Produced by GHD
for Bioenergy Australia

Fertile Ground

The role of digestate in Australia's circular economy

2022

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Bioenergy Australia is working to grow Australia's bioeconomy and usher in a clean energy future.

Our aspiration is a nation that embraces sustainable, secure, affordable and locally sourced energy sources, which in turn stimulates development and employment — without costing the climate.

Bioenergy, derived from biogenic inputs (plants, animals and their by-products and residues), is the world's primary source of renewable energy. The use of bioenergy can cost-effectively reduce carbon emissions, boost energy productivity and reliability, and pave the way to a circular economy.

Bioenergy Australia estimates bioenergy could contribute up to 33 per cent of the future global primary energy supply in 2050. It is the only renewable energy source that can replace fossil fuels in all energy markets — heat, electricity, and transport fuels.

In Australia, we've barely scratched the surface of the bioenergy opportunity. Bioenergy is diverse, deriving from myriad biomass or biofuels.

One process that creates bioenergy, in the form of biogas, is anaerobic digestion.

Anaerobic digestion is the controlled decomposition of biodegradable organic waste to produce biogas, a methane rich fuel, and digestate, a byproduct that can be used as a soil conditioner or fertiliser.

The process is well established globally for its economic and socioenvironmental benefits. These include:

- Renewable energy and fertiliser
- Reduction of waste to landfill
- Reduction of greenhouse gas (GHG) emissions

The World Biogas Association reported in 2019 that there were already 132,000 small, medium and large-scale anaerobic digesters and 50 million microdigesters operating globally with the opportunity for significant further growth.

Anaerobic digestion, offering renewable energy, heat and soil nutrient benefits, is a relatively untapped resource in Australia. Here we explore what it is and how we can do more with it.

A circular economy — where waste and pollution is eliminated, resources are circulated and nature is regenerated — necessarily runs on renewable energy. It will benefit all of society, reduce business costs and our impact on the planet.

Anaerobic digestion supports a circular economy, enabling recovery and use of the embodied energy, nutrient and heat values of organic matter.

