Closing the Loop

INTRODUCTION

‘Closing the Loop’ sets out the pork industry’s plan to move to zero waste to landfill and contribute to the circular economy.

The pig industry is a leader in ‘Closing the Loop’ on waste; both as a user of by-products from other sectors, and as an efficient user of all the resources on the farm to maximise pork production and generating energy and nutrients. This roadmap provides guidance for pork producers, regardless of size, to participate in effective waste management methods to ‘Close the Loop’.

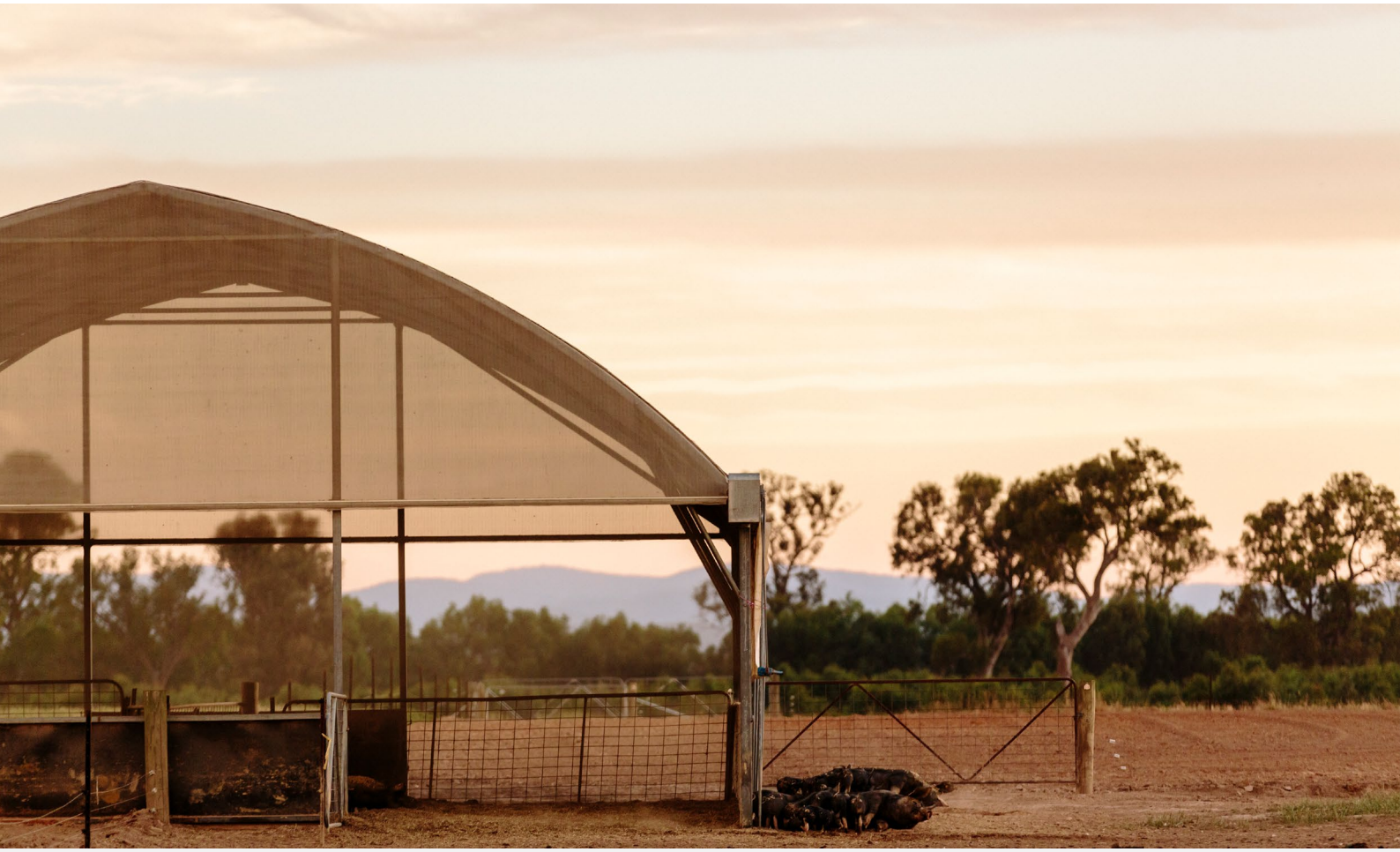
The implementation of commercially viable waste management strategies could see piggeries setting the new standard in low waste food production.

