Queensland technical methods - Urban waste

Australian Biomass for Bioenergy Assessment

March 2018

This document is part of a series describing the technical methods used to publish the Queensland based data for the Australian Biomass for Bioenergy Assessment (ABBA) <arena.gov.au/projects/the-australian-biomass-for-bioenergy-assessment-project>. All documents in the series are available to view and download at <publications.qld.gov.au>.

What is the Australian Biomass for Bioenergy Assessment?

ABBA provides detailed information about biomass resources across Australia. This information will assist project developers make decisions for new bioenergy projects, and provide linkages between potential biomass feedstocks—through the supply chain—to end users. To achieve this, ABBA collects datasets, on a state- by-state basis, about the location, volumes and availability of biomass, and publishes them on the Australian Renewable Energy Mapping Infrastructure (AREMI) platform <nationalmap.gov.au/renewables>. ABBA is managed by AgriFutures Australia with funding support from the Australian Renewable Energy Agency (ARENA).

Why urban waste industries?

As a feedstock for bioindustrial processes, urban waste offers a number of advantages over alternatives (such as agricultural crop residues). Advantages include[1]:

- Operationally—the supply of waste is comparatively consistent and reliable over time and infrastructure and processes to aggregate and store waste already exist in most instances.
- Economically—utilisation of waste converts materials that are currently a costly liability (to manage and dispose of) into a potentially valuable revenue generating asset.
- Environmentally—each tonne of waste diverted is one tonne less disposed to landfill where it generates methane, one of the most potent greenhouse gases, as well as other land, water and atmospheric pollutants

In Australia, the Clean Energy Finance Corporation estimates that 'the Australian bioenergy and energy from waste investment opportunity to 2020 is between $3.5 billion and $5 billion' and concludes that bioenergy and energy from waste electricity generation technologies are cost-competitive, deliver baseload renewable energy, and offer co-benefits compared with fossil fuel generation such as reduced disposal costs and reduced pollution from particulate emissions, sulphur dioxide and nitrogen oxides (CEFC 2015). The organic components of urban waste are already being utilized in various countries for energy generation. In the USA for example, Fulcrum <fulcrum-bioenergy.com>, has developed and demonstrated a proprietary thermochemical process that converts municipal solid waste (MSW) feedstock into low-carbon renewable transportation fuels including jet fuel and diesel.

What data about urban waste is published by ABBA?

Waste is defined in many different ways (Hyder Consulting 2011). For the purposes of this project, urban waste is defined as:

- solid waste: the organic compounds of household garbage, residues, by-products and surplus materials from commercial, industrial, construction and demolition activities, and
- biosolids: stabilised organic solids derived from treatment of sewage.

This definition captures a diverse variety of biogenic materials ranging from food, through garden refuse, to cooking oils, whilst it excludes inert and non-biogenic (e.g. fossil-fuel derived) components such as plastic, glass or metal

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1 Adapted from Perla (2010)

packaging, tyres, or concrete, steel or aluminium building components.

ABBA publishes data about:

- waste infrastructure (the location, capacity, and operator of solid waste disposal, sewage treatment and waste recovery/recycling facilities)
- organic waste (how much waste of different types is generated where), amalgamated at a local government area (LGA) level

A key feature of waste as a biomass feedstock which distinguishes it from alternatives and significantly effects its use in bioindustrial processes is its heterogeneity.

Solid waste is commonly described as comprising three main streams:

- municipal solid waste (MSW)—household garbage, normally collected at the kerbside from individual household bins.
- commercial and industrial waste (C&I)—residues discarded from manufacturing (e.g. joinery offcuts) or service industries (e.g. restaurant food waste) which may be collected at the kerbside or self-hauled.
- construction and demolition waste (C&D)—which is generally self-hauled.

Each of these streams is delivered to a transfer station, recovery facility or landfill for sorting, recovery and disposal. Irrespective of the stream from which it is derived, any one container or delivery of waste is likely to contain a diverse mix of organic components. These organic components can vary greatly in their chemical, physical and biological characteristics (Hla & Roberts 2015) with important implications for the conversion technology that different components are suited to and the pre-processing they require (Table 1).

