

DEECA Victorian Biomass and Biomethane Potential Assessment

Summary Report – Appendices

Prepared by SMEC Australia Pty Ltd

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We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it.

We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

DEECA is committed to genuinely partnering with Victorian Traditional Owners and Victoria's Aboriginal community to progress their aspirations.



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Acknowledgement

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As a company with a proud 70-year history, SMEC has established itself as a highly respected and trusted advisor and currently provides strategic advice to clients across industry and government.

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Appendix A: Methodology – Total Theoretical Assessment

Methodology – Desktop Review and Industry Engagement

A review of existing data and information provided by DEECA was conducted and used to inform the foundation for the modelling. Targeted engagement was then conducted with stakeholders across the agriculture, energy, resource recovery and water sector in order to fill data gaps identified in the initial and/or validate initial figures and residue factors to be applied in the modelling.

Targeted engagement was conducted with the following key stakeholders:

- Ausnet
- Australian Chicken Meat Federation
- Australian Meat Processing Corporation
- Australian Olive Association
- Australian Pork Limited
- City of Melbourne
- Dairy Australia
- Future Fuels Cooperative Research Centre
- Gippsland Ag
- Gippsland Water
- Grain Growers Australia
- Hort Innovation
- Meat and Livestock Australia
- Melbourne Water
- SPC Australia
- Valorify
- Veolia
- Victorian Forest Products Association
- Wine Australia
- Yarra Valley Water

Methodology – Total Theoretical Assessment

The following sections outline the approach used to model the total theoretical biomass residues and biomethane potential from the relevant sectors.

There are quality standards in place for natural gas in pipelines including Australian Standard AS 4564 which ensure its safe and efficient transportation and use. These standards focus on parameters such as energy content, contaminants, and water content. A potential biomass residue will produce a biogas comprising of a mixture of methane (50-75%), carbon dioxide (~25%), and trace other gas such as nitrogen, hydrogen sulphide, and other water vapour (USEPA, 2024). An upgrading process would be required to remove the carbon dioxide and other harmful gases from the biogas to bring it up to a methane content value greater than 90% in order to be carried through the gas pipeline.

For the purposes of this assessment, the theoretical biomethane potential values from residues have been calculated dependent on their calorific value (methane CH₄ content) and assumes upgrading from biogas to biomethane has taken place.

Broadacre

- Broadacre commodity production values were obtained from:
 - Australian Bureau of Statistics ‘*Value of Agricultural Commodities Produced, Australia – 2018-19*’
 - Australian Bureau of Statistics ‘*Value of Agricultural Commodities Produced, Australia – 2019-20*’
 - Australian Bureau of Statistics ‘*Value of Agricultural Commodities Produced, Australia – 2020-21*’
- Australian Bureau of Statistics ‘*Value of Agricultural Commodities Produced, Australia – 2021-22*’
- Australian Bureau of Statistics ‘*Australian Agriculture: Broadacre, 2022-23 financial year*’.
- An average production value for each commodity at a Victorian level was obtained from 2018-19 to 2022-23 to account for annual variabilities due to weather, economic or disease factors with a regional breakdown obtained from the 2020-21 dataset.
 - It is assumed that the regional breakdown in 2020-21 is representative of other years. It should be noted 2020-2021 occurred during an outbreak of COVID-19 which may have affected the values obtained.
- Future projections were from the Climate Change Authority ‘*Australian Agriculture emission projections to 2050*’ underlying data table; Table 4.8: Projected grain production: the central reference case
- Crop residues factors for each were calculated using the residue crop ratio, below-ground-to-above-ground ratio, and dry matter content values obtained from the *National Inventory Report 2022: Volume 2* (DCCEEW, 2024), with the final calculated residue factor for each presented below in Table A-1.

Table A–1: Calculated broadacre crop residue factors using factors sourced from (DCCEEW, 2024)

Type	Sub-Category	Residue Crop Ratio	Below-Ground-to-Above-Ground Ratio	Dry matter content	Calculated residue factor (Above Ground) – dry tonne/tonne
Wheat for grain	Cereal crops	1.5	0.29	0.88	0.94
Oats for grain	Cereal crops	1.42	0.43	0.88	0.71
Barley for grain	Cereal crops	1.24	0.32	0.88	0.74
Triticale for grain	Cereal crops	1.5	0.42	0.88	0.77
Sorghum for grain	Cereal crops	1.5	0.22	0.8	0.94
Maize for grain	Cereal crops	0.81	0.39	0.85	0.42
All other cereals for grain or seed	Cereal crops	1.46	0.36	0.88	0.82
Rice for grain	Cereal crops	1.31	0.16	0.8	0.88
Canola	Oilseeds	2.08	0.33	0.96	1.34
Other oilseeds	Oilseeds	2.08	0.33	0.96	1.34
Pulses	Non-cereal crop (pulses and legumes)	1.37	0.51	0.87	0.58
Chickpeas	Non-cereal crop (pulses and legumes)	1.37	0.51	0.87	0.58
Lentils	Non-cereal crop (pulses and legumes)	1.37	0.51	0.87	0.58
Lupins	Non-cereal crop (pulses and legumes)	1.37	0.51	0.87	0.58

- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatiles solids (VS) content, followed by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used across all broadacre residues:
 - A volatile solids ratio of 94.9 % VS (Dry Matter) (Lallement, et al., 2023)
 - A calorific value of 300 m³ CH₄/t VS (Lallement, et al., 2023)
 - An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Horticulture

Fruit and vegetable (horticulture)

- Horticulture commodity production values were obtained from:
 - Australian Bureau of Statistics ‘Value of Agricultural Commodities Produced, Australia – 2018-19’
 - Australian Bureau of Statistics ‘Value of Agricultural Commodities Produced, Australia – 2019-20’
 - Australian Bureau of Statistics ‘Value of Agricultural Commodities Produced, Australia – 2020-21’
 - Australian Bureau of Statistics ‘Value of Agricultural Commodities Produced, Australia – 2021-22’
 - Australian Bureau of Statistics ‘Australian Agriculture: Horticulture, 2022-23 financial year’.
- An average production value for each commodity at a Victorian level was obtained from 2018-19 to 2022-23 to account for annual variabilities due to weather, economic or disease factors with a regional breakdown obtained from the 2020-21 dataset.
 - It is assumed that the regional breakdown in 2020-21 is representative of other years. It should be noted 2020-2021 occurred during an outbreak of COVID-19 which may have affected the values obtained.
- Future projections were applied using Victorian population growth rates from State of Victoria Department of Transport and Planning ‘Victoria in Future: 2023 Population and household projections to 2051’.
- Crop loss/waste factors were obtained from ABARES ‘Crop loss/waste on Australian horticulture farms, 2021-22 to 2022–23’ with an average obtained over the two years from Victoria. If Victorian crop loss/waste data was not available then crop loss/waste percentages were applied from other regions with similarity to Victoria conditions in order of preference based on distance to Victoria’s main horticulture regions

including New South Wales and South Australia.

- Moisture content factors were applied to obtain the dry weight of the waste residue:
 - Fruits: 84% (Fear, et al., 2005)
 - Vegetables: 81% (Fear, et al., 2005)
 - Almonds: 4.5% (Dingke, et al., 2014)
- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatiles solids content, followed by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used across all horticultural residues:
 - A volatile solids ratio of 82.6 % VS (Dry Matter) (Gebresilasie, et al., 2025)
 - A calorific value of 314 m³ CH₄/t VS (Lallement, et al., 2023)
 - An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Fruit and vegetable processing

- Facilities and employee numbers within the Fruit and Vegetable Processing group were obtained from the 2022-23 National Pollutant Inventory List.
- Locations of facilities were allocated to an LGA region using the coordinates within the NPI list and the LGA digital boundaries.
- Commodity generation rate of 188 kg product/employee was calculated using 2023-24 data supplied by an processing facility.
- Future projections were applied using full time employee numbers in Victoria for frozen potatoes, canned tomatoes, other processed vegetables, processed fruits and jams, and orange and other juice from Centre for International Economics ‘Economic contribution of Australian horticulture’. An average of available years was used for 2030-31 onwards.
- COD in fruit and vegetable effluent was calculated using the NGER ‘Wastewater Industrial Calculator’ where 20 m³/tonne commodity is generated at 0.20 kg COD/m³.

- Waste generation rate of approximately 80 kg organics per employee was calculated using 2023-24 data supplied by a processing facility. This value is within range of range of 60 to 90 kg per tonne from apple and strawberry processing (World Bank Group, 1998).
- Waste generation rate was applied to employee numbers at each facility in Victoria.
 - A moisture content of 37% was applied to obtain the dry weight (Fear, et al., 2005).
- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatile solids content, followed by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used:
 - A calorific value of 29.3 m³ CH₄/t COD (European Biogas Association, 2021)
 - A volatile solids ratio 82.6 % VS (dry matter) (Gebresilasie, et al., 2025)
 - A calorific value of 314 m³ CH₄/t VS (Lallement, et al., 2023)
 - An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)
- Australian Bureau of Statistics *'Australian Agriculture: Horticulture, 2022-23 financial year'*.
 - An average production value for almonds, olives and wine grapes at a Victorian level was obtained from 2018-19 to 2022-23 to account for annual variabilities due to weather, economic or disease factors with a regional breakdown obtained from the 2020-21 dataset.
 - It is assumed that the regional breakdown in 2020-21 is representative of other years. It should be noted 2020-2021 occurred during an outbreak of COVID-19 which may have affected the values obtained.
- It is assumed that processing occurs in the same region where the commodity is grown, with the processed volume matching the production volume within that region.
- The following growth rates were applied:
 - Hort Innovation *'Australian Almond Innovation and Adoption Program'*
 - Grand Horizon Research *'Global Olive Oil Market Size & Outlook, 2023-2030'*
- No growth rate was applied for wine grapes as the volume of winegrape production in Australia has stagnated, as well as consumption of wine (Anderson, 2024).
- For almonds
 - Estimated shell and hull produced is 2.3 tonnes/tonne almond kernel (Almond Board of Australia, 2013)
 - Estimated moisture content of shell and hull is 10% (Arcadis, 2018)
- For olives the estimated olive pomace produced is 0.81 dry tonnes/tonne olives (Arcadis, 2018).
- For wine grapes the estimated grape marc produced is 0.0858 dry tonnes/tonne wine grape (Almond Board of Australia, 2013).
- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatiles solids content, followed by applying a calorific value, then converting the biomethane to an energy

Almond, olive and wine processing

value by applying an energy content factor for methane. The following factors were used:

- A volatile solids ratio for Almond Husks and Shells: 94.3% VS (dry matter) (Fernandez-Bayo, et al., 2020)
- A calorific value for Almond Husks and Shells: 255.3 m³ CH₄/t VS (Ali, et al., 2018)
- A volatile solids ratio for Olive Pomace: 97.6% VS (dry matter) (Reis, et al., 1999)
- A calorific value for Olive Pomace: 200 m³ CH₄/t VS (Cubero-Cardoso, et al., 2024)
- A volatile solids ratio for Grape Marc: 88.8% VS (dry matter) (Reis, et al., 1999)
- A calorific value for Grape Marc: 129 m³ CH₄/t VS (Lallement, et al., 2023)
- An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024).