Waste minimisation is of significance across all Australia, with targets in place at national, state and regional levels, including a federal government commitment to a 50 per cent reduction in food waste by 2030. In addition to government policies, major retailers have also developed programs with the aim of reducing waste.

APL’s goal of closing the loop on waste by 2025 is consistent with other parts of the food supply chain and broader public policy.

Achieving a circular economy requires a change of thinking: all inputs should be considered to ensure that any waste they generate can be used, and all waste material generated must be considered a potential resource and potential income source.

In the agri-food sector, the pig industry can improve circularity by utilising other waste products from the human food supply chain as feed sources for pigs and can also move to circular agricultural systems at the piggery itself.



How piggeries can help

The pig industry is a leader in circularity in the food sector, but more can be done to harness the opportunities to use by-products from other parts of the economy, and to reduce waste from pig production.

This roadmap is divided into five key areas. In each area the guide shows the process of closing the loop, following steps in the waste hierarchy (Reduce > Reuse > Recycle >Recover). These five areas are:

Feed

Minimising inputs, improving production efficiency to minimise wastage, substituting third party food waste products into piggery feed, alternative feed sources

Energy

Recovery of residual energy in the effluent system through methane capture from anaerobic digestion, co-digestion of third party waste products to increase methane generation, biomethane production

Nutrients

Utilising manure nutrients, nitrogen (N.). phosphorus (P) and potassium (K), in raw form, nutrient recovery to create high-value products

Water

Minimising water usage through waste reduction and reuse, on-site recycling

Solid waste

Minimising consumption and using the highest proportion of recyclable materials on-site, including plastic, cardboard and metal

Waste measurement indicators

To measure progress towards the goal of closing the loop, it is important to measure waste generation rates over time to assess change. The below table provides a range of waste indicators for different production systems:

Resource	Description	Units	Indicator	Purpose
Feed	% of ration sourced from residues and by-products	%	Ration ingredients	On-farm/supply chain benchmarking
	Estimated % feed waste in piggery	%	/kg LWG	On-farm/supply chain benchmarking
	Decrease in FCR/HFC in last 12 months	%	Change in FCR/HFC	On-farm/supply chain benchmarking
	Ration ingredients	%	% of ration using imported ingredients	On-farm/supply chain benchmarking
	Ration ingredients	%	% of ration using locally grown ingredients	On-farm/supply chain benchmarking
Energy	% of energy in manure beneficially used*	%	% of energy in manure beneficially used*	On-farm/supply chain benchmarking
	CO_2 utilisation	%	% CO_2 utilised in a beneficial way*	On-farm/supply chain benchmarking
Nutrients	Effluent / manure utilisation	%	% of N utilised for beneficial purposes*	On-farm/supply chain benchmarking
	Effluent / manure utilisation	%	% of P utilised for beneficial purposes*	On-farm/supply chain benchmarking
	Effluent / manure utilisation	%	% of K utilised for beneficial purposes*	On-farm/supply chain benchmarking
Water	% of effluent water utilised for beneficial purposes*	%	% of effluent water utilised for beneficial purposes*	On-farm/supply chain benchmarking
Solid waste	kg solid waste excluding manure	kg	/kg LW produced or exported	On-farm benchmarking
	kg of plastic waste	kg	/kg LW produced or exported	On-farm benchmarking

**Beneficial is defined as a positive, good, or advantageous result by the indicated practice. This may be in relation to pasture or crop application of solid waste products or effluent water reuse, where a beneficial application would imply meeting the requirements of the plants in question as to limit nutrient build-up above requirements or possibilities of nutrient leaching or runoff.*

Feed

Improving Feed Conversion Ratio (FCR)

Reducing waste starts with optimising inputs to the system.