For this reason solid waste data is presented using a framework that separates it across all three streams into categories that broadly group components into fractions with similar properties and hence similar suitability for different processes.

The categories are: waste food, paper and cardboard, green waste, waste timber, grease trap and oils and other organics. These categories align with those used in similar studies (e.g. Taylor et al 2011) and with the Australian Waste Database (Hyder Consulting 2011). Biosolids are reported as a separate category.

Table 1[2]: Biochemical, thermochemical, and chemical conversion platforms used to convert non-waste biofuel feedstocks can also be used to convert a variety of wastes, producing similar products

<table>
<tr><th>Conversion technology</th><th>Fraction well suited</th><th>End product</th><th>Pre-processing required</th></tr>
<tr><td>Anaerobic digestion</td><td>Waste food, food processing residues, animal waste</td><td rowspan="2">Ethanol, butanol and microbially produced alternative fuels</td><td rowspan="4">Separation of inorganic and recyclables, e.g. metal, plastic, glass, paper
Shredding</td></tr>
<tr><td>Fermentation</td><td>Foliage, food waste, animal waste</td></tr>
<tr><td>Gasification</td><td>All</td><td>Syngas, ethanol, methanol, butanol, biodiesel and gasoline</td></tr>
<tr><td>Pyrolysis</td><td>Paper/ cardboard, foliage/wood</td><td>Syngas, biodiesel and gasoline</td></tr>
<tr><td>Transesterification</td><td>Oils and greases</td><td>Biodiesel</td><td>Collection prior to disposal</td></tr>
</table>

2 Adapted from Perla (2010)

Methods

Infrastructure

Urban waste infrastructure is presented in two categories— one that shows solid waste processing and recycling facilities, and another that shows sewage treatment facilities.

The dataset for solid waste processing and recycling was derived from a list of public solid waste and recycling facilities in Queensland including their geographic coordinates published on-line by the Department of Environment and Science <ehp.qld.gov.au/waste/facilities/list> in 2014. For reporting by ABBA these types were condensed into four categories: transfer station, landfill, organic recycler, construction and demolition waste recycler.

The dataset of sewage treatment facilities was developed by combining the most recent information about the location, operator and capacity of facilities obtained from the following published sources:

- National Pollutant Inventory <npi.gov.au>
- Geosciences Australia <data.gov.au/dataset/national- waste-management-database>
- Queensland Land Use Mapping Program <qld.gov.au/environment/land/vegetation/mapping/qlump>
- Queensland Wetland Info <wetlandinfo.ehp.qld.gov.au/wetlands>

Data from these different sources was combined and cross-referenced in a GIS to create a single dataset with each facility described in terms of the LGA within which it lies, the current operator of the facility, and its operating capacity. Capacity is described in three broad classes: large >50,000 EP[3]; medium 10,000 to 50,000 EP; small <10,000 EP. For both solid waste and biosolids infrastructure datasets only facilities that were in operation at the time the data was collated are included. The geographic accuracy of both datasets was checked manually by reference to 2015 SPOT imagery and Google Earth.

Quantity and distribution of solid waste

Step 1: Determine gross quantities received per LGA

The amount (wet tonnes) of waste received by facilities across Queensland was obtained from the Department of Environment and Science (DES) Waste Reporting team. DES has statutory responsibility (under the Waste Reduction and Recycling Act 2011) for preparing annual State of Waste reports for Queensland (State of Queensland, 2016). To inform this process all local governments, registered private landfills, recyclers, organic processors, waste handlers, and operators of incinerators, industrial and mining monofills across the state are surveyed annually using a set of detailed questionnaires <ehp.qld.gov.au/waste>. The responses to these surveys are held in the Queensland Waste Data System from which the data used in this analysis was extracted.

Data provided to the project was aggregated by local government area (LGA) and covered all of the state other than two remote aboriginal councils. For these two LGAs average figures from other similar areas were substituted.

Data was obtained for the years 2013–15. The managers of the Queensland Waste Data System advised that records from earlier years were inconsistent as the form of the survey questions had changed. Since the data represents such a short time period, and cannot provide any useful indication of trend, it is presented as averaged across these two years rather than each year individually.