Livestock

Livestock (chicken, dairy, cattle, and pigs)

- Horticulture commodity production values were obtained from:
 - Australian Bureau of Statistics *'Value of Agricultural Commodities Produced, Australia – 2018-19'*
 - Australian Bureau of Statistics *'Value of Agricultural Commodities Produced, Australia – 2019-20'*
 - Australian Bureau of Statistics *'Value of Agricultural Commodities Produced, Australia – 2020-21'*
 - Australian Bureau of Statistics *'Value of Agricultural Commodities Produced, Australia – 2021-22'*
 - Australian Bureau of Statistics *'Australian Agriculture: Livestock, 2022-23 financial year'*
 - Dairy Australia *'In Focus 2023'*.
- An average production value for each livestock at a Victorian level was obtained from 2018-19 to 2022-23 to account for annual variations with a regional breakdown obtained from the 2020-21 dataset.
 - For dairy cattle, the 2022-23 data was used rather than an average value due to the annual decline of dairy cattle numbers over this period.
 - It is assumed that the regional breakdown in 2020-21 is representative of other years. It should be noted 2020-2021 occurred during an outbreak of COVID-19 which may have affected the values obtained.
- Future projections were from the Climate Change Authority *'Australian Agriculture emission projections to 2050'* underlying data tables:
 - Table 4.3: Projected beef cattle numbers: the central reference case
 - Table 4.4: Projected sheep, pig and poultry numbers: the central reference case
 - Table 4.7: Projected dairy cattle numbers by state: the central reference case
- The following residue factors were applied:
 - Meat Chickens: 0.001226 dry tonnes/ chicken (Arcadis, 2018)
 - Layers and Pullets: 0.0164 dry tonnes/ chicken (Arcadis, 2018)
 - Pigs: 0.0866 tonnes VS/year (Arcadis, 2018)
 - Dairy Cattle: 0.2418 tonnes VS/year (Arcadis, 2018)
- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatiles solids content, followed by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used:
 - A volatile solids ratio for Chicken Litter: 61.0% VS (dry matter) (Hamilton, 2016)
 - A calorific value for Chicken Litter: 245 m³ CH₄/t VS (Hamilton, 2016)
 - A calorific value for Pig manure/slurry: 245 m³ CH₄/t VS (Australian Pork Limited, 2018)

- A calorific value for Dairy Cattle Manure/ Slurry: 112 m³ CH₄/t VS (University of Southern Queensland, 2025)
- An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Meat and poultry processing

- Livestock slaughtered values for 2023-24 were obtained from:
 - Australian Bureau of Statistics ‘*Livestock Products, Australia – Quarterly statistic on livestock slaughtered and meat production*’
- Facilities and employee numbers within the Meat and Poultry Processing groups were obtained from the 2022-23 National Pollutant Inventory List.
 - Within the meat group there is no information on the NPI facilities list to indicate what type of meat is processed (eg. beef, lamb/sheep or pig). SMEC conducted a search into each facility and estimated the type of meat processed and divided by equal proportions where applicable. There is specific NPI code for poultry and therefore this value was not mixed in with pigs, other livestock. For Pigs only one facility was included in the NPI list was identified (therefore not combined with sheep cattle). Some facilities which were identified as processing both sheep and cattle, for the purpose of the assessment a 50/50 split was assumed.
 - Coverage of cattle and lamb meat processing industry from NPI list was estimated to be 75% (Arcadis, 2018) therefore the remaining 25% has not been assessed as a location was unable to allocated to this fraction and it is assumed these facilities are small in scale.
 - Coverage of poultry meat processing industry from NPI list was estimated to be 80% (Arcadis, 2018) therefore the remaining 20% has not been assessed as a location was unable to allocated to this fraction and it is assumed these facilities are small in scale.
- Future projections were from the Climate Change Authority ‘*Australian Agriculture emission projections to 2050*’ underlying data tables:
 - *Table 4.3: Projected beef cattle numbers: the central reference case*
 - *Table 4.4: Projected sheep, pig and poultry numbers: the central reference case*
- The following residue factors were applied for paunch:
 - Cattle: 0.006 dry tonnes paunch/number (Arcadis, 2018)
 - HSCW 280 kg (Tessele Consultants, 2022)
 - Bulls, bullocks and steers: 0.006 dry tonnes paunch/number
 - Assumed HSCW 280 kg (Tessele Consultants, 2022)
 - Cows and heifers: 0.0054 dry tonnes paunch/number
 - Assumed HSCW 250 kg (Breedplan, 2025)
 - Calves: 0.0024 dry tonnes paunch/number
 - Assumed HSCW 110 kg (MLA, 2017)
 - Pigs: 0.000503 dry tonnes paunch/number
 - Assumed HSCW 72 kg and 3% paunch (Arcadis, 2018)
 - TS 23.3% (University of Southern Queensland, 2025)
 - Sheep/Lamb: 0.000123 dry tonnes paunch/number
 - Assumed HSCW 23 kg and 23 kg paunch/t HSCW (Tessele Consultants, 2022)
 - TS 23.3% (University of Southern Queensland, 2025)
- For liquid residues, Chemical Oxygen Demand (COD) is used to measure the carbon in liquids by measuring the oxygen required to chemically oxidize all organic and some inorganic matter, and provides an indication of a liquid sample’s potential oxygen-consuming capacity.

- The following residue factors were applied for effluent (liquid):
 - Cattle: 0.0115 tonnes COD/number
 - HSCW 280 kg (Tessele Consultants, 2022)
 - 7.3 KL/t HSCW (AMPC, 2022)
 - 5645 mg COD/L (AMPC, 2022)
 - Bulls, bullocks and steers: 0.0115 tonnes COD/number
 - Cows and heifers: 0.0103 tonnes COD/number
 - Calves: 0.0062 tonnes COD/number
 - Pigs: 0.00274 tonnes COD/number (Arcadis, 2018)
 - Sheep/Lamb: 0.000857 tonnes COD/number
 - 6.6 KL/t HSCW
 - 5645 mg COD/L (AMPC, 2022)
 - Chickens: 0.000017 tonnes COD/number (Arcadis, 2018)
- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatiles solids content (solids), followed by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used:
 - A calorific value for Wastewater: 24.3 m³ CH₄/tonne COD (University of Southern Queensland, 2025)
 - A volatile solids ratio for Paunch: 72.1% VS (dry matter) (University of Southern Queensland, 2025)
 - A calorific value for Paunch: 207 m³ CH₄/t VS
 - An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Dairy processing

- Milk production values were obtained from:
 - Dairy Australia ‘*National Milk Production Data – Financial Year 2023/24*’
- Facilities and employee numbers within the Dairy Product Manufacturing group were obtained from the 2022-23 National Pollutant Inventory List.
 - Coverage of milk processing industry from NPI list was estimated to be 85% (Arcadis, 2018) therefore the remaining 15% has not been assessed as a location was unable to allocated to this fraction and it is assumed these facilities are small in scale.
 - 85% of milk production in Victoria was allocated to facilities using proportion of employees.
- Locations of facilities were allocated to an LGA region using the coordinates within the NPI list and the LGA digital boundaries.
- Future projections were from the Climate Change Authority ‘*Australian Agriculture emission projections to 2050*’ underlying data table; Table 4.5: Projected milk production by state: the central reference case.
- The amount of wastewater produced per ML of raw milk is estimated to be 1.99 ML wastewater/ML milk (Dairy Australia, 2021).
- Estimated COD in dairy product effluent of 0.90 kg COD/L was obtained the NGER ‘*Wastewater Industrial Calculator*’.
- The estimated effluent kg COD per litre of milk production is estimated to be 1.79 kg COD/L milk production.
- Biomethane potential was calculated by first converting the residue to biomethane by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used:
 - A calorific value 31 m³ CH₄/t COD (Dębowski, et al., 2020)
 - An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Plantation and Wood Processing

Forestry (plantation)

- Softwood and hardwood production values for 2022-23 were obtained from:
 - ABARES *'Australian forest and wood products statistics, Trade to 2023-24'*
- Spatial data of Australia's Plantations was obtained from:
 - ABARES *'Australia's plantations 2020-21 - spatial dataset'*
- Local Government Area shapefiles were obtained from:
 - GDA2020 digital boundary files: Local Government Areas - 2024 – Shapefile
- Volumes of production for 2022-23 were allocated to an LGA region based on the proportion of plantations in each LGA region using the spatial dataset and LGA digital boundaries.
 - It is assumed that harvesting occurs at an equal distribution per plantation area.
- Future projections were applied using average log availability from ABARES *'Australian plantation area and log availability'* for hardwood and softwood sawlogs and pulplogs within the Central Gippsland, Central Victoria, East-Gippsland Bombala, Green Triangle and Murray Valley national plantation inventory regions.
- Volumes of production in m³ were converted to tonnes using the following formulas from the Forest Products Commission Western Australia (FPCWA, 2017):
 - Softwood sawlogs: 0.49 tonnes/ m³
 - Softwood pulplogs: 0.405 tonnes/ m³
 - Hardwood sawlogs: 0.54 tonnes/ m³
 - Hardwood pulplogs: 0.54 tonnes/ m³
- The residues factors from plantation harvests were determined by specialist Barrie May (Arcadis, 2018).

- Residues factors used to estimate the amount of residue that could be removed from softwood and hardwood plantations are:
 - Softwood
 - Branches: 10%
 - Bark: 13%
 - Stump: 3%
 - Hardwood sawlog:
 - Branches: 13%
 - Bark: 15%
 - Stump: 8%
 - Hardwood pulplog:
 - Branches: 5%
 - Bark: 15%
 - Stump: 3%
- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatiles solids content, followed by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used across all forestry residues:
 - A volatile solids ratio of 35.3 % VS (fresh matter) (Walter, et al., 2016)
 - 177 m³ CH₄/t VS (Lallement, et al., 2023)
 - 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Wood processing (sawmills)

- Softwood and hardwood production values for 2022-23 were obtained from:
 - ABARES *'Australian forest and wood products statistics, Trade to 2023-24'*
- Spatial data of Australia's Plantations was obtained from:
 - ABARES *'Australia's plantations 2020-21 - spatial dataset'*
- Local Government Area shapefiles were obtained from:
 - GDA2020 digital boundary files: Local Government Areas - 2024 – Shapefile

- Volumes of production for 2022-23 were allocated to an LGA region based on the proportion of plantations in each LGA region using the spatial dataset and LGA digital boundaries.
- It is assumed that processing occurs in the same location where the commodity was harvested and that harvesting occurs at an equal distribution per plantation area.
- Future projections were applied using average log availability from ABARES *'Australian plantation area and log availability'* for hardwood and softwood sawlogs and pulplogs within the Central Gippsland, Central Victoria, East-Gippsland Bombala, Green Triangle and Murray Valley national plantation inventory regions.
- Volumes of production in m³ were converted to tonnes using the following formulas from the Forest Products Commission Western Australia (Arcadis, 2018):
 - Softwood sawlogs: 0.49 tonnes/ m³
 - Hardwood sawlogs: 0.60 tonnes/ m³
- Residues factors used to estimate the amount of residue that could be removed from softwood and hardwood plantations (Arcadis, 2018):
 - Softwood sawlog:
 - Wet Woodchips: 36%
 - Wet Sawdust: 5%
 - Dry sawdust: 3%
 - Bark: 8%
 - Hardwood sawlog:
 - Wet Woodchips: 30%
 - Wet Sawdust: 3%
 - Dry sawdust: 8%
 - Bark: 1%
- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatiles solids content, followed by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used:

- A volatile solids ratio for Wet Sawdust, Wet Woodchips and Bark: 35.3 % VS (fresh matter) (Walter, et al., 2016)
- A volatile solids ratio for Dry Sawdust: 96.7 % VS (dry matter) (Walter, et al., 2016)
- A calorific value for Wet Woodchips: 222.2 m³ CH₄/t VS (Gao, et al., 2023)
- A calorific value for Bark: 177 m³ CH₄/t VS (Lallement, et al., 2023)
- A calorific value for Dry and Wet Sawdust: 460.8 m³ CH₄/t VS (Gao, et al., 2023)
- An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Waste Sector

C&I Other (ANZSIC Divisions)

The following is presented for ANZSIC Divisions excluding ANZSIC Division C which is covered in Section 2.2.6 to Section 2.2.10.

- Number of employees within each LGA and ANZSIC industry were obtained from:
 - Australian Bureau of Statistics *'Jobs in Australia 2021-22 financial year.'*
- Average hours actually worked per employed person within each ANZSIC industry from December 2023 to November 2024 was obtained from:
 - Australian Bureau of Statistics *'Labour Force Australia, January 2025: Industry and Occupation'*
- Number of equivalent full-time employees (35 hours worked) within each LGA and ANZSIC industry were adjusted using the average hours actually worked per employed person.
- Waste Generation Rates (kg/EFTE/year) for ANZSIC Divisions were obtained from City of Melbourne commercial waste survey (Blue Environment, 2016). Refer to Table A-2 for waste generation rates.

