GUIDE TO

Biological Recovery of Organics

Understanding best practice methods that apply to the recovery and biological processing of organics

Sustainability Victoria

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Glossary and abbreviations

Term	Definition
Aerobic	In the presence of oxygen.
Aerated static pile composting	Also called aerated static windrow composting. Forced aeration method of composting in which a free-standing pile is aerated by a fan blowing air through perforated pipes located beneath the pile.
Amenity	The quality of a local environment in relation to health and pleasantness.
Anaerobic	In the absence of oxygen. Composting systems subject to anaerobic conditions often produce odourous compounds. Anaerobic conditions are employed in anaerobic digestion systems.
AD	Anaerobic digestion, the biological breakdown by microorganisms of organic matter in the absence of oxygen, producing biogas (a mixture of carbon dioxide and methane) and digestate (a nutrient-rich residue).
AS4454-2012	Australian Standard 4454-2012 for Composts, Soil Conditioners, and Mulches. A manufacturing standard that provides quality assurance on the processing of recycled organic products and mixtures of recycled organic products that are to be used to amend the physical and chemical properties of soils and growing media.
Best practice	Best practice represents the current 'state-of-the-art' and aims to produce outcomes consistent with the community's social, economic and environmental expectations. Continuous improvement is an important component of best practice.
Biogas	A gas produced by AD processing of organic waste. Biogas is around 50-60 per cent methane and the remainder mostly carbon dioxide.
Biomethane	An upgraded/purified form of biogas, biomethane is typically 95-99 per cent methane (CH4) and so can be used as a direct substitute for natural gas.
Biosolids	Stabilised organic solids derived from sewage treatment processes.
Buffer distance	Also known as separation distance. The distance between a waste facility and residential or other sensitive land use.
C&I waste	Commercial and Industrial waste, includes waste produced by a wide variety of businesses and industries. In the context of organic waste, key sources include manufacturing (particularly food and beverage manufacturing), accommodation and food services, retail and wholesale trade, and healthcare and social assistance sectors.
C:N ratio	Carbon to nitrogen ratio, the weight of organic carbon (C) to that of total nitrogen (N) in an organic material. This is a key quality parameter for feedstocks to most biological processing systems.
CNG	Compressed Natural Gas – a compressed form of natural gas which can be used as vehicle fuel. In this context, relates to CNG produced from refined biogas (biomethane) which may also be termed bio-CNG.
Compost	An organic product that has undergone controlled aerobic and thermophilic biological transformation through the composting process to achieve pasteurisation and reduce phytotoxic compounds, and achieved a specified level of maturity required for compost.
Composting	The process whereby organic materials are microbiologically transformed under controlled aerobic conditions to achieve pasteurisation and a specified level of maturity.
Contamination	Materials and items within a recycling process that are not readily recycled by that process. Contaminants within this context include physical and non-biodegradable materials (metals, glass, plastics, etc.), chemical compounds and/or biological agents that can have a detrimental impact on the quality of any recycled organic products manufactured from organic waste.
DELWP	Department of Environment, Land, Water and Planning

Term	Definition
EfW	Energy-from-waste, also interchangeably termed 'waste to energy'. A collection of treatment processes and technologies used to generate a usable form of energy (e.g. electricity, heat and fuels) from waste materials. EfW technologies can be divided into two broad categories: biological and thermal treatment. This guide covers biological processing only.
EPA	Environment Protection Authority Victoria
Food waste	Kitchen scraps, food manufacturing waste, catering waste. Can be from municipal sources and C&I sources.
FOGO service	Food Organics + Garden Organics – generally refers to a kerbside collection service of combined food and garden waste, mostly from domestic / municipal sources in one collection bin (usually the green-lidded bin).
Garden waste	Grass clippings, tree cuttings, plants and leaves.
Groundwater	Any water contained in or occurring in a geological structure or formation or an artificial landfill.
Leachate	Liquid released by waste, or contaminated water that has percolated through or drained from waste, and contains dissolved or suspended material from the waste.
Maturation (of compost)	The final stage of composting where the temperature is shown to decline and stabilise to an extent that it can be safely used on land and come into direct contact with plants without any negative effects.
MBT	Mechanical Biological Treatment – a group of advanced waste processing technologies that use mechanical sorting of mixed residual waste combined with biological treatment of the organic fraction, to recover resources.
MRF	Materials Recovery Facility – a purely mechanical processing system for waste. A clean MRF separates commingled dry recyclables into saleable material streams. A dirty MRF processes mixed residual wastes to extract recyclables, an organic fraction and/or a refuse derived fuel output.
MSW	Municipal Solid Waste – primarily the waste and recyclables generated by households and collected by councils, but may also include other council generated wastes.
Mulch (organic)	Any organic product (excluding polymers that do not degrade, such as plastics, rubber and coatings) that is suitable for application on soil surfaces to help conserve moisture and/or restrict weed growth.
N:P:K	Nitrogen: Phosphorous: Potassium ratio, describes the weight ratio of these primary nutrients in products to be applied as fertiliser.
OHS	Occupational Health and Safety
Pasteurised product	An organic product that has been pasteurised or sanitised by subjection to high temperatures for a period of time (e.g. 55 degrees Celsius for at least 3 days) to destroy pathogens, pests and weeds.
Paunch	Abattoir (organic) waste, i.e. stomach contents (including partially digested feed) of animals processed in an abattoir environment
Prescribed Industrial Waste (PIW)	As defined in the Environment Protection (Industrial Waste Resource) Regulations 2009. These wastes require careful management and regulation because of their potential impact on human health or the environment.

Term	Definition
Pyrolysis	Thermal breakdown of waste in the absence of air, to produce char, pyrolysis oil and syngas (e.g. the conversion of wood into charcoal).
RDF	Refuse Derived Fuel, also called Process Engineered Fuel (PEF). RDF is a solid fuel produced after processing of waste (e.g. in a dirty MRF or MBT plant) to increase the calorific value, homogenise the material, remove recyclable materials, remove inert materials, and remove hazardous contaminants.
RO	Recycled Organics – a broad term for beneficial products recovered from organic wastes and mostly used as soil conditioners or mulch.
RWRRIP	Regional Waste and Resource Recovery Implementation Plan (regional plan), published by each of the seven waste and resource recovery regions of Victoria.
VPP	Victorian Planning Provisions – provide a framework for the development of all planning schemes in Victoria.
SEPP	State Environment Protection Policy, subordinate legislation under the provisions of the Environment Protection Act 1970 to provide more detailed requirements and guidance for the application of the Act.
Shredding	Mechanical processing of materials to reduced particle size.
Soil conditioner	Any composted or pasteurised product suitable for adding to soils. This also includes products termed 'soil amendment', 'soil additive', 'soil improver' and similar, but excludes polymers that do not biodegrade, such as plastics, rubber and coatings. Soil conditioners may be either 'composted soil conditioners' or 'pasteurised soil conditioners'.
Source separated organics	Organics that have been physically sorted by the waste generator at the point of generation into an organics-only bin (or other receptacle) that contains no other types of waste.
tpa	Tonnes per annum, the most common measure of waste flows and capacity of a waste treatment facility.
Windrow	Elongated, prism-shaped pile where shredded organic waste undergoes biodegradation.

Using this guide

This guide has been developed by Sustainability Victoria (SV) to assist a variety of interested stakeholders – existing organics processors, local and state government, regulators, investors and funding agencies, waste generators, communities and community groups – in understanding the regulations, requirements and best practice methods that apply to the recovery and biological processing of organics.

The guide provides a summary of the key requirements, feedstocks and technologies, costs and planning involved in organics processing solutions.

You don't have to read the guide from start to finish; you can jump from one section to another to follow your interests or information needs.

If you need help with any of the contents of this guide or have additional questions, refer to the list of resources provided in section 9 of this guide, or contact Sustainability Victoria on +61 3 8626 8700.

1 Why recover organics?

Organic wastes make up a large proportion of the waste generated in Victoria and the recovery of organics offers a significant opportunity to reduce the environmental impacts of landfill. Data presented in the Statewide Waste and Resource Recovery Infrastructure Plan (state wide plan) indicates almost 1.45 million tonnes of food, garden and timber waste was landfilled in 2015–16[1]. Around 27 per cent of all waste landfilled in Victoria in that year was garden and food waste. Just over half of the organic wastes landfilled originated from household sources and the rest came from commercial and industrial sources. SV analysis of the 2015/16 Waste Projection Model[2] estimated that around 23 per cent of Victorian household waste was food waste and 13 per cent was garden waste.

In addition, other organic wastes fall outside of the conventional waste collection and management framework because they are reused or managed at the source.

Most agricultural organics, including crop residues and animal wastes, are predominantly managed on-farm. Some manufacturing organic waste is reused or recovered at the source and some commercial food waste from supermarkets and restaurants, is captured for reuse through channels such as charitable food rescue programs or animal feed (noting that there are restrictions on feeding waste food to pigs in Victoria[3]).

It is clear that managing organic waste responsibly and sustainably in Victoria is a significant task.

There are two primary over-arching reasons to recover organics:

- To reduce the impacts of their disposal
- To realise the value of organics as a resource

Organic waste, when disposed to landfill, decomposes and generates methane, a gas that is 25 times more potent than carbon dioxide in terms of its greenhouse impact in our atmosphere, trapping heat and contributing to climate change.

In addition, there are significant land, human and animal health and amenity risks with disposal of organic wastes including odour, ground and surface water impacts, attraction of vermin and biosecurity risks. Effective management of the waste we generate helps to protect public health, community amenity and the natural environment we so value.

What is organic waste?

Organic waste refers to any material that is derived from a natural and biodegradable substance (animal and plant matter). It can be solid material such as garden waste, food and timber; or liquid waste such as grease trap waste.

It includes avoidable and unavoidable food waste from households, supermarkets, manufacturing or restaurants and encompasses agricultural waste and effluent waste.

The Victorian Organics Resource Recovery Strategy broadly categorises organics as either biowaste, biosolids or biomass.

Biowaste – Biodegradable waste derived from household kerbside systems and commercial and industrial (C&I) sectors which is either recovered or sent to landfill through the existing waste management system.

Biosolids – This waste is the residual of sewage treatment and is the result of organic waste disposed of through waste water infrastructure.

Biomass – is a broad term that includes both biowaste and biosolids but incorporates all remaining organic materials from animal wastes and bedding, forest residues and timber waste and agricultural wastes that can be converted into beneficial products such as fuel, power or soil conditioners.

By taking a best practice approach to organics recovery, numerous benefits can be realised for soil health and renewable energy production. Recycled organic (RO) products such as compost and organic fertiliser increase soil organic matter levels and provide beneficial nutrients for growing plants and crops. Increased organic matter in soils improves soil structure, helping to reduce water use, erosion of soils, and nutrient runoff. The application of recycled organics also reduces the need for mineral fertilisers, which has upstream benefits in avoiding the extraction and processing of virgin resources and fossil fuels to produce those fertilisers.

Some recovery technologies also generate renewable energy in various forms (electricity, heat and fuels), helping to reduce our reliance on fossil fuels and offset rising energy costs.

Organics recovery facilities provide new employment opportunities including skilled jobs in the design, construction and operation of these facilities. Diverting organic waste from landfill also has the potential to provide savings in landfill disposal costs and the landfill levy set by the State Government. Hence there are potential financial and economic benefits to be realised for local councils, residents and businesses.

What are recycled organic (RO) products?

Recycled organics (RO) is a general term used by industry for products that are 'recycled' from organic waste including compost, soil conditioners, mulch and other products applied to land.

1 http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Statewide-Waste-and-Resource-Recovery-Infrastructure-Plan
2 http://www.sustainability.vic.gov.au/Government/Victorian-Waste-data-portal/Interactive-waste-data-mapping
3 http://agriculture.vic.gov.au/agriculture/livestock/pigs/swill-feeding

1.1 Victoria's plan-led approach to increased resource recovery

Greater organics recovery is a key waste management priority of the Victorian Government. Published in 2015, the Statewide Waste and Resource Recovery Infrastructure Plan (state wide plan) provides Victoria with the long term vision and roadmap to guide future planning for waste and resource recovery infrastructure to achieve an integrated waste management system.

Critical to the state wide plan is an increase in the recovery of organics to reduce our reliance on landfill and to reuse this valuable resource in a sustainable way. The plan focuses on the development of a network of spokes to support the flow of materials to regional processing hubs. For organics processing there are opportunities to develop community-based processing solutions (particularly within regional areas) that contribute to the local economy and environment; whereas Victoria's metropolitan areas lend themselves to the deployment of larger scale, more complex, regional organics processing facilities.

The state wide plan is supported by the Victorian Organics Resource Recovery Strategy (Organics Strategy)[4], the Victorian Market Development Strategy for Recovered Resources (Market Development Strategy)[5], the Victorian Waste Education Strategy (Education Strategy)[6] and the seven regional waste and resource recovery implementation plans (Regional Plans)[7] (see Figure 1).

The Regional Plans have a shorter time horizon (10 years) and identify waste and resource recovery infrastructure and service needs for each of the seven waste and resource recovery regions in Victoria. All of the Regional Plans list diversion, aggregation and recovery of organics as a strategic priority, recognising that there is an opportunity to extend and participate in food and garden waste collection services including from commercial premises.

The regional waste and resource recovery groups are actively supporting the development of innovative and viable opportunities to increase recovery of organics as a priority material, and assisting the development of markets for reprocessed materials.

The Organics Strategy is a dedicated 30-year strategy to increase organics recovery across Victoria by:

- addressing current challenges to realise the full economic value of organic wastes while protecting the community, environment, and public health and amenity
- proposing a transition to advanced technologies and improved treatment and processing of organics, and
- establishing conditions for a thriving organics recovery and processing industry that maximises value through higher quality products, materials and alternative uses.

FIGURE 1 INITIATIVES TO ACHIEVE VICTORIA'S INTEGRATED WASTE AND RESOURCE RECOVERY SYSTEM

This guide is a key tool in achieving the goals of the Organics Strategy.

While there is a need to process organic waste to divert this material from landfill, the Victorian Government also recognises that waste minimisation, together with reuse options such as food recovery services and diversion to other beneficial uses such as animal feed, have an important role to play in any future management of organics within Victoria.

4 http://www.sustainability.vic.gov.au/About-Us/Publications/Victorian-Organics-Resource-Recovery-Strategy
5 http://www.sustainability.vic.gov.au/About-Us/Publications/MarketDev-Strategy-for-resource-recovery
6 http://www.sustainability.vic.gov.au/About-Us/Publications/Strategy-planning-Waste-education-strategy
7 http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Regional-Waste-and-Resource-Recovery-Implementation-Plans

1.2 What is best practice organics recovery?

Best practice represents the current 'state-of-the-art' which is constantly evolving as knowledge grows, technologies improve and community expectations change. Continuous improvement is an important component of best practice.

Best practice governs the technical aspects of a project and also the social, environmental and financial aspects of organics recovery. It should be applied throughout the project development cycle including community engagement, technology selection, design, environmental controls, construction systems and materials, and into the operational phase.

Achieving best practice involves:

- Setting key performance indicators and targets for each phase of the project (see section 8)
- Monitoring and continually improving performance against these indicators
- Assessing or benchmarking performance against others in the industry
- Adopting quality, safety and environmental management systems, ideally seeking accreditation to recognised industry standards
- Seeking and achieving performance beyond regulatory and enforced minimum standards
- Reporting progress to stakeholders, including staff, clients, regulators and neighbouring communities

Section 8 provides a more detailed discussion of key performance indicators which are consistent with organics recovery best practice, including a discussion of social, environmental and financial aspects.

1.3 Who is this guide intended for?

This guide is intended to serve a broad audience of stakeholders with varying individual and collective information needs.

Table 1 highlights the likely priority needs of the key audiences and relevant sections within the guide for easy navigation.

This guide is designed to provide evidence-based, objective and pragmatic advice to readers, without giving preference to any particular approach or technology.

The guide provides statements about the effectiveness of individual technology solutions in managing different feedstock types, and case studies of best practice facilities in Australia and internationally. It is acknowledged that there will be valid exceptions to these statements that are difficult to capture in a broad ranging document.

TABLE 1: KEY AUDIENCES AND RELEVANT SECTIONS WITHIN THE GUIDE

Key audience	Priority Information needs
Existing organic processors looking to upgrade operations	Potential new feedstocks and how they impact on processing technology and products (section 2) Controlling feedstock quality (section 3) Broadening product markets (section 5) Key technical parameters (section 6) Best practice performance indicators (section 8)
Those interested in developing an organics processing facility	Understanding feedstocks (section 2) and feedstock quality management (section 3) Introduction to biological recovery processes (section 4) and matching feedstocks with suitable processes (section 6.1) Products and market development (sections 5.1 and 5.2) and managing process residues from biological processing (section 5.3) Comparing scales, footprints and costs (section 6) and key considerations in delivering biological processing solutions (section 7) Understanding and managing risks including biosecurity management requirements (section 7.7) Best practice performance indicators for recovery of organics (section 8)
Local and regional government authorities procuring organics processing services	Understanding feedstocks (section 2) and feedstock quality management (section 3) Introduction to biological recovery processes (section 4) and matching feedstocks with suitable processes (section 6.1) Comparing scales, footprints and costs (section 6) and key considerations in delivering biological processing solutions (section 7) Understanding and managing risks including biosecurity management requirements (section 7.7) Best practice performance indicators for recovery of organics (section 8)
Local and state government planning agencies assessing facilities	Understanding biological recovery processes (section 4) Resulting products and markets, and management of residues (section 5) Technical parameters of processing systems including footprint and scale considerations (sections 6.2 and 6.3) Key considerations in delivering biological processing solutions, including community and stakeholder engagement and risk management (sections 7.4 and 7.7) Understanding and managing risks including biosecurity management requirements (section 7.7) Best practice performance indicators for recovery of organics (section 8)
Regulators and other government agencies	Understanding biological recovery processes (section 4) Resulting products and markets, and management of residues (section 5) Technical parameters of processing systems including footprint and scale considerations (sections 6.2 and 6.3) Risk management (section 7.7) including biosecurity management requirements Best practice performance indicators for recovery of organics (section 8)
Investors and funders considering investing in organics recovery solutions	Understanding biological recovery processes (section 4) and resulting products and markets (section 5) Scales, footprints and costs of biological processing solutions (section 6) Key considerations in delivering biological processing solutions, including planning and environmental approvals, community and stakeholder engagement, timelines and risk management (section 7) Best practice performance indicators for recovery of organics (section 8)
Waste generators, particularly businesses and institutions generating large quantities of organics	Why recover organics? (section 1) Understanding feedstocks (section 2) and feedstock quality (section 3) Understanding biological recovery processes (section 4) and resulting products and markets (section 5) Best practice performance indicators for recovery of organics (section 8)
Communities and community groups	Why recover organics? (section 1) Understanding feedstocks (section 2) and feedstock quality (section 3) Understanding biological recovery processes (section 4) and resulting products and markets (section 5) Community and stakeholder engagement, risk management and project timelines (section 7) Best practice performance indicators for recovery of organics (section 8)

1.4 Constraints to recovering organic waste in Victoria

There are a number of constraints, or so-called roadblocks, which may hamper or even stop progression of an organics processing project. Examples include:

- Lack of understanding of recovery technologies by the customer
- Risk averse approaches to new technologies that are untested in Australia
- Perceptions that landfill is cheaper
- Concern over contamination in feedstocks and lack of coordinated approach to managing it
- Variations in feedstock volumes and quality with seasons or other factors
- Insufficient feedstock to support a cost efficient processing solution
- Transport and handling costs associated with aggregating feedstocks
- Undeveloped or uncertain markets for recovered products
- Competition from other products which are cheaper to produce
- Insufficient consideration of odour and biosecurity risks and how to mitigate those risks through feedstock quality control, appropriate technology selection, design and operational controls
- Community opposition, often on the basis of odour concerns – lack of a social licence to operate
- Overcoming political and governance challenges for regional collaboration between councils
- Concern over the length of contracts and being tied to one solution for such a long period
- Regulations and approvals processes
- Capacity of existing processing infrastructure and planning for the future

A coherent best practice approach, from project planning and procurement through to project implementation and operation, can help to overcome these and other perceived roadblocks.

This guide is designed to assist in understanding the elements of a best practice approach, from open community and stakeholder consultation early in the procurement of the project, to controlling feedstock quality to ensure quality products and access to end-markets, through to the best practice performance optimisation.

1.5 Scope of the guide and related guidance information on resource recovery

This guide focuses on the biological processing of separated organics (either separated at source or extracted from a mixed waste stream) and includes aerobic (predominantly composting) and anaerobic treatment processes, e.g. anaerobic digestion (AD).

For information on other resource recovery technologies including mechanical or thermal technologies that may be applied to recover organics, please refer to the Resource Recovery Technology guide (SV, 2018). It provides discussion on topics such as:

- Advanced sorting technologies which can be used to separate an organic fraction from mixed residual waste
- Thermal energy recovery solutions, which may be applied to organic waste streams, e.g. dehydration, combustion, pyrolysis and gasification
- Production and use of refuse-derived fuels (RDF) from waste.

The authors of both guides have sought to minimise duplication of information where possible by cross-referencing between the two guides. Figure 2 illustrates the relative scope of each guide in terms of waste and product flows.

This guide is primarily focused on biological processing solutions (aerobic and anaerobic) that would be delivered at commercial scale. An exception to this is the inclusion of vermiculture, normally a specialised or tailored approach and not common in large scale operations. However, successful examples of this technology exist (for putrescible organics only).

Small scale on-site technologies have not been covered, nor have other approaches to diverting and recovering organic waste that do not involve biological processing. Some examples of solutions not covered in this guide include:

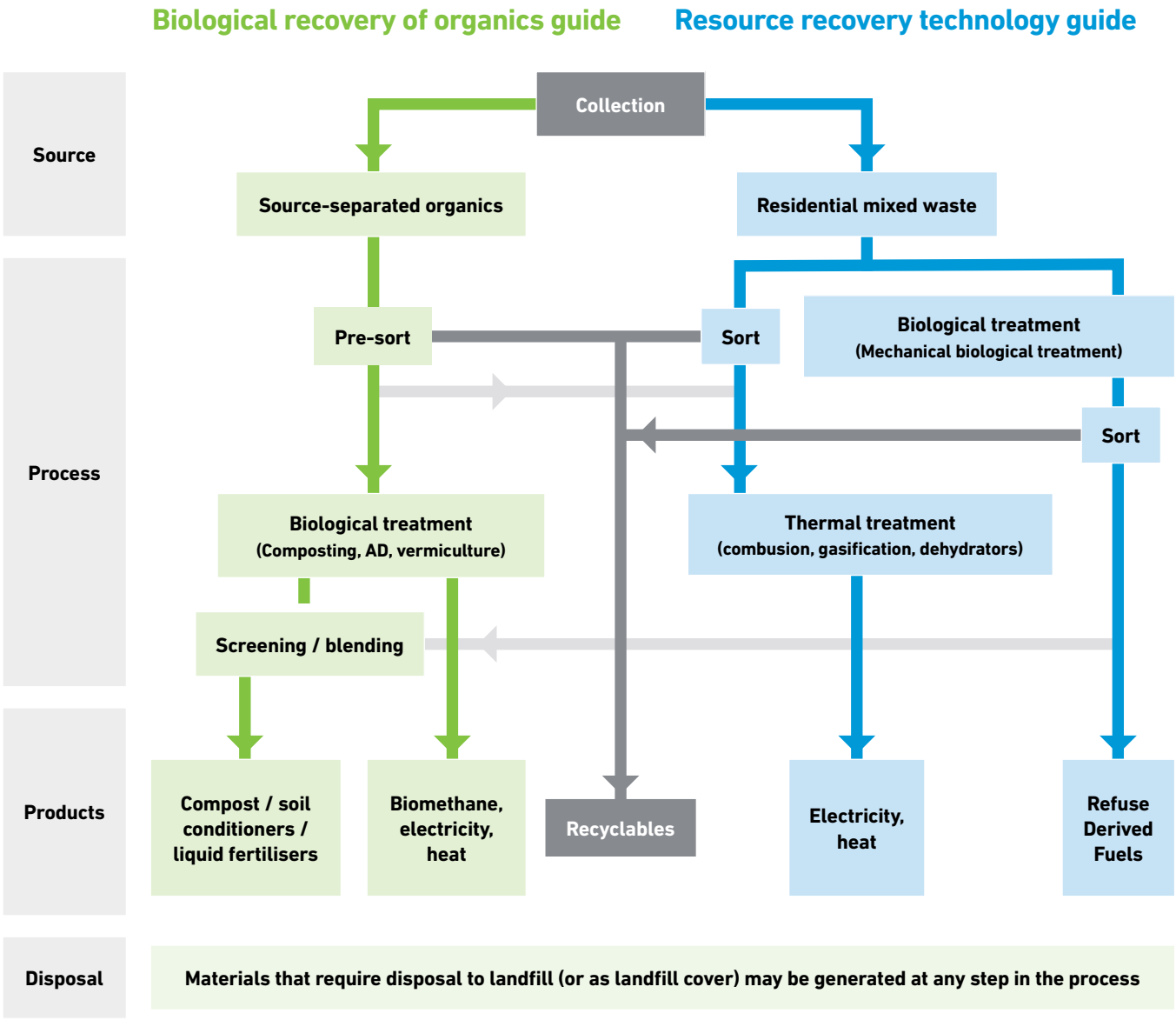
- Home-scale composting and worm farm systems are not covered by this guide. Most councils provide advice to residents on these approaches. In addition, refer to guidance provided by SV[8].
- On farm composting of crop and animal waste generated on farm and producing compost for internal use only, although noting that the same technologies are used (usually open windrow) and farmers may find some of the best practice information in this guide useful.
- Food reuse options such as food rescue programs or using food waste as animal feed (noting that there are restrictions on feeding waste food to pigs in Victoria[9]). Refer to section 7.7.6 for biosecurity information.
- Disposal of organics (typically from C&I sources) directly to sewer through trade waste agreements, either with or without pre-processing (e.g. maceration). Disposal of organics to sewer results in increased load on existing wastewater treatment plants (WWTPs) and while it is acknowledged that these plants use biological processing methods, the treatment of organics in this way is a secondary and minor function of WWTPs. Trade waste agreements are managed by the relevant water authority in each region who can provide information on requirements.