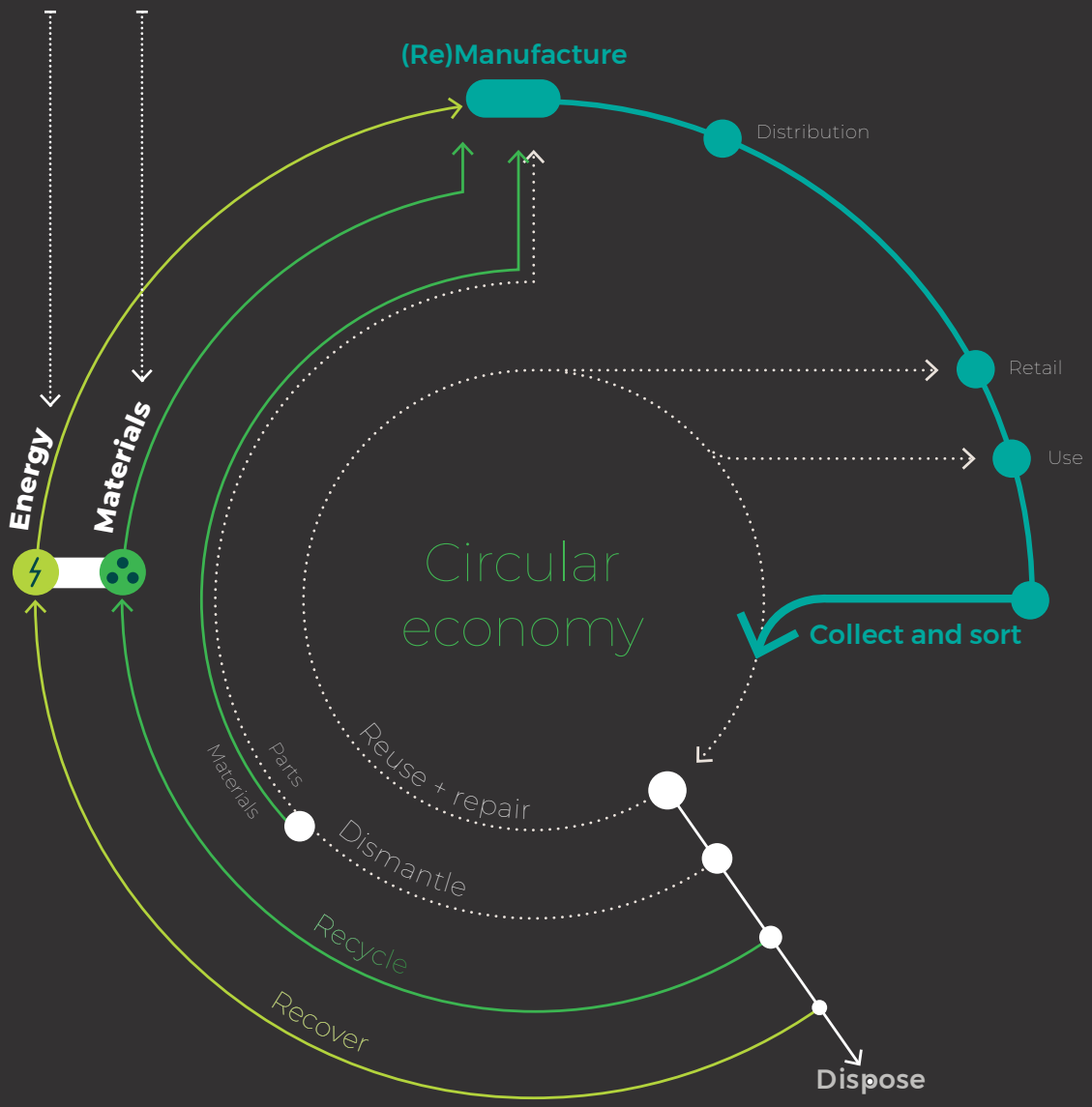


Diagram adapted from acehub.org.au

How anaerobic digestion works

Anaerobic digestion is the controlled biological decomposition of biodegradable materials, such as food waste and animal manure in digester tanks, vessels or covered ponds. Microorganisms naturally break down organic materials in the absence of air, to create biogas, which rises to the top for collection.

Biogas is mostly methane and carbon dioxide, with small amounts of water vapour and other gases.

Biogas can be upgraded by removing the carbon dioxide and other components to leave only methane, the main component of natural gas. This is sometimes called biomethane or renewable natural gas (RNG). Biogas is a reliable, renewable, local energy source that can:

- Supply homes and businesses via the natural gas grid
- Power engines
- Produce heat and electricity
- Fuel boilers and furnaces
- Run alternative-fuel vehicles.

What remains after the digestion process is known as ‘digestate’. This nutrient-rich mixture can be separated into solid and liquid fractions. It can be used as crop fertiliser, supplanting the need for conventional energy-intensive mineral fertilisers.

Alongside land application, other potential digestate uses or value-added processing options include:

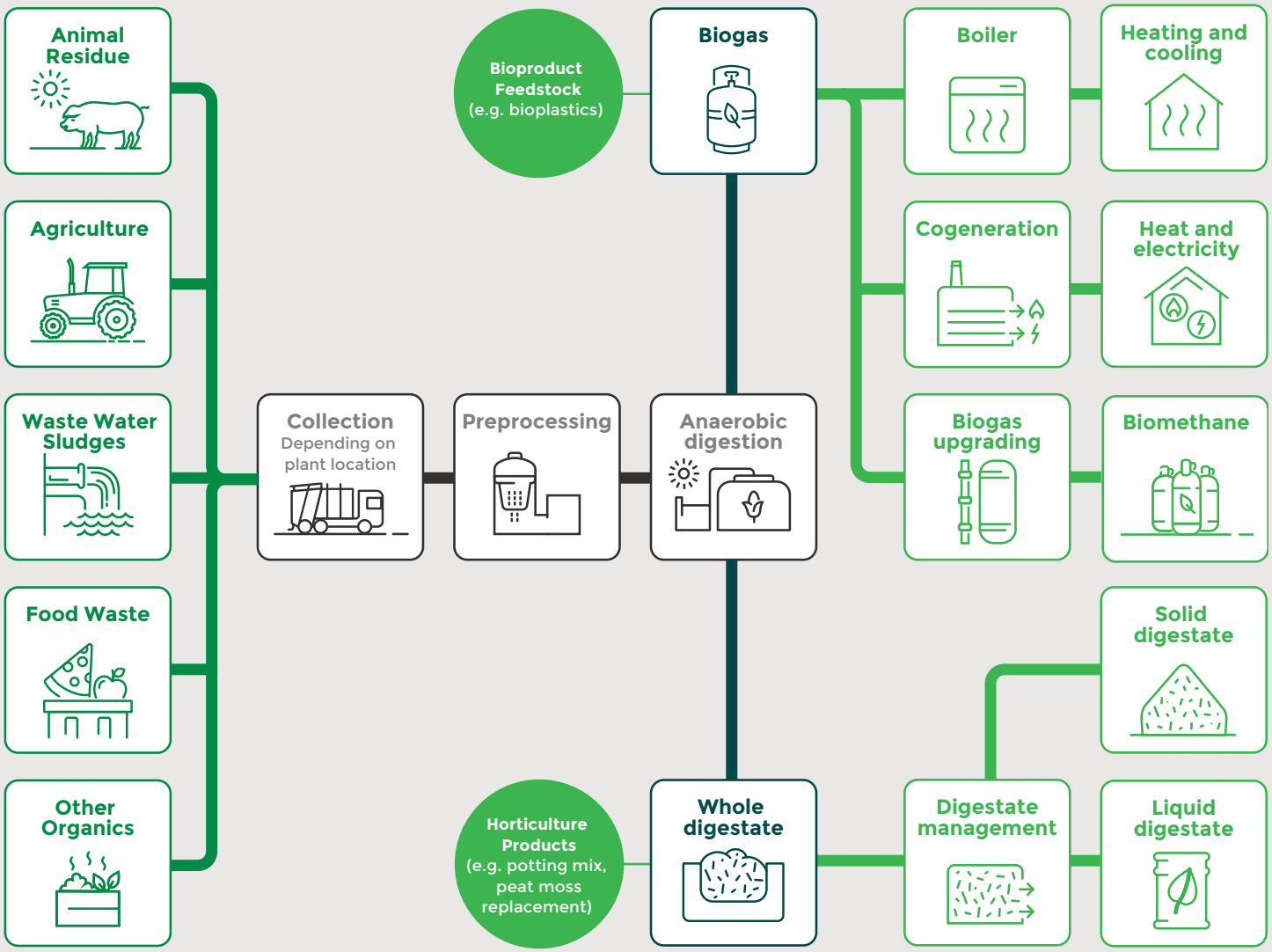
- Application to land as a soil conditioner
- Pyrolysis to create biochar used as soil conditioner
- Livestock bedding (when dried)
- Input to organic fertiliser manufacture
- Beneficial input to composting processes
- Beneficial input to potting mixes.

Digester inputs and outputs

A digester can process a range of organic materials, including:

- Animal manures
- Food and food processing waste
- Fats, oils, and greases
- Commercial and industrial organic residuals
- Organic material from agricultural and livestock production, including crop residues.

The anaerobic digestion supply chain



Farmers' rocket fuel

Digestate has been dubbed 'rocket-fuel' by farmers due to its high available nitrogen content as compared to livestock slurries.

It can be an economical, nutrient-rich organic fertiliser that enriches and replenishes the soil, while offering a solution to managing increasing amounts of organic waste.

One tonne of mineral fertiliser replaced with digestate saves up to one tonne of oil, 108 tonnes of water and seven tonnes of CO_2 emissions, according to the UK Anaerobic Digestion and Bioresources Association.

Along with nitrogen, digestate contains potash, sulphur, magnesium and trace elements, the amounts of which will vary according to the producer and types and quantities of feedstocks used. It can be applied directly to land or incorporated into soils to improve soil characteristics and fuel plant growth.

Digestates can come in several forms depending upon the process used and can comprise whole, solid or liquid digestates.

"Anaerobic digestion has been widely used around the world for the processing of waste organic materials and its popularity is still growing due to its key role in business and communities moving to adopt circular economy principles.

"In its most important role, anaerobic digestion can facilitate a diversion of large volumes of agro-industrial, domestic and commercial waste and by-products from landfill disposal and reduce the methane emissions this practice creates."

(The production and use as biofertiliser of digestate derived from source segregated organic waste, Bioenergy Association of New Zealand Technical Guide 8, March 2021).