Table A–2: Waste generation per EFTE (35 hours worked) estimates by industry and waste stream, Melbourne (based on 2016 survey)

ANZSIC Division	Garbage (kg/EFTE/year)	Organics (kg/EFTE/year)	Paper and Cardboard (kg/EFTE/year)
Accommodation and Food Services	2,453	189	296
Administrative and Support Services	67	6	95
Agriculture, Forestry and Fishing	2,076	152	429
Arts and Recreation Services	2,076	152	429
Construction	2,076	152	429
Education and Training	43	0	13
Electricity, Gas, Water and Waste Services	2,076	152	429
Financial and Insurance Services	67	6	95
Health Care and Social Assistance	34	0	33
Information Media and Telecommunications	67	6	95
Manufacturing	292	0	225
Mining	2,076	152	429
Other Services	2,076	152	429
Professional, Scientific and Technical Services	67	6	95
Public Administration and Safety	67	6	95
Rental, Hiring and Real Estate Services	67	6	95
Retail Trade	1,917	217	789
Transport, Postal and Warehousing	2,076	152	429
Wholesale Trade	2,076	152	429

- Future projections were applied using Victorian population growth rates from State of Victoria Department of Transport and Planning ‘Victoria in Future: 2023 Population and household projections to 2051’.
- Biomethane potential was calculated by first converting the residue to biomethane by determining the volatiles solids content, followed by applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used:
 - A volatile solid ratio of 22.8 % VS (fresh matter) (Figueroa-Escamilla, et al., 2021)
 - A calorific value of 288 m³ CH₄/t VS (Figueroa-Escamilla, et al., 2021)

- An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

MSW, C&I and C&D Organics

- MSW, C&I and C&D organics values for 2024-2025 to 2044-45 were obtained from:
 - Recycling Victoria ‘Projections of total organics generation, by material name, to 2053’
- Breakdown of MSW organics was obtained from: Recycling Victoria ‘Victorian Local Government Data Dashboard’. A breakdown was estimated using kerbside organics collected in 2022-23. For LGA’s which did not have organic kerbside collection this value was estimated using the average proportion of kerbside organics compared to residual MSW collected from other LGA’s within the

same region (as per former Waste and Resource Recovery Group boundaries) and then applied to the residual MSW collected in this LGA.

- Regional breakdown of C&I and C&D was obtained from organics demand in Recycling Victoria ‘Victorian Recycling Infrastructure Plan 2024’
 - No breakdown of C&I or C&D organics was able to be conducted at LGA level due to limited data on the production areas of these organics.
- Biomethane potential was calculated using the following factors:
 - Volatile Solids:
 - Food organics: 27.4% VS (fresh matter) (Lallement, et al., 2023)
 - Garden Organics: 35.3% VS (fresh matter) (Walter, et al., 2016)
 - Other Organics: 22.8% VS (fresh matter) (Figueroa-Escamilla, et al., 2021)
 - Wood/timber: 35.3% VS (fresh matter) (Walter, et al., 2016)
- Biomethane potential was calculated applying a calorific value, then converting the biomethane to an energy value by applying an energy content factor for methane. The following factors were used:
 - A calorific value for Food organics: 390 m³ CH₄/t VS (Lallement, et al., 2023)
 - A calorific value for Garden Organics: 177 m³ CH₄/t VS (Lallement, et al., 2023)
 - A calorific value for Other Organics: 288 m³ CH₄/t VS (Figueroa-Escamilla, et al., 2021)
 - A calorific value for Wood/timber: 177 m³ CH₄/t VS (Lallement, et al., 2023)
 - An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Wastewater Treatment Plants

- DEECA provided a list of wastewater treatment plants in Victoria, including the following details for the 2021–22 financial year:
 - Biological Nutrient Removal (BNR) Plant Type.
 - Sludge Management.
 - Volume effluent produced.
 - Biosolids produced.
- An assessment was conducted using the information provided as well as drawing on SMEC’s knowledge of WWTP within the list and the treatment processes.
- Where values have been provided by water corporations these have been used rather than calculations.
- The following assumptions and assessment criteria based on SMEC (Water Infrastructure Team) experience in WWTP were used in the process:
 - Any treatment plant with an inflow under 1ML/day was deemed a non-viable candidate as STP’s of this size are typically lagoon-based systems with no means of capturing any CH₄.
 - For STP’s that only indicate an activated sludge process without mentioning primary treatment, it was assumed that STPs with a capacity greater than 5 ML/ day have primary treatment present on-site.
 - The average RAW inflow COD to the STP is 650mg/l with 30% captured in primary sedimentation.
 - An average STP produces 50m³/ML of waste activated sludge per day and operates at an average MLSS of 4000 mg/L.
 - Average Waste activated sludge has a TSS/VSS ratio of 0.55.
 - The biogas generation potential of waste activated sludge was assumed to be 0.65m³ biogas/kg VSS destroyed.
 - Of the total biogas produced only 60% is CH₄ with the remaining being CO₂ and other trace gasses

- All media trickling filters have primary sedimentation tanks.
- Where no description of the STP or process information was available, it was assumed that systems capable of producing Class B and/or Class A effluent were activated sludge systems, while systems only capable of producing Class C effluent were facultative lagoon systems with no means to capture biogas due to process limitations.
- Biomethane potential was calculated by converting the calculated biomethane to an energy value by applying an energy content factor for methane. The following factor was used:
 - An energy content factor of 39.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Landfills

- A list of operating landfills was obtained from:
 - Recycling Victoria ‘Victorian Recycling Infrastructure Plan 2024’
 - Closed landfills were excluded from this assessment, as landfill gas generation is expected to decline rapidly after closure, making them an unviable long-term solution.
- Key information for these landfills was sourced from publicly available sources of data including the EPA audit register and other publicly available online documents which provided key landfill details including tonnages, LFG infrastructure, LFG capture rates, opening dates, and expected closure dates.
- Twelve landfills were included in the assessment based on the key information.
- It was assumed that landfill tonnages and waste composition for each landfill were to remain the same each year aligned with historical data until their forecasted closure date as indicated in the Victorian Recycling Infrastructure Plan. While there are government interventions underway to drive organics diversion from landfill (e.g. via introduction of access to food organics and

garden organics services for all households in Victoria by 2030) the impact on long-term LFG generation is difficult to assume.

- SMEC has assumed if a landfill closes, the BMP will peak just after last placement of waste and then decline.
- Tonnages and waste composition were entered into the Clean Energy Regulator's publicly available ‘*NGERS Solid Waste Calculator*’. Estimations were used for projections and years where no data was available.
- Outputs from the ‘*NGERS Solid Waste Calculator*’ were converted to an LFG generation rate and compared with known LFG capture values to estimate the capture efficiency.
- A default capture efficiency of 75% was used for one site which had no known LFG capture system.
- The capture efficiency was applied to all years to estimate the potential LFG capture.
 - It is assumed capture efficiency will not change however this is affected by a number of factors including expansion of gas collection system and capping.
- LFG was converted to methane, assuming a 50% methane conversion rate which is default rate used in the ‘*NGERS Solid Waste Calculator*’ and detailed in ‘*National Greenhouse and Energy Reporting (Measurement) Determination 2008*’ (DCCEEW, 2024).
- Biomethane potential was calculated by converting the calculated biomethane to an energy value by applying an energy content factor for methane. The following factor was used:
 - An energy content factor of 339.3 MJ/ m³ CH₄ (DCCEEW, 2024)

Summary calorific values

A summary of the calorific values applied in the biomethane model are shown below in Table A–3.

Table A–3: Calorific values applied in biomethane model¹

Category	Type	VS	m ³ CH ₄ /t VS	m ³ CH ₄ /t	GJ/t
Food organics MSW	FM	27%	390	107	0.0041
Garden organics MSW	FM	35%	177	62	0.0024
Other organics MSW	FM	23%	288	66	0.0025
Wood /timber MSW	FM	35%	177	62	0.0024
Food organics CND	FM	27%	390	107	0.0041
Garden organics CND	FM	35%	177	62	0.0024
Other organics CND	FM	23%	288	66	0.0025
Wood /timber CND	FM	35%	177	62	0.0024
Food organics CNI	FM	27%	390	107	0.0041
Garden organics CNI	FM	35%	177	62	0.0024
Other organics CNI	FM	23%	288	66	0.0025
Wood /timber CNI	FM	35%	177	62	0.0024
C&I Paper and Cardboard	FM	95%	307	292	0.0111
C&I Organics	FM	23%	288	66	0.0025
Cereals Straw and Chaff	DM	95%	300	285	0.0109
Non-cereals Straw and Chaff	DM	95%	300	285	0.0109
Oilseeds Straw and Chaff	DM	95%	300	285	0.0109
Fruit and Veg Cull	DM	83%	314	259	0.0099
Chicken Poultry Litter	DM	61%	245	149	0.0057
Pigs Manure Slurry	VS	N/A	450	450	0.0172
Dairy Cattle Manure Slurry	VS	N/A	112	112	0.0043
Cattle Paunch	DM	72%	207	149	0.0057
Cattle Wastewater	COD	N/A	24	24	0.0009
Sheep Paunch	DM	72%	207	149	0.0057
Sheep Wastewater	COD	N/A	24	24	0.0009
Pig Paunch	DM	72%	207	149	0.0057
Pig Wastewater	COD	N/A	24	24	0.0009
Poultry Wastewater	COD	N/A	24	24	0.0009
Dairy Cattle Wastewater	COD	N/A	31	31	0.0012
Fruit and Vegetable Processing Solids	DM	83%	314	259	0.0099

¹ Figures from various sources as outlined in Section 2.1

Category	Type	VS	m³ CH ₄ /t VS	m³ CH ₄ /t	GJ/t
Fruit and Vegetable Processing Effluent	COD	N/A	29	29	0.0011
Olive Marc	DM	98%	200	195	0.0075
Almond Husks and Shells	DM	94%	255	241	0.0092
WWTP Effluent	ML	N/A	142	142	0.0054
Plantation Bark	FM	35%	177	62	0.0024
Plantation Branch	FM	35%	177	62	0.0024
Plantation Stump	FM	35%	177	62	0.0024
Sawmill Wet Sawdust	FM	35%	461	163	0.0062
Sawmill Wet Woodchips	FM	35%	222	78	0.0030
Sawmill Bark	FM	35%	177	62	0.0024
Sawmill Dry Sawdust	FM	97%	461	446	0.0170
Grape Marc	FM	89%	129	115	0.0044

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Appendix B: Results – Total Theoretical Assessment

Results – Total Theoretical Assessment

The following sections provide an overview of the top LGAs (and Regions) displaying the highest volumes of total theoretical residues and resulting biomethane potential for each of the assessed feedstock categories.

Regional boundaries were defined using the former Waste and Resource Recovery Group boundaries to align with the regional boundaries used in the previous Australian Biomass for Bioenergy Assessment (ABBA) study conducted and include:

- Barwon South West (BSW);
- Gippsland (Gipp);
- Grampians Central West (GCW);
- Goulburn Valley (GV);
- North East (NE);
- Loddon Mallee (LM);
- Metropolitan (Metro).



Broadacre

Total theoretical broadacre residues were estimated to be approximately 8.1 million dry tonnes in 2025, which is projected to increase to over 13 million dry tonnes by 2045. This corresponds to an estimated total theoretical biomethane potential of 88 PJ in 2025 for broadacre, increasing to 112 PJ in 2035 and 144 PJ by 2045. The biomethane potential from broadacre residues presents the largest opportunity across all the biomass/residue streams assessed as part of this project. This was driven by the volume of Cereal Straw and Chaff estimated (5.9 million dry tonnes) and Oilseeds Straw and Chaff (9.7 million dry tonnes), corresponding to the top two contributors for total theoretical biomethane potential in Victoria. Non-cereals Straw and Chaff was the fourth largest contributor to total theoretical biomethane potential. A large proportion of the broadacre residues for Victoria are located in GCW and LM corresponding to high potential of theoretical biomethane generation in those regions.

