Final Report

AUSTRALIAN MEAT PROCESSOR CORPORATION

Final Report

Bio-solids upgrade. Stage 1

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Prepared by
TESSELE CONSULTANTS

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1 Executive Summary

The red meat industry has significant potential to achieve resource circularity, increase production efficiency, improve financial prospects, and reduce environmental impacts, by producing marketable products from its solid, liquid and gas by-product streams. In previous years, the global red meat industry would traditionally dispose of most red meat industry by-products in landfills, seeing them as waste rather than marketable products for reuse. The red meat industry is now ready to utilise its full potential, and as part of this, AMPC is considering how the industry can process the solid waste stream from red meat processors (sludge) into marketable bio-based fertiliser products.

AMPC has also recognised the great potential to recover useful and marketable products from the red meat processing industry and is currently funding a biobased fertiliser research project, leveraging on the integrated bioresource recovery facility recently developed (AMPC 2021b). In this concept, all putrescible solid by-products and sludges are processed via a biodigester, to recover energy via methane production. The by-product of anaerobic digestion is the digestate, which is rich in nutrients and organic matter and can be directly used as a liquid fertiliser. However, there are limitations to the application of digestate, especially in the rainy season. Therefore, the concept of further processing this resource into a dry commercial product becomes a necessity for the success of the integrated approach to bio-resource recovery.

The objective of this project is to determine the potential for producing bio-based fertiliser from anaerobic digestate at AMPC member red meat processing facilities. The project involved a mass balance to quantify potential production, a review of available processing technologies, and a requirements and market analysis to match potential bio-based fertiliser production with demand across Australia. The project also included a survey of potential off-takers, an extensive regulatory review, and a review of business model options for funding and operating the facility, including example contractual agreement documents. A multi-criteria assessment was conducted to evaluate the feasibility of implementing bio-based fertiliser facilities at red meat processors. The findings and outcomes of the above-mentioned work can be used as a basis on which to proceed with the next stages of the project.

The mass balance shows that if all facilities implement an anaerobic digester and bio-based fertiliser plant, there is potentially enough digestate available to collaborate with fertiliser producers and support a more sustainable fertiliser production in Australia.

The technology required to process the digestate, including dewatering, drying, pelleting and potentially pyrolysing or gasifying into biochar, is available. The capital and expected operating costs are reasonable and expected to generate a positive return on investment. This is due to the reduction in costly waste disposal and added income streams from the bio-based fertiliser, biogas, heat and energy produced in the anaerobic digestion part of the integrated facility, high quality reuse water from the WWTP part of the integrated facility, and carbon credits.

Off-takers have indicated interest in the product, particularly in the forestry, commercial, Natural Resource Management and mine and quarry rehabilitation sectors. For the 11 selected case study facilities strategically selected across Australia, there is market demand well in excess of potential production quantities, particularly evident in the municipal, Natural Resource Management, Landcare and mining sectors,

The preliminary digestate characterisation testing indicates a product with good NP ratios for fertiliser, although more dilute in total nutrient content than straight, primary nutrient commercial fertilisers. There is an opportunity to augment the product with additional nutrients (such as potassium) for product optimisation to suit specific end-users. In terms of pathogens, contaminants and pollutants, the digestate shows promise to be of a potentially higher quality than municipal biosolids, indicating that regulations may allow almost unrestricted use of the product.

Regulations were reviewed, and it was found that no existing regulations exist for the production and use of bio-based fertiliser derived from red meat processors. It is suggested that the municipal biosolids guidelines be used as a basis on which to build a regulatory framework.

There are several business models (for the funding and operation of the bio-based fertiliser facility) for red meat processing facilities to choose from, each with different advantages and risks, and an example of contractual agreement documents were provided in previous reports for this project.

The multi-criteria assessment shows that the overall benefits outweigh the risks of undertaking the project, and that there is potential for a positive business case for the implementation of bio-based fertiliser facilities at red meat processing plants. The establishment of a pilot plant is a crucial step in developing this technology and realising its full potential for sustainable agriculture and regional development.

2 Introduction

Australia's red meat processors generate significant waste streams that could potentially be used as feedstock for anaerobic digestion (AD) systems. These waste streams primarily include cattle, calves, sheep, lambs, and goats. The potential AD system could be used to process the waste generated during the processing of livestock, such as the sludge stream from wastewater treatment plants, DAF stream comprising of various organic and inorganic solids, and an organic solids stream.

The feedstock generated from the waste streams can then be utilised in an anaerobic digester, potentially remaining in the digester for up to 65 days. A proposed model in the Southwest of Western Australia suggests having two AD reactors operational, with a hydraulic residence time of 10-20 days. This design allows for additional feedstock to be utilised, potentially doubling the energy output. High carbon waste, such as food waste and brewery waste, can be added to the digester feed, which can affect the quality and quantity of the biogas produced, along with the quality of the digestate exiting the AD reactor.

By implementing an AD system, the meat processing industry could significantly reduce their environmental impact and move towards a more sustainable future. The AD system has the potential to provide a sustainable waste management solution, generating clean energy and valuable bio-based fertilisers. While co-digestion with additional feedstocks could enhance the business case for AD reactors and biofertilizer plants, this is not a consideration in this project.

The potential benefits of implementing AD systems in the meat processing industry are numerous. Not only does it provide an alternative and sustainable waste management solution, but it also generates clean energy that can be used to power the meat processing facility or sold back to the grid. Additionally, the bio-based fertiliser generated from the AD system can be used to improve soil health and reduce the need for synthetic fertilisers.