Step 2: Reclassify gross amount received into organic fractions

Data was provided to the project as a mixture of totals by traditional waste streams and by individual organic fractions. To standardise all of the data into individual organic fractions results from waste characterisation studies carried out previously across Queensland were synthesised and generalised proportions of fractions for MSW and C&I waste streams derived (EnviroCom unpublished). For the C&D waste stream a set of generalised proportions was developed by combining figures published in a range of sources (e.g Hyder et al 2011, Smith et al 2011, Hyder 2013, NGER 2015). The generalised proportions by waste fraction derived by this process are shown in table 2.

3 EP stands for equivalent person, the standard used when describing the capacity of wastewater treatment facilities.

Table 2: Average proportion (by wet weight) of each fraction by waste stream

	MSW (1)	C&I (1)	C&D (2)
Food	21%	10%	2%
Green	22%	8%	2%
Paper and card	16%	37%	3%
Wood	8%	14%	9%
Other organic	4%	4%	1%
Non-organic	29%	27%	83%

Notes

(1) Derived by combining results of a number of waste characterisation studies conducted in various locations across Queensland

(2) Derived from a combination of figures provided directly by various LGAs and from responses to Queensland annual waste surveys

These ratios were then applied to the gross figures per LGA. Where raw data described amounts that could be attributed directly to individual fractions these was allocated accordingly, whilst amounts described in terms of broad waste streams were apportioned to the various fractions using the factors listed in Table 2. Figures for greasetrap sludge and waste cooking oils were derived only from amounts that were directly attributed to these fractions.

Step 3: Convert to DM equivalent

For ease of comparison with other feedstock types and for use in further analysis (e.g. to calculate potential energy yield) the amounts in each fraction were converted to dry matter (DM) equivalents. This was done using moisture content for the various fractions measured by Hla and Roberts (2015) in a study of samples of organic waste collected from waste processing facility in Brisbane (Table 3).

Table 3: MC% of organic fractions of combined waste streams

	Values published by Hla and Roberts (2015)
Food	71%
Green	60%
Paper and card	20%
Timber	12%
Other	28%

Quantity and distribution of biosolids

ABBA publishes figures of the weight (wet weight and dry weight equivalent) of biosolids produced across Queensland in 2015–16. These figures were determined initially for each individual treatment facility and then aggregated for publication at LGA level.

Where sewage networks are interconnected across multiple LGAs the figures were allocated to the LGA within which the treatment facility is located (even though a portion of the raw sewage treated will have been sourced from adjoining LGAs). The figures published by ABBA are derived from a variety of data sources. Published figures were assigned a level of confidence (Table 4) depending on how directly the source data measured raw sewage treated and biosolids produced. Where data was available at multiple levels for the same site, estimates were calculated using each level of data available then cross-checked. Four LGAs contain no sewage treatment facilities (this was confirmed by consultation with staff from the Queensland Department of Natural Resources, Mines and Energy (DNRME)).

Table 4: Confidence levels for biosolid figures

Confidence level	Primary source of data
High	Based on figures of actual biosolid production
Medium	Derived from the number of connections by type
Low	Derived from the volume of raw sewage treated or treated water effluent discharged

Step 1: Derived directly from published figures

Only one LGA published actual figures for the amount of biosolids produced in its annual report. For a further 13 LGAs the amount of biosolids produced was obtained from Arkwood Organic Recycling <arkwood.com.au> who are contracted to manage almost 80% of biosolids across Queensland.

Step 2: Estimated from published figures of the number and type of connections

For 61 LGAs the amount of biosolids produced was derived indirectly from published figures of the number and type of connections (or users) in the network. Industry experts advised that the amount of solids generated per connection is much more consistent than the volume of raw sewage (as the dilution factor can vary greatly with community water conservation attitudes and behaviour). Based on experience it was suggested that on average 0.3 wet (at 80% MC) tonnes of sludge is produced at the treatment facility per year per household connection equivalent (Mike Thomas pers. comm.).

In Queensland, operators of water treatment facilities are required, by law, to report each year on their operations. As a minimum they are required to provide figures for the number of facilities they operate, and the number and type (household and commercial) of connections in the networks they manage. This information is stored in the SWIM data base administered by DNRME (DEWS 2014a). In many instances it is also published independently by operators/ LGAs.