For further sources of information and guidance, please refer to section 9 of this guide.

8 http://www.sustainability.vic.gov.au/You-and-Your-Home/Waste-and-recycling/Food-and-garden-waste/Compost

9 http://agriculture.vic.gov.au/agriculture/livestock/pigs/swill-feeding

FIGURE 2 MANAGEMENT APPROACH FOR ORGANICS, COVERED BY THE GUIDE TO BIOLOGICAL RECOVERY OF ORGANICS (THIS GUIDE) AND THE RESOURCE RECOVERY TECHNOLOGY GUIDE (SV, 2018).



2 Sources and types of organic waste and their characteristics

As noted in section 1, organic waste is a very broad category and refers to any waste material that is derived from natural animal or plant matter which is biodegradable. However, not all organic wastes are suitable for recovery through biological processing.

This guide focuses on separated organics which are suitable for biological processing (i.e. via aerobic and anaerobic processes) and they can be broadly classified into two groups:

- Organics that are separated at source and separately collected, or
- Organics that have been extracted from mixed residual wastes via mechanical processes.

The basic biological processes that can be used to recover value from both streams are essentially the same (with some variations), however the resulting products are quite different in terms of their quality, value and end markets (section 5).

This section identifies the primary organic wastes of interest and their key characteristics. Section 3 of this guide provides a more detailed discussion around controlling the quality of organic feedstocks for biological processing.

2.1 Source separated organics

Source separated organics have been separated by the waste generator at the point of generation. While they may contain some inadvertent or undesirable contamination, they are predominantly an organics-only stream and are maintained as such throughout the collection and processing phases.

This results in a low-contamination, valuable feedstock which is suitable for use in a range of biological processing technologies to create high-quality products. The benefits of source separation of organics, over extracting organics from mixed waste which is discussed below, are:

- Reduced contamination in the feedstock, leading to best product quality
- Broader markets and acceptance of the products
- Reduced processing complexity and cost
- Improved community awareness and participation in recycling their own waste

2.1.1 Source separated organics from the municipal waste stream

The primary source separated organics derived from municipal (household) sources are:

- Food waste
- Garden waste
- Clean timber waste

Councils are responsible for collecting and managing municipal organics and the three main pathways by which these materials can be separately collected from householders are:

- At the kerbside, through a separate organics collection service
- By providing drop-off points for residents to self-haul to resource recovery centres and transfer stations
- Additionally, providing residential rate payers with a hard waste collection service (including timber waste) and green waste collections (for garden organics)

Most councils offer a garden waste collection service to households and councils are increasingly offering kerbside co-collection of food and garden organics (known as FOGO). Separate collection of food is also possible but not generally practiced in Australia. Section 3.1.1 provides a more detailed discussion about kerbside organics collection options and their impact on organics quality.

Large volumes of garden waste and timber waste are also self-hauled by residents to transfer stations and resource recovery centres. Almost all councils in Victoria provide drop-off points for garden waste but separation of timber waste is less common. This is primarily down to a lack of outlets and processing solutions for timber waste. A small proportion of clean timber waste is directed to biological processing facilities, but the majority of household timber waste has been chemically treated or painted, which is not suitable for biological processing. Waste timber that has been treated with preservatives such as Copper Chrome Arsenate (CCA) or painted should generally be disposed to landfill in Victoria.

Contamination in source separated municipal organics arise when residents fail to properly separate their waste or when they wrap organic waste in plastic bags. Hence, as discussed in section 3.1.1, community education is critical to controlling the quality of this stream. This is supported by the Organics Strategy which seeks to support local governments, businesses and industry to reduce contamination in organic waste streams through education programs and guidance material.

The particle size of these feedstocks ranges from small (food waste, grass clippings) to large oversize pieces of garden waste and timber waste. Most waste facilities specify a maximum acceptable log size for garden waste. These feedstocks require pre-processing to reduce and homogenise the particle size for recovery (see section 4.1.1).

As a rule of thumb, putrescible organics like food waste and grass clippings are higher in nitrogen (N) and moisture content, whereas 'woody' organics like tree branches and timber waste are higher in carbon (C) and have a lower moisture content. All biological processes require carbon and nitrogen ratios to be balanced through mixing/blending of feedstocks to provide a balanced food source for the micro-organisms that are vital to the processes.

Food waste, in particular, needs to be carefully managed at all stages in the organics recovery supply chain - collection, transport, receival and processing - due to the higher odour and vermin attraction potential of the material. Both food and garden wastes pose potential biosecurity risks which need to be appropriately managed in accordance with regulations (refer to section 7.7.6).

2.1.2 Source separated organics from the commercial and industrial waste stream

Organics from commercial and industrial (C&I) sources suitable for biological processing include:

- Food waste
- Clean timber waste
- Garden waste
- Food and beverage processing residues, sludges and other industrial organics (note, some of these streams are prescribed industrial wastes, such as liquid food and beverage processing wastes - refer to section 2.3.1).

Cardboard and paper is also a significant C&I stream and potentially suitable for biological processing, but is best directed to recycling pathways where possible. Soiled paper and cardboard which is not suitable for recycling could potentially be recovered with other C&I organics, if accepted by the facility operator.

- C&I organics are produced by a wide variety of businesses and industries, including manufacturing (particularly food and beverage manufacturing), accommodation and food services, retail and wholesale trade, and healthcare and social assistance sectors. Organic wastes may also be generated and managed as commercial collections from festivals or other community events. In some cases, C&I organics may be subjected to pre-processing at the source such as through on-site dehydration or digestion, which will affect the feedstock characteristics.
- The proportions of each waste type vary greatly between industry sectors. Overall, food organics tends to be the main stream followed by timber waste and then lesser amounts of garden waste. Food waste originates from restaurant and hospitality industries and institutions. Clean timber waste originates from packaging (mainly pallets and crates) and off-cuts from manufacturing processes.
- Industrial processes, particularly those involved in food and beverage processing, tend to produce single material organics streams which can vary significantly depending on the source industry. Liquid streams and some solid residues from these industries are classified as prescribed industrial waste (PIW) and discussed further in section 2.3.1.

2.2 Separated organics from mixed residual waste

Source separation of organics provides a relatively clean feedstock which has a number of benefits, but also limitations. It relies on householders and businesses choosing to take part and comply with the system rules, changing their behaviour and putting in the effort to separate organics at source. There will always be a proportion of the community that chooses not to participate, resulting in 'leakage' of organics to the residual bin. Hence there may still be significant organic content in the residual bin, even with a successful organics service in operation.

In some contexts, source separation is very challenging to implement, including communities that have:

- A large proportion of high density, multi-unit dwellings[10].
- Transient populations (e.g. seasonal workforces)
- High tourism areas
- Multicultural communities with varying degrees of English language proficiency and environmental awareness

An alternative solution is to extract the organics from the mixed residual waste stream. This is at the core of mechanical-biological treatment (MBT) solutions where mixed waste is mechanically processed to extract an organic-rich fraction which is then subjected to biological processing technologies of the types discussed in this guide. The mechanical processing of mixed waste and MBT technologies are described in more detail in the Resource Recovery Technology Guide.

While organics extracted from mixed residual waste contains the same types of materials discussed previously – food and garden waste, timber, paper and cardboard – this material comes with much higher rates of contamination than source separated streams. It is technologically challenging to effectively separate waste streams into their separate components once they have been mixed at the source.

There are a number of options to extract organics from mixed waste, all resulting in slightly different organic feedstock qualities. These technologies are discussed in more detail in the Resource Recovery Technology Guide but summarised in Table 2.

10 Refer to SV's Guide to best practice for waste management in multi-unit developments: http://www.sustainability.vic.gov.au/About-Us/Publications/Guide-to-Best-Practice-for-Waste-Management-in-Multiunit-Developments

Additional guidance developed by the Metropolitan Waste and Resource Recovery Group is also available: https://mwrrg.vic.gov.au/planning/multi-unit-developments-toolkit/

TABLE 2: SUMMARY OF OPTIONS TO SEPARATE ORGANICS FROM MIXED WASTE

Separation process	Description	Resource Recovery Technology Guide (2017) reference
Mechanical processing	For example, through a shredder or bag opener (to liberate organics from bags and containers) and a trommel screen to separate the organic-rich fine fraction on the assumption that most organics are small particles (less than around 50mm). The shredding stage tends to break up glass and plastics into small fragments, resulting in high levels of contamination in the feedstock, which then requires more effort to remove those materials from the final product. This is the approach used in the GRL UR3R and Suez SAWT facilities in Sydney.	Section 3.5.1 – Shredding of timber waste
Rotary drum digesters	Processing of mixed waste in a rotary drum digester combines gentle mechanical agitation with initial composting to break down the organics into a fraction that is then easily separated by a trommel screen. By not shredding the waste, the intention is that contamination with small fragments of glass and plastic is reduced, but not eliminated. This is the approach used in the SMRC Canning Vale and Suez Neerabup facilities in Perth, the Suez plant in Cairns and the Veolia MBT facility at Woodlawn in NSW.	Section 3.2.3 – Mechanical biological treatment (MBT)
Mechanical heat treatment	Mixed waste is subjected to heat, pressure and agitation in a rotating drum autoclave or other similar process where the application of heat helps to break down the organics to a sanitised fine fibre material that can be easily separated by a trommel screen for further processing. As with rotary digesters, there is no shredding so contamination is reduced. The Biomass Solutions plant in Coffs Harbour (NSW) uses an autoclave in this way and there are a small number of reference commercial plants overseas.	Section 4.1 – Mechanical heat treatment
Wet separation	Waste is shredded then floated in a water bath such that heavy items sink to the bottom, light packaging materials float to the top. Those fractions are both mostly inert and are separated off leaving an organic-rich water slurry stream which is then usually subjected to AD. The contamination in the organic slurry is likely to be high and difficult to separate from the wet digestate. There has been limited success with this approach - it was used in the former Arrowbio plant at Jacks Gully in Sydney (now decommissioned) and the Anaeco plant in Perth (also experiencing difficulties).	N/A

All of these processes result in a feedstock that has higher level of contamination, requiring additional processing. The same basic biological processing technologies can usually be applied but the contamination complicates the processing and product refining stages. Products from such feedstock will have severely restricted markets, mostly in non-agricultural applications such as mine sites and landfill rehabilitation.

2.3 Other sources and types of organic waste

There are other types of organic waste which can be harnessed and used as complementary feedstocks for processes managing municipal and C&I organics.

These include:

- Prescribed industrial waste (PIW) organics
- Manures and animal litter and bedding
- Animal mortalities
- Agricultural (crop) residues and forestry residues
- Biosolids from wastewater treatment plants (WWTPs)

2.3.1 Selected prescribed industrial waste organics

PIW organics may include grease trap wastes, paunch and other abattoir wastes, liquid and other food and beverage processing wastes, paper pulp and wastewater with high organic and/or nitrogen loads.

PIW organics generally arise through specific industrial activities. They can either be managed through dedicated processes (including on-site treatment), or processed with other non-prescribed organic feedstocks such as those identified above, for biological processing.

PIW organics have additional limitations placed on their handling and management including that they must be transported and tracked in line with the Environment Protection Act 1970 (EP Act) and Environment Protection (Industrial Waste Resource) Regulations 2009 (IWR Regulations) and can only be accepted at a facility licenced by the Environment Protection Authority Victoria (EPA) to accept the wastes. As prescribed wastes, they present a higher environmental risk than other organic wastes and may require processing through a more advanced technology such as in-vessel composting or AD.

Commercially, processing of these streams can provide a significant revenue stream for operators which may be critical to the overall business case for a project.

2.3.2 Agricultural and forestry wastes

Another potential source of organics as complementary feedstocks for processes managing municipal and C&I organics are agricultural and forestry wastes, such as crop residues, manures, animal bedding, animal mortalities, wood chips and residues from processing of forestry products (bark, sawdust, etc). These residues provide feedstocks which are typically very clean and can be used in a blend with other organics to achieve optimum C:N ratios or moisture content.

2.3.3 Other inputs

In addition to the various organic streams identified, some facilities may be permitted to process specific liquid waste streams or inorganic materials. Examples include:

- Plasterboard
- Drilling muds

Such materials are usually blended in small proportions with organic wastes so as not to impact on the final product quality. Some of these materials, in correct proportions, can have a beneficial impact on the final product quality (e.g. ash, gypsum in plasterboard).

3 Controlling the quality of feedstock

The quality of organic feedstocks to biological processing systems is defined by a range of parameters and examples of those which may be of interest are summarised below.

TABLE 3: FEEDSTOCK QUALITY PARAMETERS – OVERVIEW

Quality Characteristic	Parameters
Physical characteristics	› Particle size distribution › Bulk density › Moisture / solids content › Calorific value / energy content › Fibrous / non-soluble content › Handling properties (e.g. is it pumpable, stackable, spade-able)
Chemical characteristics	› Heavy metals concentrations › Pesticides and other hazardous chemicals › Total and organic carbon content › pH, alkalinity
Biological characteristics	› Biodegradable carbon content › Nutrient ratios (particularly C:N) › Presence of pathogens / weeds › Odour generating potential
Physical contaminants	› Non-degradable waste (e.g. glass, plastics, metals) › Stones, soil, masonry › Treated or painted timber[12] › Hazardous substances (e.g. asbestos, batteries, electronic waste, household chemical containers)

It is also important to consider the variability in these parameters seasonally or over time. For example, the quality of garden waste varies with the seasons and moisture content will be directly affected following rainfall events.

The quality of the feedstock is a key factor in selecting the most appropriate processing technology and assessing the need to blend feedstocks to achieve desired parameters. It also affects the quality of the end-products which can be critical to establishing sustainable and secure markets. Visible physical contaminants significantly restrict marketing opportunities while chemical contaminants may limit end-use applications. It is also important to consider that some processing systems result in concentration of contaminants as a result of carbon and moisture losses during decomposition.

Feedstock quality can also have a significant impact on operational performance of a system (e.g. odour generation, energy recovery, leachate production) and on maintenance of the plant with some contaminants contributing to increased wear and damage to equipment, or higher downtime rates.

Managing contamination in feedstocks needs a coordinated approach, across the recovery chain:

- At source – education of the community and waste generators, clear guidance on acceptable materials
- During collection – inspection and monitoring procedures
- During processing – inspection procedures at waste reception; pre-processing and contaminant removal procedures / equipment; product refining and contaminant removal equipment

As such, it needs to be a coordinated effort involving the waste generators, collectors, processors and consultation with end-product customers. Placing responsibility for contaminant management entirely on one party is unlikely to be successful.

Education of waste generators (householders and businesses) is critical to the success of any organics recovery process but particularly for source separation systems. The Education Strategy is a useful reference to understand the overall framework for improving waste education in Victoria and the associated webpage provides additional links to useful education resources[12].

3.1 Collection arrangements for source separated organics

Diverting organics from landfill is a high priority for most Victorian councils and Regional Waste and Resource Recovery Groups and source separation is generally seen as the preferred option to recover organics from households and businesses.

As noted in section 2.1, there are three major pathways to collect source separated organics from householders and businesses:

- At the kerbside, through a separate organics collection service
- By providing drop-off points for residents to self-haul to resource recovery centres and transfer stations
- Additionally, providing residential rate payers with a hard waste collection service (including timber waste) and green waste collections (for garden organics)

11 Treated or painted timber is unsuitable for biological processing solutions and should generally be disposed to landfill.

12 http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Victorian-waste-education-strategy

3.1.1 Kerbside organics collections

At the household level, one option to achieve this is source separation through provision of a separate kerbside collection service for organics (third bin). There are numerous options and variations of systems and each decision on key elements has an impact on the quality of the organics feedstock that is collected.

The majority of councils in Victoria provide an organics kerbside collection service to their residents, either as a weekly or fortnightly service. Most councils collect garden waste only in the kerbside third bin but there is a growing number of councils that also collect food waste in the green bin[13].

FOGO in the Goulburn Valley

Moira Shire Council in the Goulburn Valley, Victoria, introduced a mandatory kerbside FOGO service from December 2014. A previous waste audit showed that organic material comprised a third of landfilled material from the council area and over half of household waste under the old 'two bin' system (residual waste and commingled recycling).

The new FOGO service was introduced with careful planning and a comprehensive education and engagement program, crucial to achieving low levels of contamination. The service accepts:

- Food scraps and leftovers including meat and bones
- Small prunings, branches and cut flowers
- Lawn clippings and weeds
- Shredded paper
- Animal droppings
- Small deceased animals

Householders collect their scraps in an 8 litre caddy in their kitchen, which they then empty into their 240 litre green-lidded bin, which is collected fortnightly (alternating with their recycling kerbside service).

The co-collection of food waste with garden waste (known as FOGO) is an efficient means to divert household organics from landfill, but comes with costs. Aside from the obvious additional collection costs, there may be a need for more advanced processing of the collected material due to the food content – where low cost open windrow composting of garden waste alone may have been appropriate, councils may now need to pay more for enclosed processing such as in-vessel composting or dry AD.

Thus moving from garden only to FOGO can result in a significant increase in processing costs, as well as pressures on existing suitable biological processing infrastructure to cope with additional tonnages. The regional implementation plans[14] have identified future processing infrastructure needs, including for the management of FOGO material. Processing technologies are discussed further in section 4.

It is also possible to collect food waste separately from garden waste, which would facilitate processing of the food waste in a wet AD system and cheaper open windrow processing of the garden waste. This option is not usually considered in the Australian context. For detached, single unit dwellings this would likely mean a fourth kerbside bin (in addition to garden waste) which would further add to collection costs and require significant community education to ensure success. However, for higher density or multi-unit dwellings in an urban environment that do not have gardens, a separate food waste collection may be a viable option for a third bin.

Whichever system is adopted, it must be supported by a comprehensive community education and information campaign to educate residents how to properly separate their organics, but also to convince them of the benefits of doing so. Education is critical to minimising contamination rates and maximising the capture (or yield) of organics in the system. The education program needs to be more intensive in the lead up to commencement of a new service but it also needs to be ongoing – system performance tends to improve steadily over the early years of the service. This may include an element of monitoring and inspection at the household level.

Community education should be a joint effort between the council, the collection contractor and the processor – each party has varying degrees of influence and can provide useful feedback and data to aid continuous improvement.

The SV developed Optimising Kerbside Collection Systems – A Framework for Greater Consistency in Kerbside Recycling in Victoria (2017)[15] seeks to increase recycling, improve the quality of recycled materials and reduce contamination through a more consistent approach to how we recycle. It is based on three approaches; households to recycle the same core set of materials, consistent bin configurations, and consistent bin colours.

The framework seeks to provide information to stakeholders on preferred service standards (bin configurations and colours), including for collection systems for organics (garden and combined food and garden, i.e. FOGO).

Increased source separation through the introduction of an organics collection service can lead to improved recycling and waste avoidance behaviours. The summary below identifies some of the key aspects to consider when planning an organics collection service.

13 SV provides some guidance and case studies on kerbside organics collections: http://www.sustainability.vic.gov.au/Government/Waste-and-Resource-recovery/Kerbside-waste-and-recycling

14 The regional implementation plans are available at: http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Regional-Waste-and-Resource-Recovery-Implementation-Plans

15 http://www.sustainability.vic.gov.au/About-Us/Publications/Guide-to-optimising-kerbside-collections

TABLE 4: SUMMARY OF KEY CONSIDERATIONS FOR KERBSIDE ORGANICS SERVICES

Food and/or Garden waste
A garden waste only service can be an effective means of diverting this stream from landfill, particularly in areas with a high proportion of single-unit, detached dwellings with gardens. The collected material can generally be processed via open windrow composting as a low cost option. A third garden waste bin is also a good precursor to a future progression to FOGO.
Co-collection of FOGO in a single bin is the most common approach in Australia to facilitate source separation of domestic food waste. If a garden waste service is already in place, the collection cost impact is reduced and can be offset by switching the residual collection to fortnightly (see below). The downside is that the material will generally require higher order, enclosed processing which will add to costs.
Separate collection of food waste is not generally practiced in Australia because the majority of the population also needs a solution for garden waste and providing two separate services (i.e. four bins in total) is generally cost prohibitive and imposes a significant burden on householders. It has been implemented internationally in urban settings and may be appropriate for higher density housing areas where there is limited generation of garden waste.
Voluntary vs Compulsory
Organics services which are voluntary (opt-in) and user-pays tend to achieve much lower contamination levels than those which are imposed on all households, because the users are motivated to use the bin correctly.
On the other hand, organics services which are compulsory (universal) reach a larger proportion of the population and therefore achieve a higher diversion rate of household organics generated.
Compulsory FOGO collection services must be rolled out with a comprehensive, engaging education campaign to optimise the performance of the system, in terms of participation and contamination rates.
Collection Frequency
Most garden waste services are collected on a fortnightly basis, while food or FOGO services may be collected either weekly or fortnightly.
Where a compulsory food or FOGO service is introduced, the residual waste bin collection frequency may be transitioned to fortnightly collection as a means to encourage householders to use the FOGO bin and to reduce overall collection costs.
Where residual collections are fortnightly, consideration needs to be given as to how residents can manage wastes which are potentially odourous but not accepted in the FOGO bin such as nappies and sanitary products.
Bins & Equipment
For FOGO which is co-collected on a weekly basis, a wheeled mobile garbage bin (MGB) of 120 or 240 litre capacity would normally be provided. Some flexibility for large households to get a larger bin should be considered.
Although not applied in Australia, cities in the UK and Europe that have introduced separate food only collections have usually issued each household with a 20-30 litre lidded food waste bin.
Previous trials and industry experience has shown that when introducing a food or FOGO collection service, providing householders with a separate kitchen caddy and/or compostable liner bags to gather their food scraps in the kitchen, results in higher participation rates and capture of food waste. Making the new collection service easy for householders will help to maximise yields and user satisfaction.
Where a FOGO or food collection service is introduced, the residual waste bin is often reduced in size to a small MGB (80 or 120 litre capacity), which acknowledges the significant diversion of material to the FOGO bin and further encourages proper use of the FOGO bin.

3.1.2 Self-hauled organics

Most Victorian councils provide facilities for residents and small businesses to self-haul garden waste to a drop-off point – usually a council owned resource recovery centre or transfer station. Some private sector operators also provide this service.

Such drop-off facilities are a valued service for residents that have the capacity to self-haul their garden waste (i.e. access to a suitable vehicle) and particularly for larger loads that might be generated from an occasional clean-up.

Garden waste collected in this way is generally low in contaminants and councils have an opportunity for enhanced monitoring at the drop-off point if contamination becomes an issue. Hence the material is appropriate for low-cost open windrow composting, which is the most common treatment method.

3.2 Controlling feedstock derived from mixed residual

As noted above, the guidance in this document could be applied equally to biological processing of organics which have been extracted from mixed waste.

The key advantages of extracting the organics from mixed waste are that it does not require a change in behaviour on the part of the householder and it does not require an additional kerbside collection service. That said, if a council pursues a strategy of separating organics from mixed waste, there is still a need for education of residents around keeping incompatible materials out of the residual bin (e.g. batteries, chemicals and other hazardous items), which could affect the quality of the organics stream.

The cost of additional, more complex processing of the mixed waste needs to be weighed against the benefits of not modifying the existing collection system.

