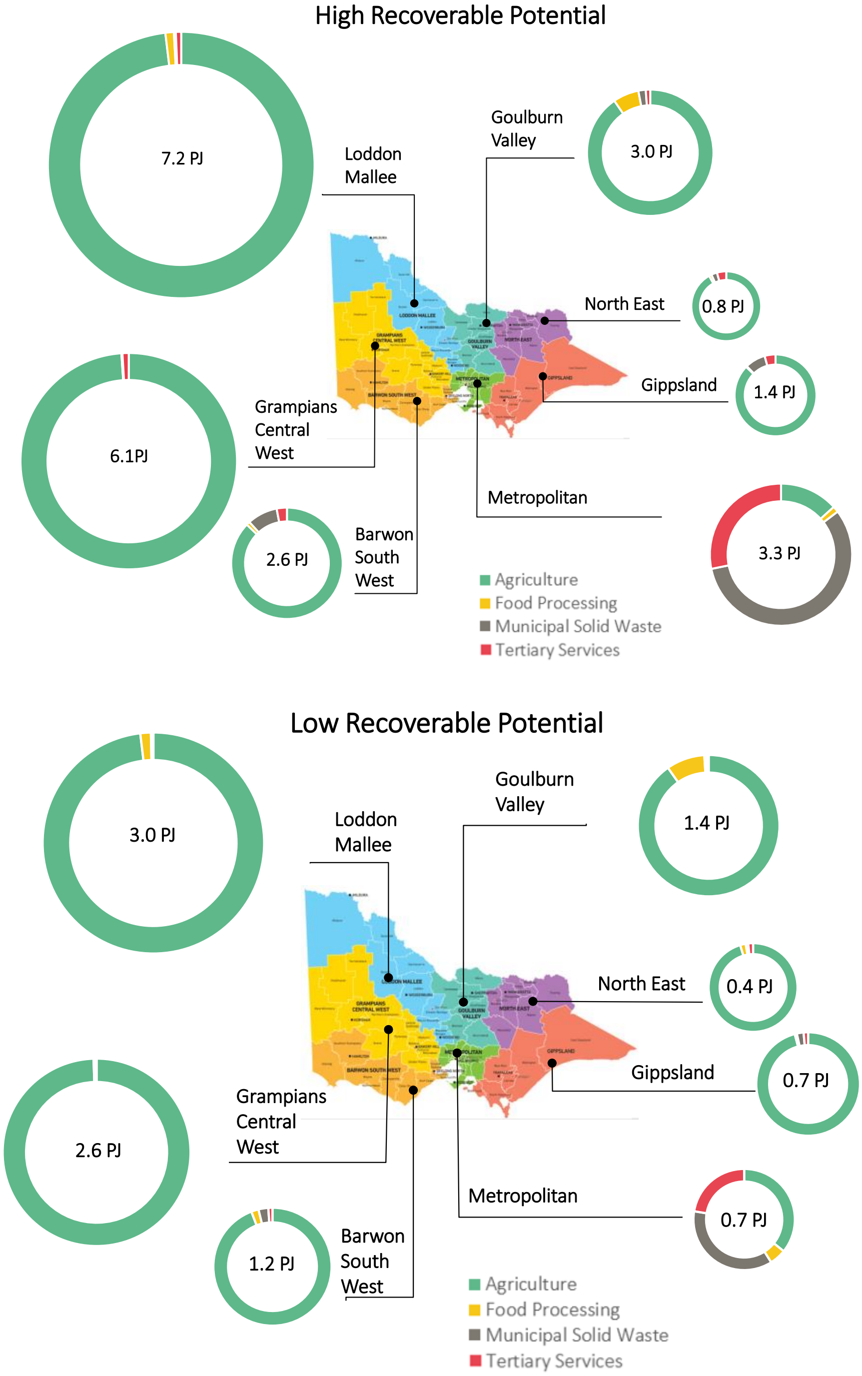
Tertiary services sector makes up 2-5% of the recoverable biogas potential with the accommodation and food services industry contributes 14-24% of the total tertiary services potential

The accommodation and food services sector include food organic waste from restaurants and other food outlets. Similar to MSW organics, this feedstock requires segregation from other waste at generation to ensure it can be recovered. This may pose a challenge since a variety of wastes are generated at these sites and contamination may occur.

4.4 Recoverable biogas potential by region

Approximately 73-79% of Victoria's recoverable biogas potential is located in the Grampians Central West, Loddon Mallee, Goulbourn Valley and Metropolitan regions (Figure 4-5). The first three regions are primarily driven by the agriculture sector whereas the Metropolitan region is driven by food organics from the MSW and Tertiary Service sectors.