To improve current grain-fed feeding systems requires reducing feed wastage into the manure management system.

Major changes which can reduce wastage include:

- Changing feed type (changing from mash to pellets or liquid food),
- Feed presentation (feeder type), and
- Feed processing (optimising feed particle size for pig growth stage).

Minor changes that can greatly reduce feed wastage include optimised feeder adjustment, cleanliness, auger monitoring and feeder pan coverage to reduce spills and overfeeding.

For new installations that deliver dry feed, electronic feeding systems that use electronic identification to provide the individual with the pre-set allocated portion will provide the greatest reduction in feed wastage. Liquid feeding systems allow for even greater savings, as do wet/dry feeders compared to using conventional dry feeders.

Utilising commercial food waste

Pigs are one part of the solution to closing the loop on an estimated 7.3 million tonnes of food wasted in Australia each year (Commonwealth of Australia 2017). Under current laws, swill (food that has been offered for human consumption) and waste meat products are illegal to be fed to pigs, meaning wastes from primary production and manufacture are the most suitable to be included in pig diets.

Primary production waste includes product loss along the supply chain which is damaged or discarded during production, packaging or handling. Surplus product may be a result of a fall in market prices or the inability of the product to meet quality or size specifications. This includes fruit and vegetables, nuts, wine grapes, crops, fish, eggs, livestock and milk.

Manufacturing waste is produced from fruit, vegetable and seafood processing and the manufacturing of oil and fat, grain mill and cereal, bakery product, sugar and confectionary, meat and meat product and dairy product.

Currently only 10-20 per cent of commercial pig herds divert food waste from primary production and manufacturing (Torok et al. 2021) utilising a very small portion of the potentially available 4 million tonnes.

Utilising by-products

By-products and co-products suitable for use in pig diets are summarised below:

Dairy	Grain milling	Animal	Vegetable	Sugar production
Whey Dried buttermilk Dried skim milk	Millrun Wheat bran Wheat pollard Rice hulls Rice bran Rice pollard Biscuit meal Brewers grain Dried distillers Grain Hominy meal	Animal fat Blood meal Meat and bone meal Hydrolysed hog hair	Dried potato meal, slices, flakes	Cane molasses Bagasse

Alternative feed sources

Insect meal has been recognised as a cost-effective and sustainable alternative to reducing protein meals in pig diets, with black soldier fly larvae (BSFL) the most promising candidate in place of high-protein feeds.

Although currently in Australia all insect farmers are of small scale or in the startup phase, the sector is receiving significant interest and investment due to the potential of closing the loop on waste whilst producing protein for use in livestock feed.

Alternate waste utilisation includes duckweed and algae. Whilst these options have promise, foundational research and development of guidelines and legal frameworks is required prior to on farm trials being implemented.

Before introducing new dietary ingredients to a commercial piggery operation, the following considerations should be addressed:

1	Check state government guidelines with regard to regulations for alternative feed for pigs.
2	Is it considered swill? Meat or meat products or any food that has been in contact with meat is prohibited. Do not use food waste from households or restaurants. For more information go to farmbiosecurity.com.au.
3	Check the supply for continuity considering swine digestive processes need time to adjust.
4	Are there storage and packaging requirements to consider and what is the shelf life?
5	What is the cost benefit, are there added costs associated with transportation and storage?
6	What is the moisture content e.g. brewers grains and vegetable by-products must be stored to minimise leaching.
7	Conduct a nutrient analysis and check variation in the nutrient content.
8	Consider contamination and toxins as feeding excess phosphorus must comply with nutrient management and waste plans while cottonseed and grain screenings can harbour mycotoxins.

Speak to your vet or nutritionist to discuss what alternative sources of feed can be utilised in your production system.