From a table of indicative average flows generated by commercial/institutional developments (DEWS 2014b) it is estimated that one commercial/industrial connection is equivalent to:

- 5 households in small towns
- 10 households in large towns
- 50 households in cities.

Applying these factors to the figures for number and type of connection obtained either from operator publications or DEWS, it is estimated the total number of household equivalents connected to each network and then calculated an estimate of the wet tonnes of sludge produced annually at each plant or LGA (depending on the available breakdown).

Step 3: Calculated from published figures for raw sewage received/treated water discharged

For three LGAs the amount of biosolids produced was only able to be derived from published figures for the volume of raw sewage received by each facility (or aggregated across the whole LGA) or the amount of treated effluent discharged for each facility. The latter was obtained from data provided by the operators and held in the WaTERS database (managed by DES). The amount of raw sewage received from effluent discharged was calculated, and the amount of biosolids produced from raw sewage treated using factors published by Lundie et al (2004) from a study of the sewage treatment system of the Sydney (New South Wales) region. These factors are:

- 1.04 GigaLitres (GL) of raw sewage received for every 1 GL treated effluent discharged,
- 0.13 KiloTonnes (KT) of dry biosolids produced for every 1 GL of raw sewage treated

Step 4: Convert to dry weight

To convert dry biosolids to wet weight a uniform moisture content factor of 80% was adopted based on advice from Arkwood that the MC% typically ranges between 75% and 85% (Jessica Allen pers. comm.).

Level of current use

An attempt was made to estimate the proportions of each of the various waste categories that is currently disposed of (and hence could be considered most available for redirection into bioindustrial use). For solid waste fractions generalised estimates of the proportion of each organic fraction which is not recovered (Table 5) were derived. These figures were determined by synthesising Queensland characterisation studies (for MSW and C&I)—as

described previously—or by combining figures provided by DES for the whole state and by Brisbane, Toowoomba, Gold Coast, Mackay and Sunshine Coast councils from individual studies (for C&D).

Table 5: Average proportion (by wet weight) of each organic fraction not recovered for each waste stream

	MSW (1)	C&I (1)	C&D (2)	Average
Food	99%	100%	100%	100%
Green	62%	84%	70%	75%
Paper and card	66%	70%	70%	69%
Timber	100%	100%	5%	68%
Other organic	99%	100%	47%	82%

Notes

(1) Derived by combining results of a number of waste characterisation studies conducted in various locations across Queensland

(2) Derived from a combination of figures provided directly by various LGAs and from responses to Queensland annual waste surveys

For biosolids, unpublished figures from Arkwood were obtained, that more than 95% of biosolids that they manage are applied to agricultural land.

The final data is rounded to the nearest 10 by the following rules:

- Data at the midpoint is rounded up (e.g. 35 has been rounded to 40)
- Data less than five is given a value of zero
- Data five or larger (but less than 10) is given a value of 10.

Outputs

- location of waste facilities and sewage treatment plants
- solid waste by LGA (dry tonnes) - split into categories of: waste food, paper and cardboard, green waste, waste timber, grease trap and oils and other organics
- biosolids by LGA (dry tonnes)

Assumptions

The assumptions made when calculating the urban waste data include:

- Composition of solid waste streams is assumed to be constant between regions and over time. Anecdotal evidence suggests that the proportions will in fact be strongly influenced by seasonal conditions (e.g. the amount of garden waste will be higher in wetter months) and by natural disasters (e.g. concentrations of green waste generated by cyclones or of C&D waste after floods). However insufficient fine-scale data is available to enable us to account for such variations. Instead, a constant general average was applied. It is worth noting that Queensland was largely free of major natural disasters in the two years over which solid waste data in this analysis were collected which suggests that the figures are likely to be conservative in the longer term.
- Moisture content of solid waste fractions is assumed to be constant throughout the year. The moisture content of material will depend on its starting MC% and the conditions and length of time it is in the collection system. Hla & Roberts (2015) found that MC% of green waste for instance, varied by up to 50% across three samples collected in Brisbane during February in one year. However, similar to above, a lack of fine-scale data prevented us from reflecting this variation in MC% in the analysis and hence general averages were used.