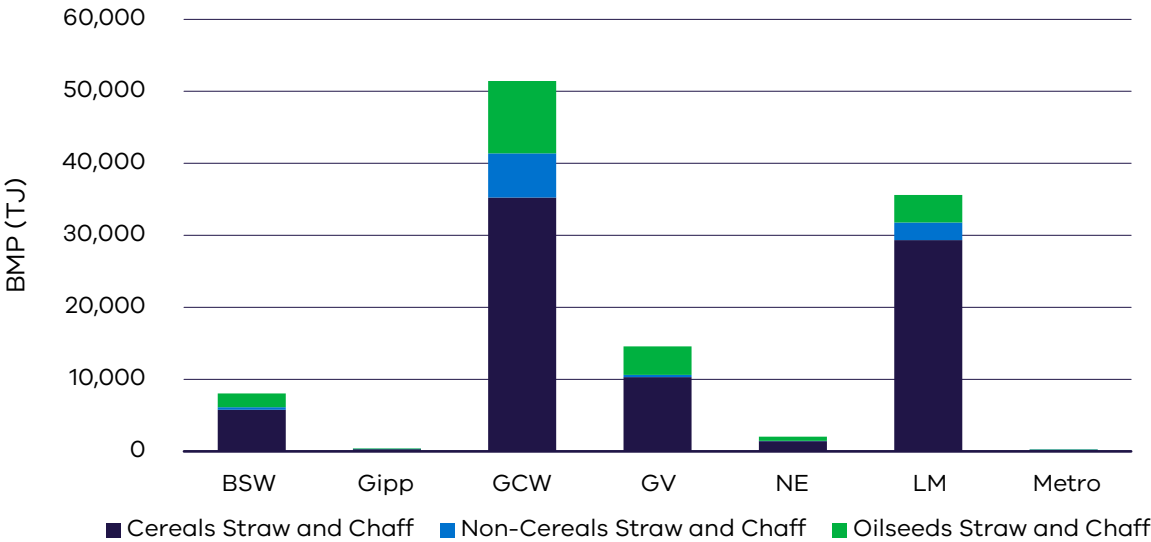


Figure B–1: Estimate of theoretical biomethane potential (BMP) from broadacre residues projected for 2035, by Region

The top five local government areas (LGA) which were identified as having the highest rates of broadacre residues are presented below in Table B–1, Table B–2, and Table B–3.

Table B–1: Cereal Straw and Chaff top five LGAs projected to 2035

LGA	Region	Cereal production (dry t)	Below-Ground-to-Above-Ground Ratio (dry t)	Dry matter content (TJ)
Yarriambiack	Grampians Central West	1,125,749	944,991	10,277
Buloke	Loddon Mallee	981,240	818,939	8,906
Mildura	Loddon Mallee	837,053	708,236	7,702
Moira	Goulburn Valley	587,215	521,945	5,676
Swan Hill	Grampians Central West	519,494	437,912	4,763

Table B–2: Non-Cereal Straw and Chaff top five LGAs projected to 2035

LGA	Region	Non-cereal production (dry t)	Below-Ground-to-Above-Ground Ratio (dry t)	Dry matter content (TJ)
Yarriambiack	Grampians Central West	425,808	248,685	2,705
Buloke	Loddon Mallee	193,429	112,968	1,229
Horsham	Grampians Central West	163,946	95,750	1,041
Hindmarsh	Grampians Central West	137,975	80,582	876
West Wimmera	Grampians Central West	132,970	77,659	845

Table B–3: Oilseeds Straw and Chaff top five LGAs projected to 2035

LGA	Region	Oilseeds, production (dry t)	Oilseeds, straw and chaff residue (dry t)	Oilseeds straw and chaff BMP (TJ)
Moira	Goulburn Valley	153,942	205,952	2,240
Ararat	Grampians Central West	140,312	187,717	2,042
Buloke	Loddon Mallee	113,820	152,274	1,656
Yarriambiack	Grampians Central West	104,810	140,221	1,525
Horsham	Grampians Central West	83,953	112,317	1,222

 Horticulture

Fruit and vegetable (horticulture)

A statewide assessment of residue from fruit and vegetable on farm was estimated to be approximately 74,000 tonnes in 2025 which is projected to increase to almost 101,000 tonnes by 2045. The theoretical biomethane potential from horticultural residues is estimated to be approximately 740 TJ in 2025 increasing to 870 TJ in 2035 and approximately 1PJ by 2045. Horticultural residues were observed to be spread across the seven regions however the assessment shows LM is responsible for 47% of the share with Mildura being a major producer of fruit and vegetables for Victoria, resulting in a higher theoretical biomethane potential compared to other regions.

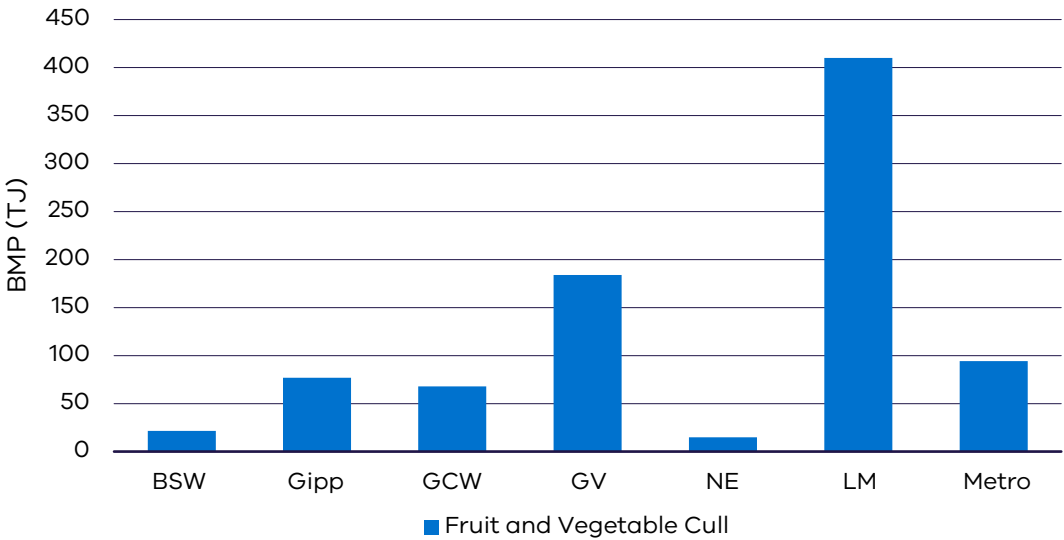


Figure B–2: Estimate of theoretical biomethane potential (BMP) from horticultural (fruit and vegetable) residues projected for 2035 by Region

The top five LGA which were identified as having the highest rates of horticultural residues are presented below in Table B–4.

Table B–4: Horticulture top five LGAs projected to 2035

LGA	Region	Fruit and vegetable production (dry t)	Fruit and vegetable residue (dry t)	Fruit and vegetable BMP (TJ)
Mildura	Loddon Mallee	365,180	21,805	216
Swan Hill	Loddon Mallee	312,322	16,161	160
Greater Shepparton	Goulburn Valley	198,709	8,173	81
Campaspe	Goulburn Valley	144,139	6,008	60
Baw Baw	Gippsland	99,271	4,114	41

Fruit and vegetable processing

Solid and liquid residues recovered from the fruit and vegetable processing industry were estimated to be 12,000 tonnes and 1,500 tonnes chemical oxygen demand (COD) for 2025, respectively which is expected to increase to around 25,000 tonnes and 3,500 tonnes COD by 2045. The corresponding total theoretical biomethane potential from all fruit and vegetable processing is expected to be 124 TJ in 2025, increasing to 193 TJ in 2035 and 256 TJ by 2045 with a large proportion (98%) of the estimated theoretical biomethane recovery derived from solid residues.

An assessment was also conducted on residues derived from the wine, olive, and almond industries which were identified as having high growth in Victoria. Residues from the almond industry was by far the largest of the three with an estimated 160,000 tonnes in 2025, expected to increase to 265,000 tonnes by 2045. This corresponds to a theoretical biomethane potential of 1.5 PJ in 2025, increasing to 1.9 PJ in 2035 and 2.5 PJ by 2045. The solid residues and resulting theoretical biomethane potential from fruit and vegetable processing are dominated by almond husks and shells from the LM region.



Chemical Oxygen Demand (COD) is a measure of the amount of oxygen required to chemically oxidise the organic and inorganic substances in a water sample and provides an indication of biomethane potential.

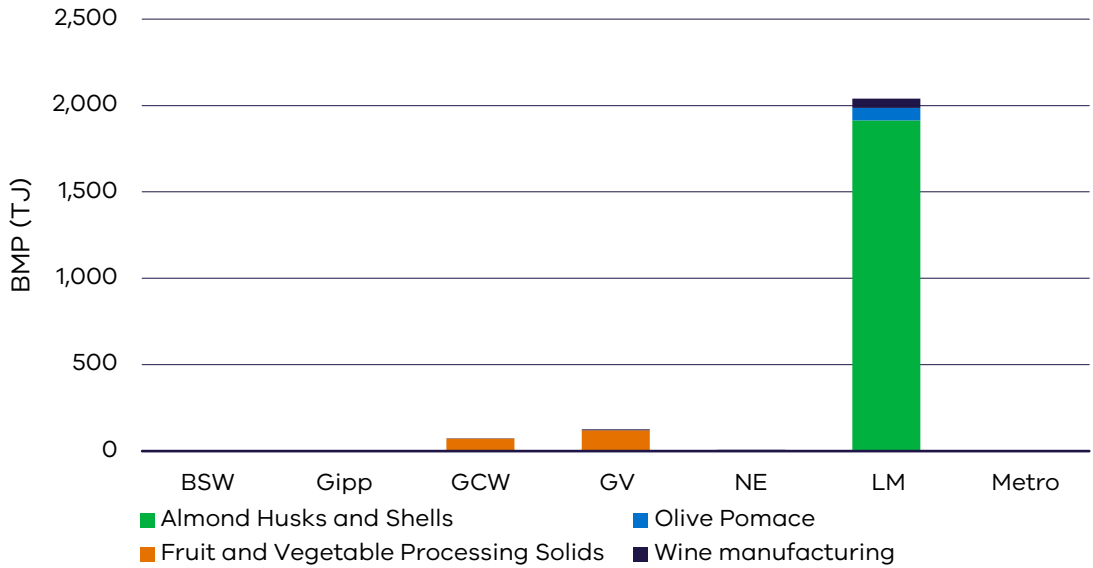


Figure B–3: Estimate of theoretical biomethane potential (BMP) from fruit and vegetable processing residues (solids) projected for 2035 by Region

The top LGA which were identified as having the highest rates of fruit and vegetable processing residues are presented below in Table B–5 to Table B–8.

Fruit and vegetable processing

Table B–5: Fruit and vegetable processing top three LGAs projected to 2035

LGA	Region	Fruit and vegetable production (t)	Fruit and vegetable processing solids (dry t)	Fruit and vegetable effluent (t COD)	Total fruit and vegetable processing BMP (TJ)
Greater Shepparton	Goulburn Valley	189,818	8,926	1206	90
Ballarat	Grampians Central West	150,799	7,091	958	71
Campaspe	Goulburn Valley	67,859	3,191	431	32

Almond processing (husks and shells)

Table B–6: Almond processing top three LGAs projected to 2035

LGA	Region	Almond production (t)	Almond husks and shells (dry t)	Almond husks and shells BMP (TJ)
Mildura	Loddon Mallee	73,590	152,330	1400
Swan Hill	Loddon Mallee	26,905	55,693	512
Gannawarra	Loddon Mallee	126	261	2.4

Olive production (olive pomace)

Table B–7: Olive manufacturing top five LGAs projected to 2035

LGA	Region	Olive production (t)	Olive pomace (dry t)	Olive pomace BMP (TJ)
Swan Hill	Loddon Mallee	69,047	6,214	46
Loddon	Loddon Mallee	37,773	3,400	25
Moira	Goulburn Valley	1,107	100	0.7
Horsham	Grampians Central West	976	88	0.7
Hindmarsh	Grampians Central West	786	71	0.5

Wine manufacturing (grape marc)

Table B–8: Wine manufacturing top five LGAs projected to 2035

LGA	Region	Wine grape production (tpa)	Grape marc (dry tpa)	Grape marc BMP (TJ)
Mildura	Loddon Mallee	91,982	7,892	35
Swan Hill	Loddon Mallee	35,251	3,025	13
Wangaratta	North East	13,678	1,174	5
Yarra Ranges	Metropolitan	9,975	856	4
Campaspe	Goulburn Valley	7,221	620	3

 Livestock and meat processing

Livestock (chicken, dairy cattle, and pigs)

A statewide assessment of residue from livestock including chicken (both broiler and egg laying chickens), dairy cattle, and pigs was conducted, with specific factors applied for each. The highest volumes of residue from livestock on farm were determined to be from dairy cattle on farm via dairy cattle manure slurry (solid residue), which is estimated to be approximately 215,000 tonnes VS in 2025 and projected to increase to 245,000 tonnes VS by 2045.