The downside of this approach is that the organic material recovered is heavily contaminated with both physical and chemical contaminants, compared with source separated organics. This may complicate downstream biological processing and refinement of the products. It will also significantly limit the market opportunities for any recovered soil conditioner products. Contaminants of particular concern in mixed waste derived organics may include:

- Heavy metals, with lead from batteries being a particular issue in some Australian MBT plants
- Glass and ceramics which tend to end up in the fines fraction and can be particularly visible in the end product
- Plastics (rigid and flexible) which may be shredded or broken down during processing

As a result of contamination issues, most compost products from existing Australian MBT plants are used for mine rehabilitation although plants in Perth and Cairns are known to direct material to broad-acre agricultural land. Compost from mixed waste organics is unlikely to be suitable for sale into urban amenity markets (landscaping, gardens) which is the main market for recycled organics products nationally.

The contaminants in organics derived from mixed waste have also caused issues with AD processing of the stream in Australian and international projects.

3.3 Acceptance criteria at processing facilities

As noted above, quality and contamination management needs a coordinated approach involving the waste generators, collectors and processors. Processing operators should proactively engage with their customers and the supply chain to ensure that feedstock quality meets their requirements. The aim should be to minimise the degree of contamination entering the facility and the need to reject loads at the facility gate.

At the processing facility, there should be clearly documented acceptance criteria and procedures for incoming feedstocks which are clearly communicated to customers. The acceptance criteria will be specific to the facility and determined by considering:

- Planning Permit requirements (if applicable)
- Inspection and testing procedures that will be applied (visual, laboratory analysis, compositional audits, specialist assessments)
- EPA Licence conditions (if applicable) stipulating which types of waste can be processed
- Waste transport certificates (if applicable) and any other documentation required
- Concentrations of specified chemical components and contaminants, and relevant acceptance thresholds
- Acceptable types and levels of physical contaminants and methods for quantifying/ estimating contamination rates
- Physical characteristics such as moisture content, particle size, handling properties
- Odour and odour potential of the feedstock

Where feedstocks are found to be in breach of the acceptance criteria, there should be clear procedures in place to either quarantine the load, remove the contaminants or reject the load from the facility and direct it to a more suitable facility.

4 Biological recovery processes

This section provides an overview of biological recovery processes that could be applied to recover the organic wastes identified in section 2. Section 6 provides more detail on specific technical parameters to be considered in implementing these technologies. The Resource Recovery Technology Guide also provides further detail on these and other technologies, including thermal processing technologies.

Biological processing of organics involves harnessing natural decomposition processes in a controlled environment to convert organic waste materials to useful and valuable products. In nature, organic matter is decomposed by a wide range of bacteria, fungi and other micro-organisms as well as worms and insects, to produce humus which is returned to the soil, contributing to natural carbon and nutrient cycles.

Decomposition can either take place in aerobic conditions (oxygen / air is present) or anaerobic conditions (no air present). In aerobic conditions, the degradable carbon in the organic matter is oxidised to carbon dioxide gas, with heat released in the process. Under anaerobic conditions, a different set of micro-organisms converts the carbon in the organic matter into a mixture of methane and carbon dioxide gases. Alternatively, if yeast is present, fermentation can occur where sugars in the organic matter are converted to alcohol and/or acids.

By facilitating this decomposition in a controlled environment with optimised conditions including temperature, moisture, aeration / oxygen levels and nutrient balance, it occurs more rapidly and consistently, providing a predictable and manageable process to convert organic waste into valuable products. In the case of anaerobic processes, the methane and carbon dioxide (biogas) is also harvested and used for its energy value.

Each technology is best suited to different types of organic feedstocks and products environments. Table 5 provides an overview of these factors to guide readers to the most relevant sections of this guide. Further detail on key technical parameters is provided in section 6 and a more detailed comparison is presented in Table 14.

TABLE 5: SUMMARY OF KEY TECHNOLOGIES FOR BIOLOGICAL PROCESSING OF ORGANICS, THEIR MATURITY, SUITABLE FEEDSTOCKS AND RESULTING PRODUCTS

Technology	Feedstocks	Products	Maturity	Section
Open windrow composting	Garden organics, stabilised biosolids, manure	Compost, mulch	Proven, well established	4.1.2
Aerated static pile composting	Garden & food organics, biosolids, manure	Compost, mulch	Proven, well established	4.1.3
In-vessel composting	Garden & food organics, food processing waste, industrial organics, liquid organics, odourous wastes	Compost, mulch	Proven, well established	4.1.4
Vermicomposting	Food organics, soft garden waste, pre-composted or digested material	Castings Worms Liquid fertiliser	Proven, but limited commercial plants	4.1.5
Wet anaerobic digestion	Food organics, biosolids, manures, food and beverage processing waste, liquid organics	Biogas / biomethane, CNG, electricity, heat Digestate (compost)	Proven, well established internationally, with increasing adoption in Australia	4.2.1
Dry anaerobic digestion	Food & garden organics, commercial organics, crop residues	Biogas / biomethane, CNG, electricity, heat Digestate (compost)	Proven, but not yet in Australia	4.2.2
Fermentation	Bagasse, crop residues, forestry residues, food processing waste, waste wood, paper & cardboard	Ethanol Stillage (compost)	Emerging (for waste)	4.2.3

4.1 Aerobic processes

4.1.1 General composting overview

The most common technology for processing organic waste is composting in its various forms. Composting is an aerobic process where organic waste is converted into a compost product which can be used as a soil conditioner in various markets (refer to section 5.2.1).

The various forms of composting differ in the way that the feedstock is mixed, aerated and contained. It is generally a flexible and robust process that works well with a range of both source separated organics and organics separated from mixed waste. However, careful control by an experienced operator is required to minimise the processing time, avoid unwanted emissions (particularly odour) and produce a high quality saleable product.

The Australian Standard for Composts, Soil Conditioners and Mulches (AS4454-2012) sets out product quality management requirements for composting operations in Australia, while EPA Victoria's guideline on Designing, constructing and operating composting facilities [16](Publication 1588.1, 2017) provides regulatory, operational and environmental guidance.

AS4454-2012 sets out requirements for the processing of organics, particularly around achieving pasteurisation of pathogens and weeds and managing contamination. It is a voluntary standard, primarily focused on assuring the quality of organic products[17] and mixtures of organic products that have been produced through composting and pasteurising techniques (refer to section 5 for product quality information).

There are a number of steps before and after the primary composting phase which are generally common to the different composting technologies, which are described in this section. The overall process is depicted in Figure 3.

16 http://www.epa.vic.gov.au/our-work/publications/publication/2017/june/1588-1

17 AS4454 does not apply to organic fertilisers such as blood and bone or liquid organic wastes, liquid seaweed products, non-organic mulches (e.g. gravel), non-organic soils and soil conditioners (e.g. gypsum and sand), non-compostable materials (e.g. plastics) and materials variously described as 'compost starters' and 'activators'.

FIGURE 3: FLOW CHART DEPICTING THE GENERAL COMPOSTING PROCESS

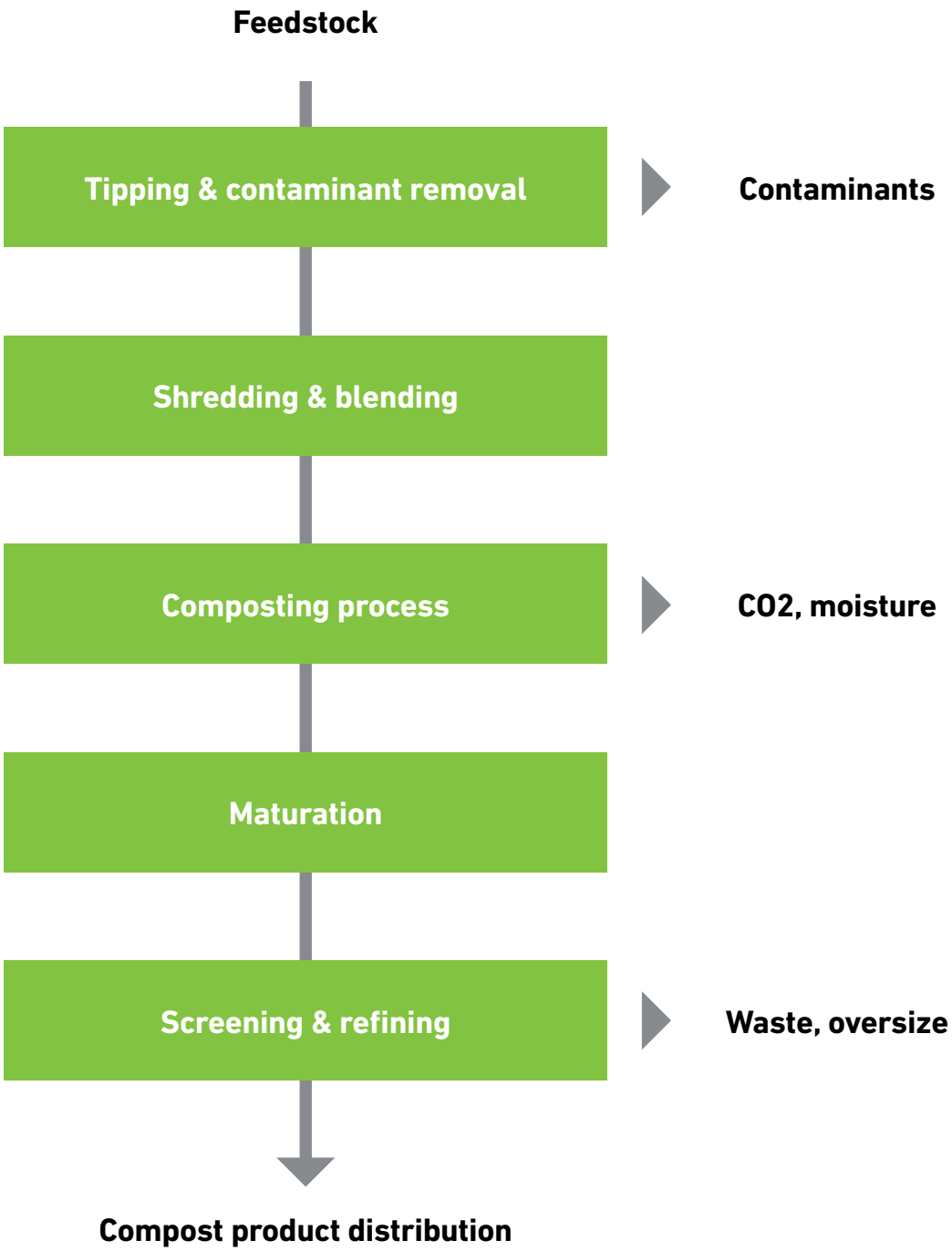


TABLE 6: GENERAL COMPOSTING PROCESS OVERVIEW

Phase	Description
Tipping and contaminant removal	The feedstock is tipped in the waste reception area and manually inspected to remove contaminants that might affect the product quality (glass, plastic bags) or damage the equipment (large stones, bricks, metal) Inspection may take place on the tipping floor / hardstand in smaller facilities or involve a conveyor picking station in larger facilities
Shredding and blending	The type of pre-processing is a function of the feedstock characteristics more than the composting system being used Materials such as garden waste and timber are processed through a shredder or grinder to reduce particle sizes (typically 50 to 150 mm) to facilitate more rapid breakdown Smaller particle sizes should be avoided as it may make it difficult for air to penetrate the waste mass during composting An over-band magnet may be employed in this stage to remove ferrous metals from the feedstock Different feedstocks are blended to balance moisture and nutrient ratios Some sites have a mixing pit where liquid streams are blended with drier materials using, for example, an excavator bucket The ratio of carbon to nitrogen content needs to be between 25 and 35 parts carbon to one part nitrogen (by weight) for an optimised process High carbon materials include woody garden waste, dry leaves and paper; while high nitrogen materials include grass clippings, food waste, biosolids and manures Garden waste contains a mix of both high carbon (woody material) and high nitrogen (leafy green material) and may be processed on its own if there is a sufficient balance of nutrients and moisture, noting that these ratios may change with the seasons Food waste and other moist materials generally need to be blended with majority garden waste to be composted effectively Overall moisture content should be around 50 per cent to 60 per cent
Composting	During the initial composting phase, the material heats up rapidly and can reach temperatures as high as 65°C (any higher is detrimental to the process) To achieve pasteurisation of pathogens and weeds the material must be held at 55°C or more, for at least 3 days To comply with AS4454-2012, open windrows must be subjected to a minimum of 3 turns, with pasteurisation conditions (e.g. above 55°C for 3 consecutive days) achieved before each turn For high risk materials (e.g. manure, animal waste, food and grease trap wastes) a minimum of 5 turns are required to comply with AS4454-2012 During the active composting and pasteurisation phase, it is critical that adequate oxygen levels are maintained throughout the compost mass, either through forced or passive aeration If anaerobic conditions are allowed to develop, offensive odours may be released Moisture levels must also be managed and maintained – moisture will evaporate and may need to be replaced to avoid the material becoming too dry Over-wetting will also have adverse impacts on air flow and leachate production
Maturation	Following the main composting phase, the material is still active and needs further stabilisation During the maturation (or curing) phase, it is placed in large windrows or piles and left for usually 2 to 3 months

Phase	Description
Screening and Refining	The matured compost then needs to be screened and refined to meet product standards and customer expectations Compost is typically screened (to around 8-10mm) to remove waste and larger particles that have not decomposed (over-size) and to provide a homogenous product Some operators may produce two size fractions – a fine compost for use in soil and turf blends, and a coarser material for use as a mulch The oversize material, if it is mostly organic, may be returned to the process for further composting and used as a bulking agent; or disposed as waste Oversize material can be a challenge and cost to manage and there is a balance to be struck between the quality of the fine compost fraction and the proportion of the oversize fraction If there are still contaminants present in the compost, additional refining steps may be applied such as wind-sifting to remove plastic film or de-stoning to remove glass and stones Some plants processing organics derived from mixed waste, where the compost has high glass content, grind the compost to crush glass particles down to a size that is less visible and similar to sand in appearance Compost products are usually sold directly in bulk, but may be blended with inert soils to produce a range of soil mixes, or bagged for sale into the residential market

4.1.2 Open windrow composting

Open windrow, or turned windrow composting is the most common and simple form of organics recovery which is often used to treat garden waste at a commercial scale. It can be applied at small scale such as on-farm composting, which is not the focus of this guide but the same operating principles and risk management approaches may be applied, regardless of size.

The prepared feedstock is formed into long uniform prism-shaped 'piles' of material known as windrows, on a large open outdoor pad. The windrows at commercial processing sites are typically up to 2-3m high and 5-7m wide at the base.

The windrows are then left for typically 8-12 weeks to compost which is a function of the feedstock mix, turning frequency and local climate. Aeration in this case is passive – the air flows through the voids in the material, so it is important that the particles are not too small, wet or compacted. Aeration is also provided through occasional mixing and turning. For small scale operations, turning may be undertaken by a front end loader or tractor drawn turning machine. Larger facilities are likely to use a specialised self-propelled compost turning machine which drives along the windrow lifting and mixing the compost, and reforming the windrow behind it.

Being an open process there is an increased risk of odour release, which is heightened whenever composting material is being moved (e.g. during initial forming of the windrow or during turning operations). As such, it is generally not suitable for urban environments and there should be adequate buffers in place around the site (see section 7.5). EPA guidance also indicates open windrowing is generally not suitable for processing more odourous waste streams, including domestic and commercial food waste. It is also more difficult to control vermin and to ensure the material is evenly subjected to sustained high temperatures that are required for pasteurisation.

Windrow composting is a low cost method of processing organics and can be established with relatively low capital investment, including at small scales. It does require a large land footprint to accommodate the windrows and can be labour intensive. The uncovered windrows may produce leachate (both seepage from the compost and contaminated runoff) which needs to be captured and managed.

Hence, processing should take place on an impermeable pad. Concrete is preferred but engineered clay with a protective working surface may be appropriate, provided it meets required standards (see EPA Guidance Publication 1588.1). The pad should be gently sloped to encourage drainage towards a single point and surrounded by earthen bunding to maintain separation between clean and dirty surface waters.

Leachate should be captured in a storage pond and appropriately managed in order to prevent impacts to land and water, as well as release of odour. In most cases, leachate can be recirculated back to the windrows in dry weather to maintain adequate moisture levels. In high rainfall periods it may need to be treated and disposed in accordance with licence conditions and or via a suitably licensed treatment plant.

Enviromix composting – Dingley Village

Image supplied by Enviromix Pty Ltd

Enviromix operates a 3 hectare open windrow composting facility at Dingley Village in Melbourne's south east, processing garden waste from local councils and commercial customers (landscapers, garden maintenance). Contaminants are removed from the material before it is shredded and then composted in windrows for at least 6 weeks with regular turning by compost turning machines, followed by further maturation. The site produces around 45,000 tonnes of AS4454 certified compost each year for landscaping and horticulture markets.

4.1.3 Aerated static pile composting

Aerated static pile composting is similar to open windrow except that, rather than regular turning of the windrows, aeration is achieved by applying forced air flow from a blower through the pile via perforated pipes installed under the windrow. The pipe is either embedded within the underlying pad or laid on top of the pad prior to first placement of the windrow (also called mobile aerated floor or MAF system). A blower is attached to the pipes and can either be set to blow air out through the windrow (positive pressure) or draw it in (negative pressure). In the case of negative aeration, there is an option to process the odorous air through a bio-filter to control odours.

Activation sensors (temperature and moisture) and timers can be installed within the windrow to optimise the air flow and balance the temperature (too much air can result in heat loss and failure to achieve pasteurisation temperatures, whilst drying out the material).

Aerated static pile composting is particularly suited to processing garden waste with minor proportions of other materials. It can also be used to process denser and wetter organics such as biosolids or food processing residues. Regular turning is not required but temperatures in the outside layers of the pile may not reach the pasteurisation temperatures, in which case at least one turning may be required.

The ability to control the air supply to the piles can allow for larger piles to be created and/or shortened processing times, increasing the land efficiency of the process. With good automated control of the aeration, the composting process can be more closely controlled than in turned windrows. The moderate additional capital investment in aeration systems is usually offset by reduced need for turning equipment and reduced footprint of the composting pad. Labour input is usually less without the turning, but energy consumption is higher for the blower.

In most other respects, an aerated static pile system is similar to an open windrow process. There is still a requirement for an impermeable pad (which may be compacted clay or concrete) and leachate capture system. In recent years a number of commercial composting operations across Australia have upgraded their operations to integrate static aerated pile composting systems as a means to increase capacity, better control odours or improve product quality.

A further variant of this process is covered aerated piles, where a fabric cover is applied over the top of the windrow. The cover adds a level of containment which improves the control of the conditions within the windrow. The covers are applied using a custom designed roller attachment to standard material handling plant. They are secured and weighed down once in place. Most use a proprietary fabric (such as Gortex) which is designed to:

- breathe, allowing carbon dioxide out
- contain odours
- keep rainfall out to reduce leachate
- retain moisture / condensation under the cover, and
- provide more even distribution of air within the windrow.

Covering the windrows provides some of the advantages of enclosed composting (see section 4.1.4) and may enable the processing of food waste. However odour issues can still arise during loading and unloading of the windrows.

4.1.4 In-vessel composting

In-vessel composting (IVC) is a group of more advanced composting systems where the process is fully contained within a vessel or building, and closely controlled to accelerate the composting process. IVC is particularly suited to more odourous waste streams such as food waste and the organic-rich fraction separated from mixed residual waste as part of mechanical biological treatment.

Under the EPA composting guidelines enclosed composting is likely to be required where the feedstock contains higher risk feedstock such as food waste, food processing waste, unstabilised biosolids, grease trap waste, fresh manure and liquid organics. Under the guidelines, feedstocks containing domestic food waste (including when mixed with garden waste) is considered medium-high risk (category 3) and requires composting in an enclosed or a covered system that provides a level of engineered control and some level of control over odour emissions. The guidelines give some flexibility in that, in some situations, a 'covered environment' may include material covers over windrows (see section 4.1.3) or an appropriate layer of mature compost. However, for facilities which have sensitive receptors nearby, an in-vessel system is likely to be required. The guidelines do not specifically encompass AD but it would likely be considered in the same light as IVC.

SORF, Dutson Downs

Image supplied by Gippsland Water

The Soil and Organic Recycling Facility (SORF) at Dutson Downs near Sale is run by Gippsland Water and recycles a range of liquid and solid organics, including various prescribed wastes through a tunnel composting process. The site receives garden waste from the east and south-east Melbourne councils, biosolids and residues from local dairy, egg and food producers. It is also licensed to process hydrocarbon contaminated soils, oily waters, tannery waste, grease trap waste, wash waters and drill muds.

Odorous wastes are processed through the IVC system for 72 hours, after being mixed with garden waste. These wastes are further composted in open windrows. The compost is used on the 8,500 hectare farm on the adjoining site and distributed to other local agricultural markets. The compost is compliant with AS4454.

The containment 'vessel' may come in many forms including:

- Bays or beds within a building (hall systems)
- Rectangular tunnels
- Rotating horizontal drums
- Plug flow composters
- Vertical flow silos or towers

Most processes provide optimal and automated monitoring and control of composting conditions by providing:

- Mechanical agitation
- Controlled forced aeration to control oxygen supply
- Containment of heat to maximise pasteurisation
- Temperature and moisture monitoring
- Containment of process air which can then be treated to remove odours

IVC can be an energy intensive process, predominantly for the power to provide the forced aeration. Typically, temperatures between 55°C and 65°C are achieved by IVC processes because the heat is contained in the vessel (any more than 65°C is harmful to the bacteria involved). Higher sustained temperatures have the advantage of destroying potentially pathogenic organisms in the waste and can also be used to dry material if desired (bio-drying).

IVC is a more intense form of composting but is often used to partially decompose and pasteurise the waste, followed by a secondary open composting and/or maturation phase. Hence the duration of the in-vessel phase will typically be between two and four weeks. This reduces the capacity requirement of the more expensive IVC phase but also adds to the overall site footprint requirement when the open windrow phase is included.

Odours are contained and captured by ensuring vessels are sealed and air is continuously extracted to maintain the vessel under negative pressure. The extracted process air is usually treated through a bio-filter. The waste is also contained from vermin and protected from weather conditions, including rainfall which might produce excessive leachate. Any leachate that does seep out during the composting process is captured and recirculated back into the compost.

Aeration is provided in a variety of ways:

- In most tunnel systems, the compost is static and aeration is provided from a blower through a network of perforated pipes in the tunnel floor (either positive or negative)
- In rotating drum systems, aeration is provided via the constant mixing and turning of the rotating waste
- In hall systems, a variety of mechanical turning equipment is used including bucket wheels, augers and windrow turning machines.

IVC systems generally can either operate in batch mode (as in tunnel systems) or in continuous processing mode, as in hall composting and rotating drum systems where fresh feedstock is regularly added at one end, and compost removed from the other.

Plug flow and vertical flow systems are usually small scale, suitable for commercial premises, institutions or precinct solutions. Plug flow systems are continuous flow and provide mixing by way of paddles or tynes on a rotating axle within a horizontal cylinder. Vertical silos have no mixing but passive aeration is encouraged by the varying temperature profile within the tower.

Bulla Organics Recycling Facility, Bulla

Image supplied by Veolia

The Bulla Organics Recycling facility was built by Veolia in late 2013, delivered as part of the service requirement under the North-West Organics Processing (NWOP) Contract, which is an agreement with the Metropolitan Waste and Resource Recovery Group and 11 participating councils in the north and west of Melbourne.

The facility uses IVC technology demonstrated at a separate Veolia facility (NRS facility) and has the capacity to process up to 85,000 tonnes per annum of kerbside food and garden organics via composting tunnels. Currently it predominately takes garden organics and is operating at full capacity. Increasing amounts of food organics are being received via some participating councils, such as Nillumbik, which has implemented a FOGO collection system for their residents.

4.1.5 Vermicomposting

Vermicomposting, or vermiculture, involves the biological decomposition of organic waste (generally food waste, biosolids, manures or nitrogen-rich garden waste) by worms and other microorganisms. It is generally suitable for high moisture, softer organics or materials such as food waste, commercial and industrial organics, manures and biosolids. The worms can be sensitive to chemical contaminants in the feedstock or changes in conditions.

Vermicomposting can be used with other materials such as garden waste, if they have been pre-composted to be more digestible by the worms. Unless the materials have been pasteurised through a composting process, vermicomposting may not destroy weed seeds and pathogens.