Whole digestate

Whole digestate, which looks like livestock manure slurry, can be separated by a dewatering process or mechanical means into solid and liquid (fractions) digestate.

Dry Matter ≈ 1-10%

Solid digestate

Solid (fraction) digestate, the solid and/or fibrous material remaining after digestion processes.

Dry Matter ≈ 20-40%

Liquid digestate

Liquid digestate, the liquid from dewatering the whole digestate.

Dry Matter ≈ 1-10%

Note: Dry matter percentages shown are indicative only and can vary significantly between technologies and processes.

Liquid digestate can be an alternative to mineral and synthetic fertilisers.

The benefits of land application include:

- Lower farm fertiliser costs
- A more readily available source of nitrogen
- Nitrogen (N), phosphorus (P), and potassium (K) trace elements
- Reduced carbon footprint
- Less packaging.

Solid digestate is the solid material separated from whole digestate. It can improve soil condition.

The benefits of land application include:

- Increased soil moisture retention
- Supplementing organic matter in the soil
- Greater land workability
- Improved soil structure
- Better drainage.
- Carbon sequestration in the soil

Solid digestate can be further refined into dry, pelletised and bagged products. Some emerging technologies can recover the nitrogen and phosphorus in digestate and create concentrated nutrient products, such as struvite (magnesium-ammonium-phosphate) and ammonium sulfate fertilisers.

Using digestate as an organic fertiliser can help reduce a farm's carbon footprint, and collectively transform the agricultural sector by reducing the need to apply synthetic and mineral fertilisers manufactured with non-renewable inputs. It can also provide carbon essential to good soil biology.

Case Study

EarthPower Technologies

EarthPower Technologies, in Sydney, Australia's first food waste to energy facility, converts organic waste from industrial, commercial and residential sources into green energy and nutrient-rich organic fertiliser. The company produces prills, a dry pelletised soil amendment for use in fertiliser blends that are sold commercially. The prills are 2mm to 4mm in diameter, 90 per cent dry matter, and comprise physical characteristics similar to many chemical fertilizers.

Benefits

Benefits for farming

- Digestate as a fertiliser can contain all macronutrients and micronutrients necessary for modern farming. Higher humus content in soil can improve moisture and carbon retention, improving soil fertility, productivity and resilience.
- Global reserves of phosphate are declining. Digestate offers the opportunity to recycle this valuable nutrient from organic waste streams. Organic fertilisers also release more slowly providing nutrients to plants for up to three years (European Biogas Association, Digestate Factsheet, 2019), with a lower risk of leaching into water than mineral fertilisers.
- Digestate is a safer fertiliser than raw organic material because it has fewer animal and plant pathogens due to the microbial conditions in the digester and after thermal treatment of digestate (where necessary)
- It can reduce the spread of invasive weeds

Benefits for the economy and employment

Anaerobic digestion incorporates proven technology, and employs skilled plant constructors, operators and service providers. It offers the possibility of thousands of jobs in regional areas. Regional job creation is, in part, driving anaerobic digestion policy in other countries, for example Denmark, Germany and UK, and would be no less an important political and economic consideration in Australia, too.

Benefits for the climate

Avoiding harmful emissions

While organic fertilisers can release low or even neutral GHG emissions throughout the production cycle, all organic materials have the potential to release powerful GHGs such as methane and nitrous oxide into the atmosphere, if uncontrolled. Digesting organic materials anaerobically enables the capture and use of GHG emissions that would otherwise be released during decomposition. Anaerobic digestion can help countries achieve GHG emissions reduction targets.

Substitute for energy intensive synthetic and mineral fertilisers

In Europe, producing a tonne of mineral fertiliser emits an average of 9.7 tonnes of CO_2 equivalent, harming the environment and extending reliance on imported natural gas. Replacing synthetic and mineral fertilisers with organic digestate fertilisers can drastically reduce emissions.

Lower costs

Digestate can be more competitively priced than mineral and other inorganic fertilisers. Farmers with high manure loads can also build their own digester to produce their digestate fertiliser locally saving on transport costs, and perhaps selling any surplus to create a new income stream.