Figure 4-5 - Regional breakdown of Victoria's recoverable biogas potential from anaerobic digestion[12]



[12] 0.5 PJ of biosolid recoverable potential energy (belonging to the MSW sector) is not displayed on this figure as this data was not available at a regional level.

Grampians Central West, Loddon Mallee and Goulbourn Valley combined make up 66% of Victorian recoverable biogas potential and are all largely driven by agricultural feedstocks, in particular cereal cropping residues.

Because there are less likely to be large energy users in agricultural regions, these anaerobic digestion projects may have limited business cases because behind the meter selling or offsetting of heat and electricity is critical to the financials of an anaerobic digestor. A potential alternative for agricultural anaerobic digestion projects is grid injection (either directly if located near a suitable injection site or via a virtual pipeline). Lastly, the biogas generated from agricultural feedstocks provides an opportunity to provide digestate at lower prices (due to lower transportation costs), as anaerobic digestion plants would be closer to potential digestate users.

The Metropolitan region accounts for 7-13% of Victorian recoverable biogas potential and is driven by MSW organics (37-58% of Metropolitan recoverable potential) and Tertiary Service organics (22-28% of Metropolitan recoverable potential).

The Metropolitan region's recoverable biogas potential is driven by the organics from MSW and Tertiary Services. While composed mainly of food organics, this feedstock is still extremely varied in its composition. Thus, instead of specialised plants focussing on mono digestion (such as for straw and chaff), anaerobic digestion plants in the Metropolitan region will need to be flexible and be able to combine different types of feedstocks. Digestate produced in the Metropolitan region faces multiple challenges such as distances from high volume digestate users and contamination that may render digestate unsuitable for land application.

Capturing the biogas potential from this region will be more of a logistical challenge than in agriculture due to the geographically distributed nature of this waste. In addition to this, securing feedstock supply agreements may be more difficult as project developers or anaerobic digestor operators require multiple waste supply agreements (as opposed to agricultural anaerobic digestion plants where little or no external feedstock supply agreements would need to be secured). However, an advantage of anaerobic digestion facilities in the Metropolitan region is the closer proximity to high energy users. This will facilitate behind the meter agreements for energy offsetting which will enhance the business case for an anaerobic digestion plant.

Greater Western Water's Melton waste to energy facility is an example of biogas production in the Metropolitan region

The successfully commissioned W2E Infrastructure Fund projects and promising business cases which are continuing into development show that some of the first steps have been taken towards capitalising on the enormous biogas potential of Victoria.

The successfully commissioned projects from the two rounds of the W2E Infrastructure Fund were developed by Greater Western Water and SMART Recycling. Western Water Corporation is a wastewater treatment provider which had spare capacity in their existing onsite anaerobic digestor. This project involved the installation of a waste receival unit to process external industrial liquid organic waste which was mixed into existing wastewater for enhanced biogas production. Currently the plant is only using waste sludge from a food processing facility, but there are plans to take more waste from other providers in the future. This example effectively shows the ability of a Metropolitan based anaerobic digestion plant to recover residue from nearby waste producers.

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APPENDIX 1 - DEFINITIONS

The following terms have been used throughout the report:

- **Organic residues** refers to excess biomass or waste material of organic nature which cannot be used for its primary purpose.
- **Substrate** is used when considering particular qualities and characteristics (eg. moisture content and lignin content) of biomass or organic residues for their suitability for anaerobic digestion.
- **Feedstocks** refers to substrates that are suitable for anaerobic digestion.
- **Biogas yield** is the amount of thermal energy in the form of methane that can be recovered from a given mass of feedstock.
- **Capture constraints** accounts for separation of organic residues, concentration of anaerobically digestible material in the waste stream and logistics of recovery. It does not account for economically recoverable feedstocks or other technical considerations (such as nutrient balance or opportunities for co-digestion).
- **High solids / dry anaerobic digestion** refers to anaerobic digestion of feedstocks up to ~35% solids (such as some dried agricultural organic residues).
- **Low solids / wet anaerobic digesion** refers to anaerobic digesiton of feedstocks with high moisture contents (e.g. >99% water such as wastewater).
- **VS** refers to volatile solids which are a component of organic matter that can be vapourised at sufficiently high temperatures.
- **COD** refers to chemical oxygen demand which is an indicative measure of the amount of oxygen that can be consumed by oxidation reactions in a solution.

APPENDIX 2 - LIST OF ORGANIC RESIDUES

Appendix 2 provides a list of the feedstocks considered in the assessment of the biogas potential with their associated volumes. These were taken from ABBA directly except for the tertiary services volumes which were calculated as per Section 2.1.1 using the waste generation rates in Appendix 3.