As well as the food source (the organic waste being recovered), the worms need to be provided with bedding material which provides a stable habitat and usually has high absorbency, porosity for air flow and a high carbon to nitrogen ratio to prevent rapid breakdown (e.g. straw, shredded paper and cardboard). In addition, the worms need adequate but not excessive moisture (more than 50 per cent water content but not saturated); adequate aeration (usually passive but aided by porosity in the feedstock and bedding material); protection from extreme temperatures; and protection from excessive disturbance and movement (worms tend to stop feeding when disturbed).

There are three basic types of vermicomposting systems:

- Windrows (batch or continuous)
- Beds or Bins (batch or continuous)
- Flow-through reactors (continuous)

For batch systems, bedding and feedstock are mixed and shredded as necessary, at the beginning of the process and the worms are added to break down the organic material over a period of weeks or months. In continuous processes, the worms are placed in the bedding material, and feedstock and new bedding are added incrementally on a regular basis. The castings are also harvested on a regular basis.

The worm castings, also called vermicompost, are generally superior in quality and soil benefits to that of conventionally produced compost. They can be used without further stabilisation however may be pelletised to improve handling. Excess worms can be harvested and are a valuable protein source for fish and animal feeds. Liquid fertiliser can also be produced by diluting and stabilising the castings (known as worm tea).

In general, the process requires more labour, space and time for decomposition and harvesting of the worms. It is more sensitive to environmental conditions than composting including temperature and acidic feedstocks. As such, its uptake on a commercial scale has been limited. There is a small number of operators using the process with a primary focus on producing castings and worms. An example is Australian Vermiculture based in Mildura, with a facility in South Australia supplying products to farmers.

There were commercial facilities constructed in the late 90's and early 2000's which are thought to be no longer operating, including the Triton facility at Lismore (NSW) processing various domestic food and garden waste, or the Vermitech facility in Redlands (Queensland) processing biosolids.

Vermiculture is normally a specialised or tailored approach and it is not common in large scale operations.

Circular Food, Somerton

Image supplied by Circular Food

Circular Food is a relatively new operation established in 2015, which processes food waste sourced from local commercial and retail food businesses. The feedstock is blended and ground into a paste which is fed to 28 commercial scale worm beds housed in a warehouse. The facility is relatively small scale, reportedly processing 1,400kg per week, but with plans to expand. The company produces a range of solid and liquid fertiliser products which are sold back to the waste producers and the broader public.

4.2 Anaerobic processes

AD involves the biological decomposition of organic wastes in the absence of oxygen, which results in the production of methane-rich biogas. It involves a complex system of different microbe groups, which must be carefully controlled to produce an optimal output of biogas. Like composting, AD still results in an organic residue (called digestate) which has value as a soil conditioner product. The benefit over aerobic processing, is the opportunity to also extract energy during the process. This comes with additional cost and complexity, which needs to be balanced against the potential revenues from energy sales.

AD is an established technology in Australia for treating sewage sludge from municipal wastewater treatment plants; wet agricultural wastes (e.g. piggery wastes); and food and beverage processing residues (e.g. brewery waste). It has also been used to process commercial food waste and food processing wastes at dedicated facilities such as EarthPower in Sydney, Richgro in Perth and more recently, Yarra Valley Water's facility digesting commercial food waste.

AD is common internationally (particularly Europe and UK) as a treatment technology for food and/or garden waste, which may be blended with other streams including biosolids and manure. AD processes can be more sensitive to feedstock and environmental changes, compared with composting.

A recent and growing trend is to upgrade biogas through a refinement process which removes the carbon dioxide and contaminants, to produce a near pure methane gas known as biomethane, which is equivalent to natural gas. Biomethane can be compressed and used as vehicle fuel (akin to compressed or liquefied natural gas) or injected into the natural gas distribution grid as a renewable substitute for fossil natural gas. The technology to refine and compress biogas is readily available, usually as compact modular plants.

This solution is becoming increasingly common in Europe and North America where biogas is injected into gas mains or used to fuel waste collection fleets, buses and other commercial light and heavy vehicle fleets. It is yet to be implemented in Australia but could be attractive in some cases given rising gas and fuel prices.

The biogas is typically 50-60 per cent methane with minor trace elements and carbon dioxide making up the balance. It is conventionally used to fuel an on-site gas engine generator to produce electricity, for either internal use or export to the grid. This technology is well proven and low risk, with various generators on the market that are specifically designed to run on biogas.

The digestate output comprises the remaining solids and nutrient-rich water from the process. Liquid digestate may be used as liquid fertiliser in agriculture, although it may need to undergo further treatment. The solid digestate will require further stabilisation (for example, through aerobic composting) before being used as a soil conditioner. Both solid and liquid digestate require analysis and quality assurance testing to ensure contaminants such as heavy metals are within acceptable levels. These outputs are PIW and advice should be sort from EPA regarding the regulatory requirements for re-use of these materials.

The volume of digestate produced from AD can be significant and it is important to consider the testing regime, quality requirements, outlets and markets for this material. The business case for a project must account for the costs associated with managing digestate (stabilisation, transport, handling and application).

All AD processes are enclosed and sealed to exclude air and contain gas, using specifically designed digester vessels. They can operate under two distinct temperature ranges: mesophilic conditions (20-45°C) and thermophilic conditions (50-65°C) and can comprise either single or multiple process stages.

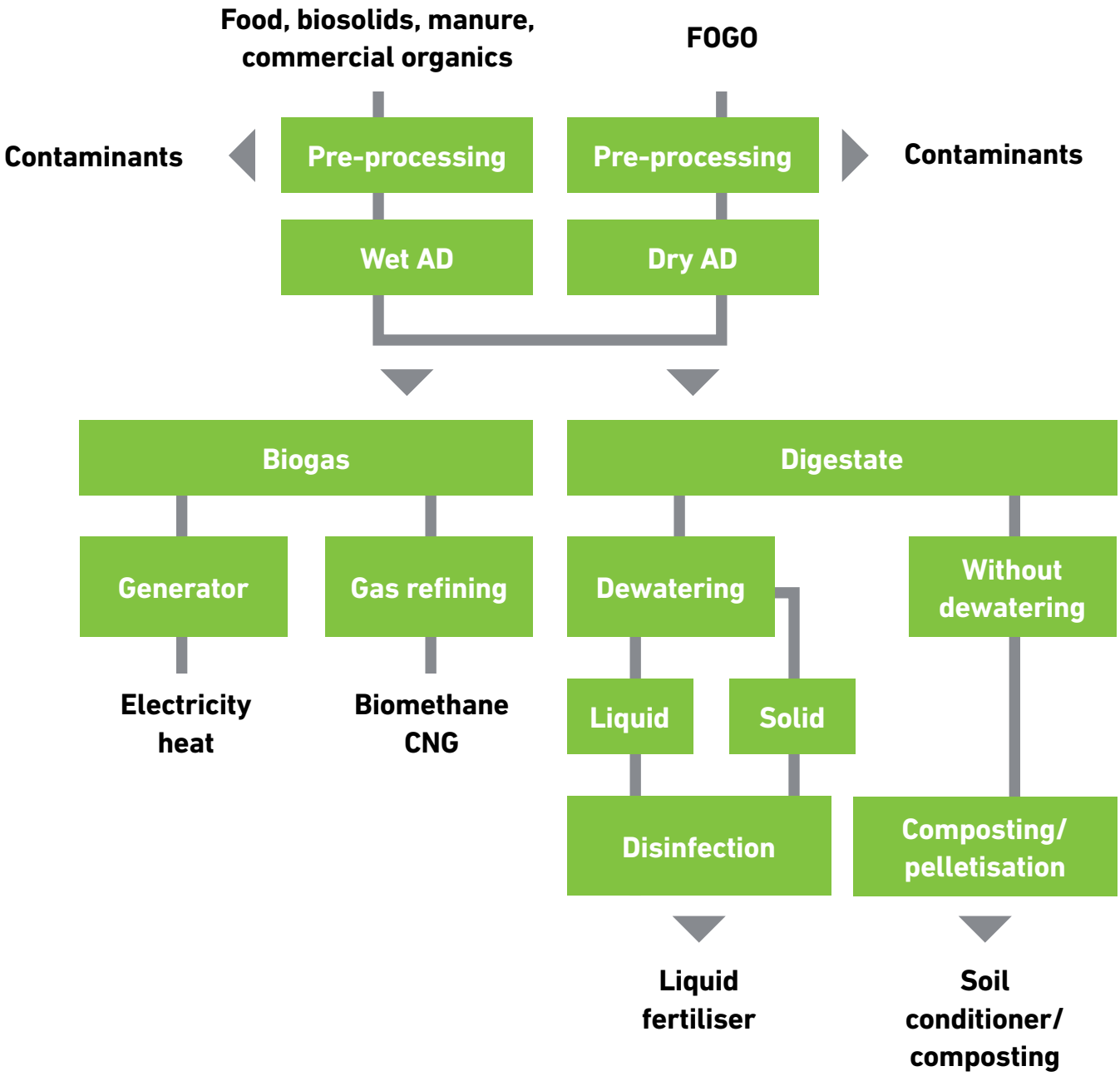
There are two principal approaches to the digestion of organic wastes:

- Wet AD processes – are most common and typically used to treat materials which are in, or can be made into, a liquid or slurry phase (i.e., pumpable), usually with a solids content of no more than around 15 per cent
- Dry AD processes – are used to treat materials which are solid, stackable and with solids content of more than 20 per cent that is not easily soluble.

The existing AD systems in Australia and most of the systems globally are wet systems. Dry systems are usually applied where the feedstock includes garden waste or other materials that are insoluble or difficult to macerate (e.g. crop residues, energy crops). Dry systems may find particular application in Australia with a growing trend to co-collect kerbside garden and food waste.

Figure 4 summarises the overall AD process and options.

FIGURE 4 FLOW CHART DEPICTING THE OVERALL AD PROCESS AND OPTIONS



4.2.1 Wet anaerobic digestion

In wet AD, the digestion takes place in a liquid or wet slurry phase. The feedstocks are typically wet and soft such as food waste, food processing waste, manures, biosolids or organic rich industrial slurries. Digestion takes place in enclosed tanks which are continuously stirred to enhance contact between microbes and the waste. In some agricultural situations, digestion takes place in a covered pond with no mixing, which is cheaper to install and run, but less efficient.

Some waste preparation may be undertaken to remove contaminants from the source separated streams, macerate the feedstock or to increase the moisture content of the inlet stream (addition of water). Solid contaminants such as plastic packaging need to be avoided or removed as far as possible. There have been many, mostly unsuccessful, attempts to apply wet AD processes to the organic fraction separated from mixed waste. In most cases, the higher rates of chemical and physical contaminants have been detrimental to the process.

Wet AD systems can operate at both mesophilic and thermophilic conditions, although they more commonly operate at lower temperature mesophilic conditions. Thermophilic conditions are likely to require the input of heat to maintain the temperature in the required range.

After digestion is complete the digestate, which is a thick slurry, is usually dewatered to separate the solid and liquid streams which can be used as fertilisers and soil conditioners.

ReWaste – Yarra Valley Water, Wollert

Image supplied by Yarra Valley Water

Melbourne's largest water retailer, Yarra Valley Water successfully commissioned its first ReWaste AD facility in Wollert in 2017. The facility diverts commercial food waste from landfill and converts it into renewable energy. The facility can process up to 100 tonnes of waste per day (33,000 tonnes a year). The waste is sourced from food markets, manufacturing, dairy waste and animal processing.

The digestion process captures the biogas which powers a 1 megawatt (MW) combined heat power (CHP) system, which is used to power the facility and the adjacent sewage treatment plant. Excess energy is exported to the grid. The facility is expected to generate 8,000 megawatt hours each year, enough to power 2,000 homes. It will generate almost a quarter of Yarra Valley Water's overall energy requirements, with waste heat also captured and used on-site. The by product from the process is a nutrient rich digestate and is currently being trialled as a fertiliser and as an additive in nutrient enhanced mulches and biochar. The facility has created four new operational jobs, with construction of a second plant currently being investigated.

4.2.2 Dry anaerobic digestion

Dry AD systems are designed for drier feedstocks including woody materials or feedstocks that have higher lignin content (the woody or fibrous structural material of plants) and are generally not soluble. The digestion reactions still occur in the liquid phase, through the constant recirculation of leachate over the waste mass.

Dry AD technologies have been used extensively in Europe and increasingly in North America, to process co-collected domestic kerbside food and garden waste, as an alternative to in-vessel composting. At medium to large scales, it can be cost competitive with IVC. It could also be used to process the organic fraction separated from mixed waste, being more robust than wet AD systems in this respect, but care will still be required to manage chemical contaminants.

Fife Council Dry AD Plant, Scotland

The facility receives co-mingled domestic garden and food waste and has a processing capacity of 43,000 tonnes per annum. The facility consists of fourteen Bioferm batch dry fermenters coupled with a Celtic Bioenergy digestate composting and pasteurisation system.

The process generates 18,000 tonnes of compost which is sold for use on the Councils estate, and biogas which is exported to the adjacent landfill, where it is utilised by dedicated CHPs that export 1.4 MW electricity to the grid and provide 900 kilowatt (kW) of heat into the district heating system in Dunfermline.

Digestion in a dry AD plant can take place in an enclosed horizontal cylinder or concrete tunnels. It can either be a continuous plug flow process or a batch process. 'Garage' style digesters are similar in appearance and construction to concrete composting tunnels whereby batches of waste are placed in the tunnel by a front end loader and then the doors are closed to seal the vessel for batch processing. This modular approach provides a high degree of flexibility in scale and future expansion options. A minimum of four tunnels is usually required to allow the batch process to act as a pseudo-continuous process in terms of both waste loading and gas production.

Dry AD systems can operate at both mesophilic and thermophilic conditions, although more commonly operate in the higher temperature range, due to the higher solids content and greater heat production from microbial activity.

The digestate is usually in solid phase with the liquid retained in the process. A further phase of aerobic composting and maturation of the solid digestate will be required to fully stabilise the residues and make them suitable as a soil conditioner. The digestate can be composted on its own or co-composted with garden waste. This should be allowed for in the space and cost allocations for the project, or alternatively the digestate could be composted off-site. Some batch technologies, including most 'garage' style digesters, allow for a short aerobic phase at the end of the digestion cycle to commence the stabilisation phase, but additional maturation is still required outside of the digester.

Blue Line Biogenic CNG Facility, San Francisco

The project which opened in 2015, uses the SmartFerm dry AD technology which is a garage-style batch process, to treat around 10,000 tonnes of mixed food and garden waste each per year. The waste is digested in eight digesters for a period of 21 days under thermophilic conditions, with supplementary heating using waste heat from the generator. The biogas is upgraded into compressed natural gas (bio-CNG) which is equivalent to 450,000 litres of diesel and is used by the operator (Blue Line) to run 10 of their waste collection trucks. The digestate is converted into high quality compost.

4.2.3 Fermentation

Fermentation is an anaerobic process, similar to that used to brew beer, whereby organic materials are converted by enzymes and microbes, into various alcohols (primarily ethanol) which can then be used in liquid fuels, blended with petroleum fuels, or as an ingredient in the manufacture of other chemicals.

The feedstock is usually first prepared, for example through grinding, to release the cellulose (starch) before enzymes hydrolyse the cellulose and convert it to simple sugars (saccharification). Those sugars are then used as a substrate for fermentation by microbes to produce ethanol. The ethanol is then distilled off and refined into fuel grade quality.

The use of fermentation of high cellulose materials such as sugar cane, sorghum and corn starch is well established and the main source of bioethanol globally and in Australia (first generation biofuels). In those materials, the sugars are more abundant and accessible. Second generation ethanol technologies focus on using waste materials as feedstocks (rather than potential food crops). Some food processing residues with high sugar or starch content may be appropriate feedstocks for conventional fermentation.

New and emerging technologies are focusing on extracting sugars from the lignin present in woody organics for fermentation. Various methods can be used to liberate and extract the sugars from lignin including enzyme or acid hydrolysis, and steam heating. Once the sugars are liberated, the fermentation process can proceed as in conventional systems to produce ethanol.

This allows a wider range of materials to be used in fermentation including waste timber, paper and cardboard, forestry residues, straw, bagasse and other agricultural residues.

The leftover residue (stillage) after fermentation of organic waste could potentially be used as soil conditioner, with further processing and stabilisation. First generation fermentation processes using energy crops exist in Australia but fermentation of waste materials is still an emerging technology.

Section 5 focuses on the products and outputs of biological processing and their markets. Further technical detail on processing technologies is provided in section 6.

5 Products and residues from biological processing

5.1 Products

The viability of any organics recovery operation will depend on having and maintaining sustainable markets for the recycled organic and/or energy products recovered. In Victoria, the growth of the organics processing industry and the recovery of more organic waste has been limited by its ability to sell these products into viable and sustainable markets. The Government acknowledges this constraint and has developed the Market Development Strategy with recovered organics as one of its priority products.

It is important to note that any product from biological processing of organics must meet an appropriate specification in order to be classed as a 'Product', whether it is in accordance with AS4454 or another customer defined specification.

Products that may be derived from biological processing of organics can be separated into two broad groups: recycled organic products and bioenergy products, which are discussed in the subsequent sections:

Recycled organic products	Bioenergy products
› Mulches › Soil conditioners including various compost products, organic fertilisers › Blended products (e.g. soil mixes, potting mix, top dressing) › Liquid fertilisers	› Gaseous fuels (e.g. biogas, biomethane, CNG) › Liquid fuels (e.g. ethanol) › Energy (electricity and heat)

5.1.1 Recycled organic products

For potential users, the range of recycled organic products and terminology used, can be confusing and it can be difficult to tell low grade, poor products from high quality products. In the past, poor quality and inconsistent products have damaged the overall market reputation of recycled organics, including those from high quality processors.

In Australia, the industry standard Australian Standard for Composts, Soil Conditioners and Mulches (AS4454-2012) sets out measures to ensure a minimum level of quality assurance for producers of recycled organics.

While use of words like "compost" do not have a clear definition, AS4454-2012 does provide a product classification system based on maturity and particle size. There are three defined particle size classifications and three defined levels of maturity. The combination of these factors gives rise to nine different product categories.

AS4454-2012 Australian Standard for Composts, Soil Conditioners and Mulches

As4454-2012 is a voluntary industry standard for compost, soil conditioner and mulch products that provides a minimum level of quality assurance which certified products must meet. The aim is for products to be of a consistent quality, not contaminated by heavy metals, and free from plant and animal pathogens and plant propagules.

Certification to the standard is not mandatory and expensive to maintain. Many processors comply with the standard without being independently certified.

There are no government regulations that cover the definition and sale of these types of recycled organic products.

TABLE 7: AS4454-2012 PRODUCT CLASSIFICATION PARAMETERS

Particle size	Maturity
› Soil conditioner › Fine mulch › Coarse mulch	› Mature compost › Composted product › Pasteurised product
› Particle size is an indicator of how quickly a product will take effect when added to the soil. Small particle sized product (soil conditioner) will act more quickly than a product with large particle size (mulch).	› Maturity indicates the level of product stability, where a mature compost is the highest level. Mature products greatly reduce the risk of nitrogen drawdown in the soil and toxicity of the product to plants. In generally, the longer a product is composted or digested, the more stable or mature the product is.

While the Standard provides a classification system and specifies quality assurance requirements for products, it does not assist users in identifying a product that meets their particular needs or that will deliver the result they are seeking. The benefits of each product type are discussed below and potential markets are discussed in section 5.2.

AS4454-2012 is voluntary and while processors generally comply with the quality and pasteurisation standards, some choose not to seek independent certification to the standard, due to the costs and compliance burden of certification. Processors are recommended to contact SAI Global or other certification agency directly to obtain a current quote for the cost of certification as well as contact NATA-certified laboratories to understand costs associated with laboratory testing, as these costs are reducing over time.

Best practice operations will have documented and certified process and quality management systems. An AS4454-2012 or other accredited quality management system has advantages, ensuring consistent management of materials, management to avoid environmental risks and allowing new higher quality products to be developed and promoted to new markets.

Any product marketed as 'fertiliser' must comply with Victoria's Agricultural and Veterinary Chemicals (Control of Use) (Fertilisers) Regulations 2015 and Department of Economic Development, Jobs, Transport and Resources' (DEDJTR) A Guide to Victorian Fertiliser Regulations[18]. This includes products marketed as 'organic fertilisers'.

Agricultural and Veterinary Chemicals (Control of Use) (Fertilisers) Regulations 2015

These government regulations apply to any product marketed as 'fertiliser', including organic fertilisers.

Organic certification

There are no government regulations that cover these types of organic products; however, products marketed as 'organic' or for use by 'organic' growers may have certification under non-government standards, such as the *Biological Farmers of Australia's Australian Certified Organic* or the *NASAA Certified Organics* schemes.

18 http://agriculture.vic.gov.au/__data/assets/pdf_file/0010/321121/Guide-to-Victorian-Fertiliser-Regulations.pdf

Mulch

Image supplied by Van Schaik's bio gro Pty Ltd

Particle size

Mulch is a 'woody' product that has been chipped/shredded to a given size. Fine mulch typically has particle sizes less than 16mm, whereas coarse mulch particle sizes exceed 16mm. Both are applied to the surface of soil primarily for moisture conservation and weed control. The application of a surface mulch can reduce surface evaporation compared to exposed or bare soil surfaces by up to 70 per cent. Mulch provides other benefits including more stable soil surface temperature, reduced risk of soil surface frost and coarse mulch can help to reduce soil erosion.

Both fine and coarse mulch are used in urban landscaping, and coarse mulch has further applications in horticulture and forXerosion management.

Maturity

- Mulch comes in varying maturity qualities. Unpasteurised (or raw) mulch has not been processed beyond chipping/shredding to a given size and presents a higher risk of spreading weed, seeds, pests and plant pathogens (particularly if produced from garden waste).
- Pasteurised mulches are either fine or coarse mulches that have been through a 'hot' composting process to destroy weed, seeds and pathogens but do not meet stability requirements set out in AS4454-2012 (i.e. it is still too biologically active for safe use in sensitive applications). Pasteurised mulches can lead to nitrogen and other nutrient draw down, pH changes and toxic impacts on plants in sensitive uses.
- Composted/Mature composted mulches are either fine or coarse mulches that have undergone controlled composting to meet stabilisation requirements for use in sensitive uses as set out in AS4454-2012. They can last up to three times longer in surface applications than pasteurised mulches.

Availability and price

Mulch is widely available and relatively low cost. Purchasing pasteurised or composted mulch is recommended; these products are more difficult to source as many producers do not further process the mulch beyond chipping/shredding to a given size.

Soil conditioners

What is a 'soil conditioner'?

The term soil conditioner (also termed soil amendment or soil improver) can be applied to any product designed to improve/amend the condition of a soil. Soil conditioners include compost, organic fertilisers and stabilised digestate from AD, as well as manure, lime, gypsum and inorganic fertilisers.

"Soil conditioner" is a broad term and soil conditioning products come under many names and guises. It can be very difficult for users to tell these products apart, or their respective uses and benefits.

Soil conditioner is any product designed to improve/amend the condition of a soil but the term provides no detail around which parameters of soil health will be impacted and how.

Compost

Compost is an organic product that has undergone controlled aerobic and thermophilic biological transformation through the composting process to achieve pasteurisation and reduce phytotoxic compounds, and achieve a specified level of maturity required for compost. Under AS4454-2012, compost is a soil conditioner of fine particle size, with typically less than 20 per cent of particles exceeding 16mm. It must meet stability requirements set out in AS4454-2012. Compost can be applied as a topdressing or dug into soils to provide biological, chemical and physical benefits to soils, including:

- Improved soil structure, drainage and water retention
- Moderation of soil pH
- Supply of organic nutrients
- Increased organic matter and beneficial soil biology

Composted or mature composted soil conditioner products have a greatly reduced risk of plant toxicity and nitrogen drawdown in the soil compared to pasteurised or un-stabilised soil conditioners.

For advice on the use and application rates of recycled organic products in agriculture including compost, the advice of an agronomist may be required for specific applications.

Digestate

Digestate comprises the remaining solids and liquid from AD processes. The quality of the digestate is dependent on the composition and quality of the feedstock used. AD typically does not decompose organics to the same extent that aerobic processing does, so digestate may require further stabilisation or maturation prior to use. For solid digestate, this is usually achieved by processing through an aerobic composting phase either on its own, or blended with garden waste. Liquid digestate may be applied to land as a fertiliser as discussed below.

Stabilised solid digestate is typically nutrient rich and may be suitable as a soil conditioned for agricultural markets, subject to appropriate quality and contamination management. Being rich in nutrients, digestate has other possible markets that are the subject of current research and trials, such as a feedstock to vermicomposting or as a food source for larvae/insects in the production of protein for animal feed.