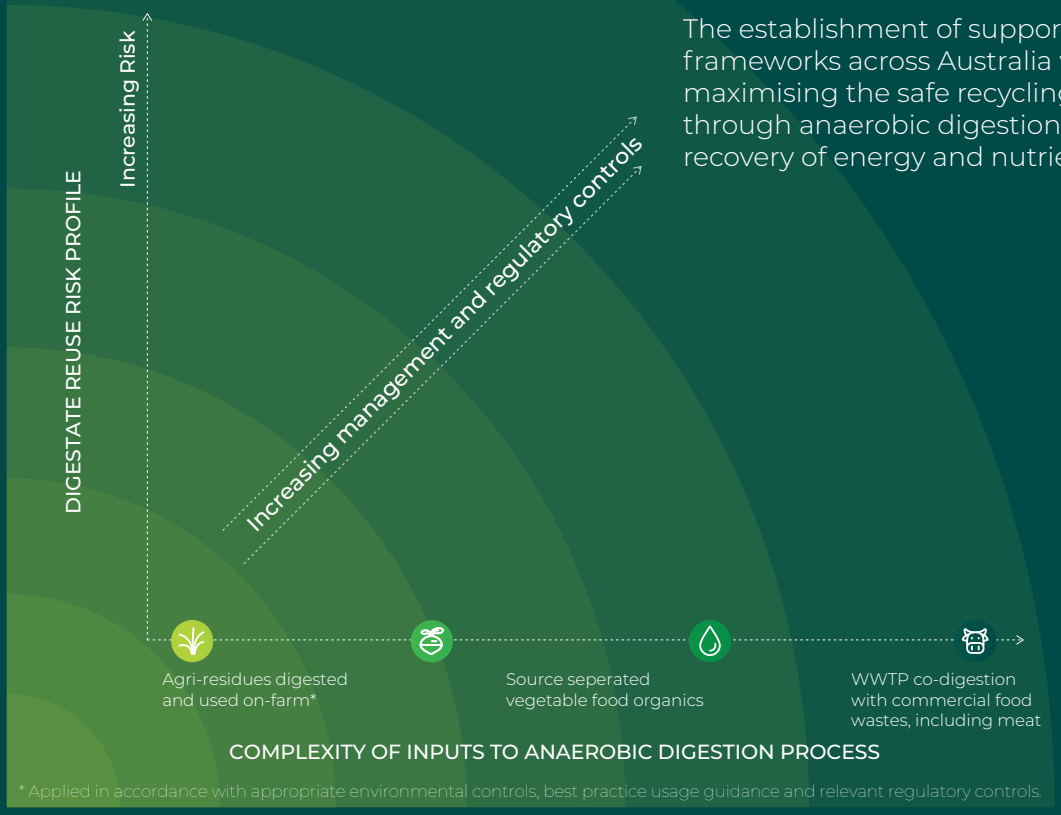
9.7 tonne of CO_2

In Europe, producing a tonne of mineral fertiliser emits an average of 9.7 tonnes of CO_2 equivalent

Maximising recovery of energy and nutrients from organic matter

The circular management of organic matter brings multiple benefits and reduces overdraw on our natural resources. Organics recycling needs to be undertaken safely, with appropriate management of the outputs from anaerobic digestion, aerobic composting, or any combination of these.

Different feedstocks have differing characteristics. For example, crop waste and manures produced and recycled on-farm present different considerations to urban-sourced food and garden organics, which require differing levels of regulation and management intervention. End uses of digestates from anaerobic digestion need to consider the sources of inputs, the management controls employed and a range of potential risks.



Appropriate, risk-based regulatory frameworks that take into account both feedstocks and proposed uses can ensure that safe recovery of organic material is suitably and proportionately managed and supported, including the need for pasteurisation for some feedstocks.

The implementation of clear policy and regulatory frameworks enables digestate end users (e.g. farmers) to be confident they are applying recovered organic material to their land safely and to enjoy its extensive nutrient and carbon benefits. Establishing trust and confidence in product benefits and performance is an important part of building demand for recycled organic products, including digestate.

As with conventional fertilisers and other agronomic inputs, user guidance on application rates may be needed in certain situations.

Germany and the UK already have regulations for digestate production and usage to support its application to land for beneficial outcomes. Nearer home, the New Zealand Bioenergy Association has developed a technical guide for "*The Production and Use as Biofertiliser of Digestate Derived from Source Segregated Organic Waste*".