An estimate of the total statewide theoretical biomethane potential from livestock (dairy cattle, pigs, and chicken) residues measures just over 2.2PJ in 2025, which is projected to increase to almost 2.6 PJ in 2035 and to over 2.8 PJ by 2045. A large proportion of this driven by the dairy cattle and pig farming industry.

Sheep and beef cattle were excluded from the assessment because their residues are not considered recoverable as these animals are typically raised on pasture. This assumption was validated by experts as part of the engagement phase.

Volatile solids (VS) are the portion of total solids in a material sample that are lost when heated (at 550°C), representing the organic content of a material that can be converted to biogas.

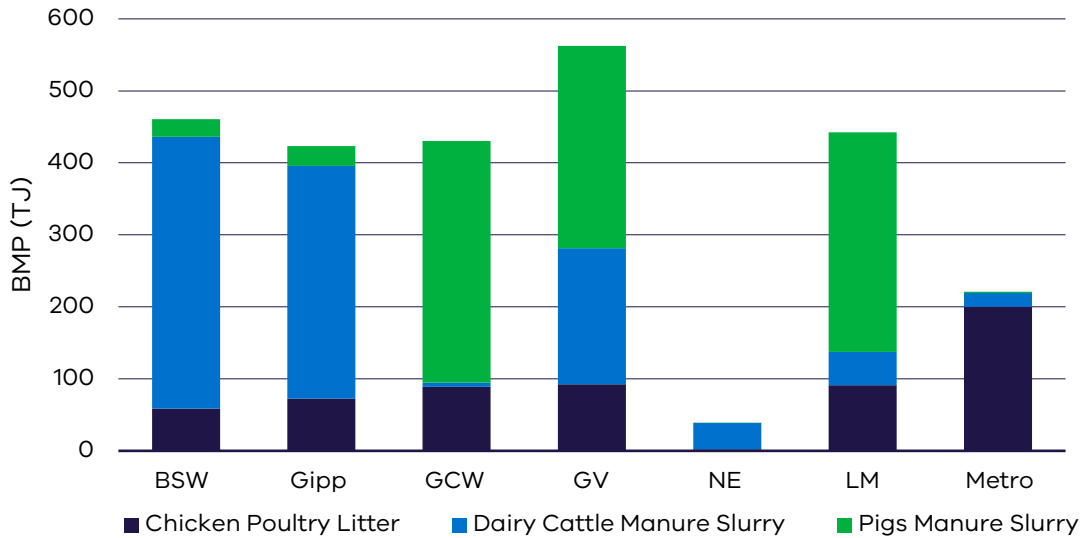


Figure B–4: Estimate of theoretical biomethane potential (BMP) from livestock residues projected for 2035 by Region

The top five LGA which were identified as having the highest rates of livestock residues for chickens, dairy cattle, and pigs are presented below in Table B–9, Table B–10, and Table B–11. All three livestock industries assessed presented opportunity for potential biomethane recovery with opportunities shared across each of the seven regions.

Table B–9: Chicken livestock top five LGAs projected to 2035

LGA	Region	Chicken livestock (no.)	Chicken poultry litter (dry t pa)	Chicken poultry litter BMP (TJ)
Loddon	Loddon Mallee	5,594,284	11,291	64
Mornington Peninsula	Metropolitan	4,131,760	10,341	59
Cardinia	Metropolitan	3,474,671	10,091	58
Greater Geelong	Barwon South West	2,640,685	8,512	49
Golden Plains	Grampians Central West	2,483,970	7,195	41

Table B–10: Dairy cattle livestock residues top five LGAs projected to 2035

LGA	Region	Dairy cattle livestock (no.)	Dairy cattle manure slurry (tVS pa)	Dairy cattle manure slurry BMP (TJ)
Corangamite	Barwon South West	153,191	37,072	159
Moyne	Barwon South West	137,821	33,353	143
Wellington	Gippsland	109,652	26,536	114
South Gippsland	Gippsland	104,477	25,283	108
Campaspe	Goulburn Valley	87,211	21,105	90

Table B–11: Pig livestock residues top five LGAs projected to 2035

LGA	Region	Pig livestock (no.)	Pig manure slurry (tVS pa)	Pig manure slurry BMP (TJ)
Campaspe	Goulburn Valley	150,870	13,126	226
Loddon	Loddon Mallee	97,163	8,453	145
Northern Grampians	Grampians Central West	76,338	6,641	114
Golden Plains	Grampians Central West	51,806	4,507	77
Greater Bendigo	Loddon Mallee	48,239	4,197	72

Meat processing (cattle, pigs, sheep, poultry)

Residues recovered from the meat processing industry (i.e. slaughterhouse waste) were evaluated for cattle, pigs, sheep and poultry, and split into solids (tonnes) and liquids (tonnes COD). The highest recoverable amounts for both solids and liquid across all meat processing industries come from cattle processing with approximately 15,000 tonnes (cattle paunch) and 29,000 tonnes COD (cattle wastewater) estimated for 2025, increasing to 20,000 tonnes and 39,000 tonnes COD by 2045, respectively.

The total estimated theoretical biomethane potential from the meat processing industry is expected to be a total 145 TJ in 2025, projected to increase to approximately 170 TJ in 2035 and 189 TJ by 2045. Residues from cattle (paunch and wastewater) were the highest across all residues evaluated, with large residue volumes occurring in BSW and the Metro regions.

Only wastewater (liquid) residues from poultry was included as part of the assessment due to solid residue mainly comprising feathers, bones, and beaks, which have little value for recovery of biomethane however were seen to be of value if used in other applications such as fertiliser (blood and bone) production.

The top LGAs identified as having the highest rates of meat processing (cattle, pigs, sheep, and poultry) residues are presented below in Table B–12 to Table B–15. The theoretical biomethane potential from all LGAs identified across the meat processing industry presented smaller opportunities when compared to livestock opportunities.



Paunch waste is a major solid byproduct of cattle slaughterhouses, consisting of partially digested food (grass, grain) from the stomach.

Table B–12: Meat processing (cattle) top five LGA projected to 2035

LGA	Region	Cattle paunch (dry t)	Cattle wastewater (t COD)	Cattle paunch BMP (TJ)	Cattle wastewater BMP (TJ)	Total cattle meat processing BMP (TJ)
Warrnambool	Barwon South West	4,601	8,826	26	8	34
Brimbank	Metropolitan	4,099	7,863	23	7	31
Latrobe	Gippsland	2,509	4,814	14	4.5	19
Latrobe	Gippsland	2,509	4,814	14	4.5	19
Wodonga	North East	1,255	2,407	7.2	2.2	9

Table B–13: Meat processing (pig) top LGA projected to 2035

LGA	Region	Pig paunch (dry t)	Pig wastewater (t COD)	Pig paunch BMP (TJ)	Pig wastewater BMP (TJ)	Total pig meat processing BMP (TJ)
Wyndham	Metropolitan	833	4,530	5	4	9

Table B–14: Meat processing (sheep) top five LGA projected to 2035

LGA	Region	Sheep paunch (dry t)	Sheep wastewater (t COD)	Sheep paunch BMP (TJ)	Sheep wastewater BMP (TJ)	Total sheep meat processing BMP (TJ)
Colac Otway	Barwon South West	394	4,641	2	4	7
Warrnambool	Barwon South West	333	3,927	2	4	6
Warrnambool	Barwon South West	333	3,927	2	4	6
Brimbank	Metropolitan	297	3,499	2	3	5
Ararat	Grampians Central West	170	1,999	1	2	3

Table B–15: Meat processing (poultry) top five LGA projected to 2035

LGA	Region	Poultry wastewater (t COD)	Sheep wastewater BMP (TJ)
Mornington Peninsula	Metropolitan	748	0.7
Greater Bendigo	Loddon Mallee	636	0.6
Whittlesea	Metropolitan	533	0.5
Greater Geelong	Barwon South West	430	0.4
Hume	Metropolitan	155	0.1

Dairy processing

Liquid residues are recovered from the dairy processing industry and are measured in tonnes COD. Total recoverable residue from the dairy industry is estimated to be approximately 8,000 tonnes COD in 2025 and increasing to 14,000 tonnes COD by 2045. This corresponds to an expected statewide theoretical biomethane potential of 10 TJ in 2025 from the dairy processing industry, increasing to 13 TJ in 2035 and 17 TJ by 2045.

The top LGA which were identified as having the highest rates of dairy processing residues are presented below in Table B–16. The theoretical biomethane potential from this sector was considered less significant when compared to those opportunities from the dairy cattle livestock industry.



Table B–16: Dairy processing top five LGAs projected to 2035

LGA	Region	Milk production (ML pa)	Dairy product manufacturing wastewater (t COD pa)	Dairy product manufacturing BMP (TJ)
Moyne	Barwon South West	783	1,401	2
Moira	Goulburn Valley	735	1,315	2
South Gippsland	Gippsland	583	1,043	1
Colac Otway	Barwon South West	514	920	1
Campaspe	Goulburn Valley	485	869	1

 Plantation and wood processing

Forestry (plantation)

A statewide assessment of residue from forestry (plantations) was conducted with the woody residue material categorised into either branch, bark or stump. Bark was shown to be highest recovered residue from plantation trees with approximately 485,000 tonnes of plantation bark estimated for 2025, followed by plantation branch (~245,000 tonnes) and plantation stump (~180,000 tonnes). With a total residue value over 900,000 tonnes in 2025, this is expected to increase to just over 1 million tonnes by 2045. The corresponding theoretical biomethane potential is expected to be approximately 2.1 PJ in 2025 which is projected to increase to over 2.5 PJ by 2035.

The plantation residues and resulting biomethane potential were highest in BSW (located within Australia’s “Green Triangle”), followed by Gipp, and NE, with the lowest opportunity present in LM and Metro regions.