It is important that appropriate steps are taken to ensure that the digestate is suitable for further use – this should include a thorough sampling regime and laboratory testing to ensure it will not cause any adverse impacts to land or water. Users of digestate are recommend to seek advice from the EPA regarding digestate applications and limitations.

Liquid and organic fertilisers

Liquid fertilisers can be made by leaching nutrients from worm castings or compost into water, or from the liquors / liquid digestate of an AD process. They tend to be rich in nutrients and can also boost soil biology.

Organic fertilisers can be produced from compost products or stabilised digestates blended with other materials to achieve more balanced nutrient ratios (N:P:K) compared with conventional composts.

Any product marketed as 'fertiliser' must comply with Victoria's Agricultural and Veterinary Chemicals (Control of Use) (Fertilisers) Regulations 2015 and DEDJTR's A Guide to Victorian Fertiliser Regulations[19]. Although it is noted that these regulations do not address all of the contaminants of concern that may be present in fertilisers from organics processing.

For advice on the use/application of liquid and organic fertilisers, engagement of an agronomist may be required for specific agricultural applications.

Blended products

Most organics processors sell recycled organics in a range of blended products, or sell to landscape suppliers that produce blended products.

Blended products include soil mixed with compost, organic fertiliser or manure to produce a manufactured topsoil or growing media (potting mix), as well as compost with added gypsum and marketed as 'clay breaker'. Where soils are recovered from urban sources or current or former farmland, soil testing protocols should be in place to ensure that contaminated soils are not used in products. Soils should comply with Australian Standards AS4419-2003 Soils for Landscaping and Garden use and potting mixes with AS3747-2003 Potting Mixes.

For agricultural purposes, composts are often also mixed with inorganic fertilisers to provide a complete product to farmers: improving soil health (i.e. soil structure, soil biology and soil organic matter) and providing balanced nutrients for maximum crop yield.

Additives such as fertilisers, coal dust, gypsum, wetting agents and water holding substances may be added to products to improve performance and appearance. The provenance of all additives should be recorded in batch records within a quality management system, to allow any issues with processes or product quality to be traced back to source.

Biochar

Biochar is a charcoal-like material that can be used as a soil conditioner and may compete with other recycled organic products. It is produced via some form of pyrolysis process rather than biological processing, from various organic feedstocks (mostly woody materials, but also dried biosolids and other organics). Pyrolysis and other thermal processing technologies are discussed in the *Resource Recovery Technology Guide*.

There has been significant interest in, and a considerable body of research undertaken, on biochar in Australia and its soil health and carbon sequestration benefits. To date however, the markets for this product have not materialised and commercial production is limited to small niche facilities. There is no accepted general specification for biochar products and it is important that producers take steps to demonstrate the product is fit-for-purpose for its intended use and will not cause adverse impacts to land or water. Producers of biochar are advised to seek EPA guidance on appropriate applications and specifications.

19 http://agriculture.vic.gov.au/__data/assets/pdf_file/0010/321121/Guide-to-Victorian-Fertiliser-Regulations.pdf

5.1.2 Bioenergy products

Anaerobic processes can produce a range of energy products including biogas from AD and its secondary energy products, or ethanol from fermentation processes. There is also potential to produce solid refuse derived fuel (RDF) from the residues of organics processing.

Biogas and biomethane

AD of organics produces biogas which is comprised of around 50–60 per cent methane (CH_4) and the remainder is mostly carbon dioxide (CO_2) plus some trace components. This biogas has a high energy content and is most commonly used to generate electricity, as discussed below.

Biogas can potentially be used directly as a gaseous fuel source in kilns and industrial furnaces, substituting for natural gas. This is unusual because it is rare for a suitable industrial user to be located in close proximity to an AD plant, but nevertheless should be considered if there are high gas consuming industries nearby.

Biogas may also be upgraded and purified to produce biomethane which is typically more than 95 per cent methane and can be used as a direct substitute for natural gas. Biomethane can potentially replace natural gas in the gas grid, as a direct substitute fuel in industrial settings or it can be compressed to vehicle fuel as either compressed natural gas (CNG) or liquid natural gas (LNG).

Biomethane is upgraded through various cleaning and compression processes which are usually available as compact modular, skid-mounted units. The technology is generally simple and well proven overseas. The carbon dioxide is released to atmosphere or can be captured for reuse (e.g. to boost greenhouse horticulture production). Water based processes may produce a wastewater stream that requires appropriate management.

The final product standard will depend on the end use of the gas but for applications in which it will replace natural gas in the general market (e.g. injection in the grid or vehicle fuel), the principal quality specification is Australian Standard AS 4564 – specification for general purpose natural gas, which sets the parameters for both injection into the gas reticulation network and for use in vehicle fuels.

The production of biomethane by upgrading biogas is well established in Europe but yet to be implemented in Australia. Across Europe, in 2013 there were 282 plants producing a total of 1.3 billion m^3 of biomethane. Of that, approximately 10 per cent was used as transport fuel and the number of biomethane filling stations is rapidly growing[20].

Electricity

Electricity can be generated from the direct combustion of biogas in a gas engine generator or other power generation technology (e.g. micro-turbines, fuel cells, etc). As a general rule, around 600m^3 of biogas (at 50 per cent methane) will produce 1MWh electric output.

The technologies to convert biogas into electricity and to control power quality are well established and readily available in Australia. There are numerous reference plants operating on biogas, primarily at wastewater treatment plants digesting biosolids.

Heat

Gas engine generators typically waste around 60–65 per cent of incoming energy content as heat. That waste heat can be captured from a gas engine generator and utilised, known as co-generation (electricity + heat). Most commonly, heat is utilised on-site to heat digester vessels, particularly if the plant is operating in thermophilic range (see 4.2). Heat can be captured and used in the form of hot water or steam and can increase the total energy recovery efficiency of a co-generation system to up to 85 per cent.

Ethanol

Ethanol may be produced from fermentation processes as discussed in 4.2.3. Ethanol is often used in blended 'bio-fuel' for motor vehicles such as E10, a blend of 10 per cent bio-ethanol and 90 per cent petrol. The Australian Fuel Quality Standards Act 2000 include standards for fuel quality and fuel information (labelling) for E10 and other products for optimum vehicle and environmental performance and labelling at the point of sale.

Refused-derived fuel (RDF)

Refused-derived fuel (RDF) is a broad term referring to solid fuels produced from highly calorific waste materials. There is no quality standard for RDF and quality is generally specified by the end customer.

In the context of biological organics processing, RDF may be produced from the residues of processing: oversize timber or woody material, or light materials including plastics removed from products. Organics separated from mixed waste will be particularly high in plastics so may give rise a highly calorific light fraction in the final product refining stage.

RDF may be either in loose form or compressed into briquettes and pellets. Refer to the Resource Recovery Technology Guide for further discussion of RDF processing, quality standards and applications.

20 http://www.biofuelstp.eu/biogas.html

5.2 Markets for products recovered from organic waste

The Victorian Government actively supports market development for products recovered from organic waste. SV's Organics Strategy includes market development priorities to help create strong and sustainable end-markets for recycled organic products by:

- working with industry to develop standard quality assurance processes and standards for recycled organic products
- providing industry with information that enables them to produce higher quality products for markets through the development of product profiles/specifications
- working with end-markets to understand/demonstrate the benefits of using organic products, and
- identifying the barriers to increasing the growth of markets for recycled organic products and work with others to develop the right conditions for markets to grow and mature.

The Market Development Strategy also highlights recovered organics as a priority material.

As the viability of any organics recovery operation will depend on sustainable markets for recycled organic and/or energy products, the following aspects are key to developing markets:

Aspect	Description
Product quality and consistency	Products must consistently meet the customers' needs. Markets and client relationships can be developed by understanding customer needs and developing guidance and product specifications for specific applications.
Product availability	Products must be available when the market needs them. For example, peaks in demand for recovered organics products may not align with seasonal production cycles. Operators should consider the timing of market demand cycles and develop production schedules and product storage to meet demand. This will help producers anticipate demand and may help identify new product and market opportunities that best match seasonal production.
Product price	Products must be available at a price that matches market expectations and perceptions of value. Operators should identify and monitor production costs and adopt continual improvement programs to increase productivity to ensure market price expectations can be met.
Market awareness of and demand for products	Customers (and potential future customers) need to know about the benefits and availability of products. Market development needs to be a joint effort of government and industry and operators should allocate budget for product and market development and marketing of products.

5.2.1 Markets for recycled organic products

The primary established end-market for composts, mulch and other soil improvers is the urban amenity market including landscaping, parks, commercial projects and home gardens. This market accounts for as much as three quarters of the Victorian recycled organics product market, according to research by SV in 2013[21].

Horticulture, viticulture, and broad-acre farming are emerging markets with good potential, based on the sheer land area dedicated to these primary industries. To date, these markets have been largely constrained in tier use of recovered organics due to transport cost from the point of most product manufacture (metropolitan fringe areas) to agricultural markets, as well as concerns over product quality assurance.

Land rehabilitation and bioremediation provide limited, low value markets for low quality products and are unlikely to take up significant volumes of material.

21 Recycled Organics Market Analysis, (SV, 2013) is available here: http://www.sustainability.vic.gov.au/About-Us/Publications/Recycled-Organics-Market-Analysis

The potential market sectors for recycled organics are presented below:

TABLE 8: SUMMARY OF RECYCLED ORGANIC PRODUCTS MARKETS IN VICTORIA

Market sector	Current market size	Detail
Urban amenity	73%	This market consists of home garden supplies/retail nurseries, recreational surface establishment and maintenance, commercial landscaping projects and local and state government projects, and is typically strong for blended soil/compost mixes and clean fine mulches.
Intensive agriculture	9%	Intensive agriculture includes viticulture, vegetable production, fruit and orchards, turf production, nursery production and wholesaling. Horticulture includes intensive food and flower production. This market can use soil conditioners such as compost and organic fertiliser, blended growing media, and mulch products in some applications. In 2016, a change to the Freshcare code of practice for food safety and quality[23] means pasteurised and composted products can be used on fruit and vegetables grown for supermarkets. Winegrape growing demands water conservation and weed control mulches and is a market for clean pasteurised and composted coarse mulches.
Extensive agriculture		Extensive agriculture includes pasture production (livestock including sheep, beef and dairy), broadacre cropping and forestry. This is an emerging market and mainly needs soil conditioners such as compost and organic fertilisers. The primary constraint is the distance from production to market, with transport adding significant cost. There are also barriers around customer perceptions of product quality and fitness-for-purpose.
Land rehabilitation	10%	Landfill and mine site rehabilitation and erosion stabilisation. This is a low value market with low quality expectations and limited willingness to pay, and is often an outlet for excess product rather than a viable market.
Bioremediation		Bioremediation for contaminated sites and biofiltration. This market is niche and uses limited quantities so is not generally a sustainable market.
Other	8%	Unidentified markets

22 https://www.freshcare.com.au/standards/food-safety-quality/

5.2.2 Markets for bioenergy

There are a number of challenges associated with accessing markets for bioenergy products that have constrained the demand to date.

Biogas and biomethane

There are broadly four potential outlets for biogas and biomethane, each with particular constraints:

Market	Constraints
Direct-to-customer	While it is possible to directly use biogas or biomethane as a fuel in industrial boilers, substituting for natural gas, direct-to-customer supply is reliant on the customer being in close proximity to the gas generation site (within viable pipeline connection distance). For financial security to justify investment in a pipeline, the customer needs to be a regular gas user that is willing to enter into a long term commercial agreement. Additionally, the ideal customer's demand profile is steady and matched to production as there is no economical way to store large volumes of biomethane. In reality, such customers are rarely available. There are reference projects in Australia, for the supply of biogas from landfills: the supply of landfill gas directly to brick kilns (Veolia's Horsley Park landfill in western Sydney) or the historic supply of landfill gas from the Remondis Swanbank landfill in Ipswich to supplement the Swanbank Power Station (no longer operating). **Main challenge: finding a suitable customer in close proximity to the site**
Pipeline injection	Gas injection into the reticulation main is becoming popular in the UK and Europe, partly due to favourable incentives that recognise gas from renewable sources and regulations, including a relaxation in gas quality standards for biogas. In most of those projects, the biogas is sourced from AD facilities processing organic wastes. So, while the technology exists and is proven, this application is yet to be implemented in Australia and has not been tested with regulatory authorities and gas pipe network operators. Rising gas prices and domestic gas shortages could make this option commercially attractive. **Main challenge: untested application and market**
Vehicle fuel	Upgraded biomethane can be further compressed or liquefied to produce a vehicle fuel equivalent to liquefied natural gas (LNG) or compressed natural gas (CNG). LNG production is energy intensive to produce and store, expensive at the small scales and has limited market in Australia. CNG can be produced using relatively simple equipment to compress gas to the required pressure, typically around 200 bar or more. One cubic metre of biogas (at normal conditions) produces around 0.45-0.50 litres of diesel-equivalent CNG fuel. CNG fuel provides a number of environmental benefits over diesel: significantly lower particulate matter (PM) emissions; nitrogen oxide (NOx) emissions compliant with latest European standards without catalytic reduction and naturally quieter engines. Net greenhouse emissions are near zero. CNG is becoming very common as an alternative and more efficient fuel for heavy vehicles in the US and Europe, including freight trucks and waste collection vehicles, and there are a significant number of projects using 'bio-CNG' sourced from AD plants, often to fuel waste collection fleets. In Australia, CNG is commonly used in urban bus fleets but broader uptake in the heavy transport industry has been slow and is being hampered by fears over rising natural gas prices. Market demand for 'bio-CNG' may increase but at present, remains relatively untested. **Main challenge: limited uptake of CNG of LNG in the broader transport market meaning that producers would likely need to utilise the fuel in their own fleets.**

Electricity

The market for electricity is well established in eastern Australia via the National Electricity Market but access to this market is not always easy for small scale projects such as AD. For electricity from biogas in the broader electricity market, the main competing electricity sources are fossil fuels (coal, gas, liquid fuels) and renewables (wind, solar, hydro).

Electricity can be sold either into the National Electricity Market (export to the grid) or directly to local electricity users, including internal/on-site use. All electricity generated from biogas is renewable and eligible to receive Renewable Energy Certificates under the national Renewable Energy Target.

Market	Constraints
On-site use	To date, the most successful projects utilising electricity from biogas have been co-located at sewage treatment facilities and the electricity has been used by the treatment plant (internal customer). Generally, using power internally and offsetting the consumption of retail grid power is far more financially beneficial than selling power into the grid at the wholesale price. However, in order to use the electricity generated internally, the site needs to have a consistent, stable demand that is matched to or greater than the electricity produced from biogas. **Main challenge: co-locating plant with an existing consistent power consuming operation**
Direct-to-customer	Every industry/business in Australia uses electricity in some capacity or another. It is possible to supply electricity directly to customers within close proximity to the electricity generation site. A review of potential adjacent customers would be required to firm up the feasibility of providing to one or more third party users, noting that providing energy directly to a private customer is subject to a number of risks, including the reliance on those customers for the long-term and the potential high capital cost and regulatory burden to establish the private network. An ideal customer or mix of customers will have consistent demand for power, long-term stability, and be in close proximity to the generating site. **Main challenge: finding reliable, stable users in close proximity to the site**
Export to National Electricity Grid	The option to export to the grid is also commonly applied as it can be implemented in most locations and provides a highly secure and reliable outlet. However, average wholesale power prices tend to be low and unpredictable. Power purchase agreements (PPA) are one option to provide long-term security of revenue but are difficult to secure, particularly for small scale projects. The cost of the grid connection and any upgrades which might be required must also be factored in and can be prohibitively expensive in some cases. **Main challenges: low and unpredictable wholesale power prices, high costs to connect to the grid.**

Heat

Waste heat produced from biogas is often used on-site in AD plants to meet internal heating demands of the AD process itself.

The sale of heat direct-to-customer is a limited option given the need for proximity to the heat demand and high cost of installing a hot water reticulation network. Heat could potentially be used for heating, cooling, drying or additional power generation purposes. Examples include:

- Heat – Greenhouses and intensive agriculture (e.g. pig farms)
- Cooling – Food cold storage
- Drying – Enhanced drying of biosolids at sewage plants, or drying woodchips and sawdust for fuel pellets
- Energy generation – Rankine Cycle generators to convert heat into mechanical energy and subsequently into electricity.

There are no general quality specifications for heat, with the end-user requirements the sole driver.

Ethanol

Bio-ethanol is most commonly used as a blended 'bio-fuel' for motor vehicles; E10 (10 per cent ethanol blend) is commonly available at various petrol stations around the state. This market is established in Victoria, despite the absence of a government mandate on use of bio-fuels which other states have in place. Most cars can use E10 fuel without modification. E85 fuel (85 per cent ethanol) has not been widely accepted due to vehicle requirements to use this type of fuel and the significant increase in fuel consumption.

Residues

5.2.3 Control and disposal of contamination and quarantined materials

As noted in section 3.3, each facility should have defined acceptance criteria and associated procedures for inspecting incoming waste and rejecting loads as needed. In most situations, unacceptable wastes or highly contaminated loads should be detected at the weighbridge and rejected in accordance with site procedures. Such procedures and clearly defined acceptance criteria are a vital component of a best practice operation.

There should also be inspection procedures in place for the waste reception and tipping areas to identify unacceptable materials as they are tipped. In the event that a load of unacceptable material is deposited at the facility and not detected in time for rejection, or discrete unacceptable items are detected within a larger load, there should be a procedure in place to separate the affected waste and move it to a defined quarantine area within the waste reception area. This will stop it being inadvertently processed while remedial action can be taken.

In the quarantine area, the load can be further assessed to determine the source of the load and most appropriate management option. In some cases, it may be safe and appropriate to remove discrete offending materials (for example, bags of rubbish in an otherwise clean load). If the load cannot be safely decontaminated and made safe for processing, the entire load should be loaded out as soon as practicable for external disposal to an appropriate landfill.

If a load is quarantined because it contains hazardous material such as asbestos or chemicals, additional isolation measures may be required to protect the safety of staff.

All quarantine and rejection events and subsequent actions should be documented through an established process.

5.2.4 Control and disposal of process residues

Almost all biological processing systems will generate a residue or residual waste stream – unwanted materials which have no beneficial use and need to be appropriately disposed or otherwise treated. As such, very few facilities achieve 100 per cent recovery performance. The exception will be facilities that only process clean single-stream organics such as biosolids, agricultural organics, or manufacturing organics.

The volume of process residues as a proportion of plant throughput will vary and is a function of the contamination levels present in the feedstock, but also the required product quality.

Contamination levels in source separated feedstocks vary and section 3.1 provides a discussion about the key factors which influence contamination rates. Additionally, if a facility accepts PIW organics as feedstock this may affect the categorisation of the process residues under the Environment Protection (Industrial Waste Resource) Regulations 2009 (IWR Regulations).

Contamination levels in organics derived from mixed residual waste also vary but tend to be high, resulting in a high proportion of residues from the biological processing.

It is important to note that the proportion of residues may not match the analysis of feedstock quality. For example, if an audit of a source separated municipal organics feedstock stream identifies that 2 per cent is 'contamination', it does not necessarily follow that 2 per cent of the process throughput will be extracted as a residual stream. Some of those contaminant materials will remain in the product stream. Conversely, the residual stream will likely contain some of the product material.

The extent of product refinement, which is a function of the required product quality, also determines the production of residues. Generally, the more refinement that is applied (screening to smaller particle size, removal light plastics or glass), the more residues are produced.

6 Key technical parameters of biological processing solutions

This section provides additional detail on key parameters and considerations to assist in the selection of an appropriate organics biological processing solution. Table 14 presents a comparison of the different technologies with respect to each of the key parameters set out in this section.

6.1 Matching processes with feedstock to produce identified products

Section 4 provides a discussion of each technology and the feedstocks which are typically suitable for each, as summarised in Table 5 in that section.

The selection of a biological processing technology is a function of many factors as summarised in Table 9 below, although this section focuses on suitability to available feedstocks and desired products.

TABLE 9: SUMMARY OF KEY FACTORS IN TECHNOLOGY SELECTION

Factor	Description
Feedstock volume	› some technologies require a minimum throughput to be commercially viable and operate efficiently › some technologies are best suited to small scale applications
Feedstock quality	› specific materials within the feedstock and their characteristics (e.g. odour potential, moisture content, lignin content, nutrient content) › chemical and physical contaminants › level of pathogens › variability of the above factors › capacity to blend feedstocks to achieve required quality
Desired end-products	› products that have secure markets / outlets › product quality requirements and customer expectations
Location of the processing plant	› proximity to sensitive receptors and environments › proximity to outlets for products and by-products › proximity to energy infrastructure
Site characteristics	› footprint requirements, as a function of capacity, vary for each technology
Regulatory constraints	› licence conditions › general guidance, such as EPA's composting guidelines and Victorian Planning Provisions (VPP) › environmental impact mitigation
Commercial factors	› gate fees that can be attained for the available feedstocks › expected revenues for products (including energy) › capital and operating costs of each technology

In general, the following principles can be applied in matching feedstocks and desired products to technology selection:

- Feedstocks which are low risk in terms of their potential environmental impacts (garden waste, waste timber, forestry residues) can be processed through lower technology, lower cost methods such as open windrow composting
- Feedstocks which present a higher risk of potential impacts (including odour generation and vermin attraction) are likely to require a processing system that provides a higher degree of process control and containment
- Feedstocks which have a high moisture content or are in liquid or slurry form, can be processed through aerobic systems by blending with adequate dry materials, but should also be considered for AD applications
- If energy recovery is a primary objective and there are outlets for specific energy products, then anaerobic processes should be assessed (digestion or fermentation)
- For anaerobic systems, the characteristics of the feedstocks will determine the most appropriate process.

Clearly, commercial considerations will prevail in technology selection and it is essential that projects are financially robust and sustainable. The revenues that can be attained from gate fees and product sales (including energy) must be sufficient to cover the capital and operating costs, and still provide a reasonable commercial margin for the operator.

6.2 Scale of processing solutions and their scalability

Each technology has a particular scale range (typically defined by the throughput of feedstock in tonnes per annum) within which it operates efficiently and is more likely to be commercially viable. For most biological processing technologies, that range is quite broad. It may include small-scale systems which are suitable for implementation in rural communities, on farms, or on-site in commercial precincts or industrial manufacturing facilities. Some technologies can be applied at much larger scale, processing a range of organics from one or more council areas and many technologies are modular in nature providing an opportunity to expand capacity as demand increases.

Generally, as the scale of a processing facility increases, the unit processing costs decrease due to efficiencies and a larger base over which to spread fixed and capital costs. Larger facilities also tend to be able to justify investment in more automated equipment and more advanced feedstock preparation and product refining systems.

On the other hand, smaller scale systems provide an opportunity to process waste close to its source of generation and reduce waste transportation costs and impacts.

TABLE 10: SUMMARY OF TECHNOLOGY SCALES AND SCALABILITY

Technology	Typical scale / context	Scalability
Open windrow composting	Broad range of scales, usually limited by large footprint requirements and the need to meet separation distances between composting facility and nearby sensitive land uses 2,000 – 50,000 tpa	Tolerant of fluctuations, relatively easy to expand capacity subject to land availability and capacity of core equipment (shredder, turner, screens)
Aerated static pile composting	Broad range of scales, modular system, can be used to increase capacity of existing open windrow operations 2,000 – 50,000 tpa	Tolerant of fluctuations, modular and easy to expand capacity with additional blower / pipe sets, subject to land availability and capacity of other core equipment (shredder, screens), also subject to land availability and the need to meet separation distances between composting facility and nearby sensitive land uses
In-vessel composting	Minimum scale to justify higher capital investment, more intensive / space efficient process than windrows, 10,000 – 100,000 tpa	Some tolerance of fluctuations, some systems are modular (e.g. tunnels) and easy to expand, less so for building enclosed systems, constrained by capacity of core equipment and residence time in IVC process, may also be constrained by need to meet separation distances between composting facility and nearby sensitive land uses – particularly for on-site maturation of pasteurised products
Vermicomposting	Typically small scale due to large footprint and labour requirements, 100 – 5,000 tpa	Less able to respond to fluctuations, scalable with addition of extra beds, subject to land availability
Wet anaerobic digestion	Broad range of scales, but long residence times require large vessels / footprint 10,000 – 50,000 tpa	Less tolerant to fluctuations, scalable with addition of extra digestion tanks, subject to land availability. Power generation and gas upgrading systems are generally modular and expandable.
Dry anaerobic digestion	Broad range of scales, minimum scale to justify higher capital investment 20,000 – 80,000 tpa	Some tolerance to fluctuations, mostly modular systems that can be expanded, subject to land availability including for digestate stabilisation
Fermentation	Likely range of scales but commercial facilities yet to be demonstrated, minimum scale to justify higher capital investment 20,000 – 50,000 tpa	Less tolerant to fluctuations, potentially scalable with addition of extra hydrolysis and fermentation vessels

6.3 Land and site requirements

EPA Victoria's guideline on Designing, constructing and operating composting facilities[23] (Publication 1588.1, 2017) provides a thorough overview of the land and site requirements for composting facilities and is a useful reference guide for other organics recovery technologies (i.e. AD, fermentation).