The establishment of supportive regulatory frameworks across Australia will help with maximising the safe recycling of organic materials through anaerobic digestion while also enabling recovery of energy and nutrients.

What's in the way?

The uptake and integration of anaerobic digestion in the organic waste management infrastructure mix varies globally, largely according to economic drivers and progressiveness of government policy.

Pioneering countries such as Denmark and Germany have seen strong government support for anaerobic digestion, with funding and tax incentives.

In Australia, anaerobic digestion is an established technology. It is used to treat sewage in municipal wastewater treatment plants, wet agricultural wastes, and food and beverage processing residues.

Examples of dedicated biowaste-to-energy facilities, processing commercial food waste, include Richgro in Perth, the Yarra Valley Water's ReWaste facility in Melbourne, and the aforementioned EarthPower, in Sydney.

Compared to other developed countries however, Australia has not widely adopted anaerobic digestion, for reasons that include:

- Unsupportive regulatory policy
- Agricultural reliance on conventional fertilisers
- Relatively low grid-supplied energy costs
- Relatively low landfill charges

Times are changing though, with increasingly demanding international and national sustainability and climate change commitments and growing government and commercial interest in circular material reuse over linear disposal to landfill.

Australia will need to overcome significant challenges if it is to grow the use of anaerobic digestion, and digestate in particular. These challenges include:

National Regulatory Policy

The Commonwealth Government's Emissions Reduction Fund Biomethane method package credits eligible biomethane projects under existing waste management emissions abatement methods. The package allows biomethane produced under eligible methods to generate Australian carbon credit units (ACCU's) which can be used to offset emissions or sold on the open market to organisations seeking to reduce their carbon footprint. However, the scope of this method package still needs expanding to properly cater for the various feedstocks that may be used, all digestion processes, and to recognise the multiple benefits offered by anaerobic digestion.

Australia does not yet have green gas certification available that would enable gas distributors and users seeking to reduce carbon footprints to be able to confidently purchase biomethane (renewable natural gas), including that produced from anaerobic digestion.

The establishment of a national mandatory green gas target alongside gas certification would further incentivise the use of biomethane by high volume gas users.

Inconsistent legal and policy frameworks for digestate use

Australia lacks consistent policy and regulation to guide the management and use of digestate. Individual Australian states set regulations governing the management and reuse of organic waste. Most Australian states have yet to classify digestate or provide a clear pathway for classifying quality-managed digestate as a product. Some state regulators have even classified digestate as reportable priority waste residue, making cost-effective beneficial use very difficult. What is needed is a clear pathway for classifying quality-managed digestates as products suitable for application to land.

The States and Territories each have different laws and policies for how anaerobic digestates may be transported and used, with digestates sometimes being captured in policies focused on

> *"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)."*
>
> Guide to Biological Recovery of Organics, Sustainability Victoria 2018

aerobic composting (which can result in confusing or irrelevant requirements), it being unclear if it is covered or not, or regulatory requirements for anaerobic digestates not sufficiently delineating by risk based on:

- their feedstocks,
- scope of feedstock sources, and
- proposed scope of digestate use

Anaerobic digestion is sometimes subject to higher regulatory barriers than aerobic composting for comparable feedstocks.

The character of end-of-waste classifications can create real disincentives for the transport and use of digestates given the reputational and regulatory outcomes for end users when low-risk materials remain classified as 'waste' until after their use. Suitable and proportionate risk-based approaches are needed.

Ultimately, a national approach may be necessary, to define supportive policy settings that will provide greater confidence for investment in anaerobic digestion infrastructure in Australia. Without clear enabling policy or consistent regulation to encourage and manage the beneficial use of digestate in Australia, uptake will remain inhibited.

Regulatory uncertainty

Greater regulatory clarity, specifically the conditions for using digestate as a commercial product, coupled with supportive policies, will encourage and support uptake. It is important that standards, policy and regulatory guidance are established and implemented for digestate products. The inconsistent approach of different jurisdictions is an impediment to investment and enabling viable projects to proceed. For example, in NSW, recyclers must rely on Resource Recovery Orders and Exemptions, such that waste-derived products can be sold into beneficial reuse markets in NSW. These orders and exemptions are only valid for two years and renewal is not assured. The quality parameters, and contamination acceptance limits and application rates are also reviewed at these 2-year intervals. This provides insufficient certainty to proponents looking to invest in new and existing projects.