Energy

Methane capture

Regardless of how efficient a piggery is at minimising feed waste and improving FCR, a proportion of the energy in feed will pass through the pig into the effluent treatment system. In traditional effluent treatment systems, this is converted through a biological process in the anaerobic effluent ponds, and energy is released to the atmosphere as methane gas.

Several options exist to utilise captured biogas, with each described below.

Heat utilisation

Boiler efficiency is approximately 90 per cent.

Electricity generation

Generator efficiencies is approximately 25-40 per cent.

Combined heat and power (CHP)

CHP conversion of methane gas into electrical energy is approximately 25-40 per cent; while an additional 45-55 per cent can be recovered as heat energy to create high-value products.

Biomethane production

Produce a high quality renewable methane gas and carbon dioxide to sell to a commercial processor.

Co-digestion

One method which assists in maximising the return on investment as well as assisting in closing the loop on waste is co-digestion. Anaerobic co-digestion is the treatment of two (or more) separate waste streams through an anerobic digestor in order to increase the methane generation from a system.

A range of waste products, by-products and co-products from agricultural, industrial and municipal sources are potentially suitable for co-digestion.

Although the use of anaerobic co-digestion can successfully reuse, reduce and recover waste, implementation requires careful consideration and consultation with experienced professionals. Co-digestion in a covered anaerobic pond is generally suitable for wastes with low solids content, while a mixed liquid digester is more suitable for wastes with higher solids.

Nutrients

Manure by-products

Piggery by-products contain significant quantities of nitrogen, phosphorus, potassium, trace elements and carbon which are valuable commodities in agricultural production. Depending on the production system, nutrient rich manure by-product streams may include:

- Effluent
- Separated solids
- Sludge
- Spent Litter

Based on typical fertiliser application rates for broadacre farming of 100kg of nitrogen and 20kg of phosphorus, a 1,000 sow conventional operation could provide enough nitrogen for 945 ha and phosphorus for 1,650 ha of broadacre farmland each year.

Current nutrient usage

Current nutrient usage in the Australian pig industry varies from farm to farm, with a high level of use of piggery manure by-products through irrigation or for land application occurring at some sites, while others operate closed systems where effluent is lost through evaporation, and nutrient either lost to the atmosphere or retained in the sludge in effluent ponds.

On-site manure use leads to a reduction in waste, particularly if crops (grain/straw) produced on-site can be utilised back through the piggery production cycle.

Although the nutrients in effluent are a valuable resource, regulatory and operational issues associated with the transport and spreading of high volume, low strength effluent can make the cost and process onerous for some piggery operators. While on-site treatment and storage of effluent and manure solids improves the operational management of application, the process does result in a loss of significant amounts of nitrogen to the atmosphere which could be considered a wasted resource. Opportunities exist for the recovery and reuse of the maximum amount of nutrients (further discussed in Section 5.4).

Mortalities use

Management of mortalities is a part of all piggery operations, with the preferred methods for disposal as recommended by Tucker (2015) shown below:

Most Preferable

Rendering

Composting

Incineration
(proper incineration)

Burial

Burning

Least Preferable

The disposal of mortalities should ideally be heading towards composting and rendering, as these are the most efficient and least wasteful methods to handle the carcase.

Nutrient recovery technologies

While some piggery by-products are utilised through agriculture, a significant portion of the nutrients are wasted through loss to the atmosphere (nitrogen) and/or retained indefinitely in closed system wastewater treatment systems.

Nutrient recovery technologies include:

- Enhanced biological phosphorus removal
- Chemical coagulation/flocculation
- Chemical precipitation/ crystallisation
- Liquid-gas stripping
- Adsorption/ion-exchange
- Settling systems

Water

Minimising potable water use

Water is both the most important nutrient for pigs and the second most valuable natural resource (after land) in Australia.

Total direct freshwater consumption has reduced from over 90L/kg LW to less than 20L/kg LW between 1980 and 2020 for conventional piggery operations.