A brief discussion on site selection, facility footprint and layout considerations is given below.

6.3.1 Site Selection

The selection of a suitable site for biological processing of organics should consider a number of factors including:

- Required capacity and footprint – discussed further in section 6.3.2
- Proximity to feedstock sources and product markets
- Access and transport links
- Inclusion in hubs of state significance as identified in the state wide plan
- Inclusion in infrastructure planning through Regional Waste and Resource Recovery Implementation Plans
- Appropriate zoning in local planning schemes (see section 7.5) Proximity to sensitive receptors, particularly residential properties and other areas regularly occupied by people
- Prevailing wind directions relative to sensitive receptors
- Level of engagement with the local community (e.g. neighbouring residents, council)
- Proximity to surface waters – leachate and contaminated runoff from open processing and waste storage areas could contaminate sensitive surface waters
- Groundwater conditions – sites with high water tables or in groundwater recharge areas should be avoided or may require additional engineering controls
- Avoiding potential sites or areas within sites that contain sensitive flora, fauna or ecological habitats protected by State or Federal legislation. Removal of particular grasses, trees, groundcover or indeed, site clearance could trigger the need for environmental approvals or costly mitigation measures
- Bush fire risks and zoning
- Aboriginal and cultural heritage value or significance
- Access to power, water supply (for process, wash down and fire-fighting purposes) and sewer connection (if required)
- Appropriate buffers between the site or core processing operations, and sensitive receptors, which are protected from future incompatible development. Ideally, buffers will be within the site boundary but external buffers may be used if they are protected from future development (e.g. easements, reserves, agricultural land). EPA Victoria provides guidance on determining appropriate separation distances based on risk which is a function of the feedstocks, plant capacity and processing technology[24]
- Site terrain – a mostly flat site will minimise site works but a gently sloping site can be beneficial in managing stormwater and leachate flows. It should also be noted that odours have a tendency to move downhill (being heavier than air) so consideration should be given to land uses downhill of a sloping site.

6.3.2 Plant footprint

Any assessment of land requirements and site layout for a biological processing facility needs to take into account space required for:

- Entry and exit roads for waste and product trucks, and weighbridge(s) with sufficient queuing space
- Internal roads for movement of plant and vehicles with adequate turning areas and separation of small / large vehicles
- Waste reception and storage, including facilities for liquids if they will be accepted – this area may need to be enclosed for odourous feedstock
- Feedstock preparation – inspection, shredding, screening plus stockpiling of prepared feedstock
- Primary biological treatment process (either aerobic or anaerobic)
- Secondary stabilisation / maturation process (aerobic)
- Final product screening, refining, packaging / bagging, storage and loading out facilities
- For AD only – digestate and gas storage, biogas refining and/or utilisation plant and associated energy infrastructure
- Biofilters, scrubbers or other odour control and ventilation equipment (if required)
- Leachate storage (ponds / tanks), leachate treatment systems (if required), 'clean' stormwater drainage / treatment
- Staff car-parking, welfare facilities (bathrooms, showers and washing facilities, lunchroom) and administration offices
- Internal buffers between core processing operations and sensitive receptors, where external buffers are not available or not protected from future development (see above).

Table 11 presents the approximate footprint requirements for each technology as a function of plant capacity and for typical scale facilities.

TABLE 11: FOOTPRINT REQUIREMENTS FOR DIFFERENT ORGANICS RECOVERY TECHNOLOGIES

Technology	Footprint per annual processing capacity (m^2 per tpa)
Open windrow composting	0.7 – 0.8 m^2 / tpa
Aerated static pile composting	0.5 – 0.6 m^2 / tpa
In-vessel composting	0.4 – 0.7 m^2 / tpa
Vermicomposting	1.0 – 2.0 m^2 / tpa
Wet anaerobic digestion	0.2 – 0.4 m^2 / tpa
Dry anaerobic digestion	0.4 – 0.7 m^2 / tpa
Fermentation	Unknown, due to few commercial references – likely similar to wet AD

23 http://www.epa.vic.gov.au/our-work/publications/publication/2017/june/1588-1

24 EPA Victoria Publication 1588.1 - Designing, constructing and operating composting facilities (June 2017), http://www.epa.vic.gov.au/~/media/Publications/ATTMX3PQ.pdf EPA Victoria Publication 1518 - Recommended Separation Distances for Industrial Residual Air Emissions Publication (March 2013), http://www.epa.vic.gov.au/~/media/Publications/1518.pdf

6.3.3 Layout Considerations

The following additional factors should be considered in determining the most appropriate layout for the site, which may further impact on the total site footprint requirements:

- Allow for separation of small and heavy vehicle traffic and separate defined pedestrian walkways around the site
- Consider one-way traffic flows to minimise potential for collisions
- Separation of customer access areas from processing operations
- Make use of the natural site features and topography to minimise earthworks, visual impact, noise impact and to optimise efficiency of material flows through the site
- Consider location of sensitive receptors and prevailing wind direction at the site when placing higher odour potential activities (waste reception, initial processing phases)
- Consider natural water flow paths in designing and locating stormwater and leachate drainage and storage facilities

SV's Better Practice Guide for Resource Recovery Centres[25] provides advice on access, traffic flows and signage which could be applied to organics recovery facilities.

6.4 Costs

This section provides indicative information on approximate costs to assist in a preliminary comparison of technologies. It is based on an assessment of public information which tends to be limited given the commercially sensitive nature of the data. For technologies which are new to the Australian market or limited, such as dry AD, there is a higher degree of uncertainty in costs.

The information below should be taken as indicative only and actual costs will depend on site and project specific factors. For each cost factor, a range is presented reflecting the range of variables that impact on cost. In particular, plant scale is a major driver of cost and larger scale plants can be expected to achieve lower range costs, and vice-versa.

6.4.1 Capital expenditure

The capital expenditure on a new biological processing facility needs to take into consideration the full range of costs to develop an operational facility, most of which are set out below.

- Land acquisition
- Environment and planning approvals (e.g. could total more than $500,000 for a large scale, high tech proposal)
- Costs of compliance – including monitoring of environmental effects to ensure that licence conditions are not breached, providing training to employees, upgrading equipment to conform to standards
- Financing costs
- Financial costs – maintaining financial assurance or guarantees required through EPA licensing or waste processing contractual arrangements
- Design – process, civil and drainage, structural, electrical and services
- Site works including demolition and clearance, excavation, ground preparation and stabilisation, and contamination management
- Civil works, foundations, hardstand areas, stormwater management
- Buildings
- Process vessels, plant, and equipment (including leachate and odour control)
- Ancillary services and connections to the site including network upgrades that may be required and paid for by the proponent, e.g. water supply, sewer connections, power supply and export transmission (if exporting energy to the grid)
- Internal roads, weighbridge(s), security measures, car-parking
- Landscaping and screening of buffers
- Commissioning and testing, including first-fill consumables (e.g. seed sludge for AD systems)

For some projects, savings can be made by co-locating the facility on an existing waste site and sharing existing infrastructure (road, weighbridges and services).

Table 12 provides an overview of typical capital costs, presented based on the annual processing capacity of the plant. It is possible that projects will fall outside the ranges presented below due to project specific factors.

25 http://www.sustainability.vic.gov.au/About-Us/Publications/Better-practice-resource-recovery-centres

TABLE 12: SUMMARY OF TYPICAL CAPITAL COSTS

Technology	Indicative capital cost[27]
Open windrow composting	$3M
Aerated static pile composting	No cover: $4M Textile cover: $7M
In-vessel composting	$9.6M
Vermicomposting	No data, due to lack of commercial references
Wet anaerobic digestion	$12M
Dry anaerobic digestion	$15M
Fermentation	No data, due to lack of commercial references

26 Indicative capital cost in 2017 for a 30,000 tpa capacity facility

6.4.2 Operating costs

The operating costs for biological processing vary depending on a range of factors including the feedstocks processed and the degree of automation installed. Key elements include labour, fuel, plant maintenance, leasing costs, overheads and management, chemicals and consumables. The long-term budget should also allow for major refurbishment or replacement of key equipment which may reach the end of its life within the project lifespan.

The typical ranges presented in Table 13 are indicative only and some facilities will fall outside these ranges. Again, scale of the operation is a major factor and larger scale plants can achieve lower unit operating costs. The costs are presented as per tonne processed. They do not include overheads and profit margins (for outsourced operations).

TABLE 13: SUMMARY OF TYPICAL INDICATIVE OPERATING COSTS

Technology	Indicative net operating cost[28]	Main factors affecting operating costs
Open windrow composting	$	Labour intensive, high fuel consumption and maintenance for mobile plant
Aerated static pile composting	No cover: $ Textile cover: $$	Labour intensive, power consumption, fuel consumption for mobile plant
In-vessel composting	$$$	Power consumption, odour control, maintenance
Vermicomposting	No data	Labour intensive, small scale
Wet anaerobic digestion	$$	Varies, labour input depends on technology and stabilisation of digestate
Dry anaerobic digestion	$$$	Labour input depends on technology, stabilisation of digestate can be labour and energy intensive
Fermentation	No data	Likely to depend on feedstock and pre-processing, stabilisation of stillage

27 Scale for indicative net operating costs in 2017 - $ = $20 to $35 per t, $$ = $35 to $50 per t, $$$ = greater than $50 per t

6.4.3 Contingencies and cost issues to consider

In addition to the indicative capex and opex costs for the different processing options provided above, contingencies should be allowed for and there are a few additional cost issues worth considering for an organics recovery facility:

- Due diligence assessments to be undertaken on land purchases. These are required to assess potential liabilities such as the level of existing land contamination. Land remediation costs can be significant.
- Costs associated with feasibility studies and associated approvals for research and development.
- Additional design controls such as odour control equipment, which may need upgrading during the project life.
- Costs associated with piling/cutting piles through rock by blasting or piling e.g. sites in western Melbourne which can feature volcanic basalt.
- Costs of quality assurance – including the cost of establishing and maintaining quality management systems (QMS), inspecting loads, compliance and certification to a product standard (e.g. costs of annual auditing) and the costs involved in a monitoring regime (e.g. staff time, monitoring equipment, laboratory testing and reporting of results).
- Costs of biosecurity risk management – including the costs of inspection, compliance and documentation systems.

6.5 Summary Comparison

Table 14 summarises the key features of each technology as described in previous sections.

TABLE 14: SUMMARY OF KEY PROCESS FEATURES AND APPROXIMATE TECHNICAL PARAMETERS

Technology	Feedstocks	Products	Typical throughput	Footprint range	Indicative capital cost[29]	Indicative net operating cost[30]
			(tonnes per annum)	(m^2 per tpa capacity)	$	
Open windrow composting	Garden organics, stabilised biosolids, manure	Compost, mulch	5,000 – 50,000	› 0.7 – 0.8	› $3M	› $
Aerated static pile composting	Garden & food organics, biosolids, manure	Compost, mulch	2,000 – 50,000	› 0.5 – 0.6	› No cover: $4M › Textile cover: $7M	› No cover: $ › Textile cover: $$
In-vessel composting	Garden & food organics, food processing waste, industrial organics, liquid organics, odourous wastes	Compost, mulch	10,000 – 100,000	› 0.4 – 0.7	› $9.6M	› $$$
Vermicomposting	Food organics, soft garden waste, pre-composted or digested material	Castings Worms Liquid fertiliser	100 – 5,000	› 1.0 – 2.0	› No data, due to lack of commercial references	
Wet anaerobic digestion	Food organics, biosolids, manures, food and beverage processing waste, liquid organics	Biogas / biomethane, CNG, electricity, heat Digestate (compost)	10,000 – 50,000	› 0.2 – 0.4	› $12M	› $$
Dry anaerobic digestion	Food & garden organics, commercial organics, crop residues	Biogas / biomethane, CNG, electricity, heat Digestate (compost)	20,000 – 80,000	› 0.4 – 0.7	› $15M	› $$$
Fermentation	Bagasse, crop residues, forestry residues, food processing waste, waste wood, paper & cardboard	Ethanol Stillage (compost)	20,000 – 50,000	Unknown	No data, due to lack of commercial references	

28 Indicative capital cost in 2017 for a 30,000 tpa capacity facility
29 Scale for indicative net operating costs in 2017 - $ = $20 to $35 per t, $$ = $35 to $50 per t, $$$ = greater than $50 per t

7 Delivering biological processing solutions

7.1 Collaborative approaches to procuring, delivering and operating biological processes

As noted in section 6.2, the cost efficiency and technical performance of a biological processing facility, like most waste processing infrastructure, improves as the scale of the facility increases.

For councils considering procuring organics processing services, there could be significant benefits in working jointly with neighbouring councils to aggregate available organics. Regional collaboration between councils to procure organics processing capacity brings a number of benefits:

- Larger volume of feedstock to offer the market, resulting in greater interest and competition in procurement
- Critical mass of feedstock to support preferred processing technology
- Potential to attract more advanced processing solutions
- Reduced costs, translating to lower gate fees for councils
- Improved processing efficiency and product quality
- Diversity of feedstock sources, which reduces the risk of feedstock disruption or quality fluctuations
- A wider range of potential sites for the facility
- Increased likelihood of a new facility being constructed in the region, with associated economic benefits

On the other hand, councils also need to consider:

- The costs and infrastructure requirements associated with aggregating and transporting organics to a centralised facility which may be outside the local government area
- Community perceptions in the area hosting the processing facility, which will receive waste from other council areas
- Governance arrangements for the procurement and contract management to minimise risks for all parties

Procurement of a new organics processing facility requires a long-term commitment from councils, typically at least 15 years. This allows the capital investment to be amortised at a reasonable rate over the contract term.

In Victoria, the Regional Waste and Resource Recovery Groups (RWRRGs) are the best vehicle to lead collaborative procurements of organics processing capacity. Indeed, the Metropolitan Waste and Resource Recovery Group (MWRRG) has led three collaborative procurements across three regions, on behalf of its member councils for the processing of organic waste.

In total, MWRRG has procured processing capacity in excess of 520,000 tpa over the next 15 years, to be provided by five different operators. One of those contracts led to construction of Victoria's largest and most advanced in-vessel composting facility (Veolia's Bulla facility) and another, even larger facility is proposed in Dandenong South (Sacyr) to process 120,000 tonnes per annum.

All seven of the RWRRGs have identified diversion and recovery of organics as a high priority in their implementation plans. As such it likely that collaborative procurements will play a significant role in new organics processing infrastructure developments over the coming years.

WRRGs or councils considering collaborative procurements may need to seek authorisation from the Australian Competition and Consumer Commission (ACCC).

7.2 Contract and delivery models

For local governments considering an organics processing solution, there are numerous options available in terms of contractual and ownership arrangements. The choice of delivery model should be made based on an assessment of the project risks and councils capability to manage and mitigate those risks. Project risks to consider include, amongst others:

- Approvals and environmental management
- Financing and costing and construction
- Technology and process
- Operations and maintenance
- Health and safety
- Regulatory requirements and compliance
- Energy prices
- Subcontractor management
- Feedstock supply and quality
- Product quality and markets
- Biosecurity risks
- Community and social impacts
- Decommissioning

Section 7.7 provides a more detailed discussion of operational risks.

Most councils have experience in developing and operating waste infrastructure which is relatively simple from a technology and process perspective (transfer stations, resource recovery centres, landfills and, in some cases, simple open windrow composting). Very few have the appropriate expertise to implement and manage a more complex biological processing facility.

Therefore, it is likely that some or most of the work associated with the deployment and ongoing management of a biological processing solution will be outsourced to experienced contractors. While it is possible for a council to manage the deployment of a processing facility and to acquire or train up staff to operate and maintain it, the risks in doing so and the associated costs, are likely to outweigh any potential short-term financial savings by keeping it in-house.

There will be some risks, such as feedstock supply and quality, over which the contractor has little control and these are best managed by council to avoid paying a significant risk premium in the contract price.

The choice of project delivery model is also a function of council's access to capital and competing priorities for that capital; whether council has a suitable site available; and the level of risk sharing that is acceptable to council.

Table 15 provides an overview of some of the delivery models which may be considered. It is not intended to be comprehensive and there are many options and variations on these models.

TABLE 15: SUMMARY OF COMMON PROJECT DELIVERY MODELS FOR LOCAL GOVERNMENTS

Delivery Model	Description	Risks	Benefits
Service contract	Council engages a contractor to provide organics recovery services. The Contractor has the choice to use an existing facility or build a new one.	› May not lead to development of a new facility › Council has no control over how material is processed › Likely to be a minimum supply volume ('put or pay' contract)	› Simplified procurement and specification › Council just pays an agreed gate fee, regardless of where or how the material is processed › Facilitates lowest cost option › Can be a shorter contract term
Build, own, operate	Contractor owns and funds the facility and is responsible for designing, constructing, operating and maintaining the plant over the contract term	› Long-term commitment for council with limited control over plant design and operations › No potential to improve or upgrade the plant with new innovations, unless contractor led › Reliance on single contractor to perform throughout the term › Council pays a risk premium within gate fees, for risks put onto the contractor	› Contractor takes on most design, construction and operational risks › No capital investment from Council › Efficiency benefits of a single contract
Build, own, operate, transfer	Contractor owns and funds the facility on Council land, and is responsible for designing, constructing, operating and maintaining the plant over the contract term	› Long-term commitment for council with very little control over plant design and operations › No potential to improve or upgrade the plant within the contract term, unless contractor led › Council may have responsibility for decommissioning and closure risks	› Contractor takes on most design, construction and operational risks › No capital investment from Council › At the end of the contract term, ownership of the facility transfers to Council › Flexibility to continue operations and upgrade beyond initial term
Design and build	Council owns and funds the facility, engaging a contractor for the design and construction. Council can either operate the facility or engage a contractor to operate and maintain on its behalf.	› Council funds the project › Council needs to specify the facility requirements accurately › Challenge to ensure plant design is optimised for operations › Council needs to manage interfaces between contractors › Council shares the design, construction, process, maintenance, market and revenue risks › No investment by the contractors	› Council retains full control over contracts › Council shares in revenues and upsides › Full flexibility to change plant and introduce innovation
Joint Venture	Council and the Contractor agree to work in partnership, possibly through a separate jointly owned company, to deliver and operate the project. Funding and risks are shared by both parties.	› Council shares all project costs and risks › Unusual for small scale projects › Higher management costs for Council	› Council involved in decision making throughout › Council gets benefits of contractor expertise › Full flexibility to introduce new innovations › Council shares in upsides

7.3 Working with solution providers

Prior to procuring a new organics processing facility, it is important that councils are well informed about the different technologies available and their characteristics, and the capabilities of contractors in the market. Councils should be cautious about settling on a particular technology or solution prior to procurement, or being overly prescriptive in the tender specification, as this may preclude offers of innovative technical or commercial solutions.

Tender specifications should focus on overall objectives and desired outcomes, rather than specifying how they should be achieved. This gives tenderers flexibility to offer solutions which may not have been considered.

To become better informed, councils can refer to resources such as this guide and the other references detailed in section 9 of this guide. Professional advice and support should be sought from experienced consultants where necessary.

The other way to become informed about market capabilities, is to undertake a soft-market testing or market sounding process. This can be done by council directly by issuing a call for Expressions of Interest of market sounding request for information. Alternatively, an independent consultant could be engaged to consult with the market on council's behalf.

These processes can be useful in finding out what potential solutions and expertise is available in the local market, but it is important to understand that any information provided through a market sounding exercise is non-binding until it is confirmed through a formal tender process.

7.4 Engaging with communities and other stakeholders

Organics processing facilities can be controversial with local communities given the perception of odour issues and the history of poor performing facilities in this respect. Meaningful engagement with the local community will be critical to successful implementation of any biological processing project. Community engagement should commence in the early stages of project planning, play a key role in the approvals process (further discussed in section 7.5) and then carry through to the operational phase.

For more specific guidance, the MWRRG has also published a Community and Stakeholder Engagement Guide[30] aimed at the waste and resource recovery sector. The guide explains why community engagement is important in waste projects; principles that can be used to guide community engagement activities; best practice engagement planning; and engagement methods, templates and tips for site operators and project proponents. Additionally, MWRRG have developed a toolkit for educators to help councils communicate with their residents from culturally diverse backgrounds about waste, recycling and litter[31].

During operations, plant managers should maintain regular contact local residents and interested stakeholders and consider establishing regular communication forums such as community meetings and newsletters. Nearby residents should be provided with a contact number and other means to lodge complaints or suggest improvements. Procedures for receiving, managing and responding to complaints should be clearly set out and communicated to all staff and a detailed complaint log book should be maintained including actions taken.

If the project is subject to an approval under environment and planning legislation, engagement with the community is usually mandatory and further guidance will apply (refer to section 7.5). EPA Victoria has developed a guideline on planning for community engagement[32] which outlines the steps in developing a community engagement plan.

Furthermore, the key to successful source separation of organics from contaminants lies in the actions of waste generators. Education of specific feedstock generators and the wider community should therefore be undertaken to raise awareness of the importance of correct separation procedures to support contamination reduction programs.

The Back to Earth Initiative[33], run in partnership with MWRRG and 19 metropolitan councils, is a communications and community engagement program aimed at minimising contamination in green waste bins and encouraging service uptake among households. The program is a key part of the collaborative procurement approach to support the successful operation of new organics processing facilities in metropolitan Melbourne. This program has been adopted by other regional WRRGs and continues to expand across Victoria and support the introduction of new garden waste and FOGO services.

Developers may wish to consider the following education activities: provision of a visitor's centre, tours for the public or other educational institutions such as local schools, provision of educational signage educational material, online websites that provide "real time" pictures or performance data.

30 https://www.mwrrg.vic.gov.au/engagement/community-and-stakeholder-engagement-guide/
31 https://www.mwrrg.vic.gov.au/engagement/culturally-diverse-communities
32 EPA Victoria, A planning process for community engagement, Publication 1145.1 (2010), http://www.epa.vic.gov.au/our-work/publications/publication/2010/march/1145-1
33 http://backtoearth.vic.gov.au/

7.5 Planning and environmental approvals for biological processes

Before proceeding with development of an organics recovery facility, it is important to determine which planning and environment legislation applies and whether or not any regulatory approvals need to be obtained. This also applies to upgrades (or new) supporting infrastructure such as roads, power infrastructure (power lines, substation upgrades), water or gas supply pipelines. This can make a difference to the overall cost of the development, completion time, stakeholder consultation requirements and delivery approach. Regulators have significant influence over the design, construction and operation of some facilities and their location.

Relevant legislation exists at local Government, State and Federal (Commonwealth) level and addresses issues such as: visual impact of a facility, noise, odour, air quality, traffic, community consultation, contamination, groundwater, creeks and rivers (surface water), consistency with local planning conditions, cultural heritage (aboriginal and built heritage), ecology (flora and fauna), and waste, to name a few.

Environment and Planning regulators include: local councils; the Victorian Environment Protection Authority (EPA); State Departments (addressing Planning, Environment, Health); Aboriginal Victoria; Registered Aboriginal Parties (RAPs); local water authorities (for sewer and mains water); local catchment management authorities (CMA's); and emergency services (Police, ambulance, fire brigade). In some cases, Federal regulators will get involved if the project impacts on Commonwealth owned land or on issues of Commonwealth significance. A brief summary of the relevant legislation and approvals is supplied below. This focuses on primary approvals to proceed with construction and operation of the facility. A number of secondary approvals may be needed.

Advice from a statutory planner and environmental specialists is likely to be required in order to identify the need for and compile these approval applications.