Haulage and spreading costs

For some digestates, transport costs can be high due to distances between feedstock sources and end users and some digestates' high water content. Setting up local plants or sharing costs between supply chain participants may mitigate these issues. In some jurisdictions, digestate is considered a controlled or regulated waste requiring transport by licensed contractors and tracking and reporting of each consignment, adding to overall usage costs. Farmers will otherwise need to consider if the costs of transporting and applying digestate are worthwhile.

Lack of awareness and safety concerns

Farmers and regulators may be poorly informed (or even misinformed) about the benefits of digestate, and defining compliance obligations, making them reluctant to embrace its use. A concerted information/education campaign to communicate the advantages of digestate and correct misconceptions about its safety would be helpful.

Commercial and competitive considerations

Australia has so far lacked funding and focus to explore circular economy approaches and potential opportunities for farmers to collaborate and scale-up use of organic fertilisers, including digestate. A competitive incumbent mineral fertiliser industry, which benefits from avoiding costs associated with enhancing sustainability and closing the nutrient cycle, has generally not embraced biogenic inputs to-date. Incumbent suppliers also have the luxury of well-defined product standards and usage guidance built on years of agronomic extension work.

So, now what?

The developed world is moving towards more circular economies with shorter supply chains.

Countries and governments of every level are looking to reuse and recycle wherever possible, to conserve natural resources and do less harm to our shared environment.

Bioenergy will play a central role in creating a circular economy. Anaerobic digestion will be an increasingly important process for the supply of that bioenergy, in the form of biogas.

As biogas production increases, so will digestate as its corresponding residual output.

Digestate offers an economical, enriching fertiliser that bolsters and replenishes the soil, while reducing waste to landfill and lessening GHG emissions.

The sooner we do more with digestate the better. Australia can encourage greater use of digestate by:

- Building awareness of its environmental, social and financial benefits and debunking misconceptions
- Working to overcome the incumbent inertia of established mineral fertiliser use
- Creating financial incentives for investment in anaerobic digestion technology
- Drafting supportive policies and legal frameworks for management and use
- Developing greater regulatory clarity and certainty about management and use.

To discuss how we can work together to promote the adoption of digestate, and hasten a cleaner energy future, please contact:

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IEA Bioenergy
Technology Collaboration Programme

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Case Study

Higher order organic waste use in New South Wales

Anaerobic digestion as a way to turn municipal organic waste into higher value products, such as biogas, biomethane, and biofertilisers, is re-emerging in New South Wales as landfills reach capacity and following the NSW Environment Protection Authority's ban on land application of mixed waste organic output material.

Food waste is the second largest commercial and industry organic waste in NSW, totalling more than 300,000 tonnes in Sydney alone. NSW households throw out more than 800,000 tonnes of food waste annually. The wastage in dollar terms is about $10 billion, or $3,800 per household each year.

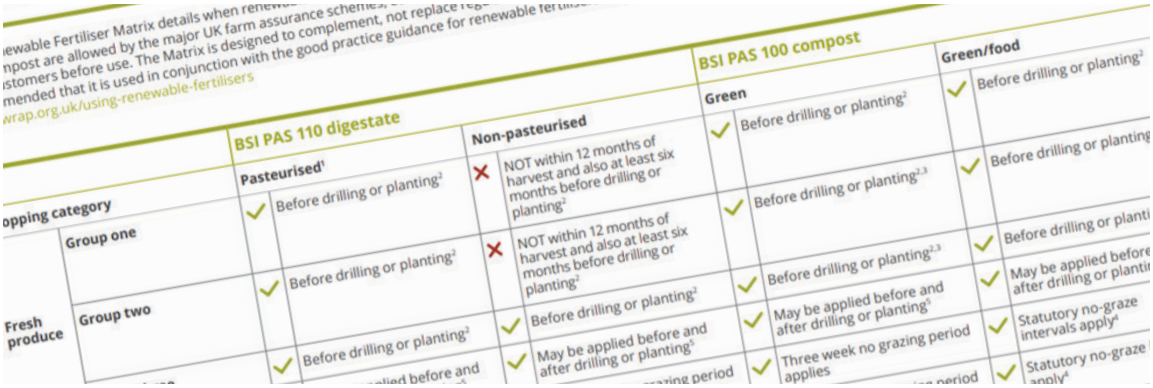
Recovering waste for its highest order use, wherever possible, should be the focus in accordance with waste hierarchy principles. This offers significant benefit in collecting and converting food waste into higher value products through anaerobic digestion, instead of sending it to landfill.