Table 5-1– List of feedstocks considered in the biogas potential assessment

Sector	Source and Feedstock	Volume	Units
Agriculture	Cropping - Cereals - Straw/chaff	4,512,698	dry tonne pa
Agriculture	Cropping - Oilseeds - Pods	352,398	dry tonne pa
Agriculture	Livestock Cattle Dairy Manure - Slurry (VS)	426,773	tonne VS pa
Agriculture	Livestock Chickens - Poultry litter	24,633	dry tonne pa
Agriculture	Livestock Pigs Manure Slurry (VS)	46,192	tonne VS pa
Agriculture	Livestock Other Poultry Layers - Pullets & Poultry litter	64,786	dry tonne pa
Construction Demolition Waste	Garden Organics	915,849	dry tonne pa
Construction Demolition Waste	Timber	3,480,007	dry tonne pa
Food Processing	Dairy Manufacturing - Wastewater	5,876	tonne COD pa
Food Processing	Fruit and Nuts Processing (Almond processing - husks and shells)	88,291	dry tonne pa
Food Processing	Fruit and Nuts Processing (Fruit Processing Facilities Process Solid Waste)	14,064	dry tonne pa
Food Processing	Meat Processing - Beef - Paunch	6,133	dry tonne pa
Food Processing	Meat Processing - Beef - Wastewater	12,142	tonne COD pa
Food Processing	Meat Processing - Pork - Paunch	598	dry tonne pa
Food Processing	Meat Processing - Pork - Wastewater	3,372	tonne COD pa
Food Processing	Meat Processing - Poultry - Wastewater	1,833	tonne COD pa
Food Processing	Wine Manufacturing - Grape Marc	26,218	dry tonne pa
Forestry	Forest Harvest Residues - Plantation Hardwood - Bark	297,636	dry tonne pa
Forestry	Forest Harvest Residues - Plantation Hardwood - Branch	102,938	dry tonne pa
Forestry	Forest Harvest Residues - Plantation Hardwood - Stump	58,202	dry tonne pa
Forestry	Forest Harvest Residues - Plantation Softwood - Bark	262,741	dry tonne pa

Sector	Source and Feedstock	Volume	Units
Forestry	Forest Harvest Residues - Plantation Softwood - Branch	102,939	dry tonne pa
Forestry	Forest Harvest Residues - Plantation Softwood - Stump	67,368	dry tonne pa
Forestry	Wood Processing Residues - Native Hardwood - Bark	2,263	dry tonne pa
Forestry	Wood Processing Residues - Native Hardwood - Sawdust	59,403	dry tonne pa
Forestry	Wood Processing Residues - Native Hardwood - Woodchip	67,323	dry tonne pa
Forestry	Wood Processing Residues - Plantation Hardwood - Bark	216	dry tonne pa
Forestry	Wood Processing Residues - Plantation Hardwood - Sawdust	7,130	dry tonne pa
Forestry	Wood Processing Residues - Plantation Hardwood - Woodchip	8,077	dry tonne pa
Forestry	Wood Processing Residues - Plantation Softwood - Bark	88,470	dry tonne pa
Forestry	Wood Processing Residues - Plantation Softwood - Sawdust	180,412	dry tonne pa
Forestry	Wood Processing Residues - Plantation Softwood - Woodchip	398,121	dry tonne pa
Horticulture	Fruit and Vegetable - Cull Fruit	13,378	dry tonne pa
Horticulture	Fruit and Vegetable - Cull Onions	139	dry tonne pa
Horticulture	Fruit and Vegetable - Cull Other Vegetables	6,811	dry tonne pa
Horticulture	Fruit and Vegetable - Cull Potatoes	4,988	dry tonne pa
Municipal Solid Waste	Municipal Solids - Biosolids	123,635	dry tonne pa
Municipal Solid Waste	Municipal Solid Waste / Solid - Organics	382,926	dry tonne pa
Municipal Solid Waste	Municipal Solid Waste / Solid - Paper and Cardboard	272,921	dry tonne pa
Tertiary Services	Wholesale Trade Organics	12,814	dry tonne pa
Tertiary Services	Wholesale Trade Paper and Cardboard	109,629	dry tonne pa
Tertiary Services	Retail Trade Organics	57,225	dry tonne pa
Tertiary Services	Retail Trade Paper and Cardboard	397,237	dry tonne pa
Tertiary Services	Accommodation and Food Services Organics	153,218	dry tonne pa
Tertiary Services	Accommodation and Food Services Paper and Cardboard	172,988	dry tonne pa
Tertiary Services	Transport, Postal and Warehousing Organics	6,111	dry tonne pa