TABLE 16: SUMMARY OF PLANNING AND ENVIRONMENTAL APPROVALS FOR BIOLOGICAL PROCESSING OF ORGANICS

Relevant legislation / regulation / policy	Detail
Statutory framework	
Planning: *Planning and Environment Act 1987*	The Planning and Environment Act 1987 sets out the framework for land use, planning and development in Victoria, including the preparation and administration of planning schemes. Under the Act, the Victoria Planning Provisions (VPP) provide standard land use zonings and a template for individual municipal planning schemes. Municipal planning schemes are binding on all people and corporations, and set out permitted land uses for different land zoning. Zones and permitted uses are contained in the VPP, which defines composting as a "use with adverse amenity potential".
Environmental protection: *Environment Protection Act 1970*	The *Environment Protection Act 1970* is a key legislative tool used in Victoria to protect the environment. Subordinate legislation under the Act includes: › state environment protection policies or SEPPs for specific segments of the environment such as air, noise and groundwater › waste management policies governing the management of specific wastes › environment protection regulations. Organics processing facilities must comply with relevant environmental protection legislation, policies and regulations. Facilities should also be consistent with the local and regional waste management plans relevant to their location.
Premises that require works approvals and licencing by EPA: *Environment Protection (Scheduled Premises) Regulations 2017*	The *Environmental Protection (Scheduled Premises) Regulations 2017* prescribe the premises that are subject to works approval and/or licensing by EPA, and provide for exemptions in certain circumstances. They provide a means to effectively manage these premises in a transparent way, which ensures an adequate level of community confidence is maintained.
Industrial waste: *Environment Protection (Industrial Waste Resource) Regulations 2009*	The *Environment Protection (Industrial Waste Resource) Regulations 2009* provides schedules of prescribed waste. These are wastes that pose environmental, health and amenity risks and cannot be managed through conventional landfilling. Prescribed wastes must be managed by premises scheduled and licensed to receive the materials, and transported by approved vehicles and operators using waste transport certificates to track the correct transport and management of materials. Some prescribed wastes such as biosolids, wastewaters, food processing wastes, grease trap and paunch waste have organic loads and can be managed through composting and digestion technologies. Any facility receiving such materials must be licensed to do so and complete waste transport certificates for materials received.
OH&S: *Occupational Health and Safety Act 2004* *Occupational Health and Safety Regulations 2017* (OHS Regulations) *and Equipment (Public Safety) Regulations 2017* (EPS Regulations)	The *Occupational Health and Safety Act 2004* establishes the statutory framework for providing a safe working environment. Like the Environment Protection Act 1970, this Act has subordinate legislation and several guidance documents relevant to the recovery of organics.
Environmental management requirements: State Environment Protection Policies (SEPPs)	Victorian SEPPs aim to safeguard the public health, community amenity and natural environment we so value, and protect these from the effect of pollution and waste. SEPPs define the environmental quality objectives and describe the attainment and management programs that will ensure the necessary environmental quality is maintained and improved. Under the *Environment Protection Act 1970*, the requirements in environmental regulations, works approvals, licences and other regulatory tools must be consistent with SEPPs.

Relevant legislation / regulation / policy	Detail
Biosecurity management requirements: *Plant Biosecurity Act 2010* *Catchment and Land Protection Act 1994* (CaLP Act) *Livestock Disease Control Act 1994 (LDC Act)* *Livestock Disease Control Regulations 2017* *Agriculture and Veterinary Chemicals (Control of Use) (Ruminant Feed) Regulations 2015.*	Under the Plant Biosecurity Act 2010, landholders have an obligation to manage biosecurity risks but all parties along the recycled organics supply chain have a role to play, including organic waste collectors, transporters, processors and product distributors. For processing facilities, careful and considered sourcing of feedstock, clearly defined acceptance criteria, and transparency along the feedstock supply chain are critical to manage biosecurity risks. During processing, effective pasteurisation is essential, as are procedures to prevent cross-contamination between raw feedstock and finished product, by ensuring cleaning of plant and equipment and separation of feedstock and product areas. The CaLP Act covers noxious weed and pest animal management in Victoria, to protect primary production, Crown land, the environment and community health from adverse effects. The CaLP Act prohibits the movement and sale of noxious weeds and weed seeds of all categories anywhere in the State. The LDC Act and subordinate regulations place restrictions and conditions on the management of certain materials to prevent livestock from feeding on, or coming in contact with, food wastes that may contain animal products, due to the risk of spreading exotic diseases such as foot-and-mouth disease. The sale and distribution of unpasteurised products from biological processing poses a significant biosecurity risk which may contravene these regulations.
Planning approval: Planning and Environment Act 1987 *Planning and Environment Amendment (General) Act 2013*	Once a site has been chosen, it should be determined whether a planning permit is required. This should be done through discussion with a council planning officer. Early discussion will also identify any other council requirements which may need to be met. Composting and recycling facilities which process more than a set threshold of waste are likely to require a planning permit and are not permitted in, or within a recommended threshold distance of, land zoned for sensitive uses, such as residences, business districts, schools or hospitals. The threshold distance is the minimum permitted distance from any part of the land of the proposed use or buildings and works, or the site where the organics or recycling facility is to be developed, to land zoned for sensitive uses. Where a planning permit is required, applicants will need to provide supporting information to the local council or other responsible authority. This information may include an assessment of the potential impacts of the facility on the environment, traffic and surrounding land use. Planning permits may be specifically required to remove native (protected) vegetation from the development site. In some cases, the planning zone on the land is not appropriate for development of an organics facility, or alternatively is not conducive to future upgrades. In this case, the developer may be required to amend the zoning to facilitate development. In this case an amendment to the planning scheme is required, which involves a formal application to council and State Minister for Planning.
R&D approval: Research, development and demonstration approval form, EPA Publication 1369.3	If you are the occupier of scheduled premises, or would become scheduled with the installation of your proposed project, you may apply for RD&D approval, provided the works are for genuine research, development or demonstration. Prior to completing an application form, the RD&D pathway must first be confirmed by EPA.

Relevant legislation / regulation / policy	Detail
EPA works approval: EPA's works approval assessment process (publication 1657) Works approval application guideline (publication 1658) Selected scheduled premises prompt sheets (publication 1659) Approvals proposal pathway (publication 1560.2)	Under the regulations, any premises with aerobic or anaerobic composting which is designed to or has a capacity to process (1) more than 100 tonnes of waste or 200 cubic metres per month or (2) accept more than 70 tonnes or 140 cubic metres of organic waste in any month and produce more than 50 tonnes of pasteurised material, compost or digestate in any month must have EPA works approval and an operating licence. In addition to this, some developments are exempt from a Works Approval. Refer Section 10, 11 and 12 of the Regulations or Section 19A and Section 20 (l) of the Environment Protection Act 1970. Depending on the nature of the facility, additional approvals may be required for other activities eg. Power generation, storage of other industrial (non-organic) wastes. An application for a Works Approval should be completed in consultation with the EPA as all EPA works approvals and licences will reflect specific site and process circumstances. Reference should be made to Instructions for Completing Works Approval, Licence and Licence Amendment Applications (EPA publications 1560.2, 1657, 1658 and 1659) and to Environmental Guidelines for Composting and Other Organic Recycling Facilities (EPA Publication 508). Prior to submitting a Works Approval, the developer is advised to meet with the EPA and to submit an Approvals proposal pathway form to the EPA (publication 1560.2). This assists in determining if a works approval is required, the approval pathway EPA have nominated for the project (fast track or standard) and if an exemption is possible. In assessing works approval applications, EPA will, among other things, consider the need for the following: › An assessment for historical compliance performance for existing sites › Limits on the tonnage of waste that may be received by the facility › The use of best practice technologies › The enclosing of part or all of the composting process and use of appropriate odour controlling technologies to treat air removed from the facility › Minimum separation distances to sensitive land uses (for example, residential) › Noise generated by the facility at local houses or other sensitive uses such as schools, hospitals › Discharges (if any) to land or surface water › The installation of energy recovery facilities where the process generates significant greenhouse gases A Works Approval focusses on potential environmental risks during construction and operation. However, it is not an approval to operate. A Works Approval only allows the developer to construct and sometimes commission the facility. An EPA Licence is required for ongoing operation (refer below).
EPA licence to operate: *Environment Protection Act 1970*	Prior to or during commissioning of a Scheduled Premises, the owner will negotiate the terms of the operating Licence with the EPA. Licence conditions set by the EPA typically include the following principles: › no detection of offensive odours beyond site boundaries › no discharge of nuisance particles beyond site boundaries › no burning of waste or compost at the site › no discharge of waste, wastewater or litter to land, groundwater or water environments › no visible matter (such as scum, colour or litter) in stormwater runoff from the site Noise levels to meet requirements of the SEPPs at all nearby residences or sensitive uses › acceptance of EPA approved waste types only › ongoing annual performance reporting in accordance with EPA licence approval conditions. An EPA licence will require the operator to report their environmental performance on an annual basis through an online reporting system (known as the Annual Performance Statement). Licence conditions may also require mandatory sampling and environmental monitoring activities take place to confirm performance levels are being met.

Relevant legislation / regulation / policy	Detail
Other approvals	
EPBC Referral – Federal government	Under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act), when a proposed project could potentially have significant impact on a matter of national environmental significance protected by the EPBC Act, a written referral must be sent to the Australian Government Minister for the Environment. The purpose of the referral process is to determine whether or not a proposed action will need formal assessment and approval under the EPBC Act. A referral is the principal basis for the Minister's decision as to whether approval is necessary and, if so, the type of assessment that will be taken.
EES Referral – Victorian government	Under the Environment Effects Act 1978, when a proposed project could potentially have significant environmental effects, a written referral must be sent to the Victorian Minister for Planning requesting a decision on whether an Environment Effects Statement (EES) is required. A project may be referred by a proponent or decision-maker. If deemed significant, then an Environment Effects Statement (EES) is required. An EES usually contains: › A description of the proposed development › An outline of public and stakeholder consultation undertaken during investigations and the issues raised › A description of the existing environment that may be affected › Predictions of significant environmental effects of the proposal and relevant alternatives › Proposed measures to avoid, minimise or manage adverse environmental effects › A proposed program for monitoring and managing environmental effects during project implementation.
Cultural Heritage Management Plan (CHMP) – Victorian government	If a proposed development could affect Aboriginal cultural heritage, a Cultural Heritage Management Plan (CHMP) prepared by a Heritage Adviser may be required. A CHMP usually contains an assessment of the potential impact of a proposed activity, and measures to be taken in order to manage and protect Aboriginal cultural heritage in the affected area. A CHMP is required when high impact activities are planned in an area of cultural heritage sensitivity, as defined by the *Aboriginal Heritage Regulations 2007*. In such an area, planning permits, licences and work authorities can't be issued unless a CHMP has been approved for the activity.

7.6 Project timelines

The varying complexity of different sites and technologies may involve project programs of between one and five years before operations at a new facility can commence; this may impact on feedstock supply, availability of markets, costs and a range of contractual arrangements.

Notably, different timelines apply to different types of projects (i.e. complexity in feedstock combinations and processing technologies). For example, the timeline associated with the deployment of an open windrow composting facility in a regional area is typically significantly less than that associated with the deployment of a high tech, large scale processing facility in metropolitan area such as an AD or in-vessel composting facility.

Please note that the timeframes provided below are indicative only for the development of new facility and should be validated against the specific requirements of the project.

For a contract where processing will occur at an existing organics processing facility the timeline is likely to be much shorter, provided that the existing facility hold the necessary permits and approvals.

TABLE 17: APPROXIMATE PROJECT TIMEFRAMES TO DESIGN, CONSTRUCT AND COMMISSION AN ORGANICS PROCESSING SOLUTION, UNDER THREE DIFFERENT HYPOTHETICAL SCENARIOS.

Project Requirement	Scenario 1: Open windrow composting in regional area	Scenario 2: High tech, large scale processing facility in regional area	Scenario 3: High tech, large scale processing facility in metropolitan area
Feasibility study / Business case	3 months	6 months	6 months
Environmental and planning approvals Works approval (EPA Victoria)	6 weeks – 4 months for obtaining approval. Allow additional 1 – 3 months for completion of supporting studies.	6 weeks (fast track) to 4 months (standard) for obtaining approval. Allow 3 – 4 months for completion of supporting studies. Add another 6 months for VCAT appeal for high risk/impact project or projects that are not supported by the community.	Allow 4 months for obtaining approval. Allow 3 – 4 months for completion of supporting studies. Add another 6 months for VCAT challenges for high risk/impact project or projects that are not supported by the community.
Works approval exemption	Unlikely to be required	2 – 4 weeks for a determination from EPA. Allow 1 – 4 months for completion of supporting studies.	2 – 4 weeks for a determination from EPA. Allow 1 – 4 months for completion of supporting studies.
Planning scheme amendments (if required)	Up to 12 months	Up to 12 months	Up to 12 months
Planning permit (including completion of studies)	3 – 6 months	4 – 12 months	4 – 12 months
Cultural heritage management plan (if required)	3 – 6 months	3 – 6 months	3 – 6 months
EPBC referral	3 – 6 months	3 – 6 months 6 – 18 months for high risk project	3 – 6 months 6 – 18 months for high risk project
Environmental Effects Statement (EES) (Victorian Department of Planning)	Highly unlikely - unless a significant impact on protected flora, fauna or other matters identified in the EPBC Act (Refer section 7.6)	Unlikely but more likely to occur if there is a significant impact on Commonwealth protected flora, fauna or other matters identified in the EPBC Act. This includes projects with a significant impact on the community (Refer section 7.6)	Unlikely but more likely to occur if there is a significant impact on Commonwealth protected flora, fauna or other matters identified in the EPBC Act. This includes projects with a significant impact on the community (Refer section 7.6)
Design: Concept design and Detailed design	2 months	4-6 months	4-6 months years
Construction	3 – 6 months	12-18 months	12-18 months
Commissioning phase	2 – 4 months	6 – 8 months	6 – 8 months

7.7 Operational risk management

Biological processing of organics presents a variety of risks across environmental, technology, commercial, safety and human health. This section focuses on risks associated with operating a biological processing facility. The control of risks associated with feedstock quality and product quality and markets have been covered in sections 3 and 5 respectively.

Australian and international standard 31000:2009 on Risk management - Principles and guidelines provides a framework by which to assess and manage risks. Most councils and private organisations will also have their own internal enterprise risk assessment and management framework.

7.7.1 Health and Safety

Organics processing facilities present a number of health and safety risks for staff, contractors, customers and the general public. Management has responsibilities under the Occupational Health and Safety Act 2004 and the recent Occupational Health and Safety Regulations 2017 to provide and maintain a safe working environment.

WorkSafe Victoria provides general workplace guidance on staff amenities and working environment[34]. However, the higher risk nature of organics processing requires a comprehensive assessment of hazards and risks to develop appropriate control measures. This should be part of a broader Health and Safety Management System, which for larger operators may be certified to AS4801 Occupational Health and Safety Management Systems.

Hazards to be considered may include:

- Manual handling
- Working in and around heavy plant and machinery
- Biological hazards (exposure to pathogens in raw waste, microbes and fungi, and bio-aerosols – see below)
- Electrical hazards
- Combustible gases and fuels
- Hazardous substances
- Fire (see below)
- Confined spaces (composting and digestion vessels)
- Environmental risks
- Risks from pests and vermin

Bio-aerosols are a particular and little known risk with biological processing operations. Bio-aerosols refer to micro-organisms which may become airborne in fine particles and mist during mechanical processing operations (e.g. turning of compost), exposing workers to potential health risks. There is a body of research and guidance on managing this particular risk, including from the UK[35].

WorkSafe Victoria provides a range of general guidelines and reference documents on its website including a page dedicated to Waste and Recycling industry safety which may be relevant[36].

There is also a Code of Practice for the Storage and Handling or Dangerous Goods (2013)[37] which is specifically relevant to flammable gases and fuels.

7.7.2 Fire

Fire is one of the most significant risks at a biological processing facility given the large volumes of combustible material stored on site at any time. Garden waste and waste timber present particular risks given their high calorific value.

Organics that are waiting to be processed or in the initial phase of a composting process present an additional risk given the natural propensity to heat up. In large piles, that heat is contained in the middle of the pile and can intensify to the point of spontaneous combustion.

Self-ignited fires in garden waste stockpiles are not uncommon and the WA Government has published specific guidance on managing fire risks in garden waste stockpiles[38]. According that document, moisture content is a critical factor in avoiding spontaneous combustion – at moisture levels above 45 per cent, there is enough moisture available to keep pile temperatures at safe levels; less than 20 per cent moisture and there will not be enough to sustain the biological activity that generates the heat. Hence, moisture content between 20 per cent and 45 per cent is the highest risk zone for spontaneous combustion.

Other factors which contribute to spontaneous combustion include:

- Pockets of dry material
- Significant proportions of bark, soil and leaves
- Large piles, which trap heat due to low surface area to volume ratio
- Limited pile aeration (to allow heat to escape) due to highly compacted material
- Prolonged storage of undisturbed piles, which enables excessive heat accumulation

To minimise fire risk:

- Smaller piles are preferred
- Prolonged storage of unprocessed organics should be avoided and stockpiles should be turned occasionally to provide ventilation
- Separation should be provided between piles to stop fires spreading and allow access for fire-fighting equipment
- Regular monitoring and inspection procedures should also be in place including testing the pile internal temperatures and moisture levels, and looking for signs of smouldering (hot gases, smoke).

It should be noted that steam arising from compost piles is normal but may be mistaken for smoke by members of the public so this should be considered in community engagement activities and communications.

Organics stockpiles are also prone to ignition from other sources including arson, lightning, discarded cigarettes, hot ashes in incoming loads, and heat or sparks from plant and equipment. Operational procedures and security measures (see below) should be designed to mitigate these risks.

34 Worksafe Victoria, Workplace Amenities And Work Environment - Compliance Code, 2008 http://www.worksafe.vic.gov.au/pages/forms-and-publications/forms-and-publications/workplace-amenities-and-work-environment-compliance-code

35 UK Health and Safety Executive Research Report - Bioaerosol emissions from waste composting and the potential for workers' exposure, 2010, http://www.hse.gov.uk/research/rrpdf/rr786.pdf

36 https://www.worksafe.vic.gov.au/pages/safety-and-prevention/your-industry/waste-and-recycling a

37 https://www.worksafe.vic.gov.au/pages/forms-and-publications/forms-and-publications/code-of-practice-for-the-storage-and-handling-of-dangerous-goods-2013

38 Western Australian Department of Fire and Emergency Services Information Note – Bulk Green Waste Storage Fires, September 2014 https://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireInfoNotesPublications/DFES-InfoNote-GreenWaste.pdf

AD facilities present additional risks with the production and storage of flammable gases (methane in biogas). All equipment in contact with or close proximity to biogas must be appropriately designed and rated for explosive zone use, and methane detection alarms should be installed in critical locations where gas may leak and accumulate. Gas infrastructure including biogas installations are regulated by Energy Safe Victoria in accordance with the Gas Safety Act 1997 and Gas Industry Act 2001[39]. More general requirements may also be specified under the provisions of the Dangerous Goods regulations (see Worksafe Victoria's Code of Practice for the Storage and Handling or Dangerous Goods).

Organics processing facilities should have plant and facilities on site to combat fires which may include:

- Fire hoses, hydrants, extinguishers and / or high capacity pumps
- Sufficient storage of fire-fighting water (tanks or ponds)
- Mobile plant to move and isolate burning material (e.g. front end loader or excavator)
- Staff trained safely respond to and contain a fire in its early stages

Operators are advised to conduct a risk assessment and consult with local fire authorities to review fire preparedness and emergency plans and to make them aware of the risks at the site.

7.7.3 Security

Organics processing facilities present a number of safety risks to the public so it is vital that there are adequate measures in place to keep unauthorised persons out of the facility. Risks include:

- Large stockpiles of highly combustible material, which may attract arson attacks
- Flammable gases (in the case of AD facilities)
- Valuable mobile and fixed plant which may be prone to vandalism and theft
- Deep water bodies (leachate and stormwater ponds)

Adequate security fencing should be installed around the entire site and operators should also consider the need for other measures such as closed-circuit cameras, sensor lighting, alarms on buildings and security patrols.

7.7.4 Environmental risks

Organics processing facilities have the potential to impact the environment through effects on air quality, land, water and ecology. This is best assessed in the planning stage of a project (refer to section 7.5) and management plans put in place to mitigate or manage impacts.

Development of an Environmental Management Plan (EMP) is recommended by EPA Victoria as a means to mitigate environmental risks at each stage of the process and ensure compliance with regulatory requirements.

Odour is a particular concern with any organics processing facility and the main source of complaints from the community. Odour management should either be addressed in the EMP or in a separate Odour Management Plan. Odour control is further discussed in section 7.7.5.

During operations, regular monitoring of environment parameters should be undertaken in accordance with the EMP and licence conditions. Refer to section 8.2.2 for examples of environmental indicators for best practice during operations.

7.7.5 Odour control

Odour control is important across all stages of processing organic waste, including:

- Putting in place protocols to minimise odour generation from materials on receival, including minimising storage of unprocessed organics and enclosing waste reception areas
- For composting, maintaining aerobic and optimal composting conditions to minimise odour from the composting operations
- For outdoor composting operations, only turning compost during favourable weather conditions
- For enclosed systems, installing exhaust systems to extract air for treatment through a filter
- Using exhaust and dust control systems and appropriate protective equipment to protect staff from OHS risks
- Preventing leachate storage ponds from going anaerobic by installing aeration

Effective process monitoring is critical to odour control, regardless of the biological processing technology utilised. For outdoor processing, e.g. open windrow composting, monitoring of weather conditions and clear procedures to avoid undertaking high odour activities during adverse weather conditions

For enclosed processing, management of emissions from the aeration system. If air is drawn through piles, the exhaust can be treated through filters. If it is blown, then the rate of emissions from piles needs to be limited. Low airflow velocities over a prolonged period are generally better for odour control than shorter 'bursts' of air at higher velocities. Systems that capture and treat exhausts are preferred. An extended period of aeration to slowly 'flush' the materials with fresh air immediately prior to moving materials can reduce odour emissions during handling.

In respect to the choice of odour control measures, the Victorian EPA will expect the developer to consider "best practice" according to EPA Guideline 1517 – Demonstrating Best Practice and manage odour as per requirements of SEPP Air Quality Management. Recommended measures are outlined in Designing, constructing and operating composting facilities[40] (EPA publication 1588.1, 2017). This usually applies to issues such as the selection of particular odour treatment technologies (biological vs chemical) and how the facility is operated, all of which are designed to reduce environmental risk. This requirement is usually formalised if and when the developer submits an EPA Works Approval. The EPA will assess the proposed odour treatment technologies and mitigation measures with cost in mind.

39 http://www.esv.vic.gov.au/technical-information/gas-infrastructure-and-pipelines/gas-infrastructure-and-pipeline-safety/

40 http://www.epa.vic.gov.au/our-work/publications/publication/2017/june/1588-1

7.7.6 Biosecurity

Organic wastes have the potential to carry weeds, pests and diseases (both plant and animal). Garden waste in particular raises concerns around the spread of weeds, plant diseases and invasive insect species; given the large volumes, wide variety of plants included and difficulties in tracing or controlling the sources of the material. Agricultural residues such as fruit and vegetable waste, manure or animal bedding, also need to be carefully managed to prevent the spread of diseases between farms and regions.

In Victoria, the main legislative instrument to manage plant pest and disease risks is the Plant Biosecurity Act 2010 and subordinate regulations, the Plant Biosecurity Regulations 2010. The management of noxious weeds is covered separately by the Catchment and Land Protection Act 1994. The main legislative instrument to manage animal disease risks is the Livestock Disease Control Act 1994 and subordinate regulations, the Livestock Disease Control Regulations 2017, and the Agriculture and Veterinary Chemicals (Control of Use) (Ruminant Feed) Regulations 2015.

For commercial activities, the movement of plant products and material, equipment and soil may be subject to controls or prohibition. Under the Plant Biosecurity Act, orders can be made which allow areas in Victoria to be declared, and conditions imposed on the movement of certain materials, to prevent the spread of a pest or disease into or out of that area. Such orders may have impacts on the movement of organic waste and recycled organic products into or out of declared areas and processors must be cognisant of any active orders in the regions in which they operate. The Plant Quarantine Manual[41] identifies the plant pest and disease threats, and the conditions imposed on certain products, residues and equipment to prevent their spread.

Examples of material streams that have conditional requirements on their management include:

- Grape marc which may potentially host grape phylloxera, has requirements including that grape marc being transported into Victoria is certified as being sourced from a declared phylloxera-free area or state, or otherwise requires processing (fermentation for at least four days, or composting for at least three months), at least 500 meters from any grape vines in a secure and segregated location, prior to transportation into Victoria.
- Landscaping materials and soil sourced from a property within 5 kilometres of a red imported fire ant (RIFA) outbreak is prohibited unless it is treated by either heat to a minimum of 65.5°C, frozen to at least –20°C for at least 24 hours, or processed by a mechanical method such as hammer milling to be free from RIFA.

Movement of live noxious weeds or their seeds is prohibited under the Catchment and Land Protection Act unless a permit has been obtained. There are more than 100 declared noxious weeds[42], some of which are widely established, thus it is likely that general urban green waste may occasionally contain small amounts of these species. This possibility is not viewed as creating a high biosecurity risk and permits are not required for transport of such material. However, in cases where large amounts of any noxious weed are likely to be present in the material stream or where high priority noxious weeds (such as State prohibited weeds) may be present in any amount Agriculture Victoria should be consulted and permits that specify conditions for transport, processing and use of the final product may be required.