Future potential

In 2016 the Queensland Government commissioned a study of future waste management infrastructure needs across the state. As part of this study future waste generation was estimated as the primary driver for infrastructure requirements. The authors of the study concluded that:

'… projections of future waste generation are dependent on many factors and subject to a high degree of uncertainty. Population growth and economic activity are generally accepted as the major factors. On the other hand, manufacturers and retailers are becoming more aware of packaging waste and taking measures to reduce it. Examples include light-weight packaging and re-usable shopping bags. Furthermore, anecdotal evidence within the recycling industry suggests there has been a significant drop in the generation of paper and cardboard waste. This is linked to a recent downward trend in consumption of paper products, which can mostly be attributed to a decline in sales of print media products (newspapers, magazines and marketing materials) due to substitution with electronic and online alternatives.

In the short-term, it is reasonable to assume that waste generation across all streams will be somewhat aligned to the growth of the Queensland economy (which also accounts for population growth). Longer term, it is reasonable to assume that waste generation per capita will not continue to grow indefinitely and that it will eventually plateau or start to reduce.' (Arcadis 2017)

After reviewing recent historical data the report's authors determined that the best medium-term surrogate of waste generation was gross state product (GSP). GSP includes a component reflecting change in population numbers, as well as a component reflecting the consumption habits of the population in relation to their comparative wealth. The authors predicted that in the longer-term, as the influence of regulatory incentives and community pressures to reduce waste grows, waste generation per capita would plateau and overall trends will become more closely aligned with population trends alone.

Available forecasts predict that the Queensland economy will grow steadily in the near-term, with GSP reaching 4.5% growth in 2016–17 and then dropping back to 3.25% by 2018–224. Population is predicted to grow at a more modest average of 2% per year out to 2036 (ABS, 2015). This growth is not uniform across the state however. The population is predicted to grow fastest around coastal nodes: in the South east (Brisbane, Gold Coast and Sunshine Coast, central (Rockhampton/Gladstone) and north (Townsville/ Mackay/Cairns) whilst in inland areas, particularly in the south and west it is predicted to decline (Figure 1).

Using this approach total waste generated across Queensland is forecast to increase from approximately 8 million tonnes in 2015–16 to 15 million tonnes in 2044–45.

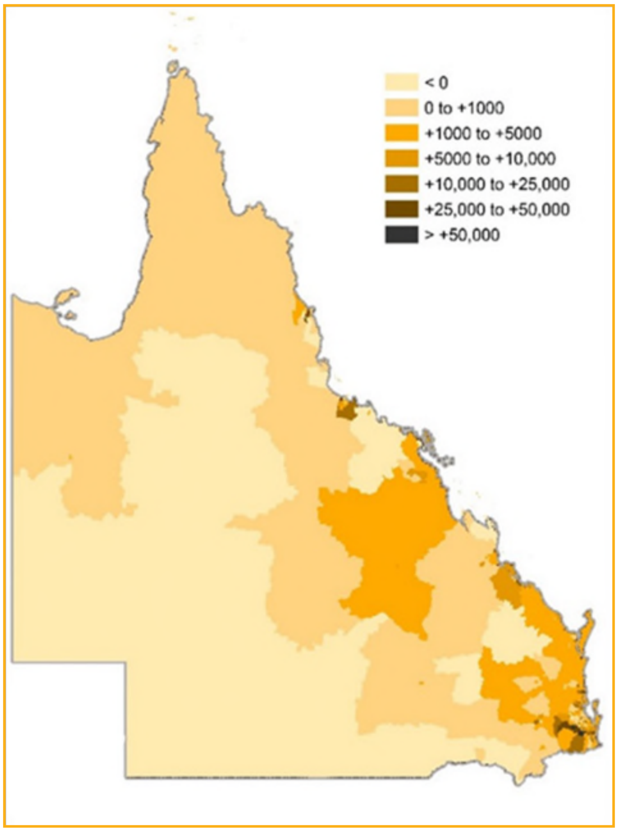

Figure 1: Predicted population change 2016–36 (by SA2)

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