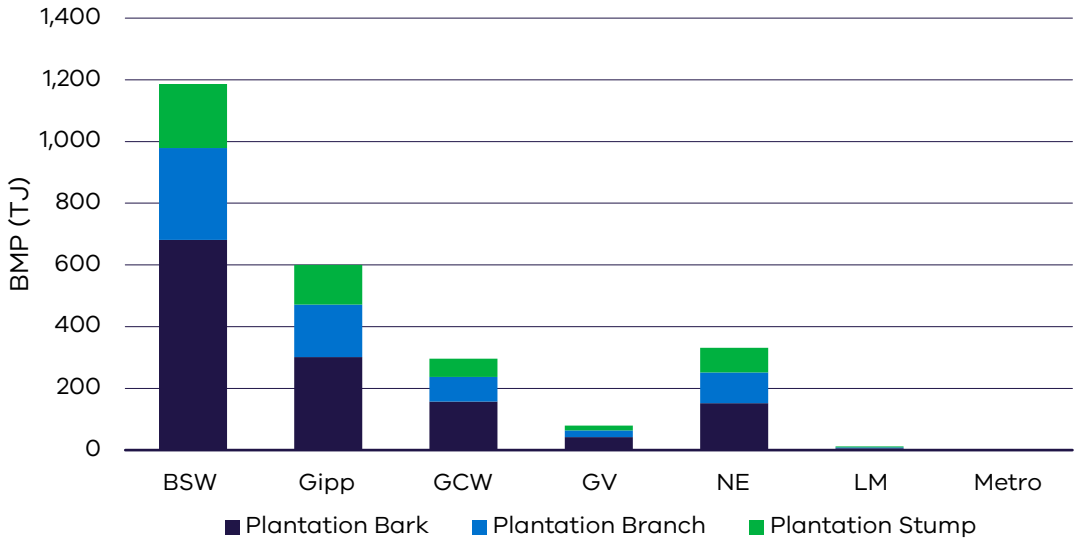
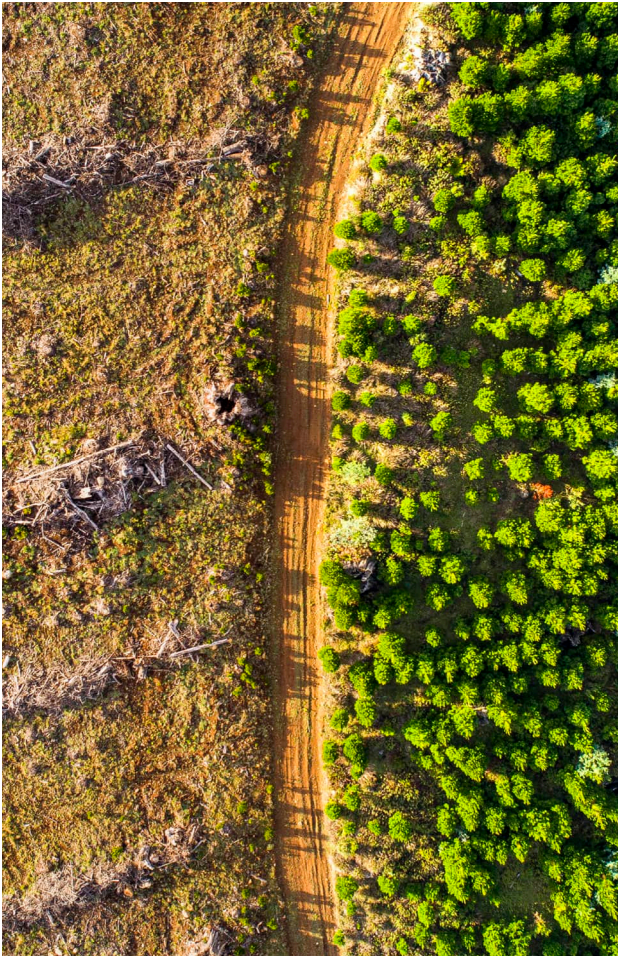


Figure B–5: Estimate of theoretical biomethane potential (BMP) from plantation residues projected for 2035 by Region

The top five LGAs which were identified as having the highest rates of plantation residues are presented below in Table B–17. Glenelg in Barwon South West showed significant potential for biomethane with a total BMP of 757 TJ corresponding to 17% of the 2035 renewable gas target.

Table B–17: Plantation top five LGAs projected to 2035

LGA	Region	2035 – Hardwood and softwood production (m³)	Plantation bark (t)	Plantation branch (t)	Plantation stump (t)	Total plantation BMP (TJ)
Glenelg	Barwon South West	2,334,337	172,697	83,723	60,577	757
Wellington	Gippsland	977,873	67,163	41,417	32,449	337
Southern Grampians	Barwon South West	610,693	49,366	17,286	12,187	188
West Wimmera	Grampians Central West	504,799	38,015	16,777	11,884	159
Latrobe	Gippsland	454,081	33,520	16,376	10,202	143

Wood processing (sawmills)

An assessment was conducted on solid residues recovered from the wood processing industry including wet woodchips, wet sawdust, dry sawdust, and bark. The largest recoverable residue was determined to be from wet woodchips with approximately 315,000 tonnes estimated at 2025, increasing

to 360,000 tonnes by 2045. Other sawmill residues were estimated at a combined 150,000 tonnes increasing to 175,000 tonnes by 2045. The corresponding theoretical biomethane potential from residues recovered from the sawmill industry was estimated to be approximately 1.9 PJ, increasing to over 2.2 PJ by 2035.

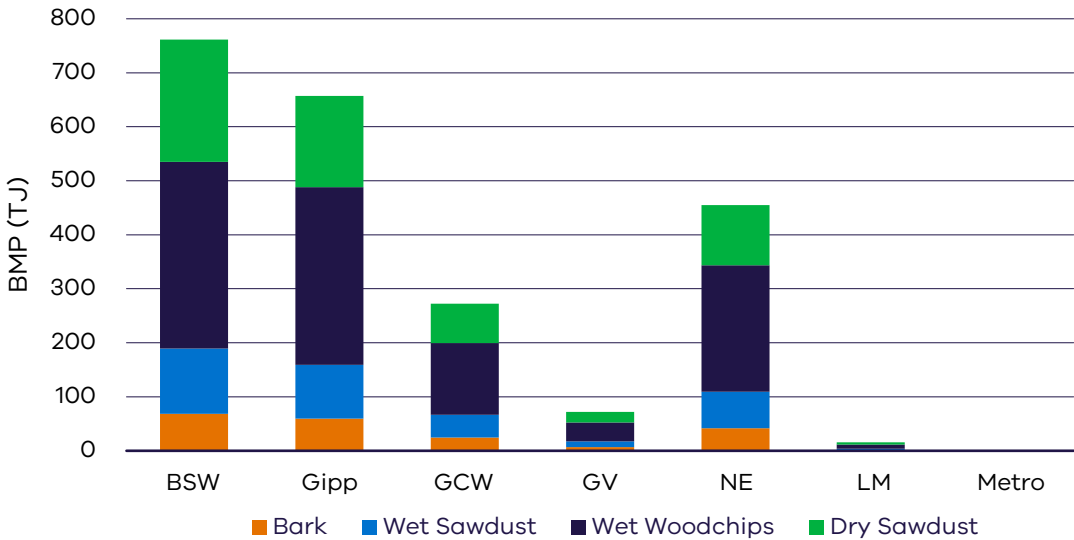


Figure B–6: Estimate of theoretical biomethane potential (BMP) from wood processing residues projected for 2035 by Region

The top LGA which were identified as having the highest volumes of residues from the wood processing is presented below in Table B–18.

Table B–18: Wood processing top five LGAs projected to 2035

LGA	Region	Sawmill bark (tpa)	Sawmill wet sawdust (tpa)	Sawmill wet woodchips (tpa)	Sawmill dry sawdust (tpa)	Total wood processing BMP (TJ)	% 2035 Renewable Gas Target (4.5 PJ) (Note: 1 PJ = 1,000 TJ)
Glenelg	Barwon South West	23,745	15,570	100,048	10,120	625	14%
Wellington	Gippsland	16,235	10,225	72,329	6,218	425	9%
Towong	North East	5,363	3,353	24,119	2,014	140	3%
Alpine	North East	5,065	3,167	22,782	1,997	134	3%
Latrobe	Gippsland	4,708	3,081	19,893	1,933	123	3%

 Waste sector

C&I Other (ANZSIC Divisions)

An assessment was conducted for C&I Other (ANZSIC Divisions) to evaluate residues which could be recovered from industries including accommodation and food services, retail, and wholesale trade (a full list of ANZSIC Divisions evaluated can be viewed in Appendix A). Potential residues include recovered organics (which may include high proportion of food organics, and some garden organics) and recovered paper and cardboard (expected to be a clean stream with a dedicated paper and cardboard bin).

Paper and cardboard presented the highest potential for recovery from ANZSIC Divisions with approximately 1.37 million tonnes of paper and cardboard estimated to be discarded in 2025 which is projected to increase to over 1.8 million by 2045. An additional 395,000 tonnes is estimated to be recovered as organic residue in 2025 which is projected to increase



to 535,000 tonnes by 2045. This corresponds to an estimated theoretical biomethane potential of 16PJ in 2025, increasing to 19 PJ in 2035 and 22 PJ in 2045. C&I Other residues and resulting biomethane potential were observed to be the highest in the Metro region with a high proportion of commercial and industrial businesses located within this region.

The top five LGA which were identified as having the highest rates of C&I Other residues are presented below in Table B–19. The theoretical biomethane potential from all five LGAs identified presented significant opportunity to meet the 2035 renewable energy target ranging from 15% to 26% contribution.

Table B–19: C&I Other (ANZSIC Codes) top five LGA projected to 2035

LGA	Region	No. of employees (FTE)	C&I organic waste (dry t)	C&I paper and cardboard waste (dry t)	BMP C&I organics (TJ)	BMP C&I paper and cardboard (TJ)	Total BMP C&I Other (TJ)
Casey	Metropolitan	407,379	27,328	97,849	69	1,090	1,158
Wyndham	Metropolitan	348,284	22,098	77,891	55	867	923
Greater Geelong	Barwon South West	290,947	19,705	66,774	49	744	793
Hume	Metropolitan	248,224	17,124	59,390	43	661	704
Whittlesea	Metropolitan	245,350	16,502	57,665	41	642	684

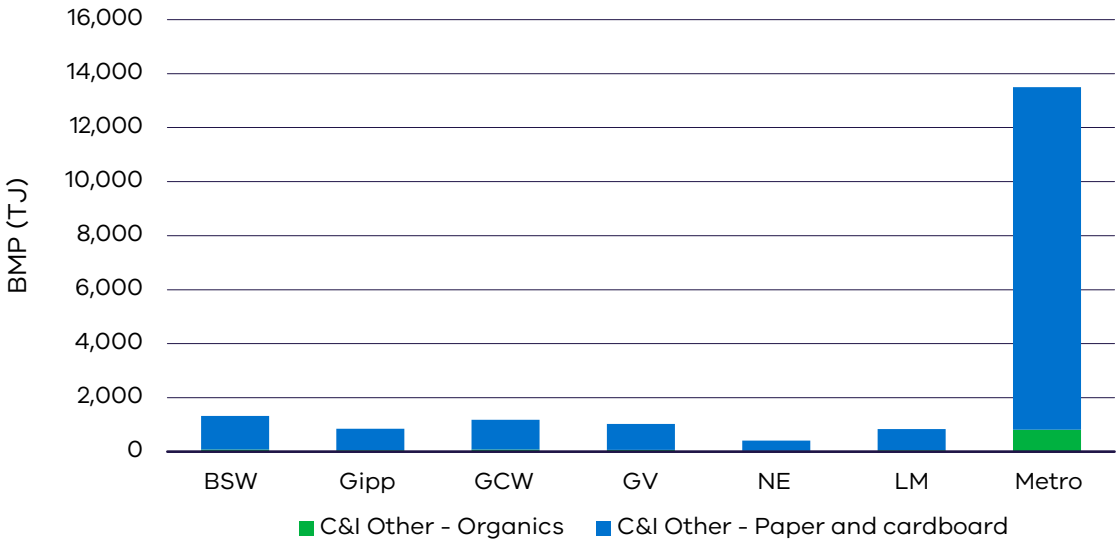


Figure B–7: Estimate of theoretical biomethane potential (BMP) from C&I Other (organics, paper and cardboard) residues projected for 2035 by Region

Municipal Solid Waste (MSW)

An assessment was conducted on municipal solid waste (MSW) organic residues recovered via council kerbside organics collections and other waste and resource recovery services (e.g. hard rubbish collection, transfer station drop off). The highest recovered organic residue is expected to be derived from garden organics which makes a large proportion of the food and garden organics (FOGO) service being delivered by councils, expected to be 920,000 tonnes in 2025 increasing to over 1.2 million tonnes by 2045. This was followed by food organics which is estimated to be 650,000 tonnes in 2025 increasing to 870,000 tonnes by 2045. Wood/ timber and other organics made up smaller fractions of the organic residues recovered from the municipal sector.

The theoretical biomethane potential from the MSW organic residues was estimated to be approximately 5.4 PJ in 2025, increasing to 6.4 PJ in 2035 and 7.4 PJ in 2045. It is important to note that food organics and garden organics are collected in the same bin for many councils in Victoria which will impact the estimated biomethane potential for this stream. Additionally there are concerns with high contamination rates present in these streams compared to other residues/biomass which may be applied as feedstocks in energy recovery application.