More than 40 NSW councils are already providing source-separated Food Organics and Garden Organics (FOGO) kerbside collections. Bioenergy Australia encourages governments to focus on greater organics separation to provide a cleaner feedstock for anaerobic digestion and the creation of quality-managed digestate for fertilisers. The National Waste Action Plan includes support for the implementation of FOGO services across Australia. Australia's National Soil Strategy is accompanied by the Food Waste for Healthy Soils funding program.

More broadly around Australia, momentum is gathering to divert the disposal of food waste. For example, Woolworths' new Sustainability Plan includes a commitment of zero food waste to landfill by 2025 and net positive carbon emissions by 2050. More councils are also implementing FOGO services.

Case Study

Digestate in the UK



ewable Fertiliser Matrix details when renew
mpost are allowed by the major UK farm assurance schemes
stomers before use. The Matrix is designed to complement, not replace
mended that it is used in conjunction with the good practice guidance for renewable fertil
wrap.org.uk/using-renewable-fertilisers

		BSI PAS 110 digestate			BSI PAS 100 compost		
		Pasteurised[1]		Non-pasteurised	Green		Green/food
opping category		✓	Before drilling or planting[2]	✗ NOT within 12 months of harvest and also at least six months before drilling or planting[2]	✓	Before drilling or planting[2]	✓ Before drilling or planting[2]
Fresh produce	Group one	✓	Before drilling or planting[2]	✗ NOT within 12 months of harvest and also at least six months before drilling or planting[2]	✓	Before drilling or planting[2,3]	✓ Before drilling or planting
	Group two	✓	Before drilling or planting[2]	✓ Before drilling or planting[2]	✓	Before drilling or planting[2,3]	✓ Before drilling or planti
		✓	lied before and	✓ May be applied before and after drilling or planting[5]	✓	May be applied before and after drilling or planting[5]	✓ May be applied before after drilling or planti
				zing period	✓	Three week no grazing period applies	✓ Statutory no-graze intervals apply[4]
						period	✓ Statutory no-graze apply[4]

The UK charity **Waste and Resources Action Programme** (WRAP) works with businesses, individuals and communities towards a circular economy. Working with farm assurance and other food-chain stakeholders, it has developed a Renewable Fertiliser Matrix to standardize the safe use of renewable fertilisers. WRAP intends the matrix as a guide to complement regulatory requirements.

The matrix details when renewable fertilisers can be used to grow different crops. It is based on a scientific research program, which evaluated the risks to human and animal health and the environment from the application of digestate and compost to land. It is also based on discussions with key industry representatives and crop assurance schemes.

The UK has instituted a **Biofertiliser Certification Scheme** providing assurance to consumers, farmers, food producers and retailers that biofertiliser is safe and of good quality. Digestate and compost manufacturers must comply with process and product specifications to be eligible for certification.

The **British Standards Institution's Publicly Available Specification** 110 (BSI PAS 110 or PAS110) gives a baseline quality specification for digestate, ensuring it is consistent, safe and reliable to use. Each PAS specifies minimum quality criteria.

The **Anaerobic Digestate Quality Protocol** applies in England, Wales and Northern Ireland, and sets out criteria for the production and use of digestate.

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Bioenergy Australia

Our Work

We are committed to accelerating Australia's bioeconomy. Our mission is to foster the bioenergy sector to generate jobs, secure investment, maximise the value of local resources, minimise waste and environmental impact, and develop and promote national bioenergy expertise into international markets.

Australia lags behind the world when it comes to bioenergy, and we aim to change that. We empower, share knowledge, and connect Australian bioenergy producers, investors, researchers, and users to make Australia's bioeconomy world-class.

We Advocate

We Campaign

We Inform

We Connect

Be a part of Australia's bioenergy future: Get in touch today.

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