Sector	Source and Feedstock	Volume	Units
Tertiary Services	Transport, Postal and Warehousing Paper and Cardboard	44,559	dry tonne pa
Tertiary Services	Financial and Insurance Services Organics	1,728	dry tonne pa
Tertiary Services	Financial and Insurance Services Paper and Cardboard	16,929	dry tonne pa
Tertiary Services	Rental, Hiring and Real Estate Organics	586	dry tonne pa
Tertiary Services	Rental, Hiring and Real Estate Paper and Cardboard	5,745	dry tonne pa
Tertiary Services	Professional, Scientific and Technical Services Organics	4,298	dry tonne pa
Tertiary Services	Professional, Scientific and Technical Services Paper and Cardboard	42,116	dry tonne pa
Tertiary Services	Administrative and Support Services Organics	1,206	dry tonne pa
Tertiary Services	Administrative and Support Services Paper and Cardboard	11,821	dry tonne pa
Tertiary Services	Public Administration and Safety Organics	999	dry tonne pa
Tertiary Services	Public Administration and Safety Paper and Cardboard	40,190	dry tonne pa
Tertiary Services	Education and Training Organics	3,596	dry tonne pa
Tertiary Services	Education and Training Paper and Cardboard	32,726	dry tonne pa
Tertiary Services	Health Care and Social Assistance Organics	4,748	dry tonne pa
Tertiary Services	Health Care and Social Assistance Paper and Cardboard	211,880	dry tonne pa
Tertiary Services	Arts and Recreation Services Organics	6,668	dry tonne pa
Tertiary Services	Arts and Recreation Services Paper and Cardboard	28,004	dry tonne pa

APPENDIX 3 - WASTE GENERATION RATES FOR TERTIARY SERVICES SECTOR

Appendix 2 lists the waste generation rates used for the tertiary services sector waste calculation outlined in Section 2.1.1. These values were sourced from the SRU 2013 and Blue Environment 2018 reports.

Table 5-2 – Waste generation rates for the tertiary service sector sub industries

Feedstock	Waste per FTEE (wet kg pr year)
Wholesale Trade Organics	450
Wholesale Trade Paper and Cardboard	1100
Retail Trade Organics	600
Retail Trade Paper and Cardboard	1190
Accommodation and Food Services Organics	3100
Accommodation and Food Services Paper and Cardboard	1000
Transport, Postal and Warehousing Organics	120
Transport, Postal and Warehousing Paper and Cardboard	250
Financial and Insurance Services Organics	50
Financial and Insurance Services Paper and Cardboard	140
Rental, Hiring and Real Estate Organics	50
Rental, Hiring and Real Estate Paper and Cardboard	140
Professional, Scientific and Technical Services Organics	50
Professional, Scientific and Technical Services Paper and Cardboard	140
Administrative and Support Services Organics	50
Administrative and Support Services Paper and Cardboard	140
Public Administration and Safety Organics	20
Public Administration and Safety Paper and Cardboard	230
Education and Training Organics	50
Education and Training Paper and Cardboard	130
Health Care and Social Assistance Organics	40
Health Care and Social Assistance Paper and Cardboard	510
Arts and Recreation Services Organics	350
Arts and Recreation Services Paper and Cardboard	420

APPENDIX 4 - RECOVERY RATES

Appendix 3 lists the recovery rates for each feedstock considered in the assessment. Considerations behind these recovery rates are provided in Table 4-1.

Table 5-3 – High and low recovery rates for feedstocks in biogas potential assessment