Although there is some scope to further reduce direct freshwater usage through improvements in efficiency, maintenance and FCR, the most promising opportunities come from water treatment.

The extended water cycle for piggeries includes water use in cropping. Reducing demand on irrigated crops and conducting a more thorough analysis of water for feed grain would be beneficial to reduce demand.

Water recycling

Advanced water treatment plants (AWTPs) are becoming more common in Australian meat supply chains. Technologies available within AWTP that are relevant to on-farm piggeries include:

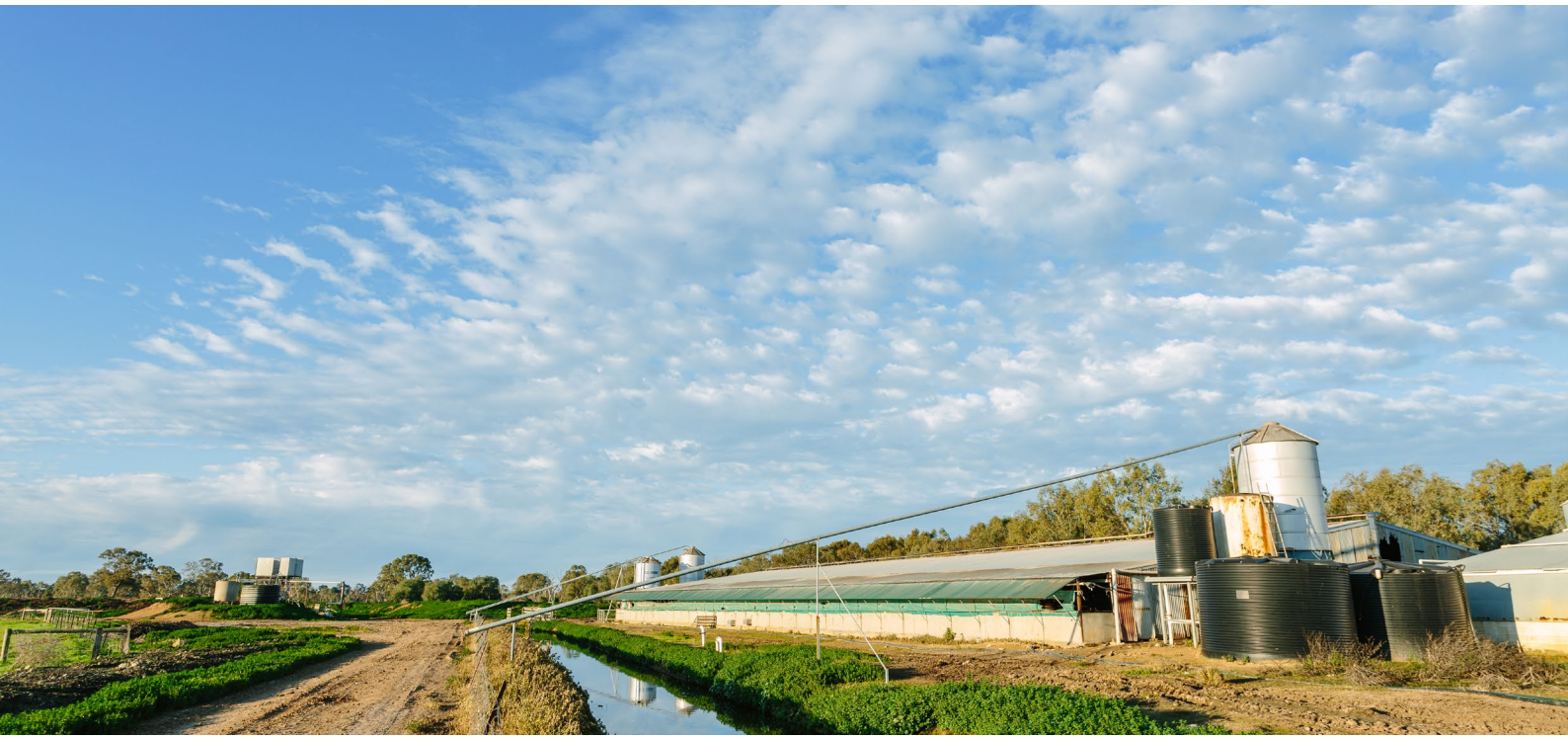
- Membrane filtration
- Disinfection treatments

Different water quality standards, regulatory approvals and monitoring requirements are applicable for different uses.