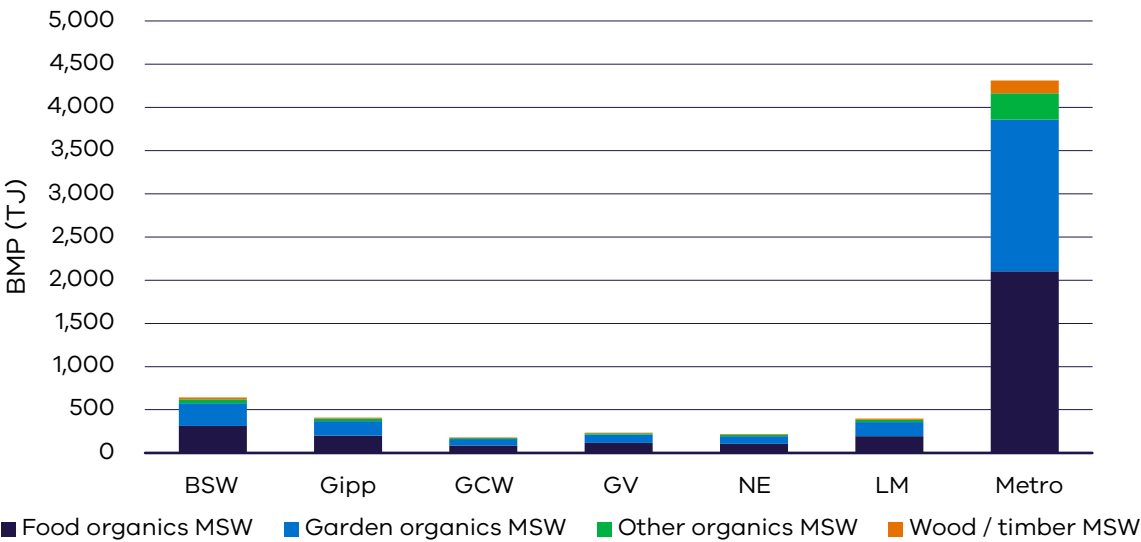


Figure B–8: Estimate of theoretical biomethane potential (BMP) from MSW organic residues projected for 2035 by Region

A regional overview of organic residues sourced from the MSW sector and the resulting biomethane potential are presented below in Table B–20 and Table B–21.

Table B–20: Organics residues from MSW projected to 2035 by Region

LGA	MSW food organics (tpa)	MSW garden organics (tpa)	MSW other organics (tpa)	MSW wood/ timber (tpa)	Total MSW organics (tpa)
Barwon South West	76,708	109,728	18,141	9,157	213,733
Gippsland	48,988	70,076	11,585	5,848	136,496
Grampians Central West	21,397	30,608	5,060	2,554	59,620
Goulburn Valley	28,225	40,374	6,675	3,369	78,643
North East	26,114	37,355	6,176	3,117	72,762
Loddon Mallee	47,477	67,914	11,228	5,667	132,287
Metropolitan	514,699	736,261	121,724	61,440	1,434,124

Table B–21: Estimate of theoretical biomethane potential (BMP) from MSW organic residues projected to 2035 by Region

LGA	MSW food organics BMP (TJ)	MSW garden organics BMP (TJ)	MSW other organics BMP (TJ)	MSW wood/ timber BMP (TJ)	Total MSW organics BMP (TJ)	% 2035 Renewable Gas Target (4.5 PJ) (Note: 1 PJ = 1,000 TJ)
Barwon South West	313	262	46	22	642	14%
Gippsland	200	167	29	14	410	9%
Grampians Central West	87	73	13	6	179	4%
Goulburn Valley	115	96	17	8	236	5%
North East	107	89	15	7	219	5%
Loddon Mallee	194	162	28	14	398	9%
Metropolitan	2,101	1,757	305	147	4,310	96%

Commercial and Industrial (C&I) Waste

Organic residues recovered from the commercial and industrial (C&I) waste sector were evaluated and includes solid materials and waste recovered from commercial and industrial activities including waste from offices, manufacturing, schools, universities and small to medium enterprises. The highest recovered organic residue is expected to be derived from wood and timber expected to be 485,000 tonnes in 2025 increasing to over 655,000 tonnes by 2045. The total theoretical biomethane potential from C&I organic residues is estimated to be approximately 3.9 PJ in 2025, increasing to 4.6 PJ in 2035 and 5.3 PJ in 2045.

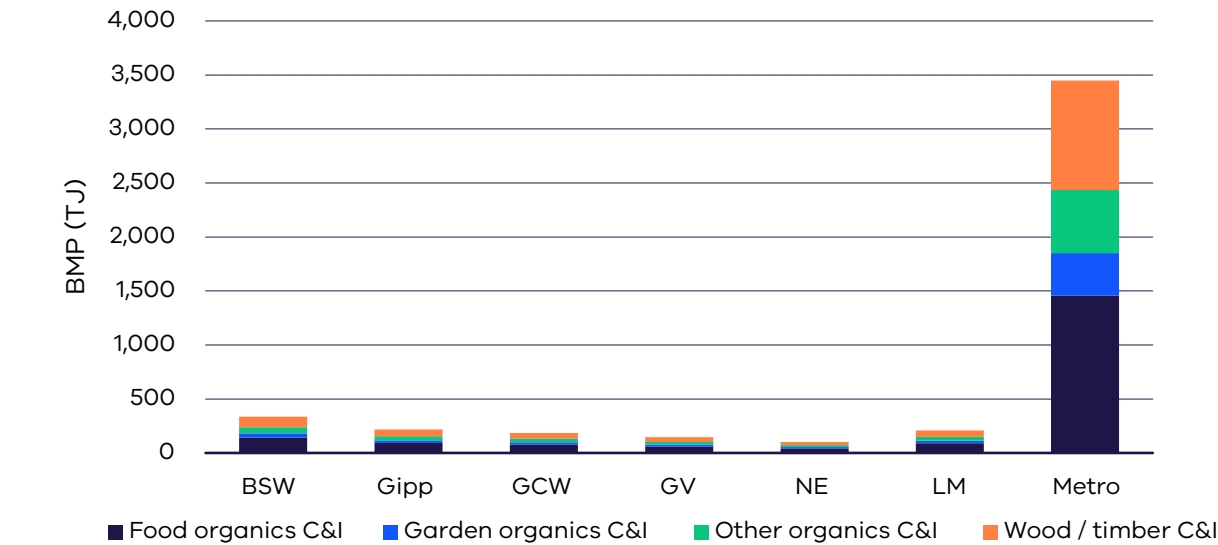


Figure B-9: Estimate of theoretical biomethane potential (BMP) from C&I organic residues projected for 2035 by Region

A regional overview of organic residues sourced from the C&I sector and the resulting biomethane potential are presented below in Table B-22 and Table B-23.

Table B-22: Organics residues from C&I projected to 2035 by Region

LGA	C&I food organics (tpa)	C&I garden organics (tpa)	C&I other organics (tpa)	C&I wood/ timber (tpa)	Total C&I organics (tpa)
Barwon South West	34,859	16,116	22,755	41,463	115,193
Gippsland	22,556	10,428	14,723	26,828	74,535
Grampians Central West	19,121	8,840	12,482	22,743	63,186
Goulburn Valley	15,033	6,950	9,813	17,881	49,677
North East	10,573	4,888	6,902	12,576	34,940
Loddon Mallee	21,705	10,035	14,168	25,817	71,725
Metropolitan	356,854	164,981	232,942	424,453	1,179,230

Table B-23: Estimate of theoretical biomethane potential (BMP) from C&I organic residues projected to 2035 by Region

LGA	C&I food organics BMP (TJ)	C&I garden organics BMP (TJ)	C&I other organics BMP (TJ)	C&I wood/ timber BMP (TJ)	Total C&I organics BMP (TJ)	% 2035 Renewable Gas Target (4.5 PJ) (Note: 1 PJ = 1,000 TJ)
Barwon South West	142	38	57	99	337	7%
Gippsland	92	25	37	64	218	5%
Grampians Central West	78	21	31	54	185	4%
Goulburn Valley	61	17	25	43	145	3%
North East	43	12	17	30	102	2%
Loddon Mallee	89	24	36	62	210	5%
Metropolitan	1,457	394	584	1,013	3,448	77%

Construction and Demolition (C&D) Waste

Construction & Demolition (C&D) waste is the solid materials and waste generated from residential and commercial construction and demolition activities, e.g. bricks and concrete. Similar to the C&I sector, the highest recovered organic residue is expected to come from wood and timber which is estimated to be 145,000 tonnes in 2025 projected to increase to 195,000 tonnes by 2045. Food organics, garden organics, and other organics, make up a much smaller proportion of the residues recovered from the C&D sector. The theoretical biomethane potential from C&D waste is estimated to be 419 TJ in 2025, increasing to 491 TJ in 2035 and 565 TJ by 2045, presenting a much smaller potential for biomethane recovery when compared with the MSW and C&I sector.

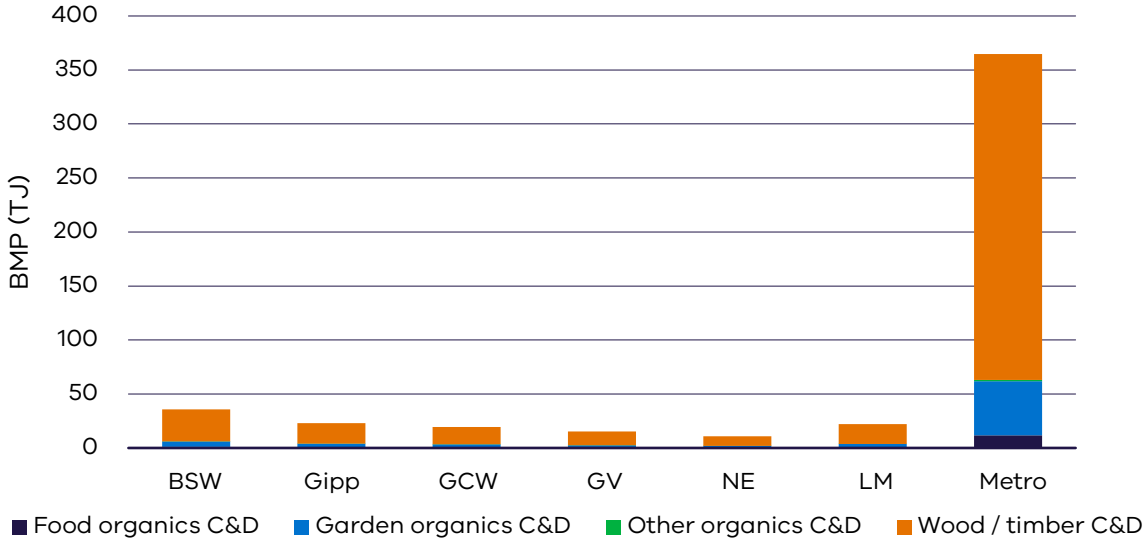


Figure B-10: Estimate of theoretical biomethane potential (BMP) from C&D organic residues projected for 2035 by Region

Construction and Demolition (C&D) Waste

A regional overview of organic residues sourced from the C&D sector and the resulting biomethane potential are presented below in Table B-24 and Table B-25.