Sector	Feedstock	Recover-able rate % - Low	Recover-able rate % - High
Agriculture	Cropping - Cereals - Straw/chaff	15%	40%
Agriculture	Livestock Cattle Dairy Manure - Slurry (VS)	60%	100%
Agriculture	Cropping - Oilseeds - Pods	27%	27%
Agriculture	Livestock Other Poultry Layers - Pullets & Poultry litter	60%	100%
Agriculture	Livestock Pigs Manure Slurry (VS)	60%	100%
Agriculture	Livestock Chickens - Poultry litter	60%	100%
Construction Demolition Waste	Garden Organics	0%	0%
Construction Demolition Waste	Timber	0%	0%
Food Processing	Meat Processing - Beef - Wastewater	70%	70%
Food Processing	Fruit and Nuts Processing (Fruit Processing Facilities Process Solid Waste)	50%	84%
Food Processing	Dairy Manufacturing - Wastewater	70%	70%
Food Processing	Meat Processing - Pork - Wastewater	70%	70%
Food Processing	Wine Manufacturing - Grape Marc	50%	84%
Food Processing	Meat Processing - Poultry - Wastewater	70%	70%
Food Processing	Meat Processing - Beef - Paunch	50%	84%
Food Processing	Meat Processing - Pork - Paunch	50%	84%
Food Processing	Fruit and Nuts Processing (Almond processing - husks and shells)	0%	0%
Forestry	Forest Harvest Residues - Plantation Hardwood - Bark	0%	0%
Forestry	Forest Harvest Residues - Plantation Hardwood - Branch	0%	0%
Forestry	Forest Harvest Residues - Plantation Hardwood - Stump	0%	0%
Forestry	Forest Harvest Residues - Plantation Softwood - Bark	0%	0%
Forestry	Forest Harvest Residues - Plantation Softwood - Branch	0%	0%
Forestry	Forest Harvest Residues - Plantation Softwood - Stump	0%	0%
Forestry	Wood Processing Residues - Native Hardwood - Bark	0%	0%
Forestry	Wood Processing Residues - Native Hardwood - Saw-dust	0%	0%
Forestry	Wood Processing Residues - Native Hardwood - Wood-chip	0%	0%
Forestry	Wood Processing Residues - Plantation Hardwood - Bark	0%	0%

Sector	Feedstock	Recover-able rate % - Low	Recover-able rate % - High
Forestry	Wood Processing Residues - Plantation Hardwood - Sawdust	0%	0%
Forestry	Wood Processing Residues - Plantation Hardwood - Woodchip	0%	0%
Forestry	Wood Processing Residues - Plantation Softwood - Bark	0%	0%
Forestry	Wood Processing Residues - Plantation Softwood - Saw-dust	0%	0%
Forestry	Wood Processing Residues - Plantation Softwood - Woodchip	0%	0%
Horticulture	Fruit and Vegetable - Cull Fruit	100%	100%
Horticulture	Fruit and Vegetable - Cull Other Vegetables	100%	100%
Horticulture	Fruit and Vegetable - Cull Potatoes	100%	100%
Horticulture	Fruit and Vegetable - Cull Onions	100%	100%
Municipal Solid Waste	Municipal Solid Waste / Solid - Organics	6%	55%
Municipal Solid Waste	Municipal Solid Waste / Solid - Paper and Cardboard	0%	0%
Municipal Solid Waste	Municipal Solids - Biosolids	50%	50%
Tertiary Services	Organics	6%	38%
Tertiary Services	Paper and Cardboard	0%	0%

APPENDIX 5 - SUBJECT MATTER EXPERT INTERVIEWS

Subject matter experts were interviewed from leveraging Bioenergy Australia's network. The objective of these interviews was to validate biogas yields and/or recovery rates for different kinds of feedstocks.

Table 5-4 – List of organisations consulted during the biogas potential assessment

Organisation	Scope of interview
Jemena	Feedstock recovery rates
Griffith University	Feedstock recovery rates
Helmont Energy	Feedstock recovery rates
LMS Energy	Feedstock recovery rates
Delorean Energy	Feedstock recovery rates

APPENDIX 6 - ACRONYMS

Table 5-5 – Acronyms used in this report

Acronym	Full name
ABBA	Australian Biomass for Bioenergy Assessment
AD	Anaerobic digestion
ABS	Australian Bureau of Statistics
ANZSIC	Australian and New Zealand Standard Industry Classification
AREMI	Australian Renewable Energy Mapping Infrastructure
ARENEA	Australian Renewable Energy Agency
C&D	Construction and demolition
FOGO	Food organics / garden organics
FTEE	Full time equivalent employee
MSW	Municipal solid waste
NPI	National Pollutant Inventory
NSW	New South Wales
SME	Subject matter experts
VS	Volatile solids
W2E	Waste to energy

CONSULTING

Paris
89 rue Réaumur
75002 Paris,
France

+33 1 82 83 83 83
contact.paris@enea-consulting.com

Hong-Kong
Suite D, 6th floor,
Ho Lee commercial building
38-44 d'Aguilar Street, Central,
Hong Kong

contact.hongkong@enea-consulting.com

Melbourne
Level 12, 360 Elizabeth Street
Melbourne VIC 3000,
Australia

contact.melbourne@enea-consulting.com

Sydney
Level 10, 580 George Street,
Sydney NSW 2000
Australia

sydney@enea-consulting.com

Singapore
The Work Project, Level 12, Capital Tower,
168 Robinson Rd, Singapore 068912,
Singapore

singapore@enea-consulting.com