Potential use options for recycled water include:

- Hose down and cleaning water
- High volume irrigation water
- Cooling water
- Stock drinking water

Depending on the end use of the recycled water and the relevant state government regulations, a water recycling scheme may require approval from the state government agency.



Solid Waste

Solid waste generation is an important and easily measurable waste stream and is often an important key metric in supply chain waste assessments. Solid waste can be categorised as:

Recyclable

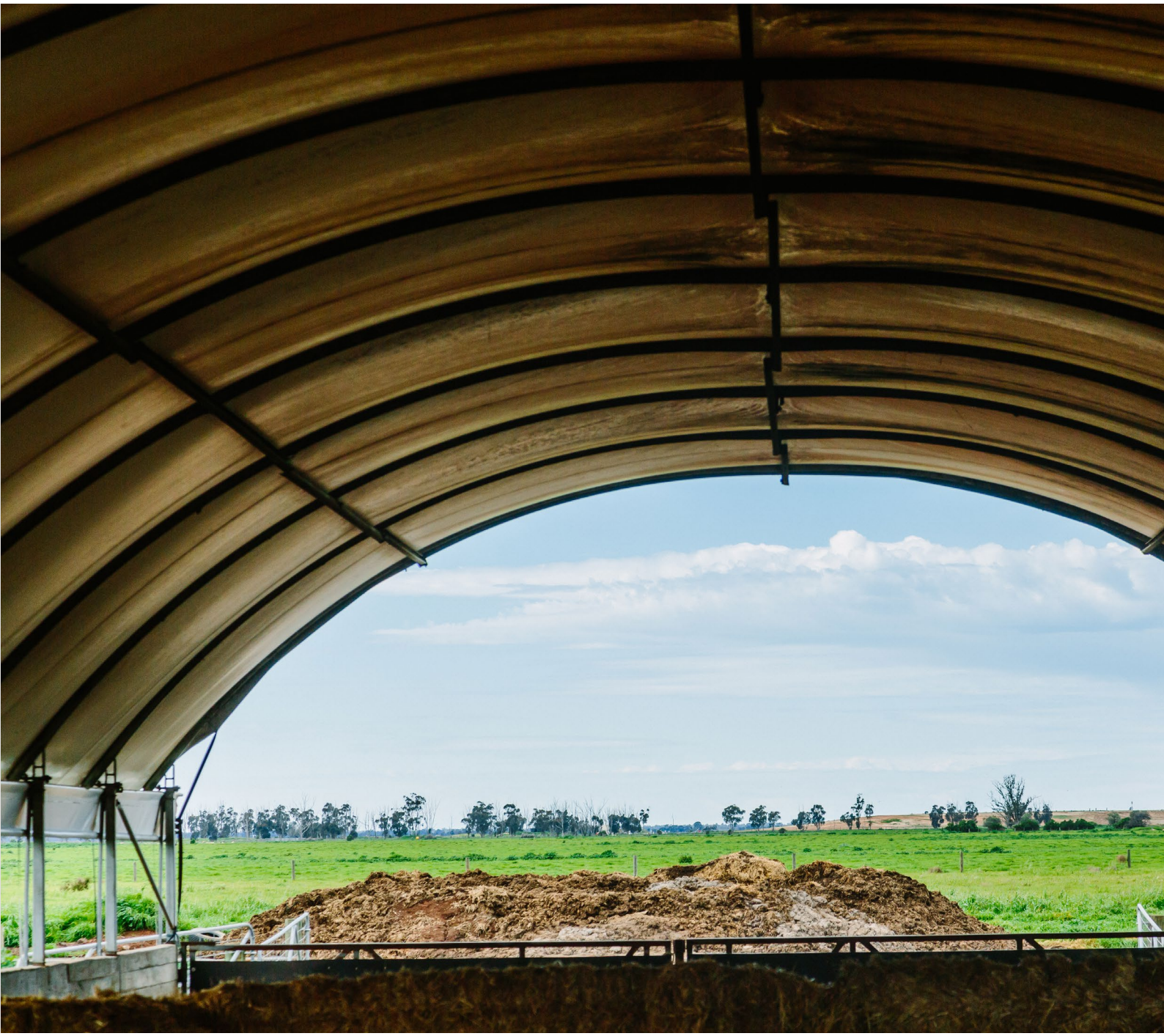
Recycling is the process of converting waste into a reusable material.