Table B-24: Organics residues from C&D projected to 2035 by Region

LGA	C&D food organics (tpa)	C&D garden organics (tpa)	C&D other organics (tpa)	C&D wood/timber (tpa)	Total C&D organics (tpa)
Barwon South West	282	2,048	49	12,349	14,728
Gippsland	182	1,325	32	7,991	9,530
Grampians Central West	155	1,123	27	6,774	8,079
Goulburn Valley	122	883	21	5,326	6,352
North East	86	621	15	3,746	4,467
Loddon Mallee	176	1,275	31	7,689	9,171
Metropolitan	2,887	20,961	505	126,421	150,774

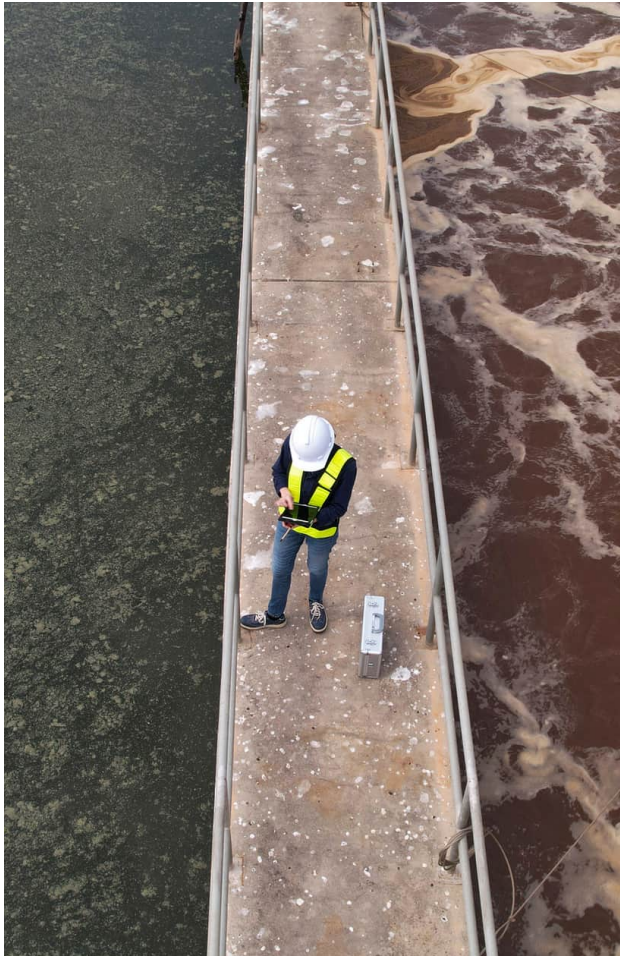
Table B-25: Estimate of theoretical biomethane potential (BMP) from C&D organic residues projected to 2035 by Region

LGA	2035 – C&D food organics BMP (TJ)	2035 – C&D garden organics BMP (TJ)	2035 – C&D other organics BMP (TJ)	2035 – C&D wood/timber BMP (TJ)	Total C&D organics BMP (TJ)
Barwon South West	1	5	0	29	36
Gippsland	1	3	0	19	23
Grampians Central West	1	3	0	16	20
Goulburn Valley	0	2	0	13	15
North East	0	1	0	9	11
Loddon Mallee	1	3	0	18	22
Metropolitan	12	50	1	302	365



Wastewater Treatment Plants

An assessment on biomethane recovery from 28 identified in-scope wastewater treatment plants (WWTP) was conducted. This involved evaluating the amount of biomethane which could be recovered from the treatment process of in-scope WWTP based on the volume of effluent processed. The calculated potential theoretical biomethane recovery from the process of in-scope WWTP was estimated to be 1.7 PJ in 2025 increasing to 2.3 PJ by 2045. The Metro region has by far the greatest potential for biomethane recovery from WWTP.



The top LGA which were identified as having the highest biomethane potential from WWTP is presented below in Table B–26.

Table B–26: Top five LGAs for theoretical biomethane from WWTP projected to 2035

Top 5 LGA	Region	WWTP effluent processing	WWTP BMP (TJ)
Wyndham	Metropolitan	245,688	1,193
Greater Dandenong	Metropolitan	192,291	883
Greater Geelong	Barwon South West	34,958	131
Ballarat	Grampians Central West	14,203	45
Mornington Peninsula	Metropolitan	12,465	40



Landfills

Potential biomethane recovery from 12 identified in-scope landfills was conducted which involved an assessment of the landfill gas and potential biomethane generated at each of the sites. The assessment accounted for potential closure dates of specific landfill sites where known. Approximately 6.1 PJ of biomethane is estimated to be generated from in-scope landfills in 2025, which is projected to increase to 7.8 PJ in 2035. The Metro region offers a significant proportion of the biomethane potential from landfills accounting for approximately 91% of the total.



The top LGA which were identified as having the highest biomethane potential from landfills is presented below in Table B–27.

Table B–27: Top five LGAs for biomethane from landfills projected to 2035

Top 5 LGA	Region	Landfill BMP (TJ)
Casey	Metropolitan	2,556
Melton	Metropolitan	2,253
Whittlesea	Metropolitan	1,581
Wyndham	Metropolitan	607
Golden Plains	Grampians Central West	187

Appendix C: Maps – statewide practically available biomethane potential by LGA (PJ)

Figure C–1: Current statewide practically available biomethane potential by LGA (PJ)

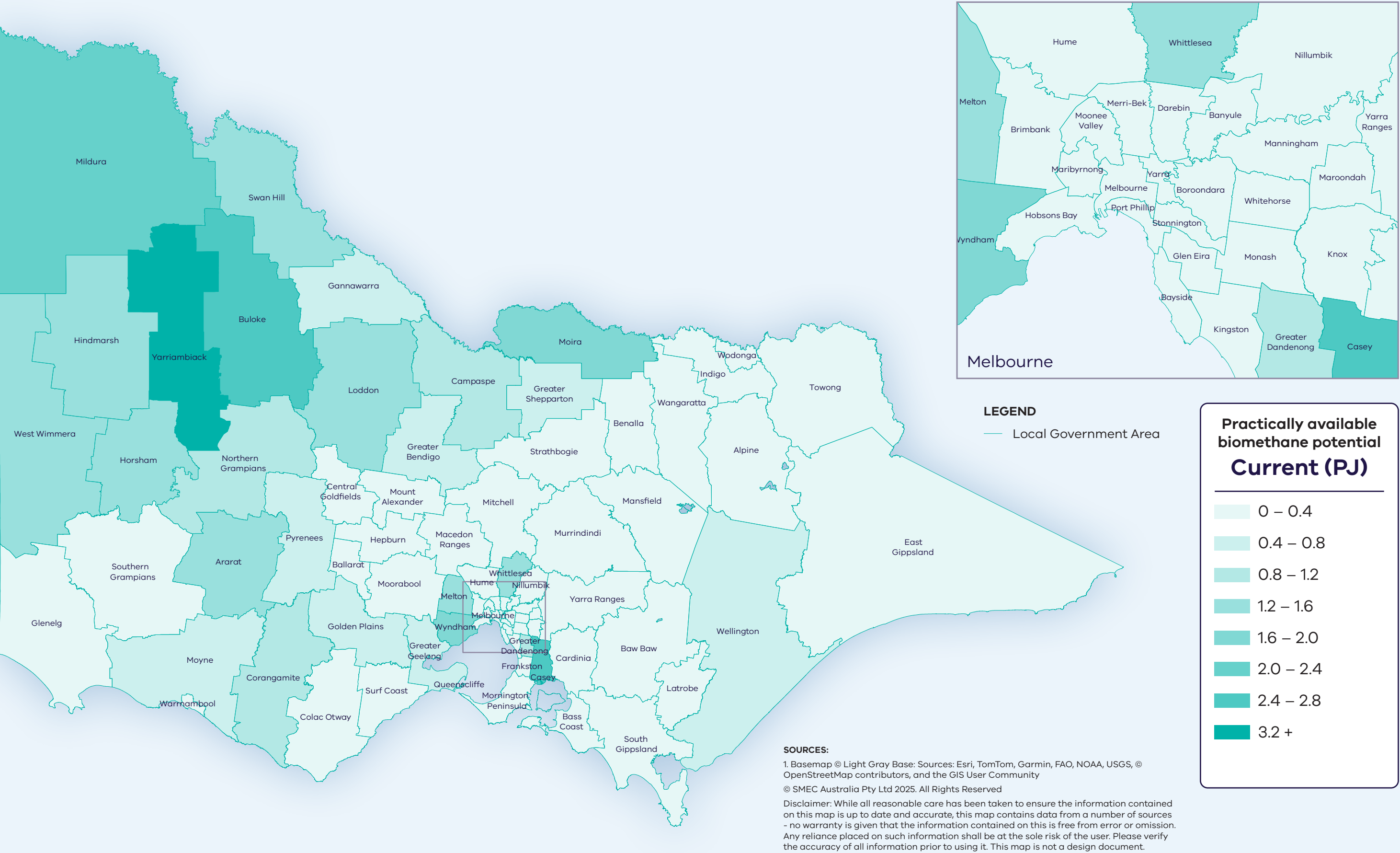


Figure C–2: Statewide practically available biomethane potential for 2035 by LGA (PJ)

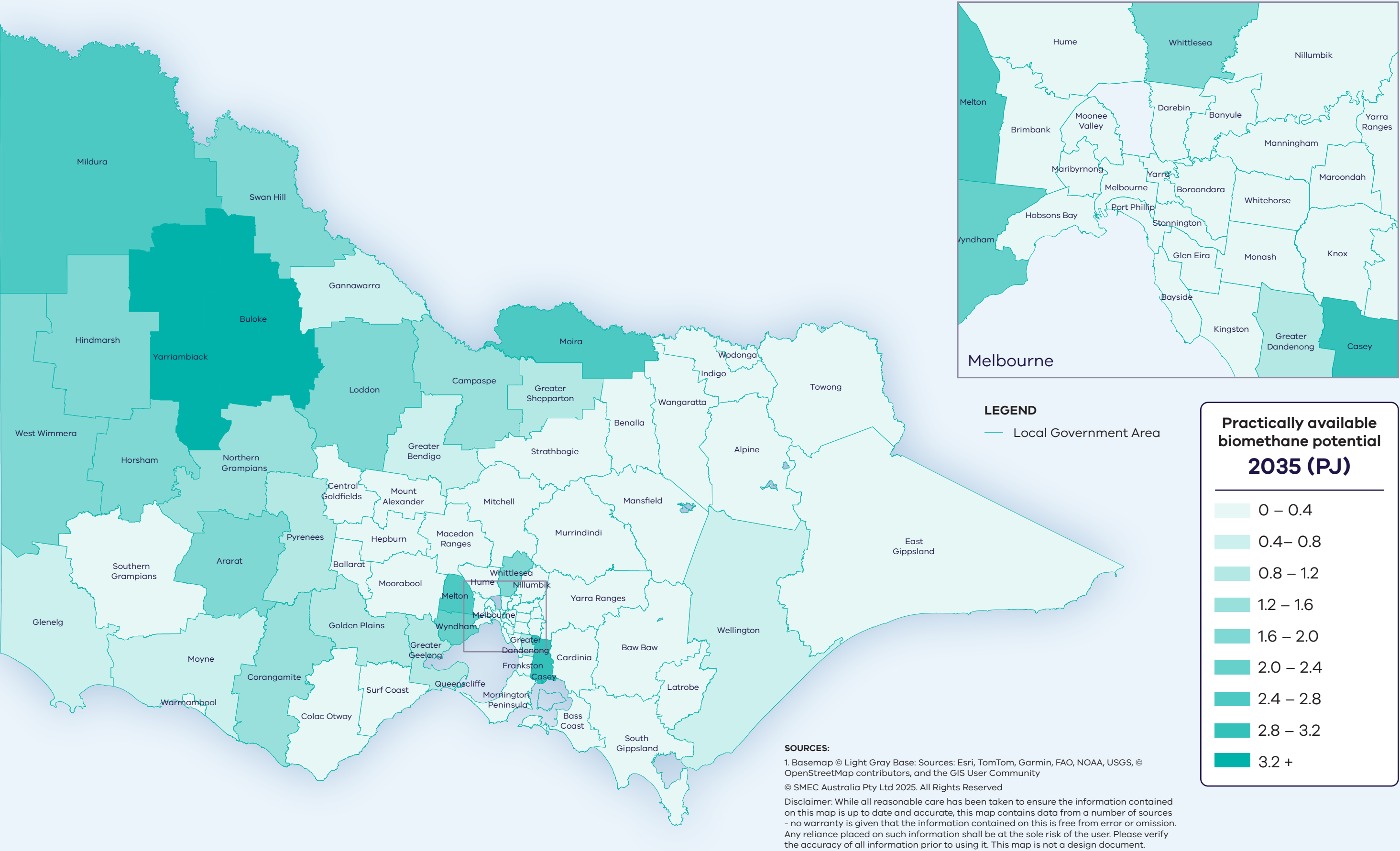


Figure C–3: Statewide practically available biomethane potential for 2045 by LGA (PJ)