- The Livestock Disease Control Act 1994 and subordinate regulations place restrictions and conditions on the management of certain materials to prevent livestock from feeding on, or coming in contact with, food wastes that may contain animal products, due to the risk of spreading exotic diseases such as foot-and-mouth disease. For organics processors, this highlights the need to effectively pasteurise all recycled organic products that may be ultimately applied to grazing land.

Examples of material streams that have conditional requirements on their management include:

- Swill feeding – Swill is the traditional name for food scraps or food waste that contains or has been in contact with mammalian meat. To mitigate the risk of spreading foot-and-mouth disease and other exotic diseases of pigs, the feeding of swill to pigs is prohibited. Section 41 of the Livestock Disease Control Act prohibits the feeding, storage, collection, and supply for use for the feeding to pigs of any material originating from a mammal or that has been in direct contact with material originating from a mammal.
- Sewage – Raw sewage can contain eggs from the human tapeworm, the cause of Cysticercus bovis or 'beef measles' in cattle, and 'pork measles' in pigs, which may impact on Australia's export markets. The tapeworms can also cause human health issues. The depositing or spreading of night-soil or sewage on land used to graze cattle or pigs is prohibited under section 43 of the Livestock Disease Control Act.
- Ruminant Feed Ban – Australia has an inclusive ban on the feeding to ruminants of all meals, including meat and bone meal, derived from all vertebrates, including fish and birds. The Ruminant Feed Ban maintains Australia's freedom from Bovine Spongiform Encephalopathy (BSE, or Mad Cow Disease) and Scrapie, through the prohibition of the feeding of Restricted Animal Material. Restricted Animal Material is any material taken from a vertebrate animal, other than tallow, gelatine, milk products or oils. It includes meat, rendered products such as blood meal, meat meal, meat and bone meal, fish meal, poultry meal, feather meal, and manure and compounded feeds made from these products.
- Operators and proponents of biological processing facilities should be familiar with their regulatory obligations and consider the biosecurity risks associated with the feedstock that is being collected and transported to their facility for processing. They should also be aware of any particular biosecurity issues specific to the areas where they operate, source feedstock and distribute products.
- Particular care needs to be taken when transporting feedstock, including food and garden waste, from urban areas to regional processing facilities or between agricultural regions, to ensure biosecurity risks are minimised.

For processing facilitates, careful and considered sourcing of feedstock, clearly defined acceptance criteria, and transparency along the feedstock supply chain are critical to reduce biosecurity risks. There are risks that need to be assessed and managed right along the feedstock supply chain from collection to transfer, transport and storage of organic wastes.

During processing, effective pasteurisation is essential, as are procedures to prevent cross-contamination between raw feedstock and finished product, by ensuring cleaning of plant and equipment and separation of feedstock and product areas.

The sale and distribution of unpasteurised products from biological processing poses significant biosecurity risks which may contravene these regulations and cause significant damage to Victoria's valuable agricultural industries.

41 http://agriculture.vic.gov.au/agriculture/horticulture/moving-plants-and-plant-products/importing-plants

42 http://agriculture.vic.gov.au/__data/assets/pdf_file/0009/365094/Victorian-noxious-weeds-list-by-common-name-20-July-2017.pdf

8 Setting performance measures to ensure best practice

8.1 Performance Indicators

There are a number of key performance indicators (KPIs) which clients and project proponents should consider in specifying biological organics processing services or assessing solution options. These cover technical, commercial and environmental performance of the process and include a number of general indicators, as well as technology specific indicators.

8.1.1 General KPIs for all technologies

The following KPIs can be applied to all biological processing technologies:

- Compliance with relevant regulations and guidance (including EPA Composting Guidelines)
- Development and implementation of a community engagement plan
- Clearly documented waste acceptance criteria and procedures, communicated to all customers
- Development and implementation of a contamination management system including pre- and post-processing extraction of contaminants
- Compliance with the pasteurisation and product quality requirements in AS4454-2012: Australian Standard for Composts, Soil Conditioners and Mulches. Independent certification to the standard is not mandatory but may be appropriate depending on the end-product markets
- Appropriate systems for monitoring and recording input and output material quantities and qualities
- Appropriate systems for monitoring and recording key process parameters
- Development and implementation of a comprehensive, site specific Odour Management Plan taking into account odour dispersion modelling results, feedstock risks, technology factors, and sensitive receptor locations
- Appropriate systems in place to manage vermin including birds, insects and rodents
- Development and implementation of fire prevention and emergency preparedness plans, in consultation with local fire authorities
- Appropriate stockpile management procedures (including maximum volumes in storage) and contingency plans in the event that processing is disrupted
- Appropriate systems in place to manage wastewater streams (leachate, contact water, liquid digestate) to maximise on-site reuse and/or provide appropriate treatment and disposal pathways
- Appropriate systems in place to manage stormwater, including measures to isolate clean runoff from process areas, and to harvest rainwater for process use
- Appropriate measures to manage dust, noise, wind-blown litter

8.1.2 Aerobic processing KPIs

The following KPIs can be applied more specifically to aerobic processing technologies:

- Procedures in place to minimise the risk of spontaneous combustion of materials (see section 7.7.2)
- Compliance with EPA Victoria's Composting guidelines

8.1.3 Anaerobic processing KPIs

The following KPIs can be applied more specifically to anaerobic processing technologies:

- Procedures in place to optimise biogas production and avoid harming the anaerobic microbes with contaminants or unsuitable process conditions
- Monitoring and management of air emissions from any on-site power generation or gas flares, to comply with relevant licence emission standards
- Compliance with regulatory requirements and guidance around safe installation and operation of biogas storage, processing and utilisation equipment, including Dangerous Goods regulations; provisions under the Occupational Health and Safety Act 2004 and provisions under the Gas Safety Act 1997 (as regulated by Energy Safe Victoria)
- Development and implementation of procedures to monitor and maintain compliance with quality standards for biomethane and gaseous products (e.g. Australian Standard AS 4564 – specification for general purpose natural gas)
- Processes in place to ensure appropriate aerobic stabilisation of solid digestate outputs

8.2 Financial, environmental and social indicators for best practice recovery of organics

8.2.1 Technology selection and design considerations

One way to incorporate financial, social, environmental considerations into the technology selection and project design is to apply a multi-criteria analyses (MCA). This involves comparing options (including technology and site selection options) against a set of agreed criteria. Each option is assessed according to their (future) performance against each criteria, resulting in an overall score for each option. This score allows each of the options to be ranked, from preferred to least preferred.

The MCA process can be scaled according to the complexity of the project and the stage of the project. It can be applied during site selection, selection of a concept design and then later during selection of particular technologies or vendors. For large projects, additional information may be required to support and justify the MCA analyses. This might include by detailed analyses against each criteria, using the results of site environment studies, completion of desk based reviews and high level Capex/Opex estimates and modelling.

Developers have the option to provide some or all of the results of their MCA analyses to regulators and the public so that the decision making processes are transparent (excluding any commercially in confidence or sensitive data). This is usually done as part of a regulatory approval process to justify the design decisions made.

Examples of criteria that could be applied are described below.

- Environment: Examples include likely operational noise and odour impacts, removal of protected vegetation, opportunities to reduce or reuse wastes, energy / greenhouse gas reduction, likely environment approvals and future liabilities associated with management, water use, waste reuse
- Social: Potential employment opportunities, education (through provision of signage, visitors centre, tours), direct impact on community (noise, odour etc), visual impact
- Financial: Capex, Opex (including NPV calculations), future costs associated with technical redundancy, avoidance of future costs associated with rising energy and water prices, capacity for future expansion or co-location of other industrial facilities
- Other: Future 'proof' the site by exploring the application of new technologies or processes. This may be undertaken initially through small scale research and development (R&D) projects. Also, consider if additional buffer distance may be required in any future change scenarios (e.g. change in feedstocks, increase in facility throughput, or residential encroachment of the facility's boundaries).

8.2.2 Operational considerations

A key principle of the Victorian EPA's Demonstrating Best Practice guideline (publication 1517) is being able to demonstrate integration of financial/economic, environmental and social considerations. This refers to the need for measures to be cost-effective and in proportion to the significance of the environmental problems being addressed. Examples of criteria that could be applied to the operations of an organic processing facility include:

- Environment: Setting targets and monitoring greenhouse gas emissions from organic wastes, with continuous improvement plans to reduce emissions. Odour control and ensuring that facilities are meeting the odour criteria specified in licence conditions and as outlined as "best practice" as per Victorian EPA Guideline publication 1517. In general, this refers to incorporation of best practice and continuous improvement requirements in meeting SEPP requirements (noise, protection of surface waters and groundwater, prevention and management of contaminated land and air quality management).
- Social: Adopting and operating under quality and environmental management systems, such as Australian Standards AS/NZS ISO 14001 (Environmental Management System), 9001 (Quality Management System), 3100 (Risk Management Standard) and 4801 (Occupational Health and Safety Management Systems). Reporting monitoring data and other progress to stakeholders, including staff, clients, regulators and neighbouring communities on a set regular basis.
- Financial: Assessing the ongoing operational and maintenance costs of equipment, and including these expected costs and contingency as part of the annual budgetary planning and allocation of funds. This would include consideration of the number of staff required to keep the plant operational alongside the relevant Occupational and Health and Safety requirements and obligations, and ongoing monitoring and assessment of technology operational performance. Fundamental to the long-term sustainability of any facility, will be the ability for the facility to generate a profit. This will be contingent on balancing the revenue gathered or costs incurred in aggregating feedstock, alongside revenue that can be gained for outputs (electricity, compost, biogas etc). The economics of each facility will be unique and will need to be considered on a case by case basis.
- Other: Assessing or benchmarking operations performance against others in the industry, domestically and internationally. Engagement and feedback from waste generators (feedstock suppliers) and end market organisations to recognise potential operational efficiencies and adapt continual improvement alongside the needs of downstream and upstream markets.

9 Sources of further information

This section contains links to additional information, covering:

- Guidance
- Publications by SV and MWRRG
- Legislation
- Regulations and policies
- Australian standards
- Other sources of information

If you need help with any of the contents of this guide or have additional questions, please contact SV on +61 3 8626 8700.

Source, Title (Year)	Description, Link
Organics Specific Guidance	
Sustainability Victoria, Kerbside Organics collection (2017)	High level overview of kerbside organics collection options with links to more detailed guidance and selected case studies http://www.sustainability.vic.gov.au/Government/Waste-and-Resource-recovery/Kerbside-waste-and-recycling/Kerbside-organics-collection
Commonwealth Department of Environment and Energy, Food and Garden Waste Best Practice Collection Manual (2012)	A step-by-step guide to planning and implementing a food and garden waste collection service, prepared by Hyder Consulting (now Arcadis) http://www.environment.gov.au/protection/national-waste-policy/publications/food-and-garden-organics-best-practice-collection-manual
SV and MWRRG publications	
› Sustainability Victoria, Statewide Waste and Resource Recovery Infrastructure Plan (SWRRIP)	Victoria's 30-year state waste plan which provides a long-term vision and roadmap to guide future planning for waste and resource recovery infrastructure in the state. http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Statewide-Waste-and-Resource-Recovery-Infrastructure-Plan
› Sustainability Victoria, Victorian Organics Resource Recovery Strategy (2015)	This strategy is a key priority of delivering the 30 year SWRRIP. It provides a strategic statewide approach for government, business/industry and the community to better manage organic waste. http://www.sustainability.vic.gov.au/About-Us/Publications/Victorian-Organics-Resource-Recovery-Strategy
› Sustainability Victoria, Victorian Market Development Strategy for Recovered Resources (2016)	This strategy is a key priority of delivering the 30 year SWRRIP. It has been developed to support initiatives to stimulate markets for the use of recovered materials. http://www.sustainability.vic.gov.au/About-Us/Publications/MarketDev-Strategy-for-resource-recovery
› Sustainability Victoria, Victorian Waste Education Strategy (2016)	This strategy is a key priority of delivering the SWRRIP. It provides a consistent and coordinated approach to waste and resource recovery education. http://www.sustainability.vic.gov.au/About-Us/Publications/Strategy-planning-Waste-education-strategy
› Sustainability Victoria, Victoria's Waste & Resource Recovery Infrastructure Investment Prospectus (2015)	The Prospectus presents significant opportunities for waste and resource recovery infrastructure in Victoria. In particular, the document highlights the principle material streams, which includes organic waste, which are of importance to the state. http://www.sustainability.vic.gov.au/About-Us/Publications/Victorias-Waste-and-Resource-Recovery-Infrastructure-Investment-Prospectus
› The seven Regional Waste and Resource Recovery Implementation Plans (2017)	The Regional Implementation Plans (one each for the seven Waste and Resource Recovery Groups, WRRGs), outline the waste and resource recovery infrastructure, service needs, and how these can be met over at least the next 10 years for each region. http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Regional-Waste-and-Resource-Recovery-Implementation-Plans

Source, Title (Year)	Description, Link
› Sustainability Victoria, Guide to best practice for waste management in multi-unit developments (2017)	This guide outlines things to consider when designing a waste management system for medium-or high-density residential, mixed use and integrated housing developments. http://www.sustainability.vic.gov.au/About-Us/Publications/Guide-to-Best-Practice-for-Waste-Management-in-Multiunit-Developments
› MWRRG, Community and Stakeholder Engagement Guide (2016)	This guide has been developed to assist the waste and resource recovery sector to deliver meaningful and successful community and stakeholder engagement and delivers on one of the key actions outlined in the aforementioned Waste Education Strategy, by providing a kit to assist waste and resource recovery sites and operators to meaningful engage with their communities. https://www.mwrrg.vic.gov.au/engagement/community-and-stakeholder-engagement-guide/
› MWRRG, Engaging with Culturally Diverse Communities on Waste, Resource Recovery and Litter – a Kit for Educators (2017)	MWRRG has produced a toolkit to help councils communicate with their residents from culturally diverse backgrounds about waste, recycling and litter. https://www.mwrrg.vic.gov.au/engagement/culturally-diverse-communities/
› MWRRG, Bin Standardisation Guide (2017)	This guide was developed by MWRRG to support metropolitan councils to align their current kerbside garbage, recycling and organics bins with Standards Australia's ***Mobile Waste Containers – colours, markings and designation requirements AS 4123.7 – 2006 (R2017).*** https://www.mwrrg.vic.gov.au/projects/current-strategic-projects/bin-standardisation-guide/
› MWRRG, Back to Earth Initiative	MWRRG's Back to Earth Initiative runs in partnership with councils to support the successful operation of new organics processing facilities. The Back to Earth initiative shows us how what we put into our green waste bins can become a useful product that nourishes gardens and farms. http://backtoearth.vic.gov.au/about-the-initiative.html
Legislation and Regulations	
Environment Protection Act 1970 (EP Act)	› The ***Environment Protection Act 1970*** is a key legislative tool used in Victoria to protect the environment. Subordinate legislation under the Act includes: state environment protection policies or SEPPs for specific segments of the environment such as air, noise and groundwater; waste management policies governing the management of specific wastes and, environment protection regulations. Organics processing facilities must comply with relevant environmental protection legislation, policies and regulations. Facilities should also be consistent with the local and regional waste management plans relevant to their location. This Act is currently under review (at the time of writing). http://www.epa.vic.gov.au/about-us/legislation/acts-administered-by-epa#EPAct
Occupational Health and Safety Act 2004 (OHS Act)	› The ***Occupational Health and Safety Act 2004*** covers the health and safety responsibilities, roles and rights of everyone involved in making workplaces safer. It is relevant to employers, those who manage and control workplaces, employees, manufactures and suppliers. › http://www.worksafe.vic.gov.au/pages/forms-and-publications/forms-and-publications/occupational-health-and-safety-act-2004-summary
Environment Protection (Scheduled Premises) Regulations 2017 (Scheduled Premises Regulations)	The ***Environmental Protection (Scheduled Premises) Regulations 2017*** prescribe the premises that are subject to works approval and/or licensing by EPA, and provide for exemptions in certain circumstances. They provide a means to effectively manage these premises in a transparent way, which ensures an adequate level of community confidence is maintained. http://www.epa.vic.gov.au/about-us/legislation/regulations#Scheduled

Source, Title (Year)	Description, Link
Environment Protection (Industrial Waste Resource) Regulations 2009 (IWR Regulations)	The *Environment Protection (Industrial Waste Resource) Regulations 2009* provides schedules of prescribed waste. These are wastes that pose environmental, health and amenity risks and cannot be managed through conventional landfilling. These Regulations are currently under review (at the time of writing). http://www.epa.vic.gov.au/about-us/legislation/regulations#Scheduled
Occupational Health and Safety Regulations 2017 (OHS Regulations)	The OHS Regulations are made under the OHS Act and prescribe what an employer must do to comply with the OHS Act duties and provide the foundation for Victorian businesses to delivery successful health and safety outcomes. They provide a range of duties and requirements about how work should be conducted around common workplace hazards and activities. https://www.worksafe.vic.gov.au/news/notices/ohs-regulations-reform-2017
Agricultural and Veterinary Chemicals (Control of Use) (Fertilisers) Regulations 2015	Any product marketed as 'fertiliser' must comply with Victoria's *Agricultural and Veterinary Chemicals (Control of Use) (Fertilisers) Regulations 2015* and Department of Economic Development, Jobs, Transport and Resources' (DEDJTR) *A Guide to Victorian Fertiliser Regulations.* http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/95daf3d8286def33ca256da4001bc4e8/A935BE8D99FDD5F6CA257ECF001A4214/$FILE/15-108sra%20authorised.pdf http://agriculture.vic.gov.au/__data/assets/pdf_file/0010/321121/Guide-to-Victorian-Fertiliser-Regulations.pdf
Plant Biosecurity Act 2010	Under the *Plant Biosecurity Act 2010*, management of biosecurity risks is an obligation of landholders but with flow-down requirements on suppliers of feedstock, processors of feedstock and users of recycled organic (RO) products. The Act and *Plant Biosecurity Regulations 2010* apply to all plants and plant products, including fruit, vegetables, nuts, seeds and grains, forests and timber, native flora and ornamental plants. (Note, weeds are covered under the CaLP Act.) http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/51dea49770555ea6ca256da4001b90cd/106631C64775BAAECA25779E001D4947/$FILE/10-060a.pdf
Catchment and Land Protection Act 1994 (CaLP Act)	The CaLP Act covers noxious weed and pest animal management in Victoria, to protect primary production, Crown land, the environment and community health from adverse effects. The CaLP Act prohibits the movement and sale of noxious weeds of all categories anywhere in the State, and covers weed seeds occurring as contaminants in seed lots, plant products or on vehicles, machinery or animals. http://www.legislation.vic.gov.au/domino/Web_notes/LDMS/LTObject_Store/LTObjSt1.nsf/d1a8d8a9bed958efca25761600042ef5/a6c08457004d6b0eca257761001b712e/$FILE/94-52a041.pdf
Livestock Disease Control Act 1994 (LDC Act)	The LDC Act 1994 provides the legal basis for monitoring and control of diseases of animals to protect Victorian livestock from disease and to maintain and enhance domestic and international market access. The legislation also aims to protect public health by preventing diseases that are transmissible to humans, to provide compensation for certain livestock losses, and to facilitate the operation of livestock traceability systems for the purposes of market access and disease and residue control. http://www.legislation.vic.gov.au/domino/Web_Notes/LDMS/LTObject_Store/ltobjst9.nsf/DDE300B846EED9C7CA257616000A3571/07754A89299915DBCA2580D50078792E/$FILE/94-115aa076%20authorised.pdf

Source, Title (Year)	Description, Link
Regulatory Guidelines and Policies	
EPA Victoria, Demonstrating best practice, publication 1517 (2013)	This guideline outlines how EPA assesses best practice and provides guidance on how to demonstrate compliance with best practice requirements. http://www.epa.vic.gov.au/our-work/publications/publication/2013/february/1517
EPA Victoria, Designing, constructing and operating composting facilities, publication 1588.1 (2017)	This guideline outlines how the *Environment Protection Act 1970* and associated policies and Regulations are applied to the assessment of proposals for thermophilic, aerobic composting. The guideline focuses on providing standards for the processing of specific wastes, standards for products and separation distances for composting facilities. http://www.epa.vic.gov.au/our-work/publications/publication/2017/june/1588-1
	The draft guidelines on composting focus on providing standards for the processing of specific wastes, standards for products and separation distances. It should be noted that these guidelines are not final and subject to change following further consultation with industry, community and government. http://www.epa.vic.gov.au/our-work/publications/publication/2014/september/1577
EPA Victoria, Energy from Waste guideline, publication 1559 (2013)	This guideline outlines how the Environment Protection Act 1970 and associated policies and Regulations are applied to the assessment of proposals that recovery energy from waste. http://www.epa.vic.gov.au/our-work/publications/publication/2013/december/1559
EPA Victoria, Approvals proposal pathway, publication 1560.2 (2017)	The approvals pathway guideline supports approval applicants to complete the approvals proposal form and pathway form, which includes assistance with applying for exemptions, fast track works approval, standard works approval and Research, Development and Demonstration (RD&D) approvals. http://www.epa.vic.gov.au/our-work/publications/publication/2017/june/1560-2
EPA Victoria, Works approval assessment process – information bulletin, 1657 (2017)	This publication provides an overview of the works approval process. It does not provide detail on what is required in a works approval application (refer to publication 1658 below), but provides a high level of the process, including post decision processes. http://www.epa.vic.gov.au/our-work/publications/publication/2017/june/1657
EPA Victoria, Works approval application guideline, publication 1658 (2017)	This guideline explains what information is required in a works approval application, and caters for all application, ranging from a simple proposal through to highly complex ones. http://www.epa.vic.gov.au/our-work/publications/publication/2017/june/1658
EPA Victoria, Scheduled premises prompt sheets, publication 1659 (2017)	This publication provides prompt sheets for a number of scheduled categories, which includes waste treatment, disposal and recycling, and Schedule A07 – Organic Waste Processing (as defined in the guidelines). It lists common operational activities, potential environmental impacts and examples of best practice for pollution controls from such facilities. http://www.epa.vic.gov.au/our-work/publications/publication/2017/june/1659
EPA Victoria, Licence management guidelines, publication 1322.7 (2016)	This guideline provides assistance to the licence-holder to understand and manage their licence by providing guidance on things to consider when complying with your licence and demonstrating compliance. http://www.epa.vic.gov.au/our-work/publications/publication/2016/september/1322-7
EPA Victoria, Licence assessment guidelines, publication 1321.2 (2011)	This guideline provides information to licence-holders of single-site, corporate and accredited licences on how to establish an appropriate monitoring program. http://www.epa.vic.gov.au/our-work/publications/publication/2011/june/1321-2

Source, Title (Year)	Description, Link
Australian Standards	
AS4454-2012: Australian Standard for Composts, Soil Conditioners and Mulches (2012)	This Standard specifies requirements for organic products and mixtures of organic products that are to be used to amend the physical and chemical properties of natural or artificial soils and growing media. It applies to organic products and mixtures of organic products that have been treated by pasteurizing or composting procedures as defined by the Standard https://infostore.saiglobal.com/store/Details.aspx?ProductID=1512286
AS4564: Australian Standard Specification for General Purpose Natural Gas (2011)	This Standard specifies the requirements for the safe composition, transportation and supply of general purpose natural gas for use in natural gas appliances and equipment, and for use as fuel in natural gas vehicles. It applies to natural gas that is from biogas and other sources where the gas is provided for direct or blended supply on a commercial basis through supply systems serving general purpose customers. https://infostore.saiglobal.com/en-au/Standards/AS-4564-2011-1466954/
AS/ISO 31000: Risk management - Principles and guidelines (2009).	This Standard provides principles and generic guidelines on risk assessment and ca be applied to a wide range of activities, including strategies and decisions, operations, processes, functions, projects, products, services and assets. https://infostore.saiglobal.com/store/details.aspx?ProductID=1378670
Other sources of information	
Bioaerosol emissions from waste composting and the potential for workers' exposure (2010)	This study, funded by the UK Health and Safety Executive (HSE) and Environment Agency was undertaken with an aim of measuring bioaerosol emissions form a representative range of commercial UK composting facilities. The report provides data that could be used by composting facilities to better understand the likely bioaerosol emissions and therefore exposure controls that could be applied for such facilities http://www.hse.gov.uk/research/rrpdf/rr786.pdf
Farm Biosecurity guidance	Farm biosecurity is a set of measures designed to protect Australia's farms from the entry and spread of pests, diseases and weeds; primarily aimed at agricultural producers. The website provides a range of information resources and guidance documents. It is part of the Farm Biosecurity Program; a joint initiative of Animal Health Australia (AHA) and Plant Health Australia (PHA). http://www.farmbiosecurity.com.au

Notes

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