Compostable

Composting natural materials into a nutrient-rich substrate.

Biodegradable

Any material that can be decomposed by bacteria and micro-organisms.



A large portion of the waste generated from a piggery site can be recycled if the correct method of disposal is followed:

Category	Recyclable	Method of disposal
Metal (e.g. feeders, gates, crates)	✓	Scrap metal company offers collection or use of a collection bin free of charge. The dealer pays for the scrap metal (copper, aluminium, stainless steel, lead, steel, brass) by weight.
Concrete (e.g. slatted flooring)	✓	Can be disposed of to a concrete recycling facility, free of charge.
Expanded polystyrene (e.g. eskies)	✓	Dropoff at an EPS collection facility.
Rigid plastic (e.g. penguin feeders, slatted flooring, feeders)	✓	Plastics recyclers offer pickup, drop-off or a collection bin.
Rubber (e.g. matting)	✓	Rubber tyre recycling and disposal service offer pickup.
PVC (e.g. polypipe)	✓	Needs to be free from contamination and in sufficient, ongoing quantities to warrant feeding offcuts into production processes. Alternatively, use a construction waste company for disposal.
Paper and cardboard	✓	Recycle in curb side or industrial specific recycling bin.
Glass (e.g. medicine & vaccination bottles, coffee jars)	✓	Remove the plastic or metal lids and dispose of in general waste. Bottles can then be disposed of in the recycling bin. No need to remove paper labels.
Chemical drums	✓	Cleaned containers recycled through the drumMUSTER program.
Plastic AI straws	✓	AI straws may be recycled if they are collected and tied into bundles or packaged into containers of the same type of plastic. Once repackaged, the straws can be processed through the normal plastics recycling.
Feed bags (woven polypropylene)	✓	Feed bags may either be returned to the producer for reuse, or recycled through the REDcycle system. The REDcycle system does require bags to be cut into A3 sized pieces which will require additional processing by producer.
Cling film pallet wrapping	✓	Pallet wrap can be recycled if bundled. Once bundled then the wrap can be recycled through the REDcycle system.
Baling twine	✓	Baling twine can be recycled if bundled together into clean bundles. Once bundled, the twine can be processed through the normal plastics recycling.
Sharps bin	✗	Place all needles and syringes in a sharps disposal container. Syringes are not recyclable. Collection company will dispose of in a thermal treatment facility.

Review your waste management systems and choose some alternative actions you can take to reduce your impact and help close the loop on waste.

Long-term options to reduce wastes include:

- Going paperless – utilising electronic data recording
- Removing the single-use of eskies - businesses are using thick cardboard as an alternative which is strong enough to protect the product and costs the same to use. For thermal insulation, leak proof hard plastic tubs can be used and returned at each collection time to be reused e.g. veterinary industry.

MORE INFORMATION

For a copy of the Sustainability Framework have a look on **APL's website** or contact Rowena Davis at **rowena.davis@australianpork.com.au**

For technical information, contact Gemma Wyburn at **gemma.wyburn@australianpork.com.au**