In conclusion, the utilisation of AD systems in the meat processing industry has significant potential for reducing environmental impact and moving towards a more sustainable future. However, further research and planning are required to determine the feasibility and benefits of implementing such systems in the industry.

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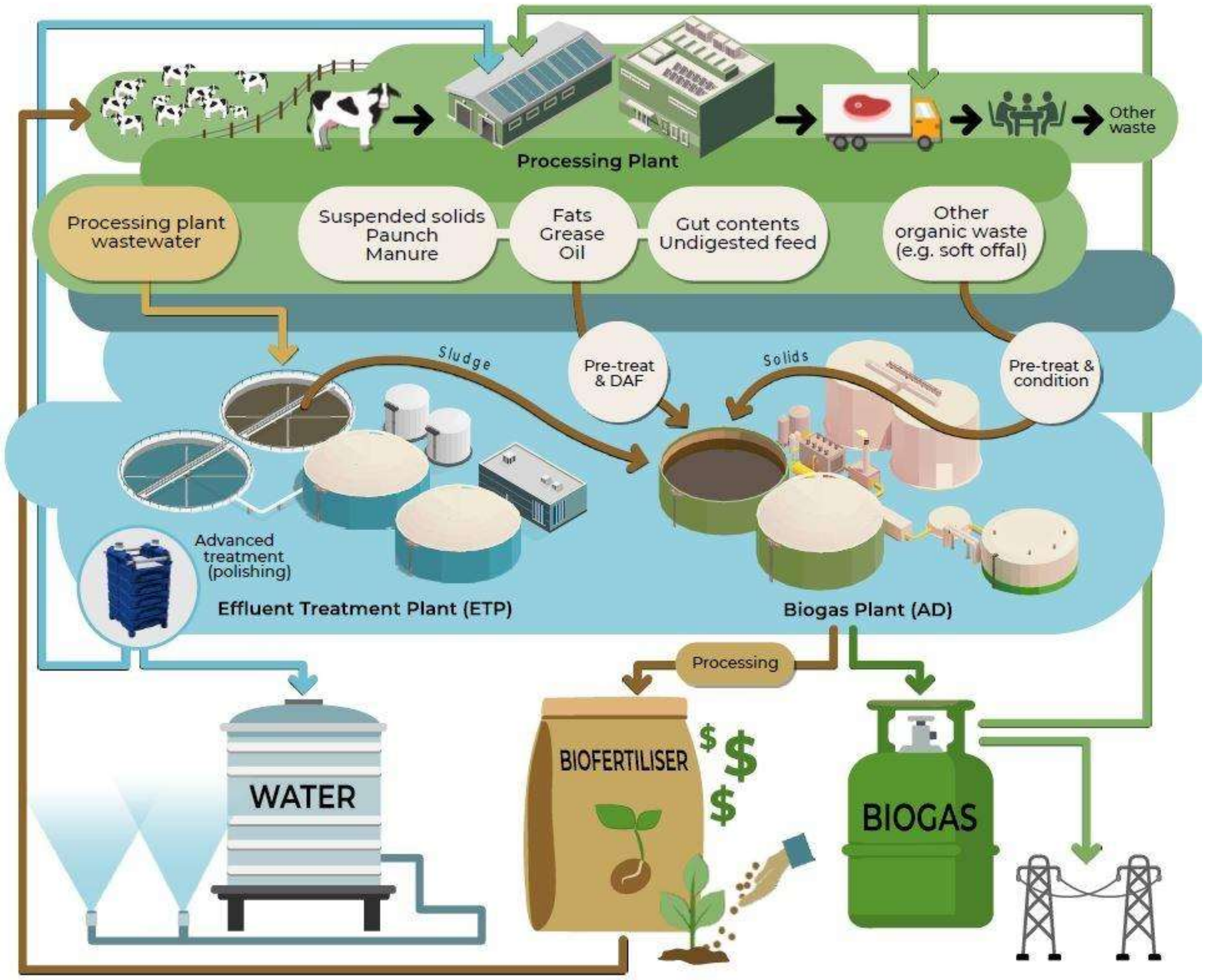


3 Project Objectives

The key objective of the Bio-based Solids Upgrade Project is to establish feasible methodologies for re-processing bio-based solid waste from the red meat industry into commercially suitable bio-based fertilisers. The first stage of this project involves an assessment and pre-feasibility exercise. The desired long-term outcomes include:

- Establish feasible methodologies for re-processing bio-based solids from red meat processing facilities
- Implementation of plant pilot trials for re-processing bio-based solid waste into bio-based fertilisers
- Implementation of upgrades for processing red meat processing facility bio-based solids, resulting in large-scale, commercial re-use of red meat solid waste in the form of bio-based fertilisers

The long-term outcomes will be reached by achieving the following objectives:

- Quantify the volume of bio-based solids currently generated by the red meat industry in Australia (desktop assessment, including assumptions of existing wastewater pond treatment plants and other solid wastes)

- Classify types of waste that will be generated from the future Integrated Bioresource Recovery Facilities (primary and activated wastewater treatment plant sludges produced from a future modular wastewater treatment plant, other redirected solid waste from red meat processing facilities)
- Review options to convert these solids into intermediate by-products or resources that could then be accepted by off-takers with a commercial value
- List and map potential end users based on their geographic location and proximity to existing red meat processing facilities
- Engage with potential end users, supported by an Expression of Interest process, to understand the requirements and willingness to receive (and pay) for the bio-based fertiliser products
- Review regulatory barriers that will need to be addressed to enable the by-products to not be considered as waste in each mapped jurisdiction
- Produce a model of a likely resource recovery facility, the future Integrated Bioresource Recovery Facility, supported by example documentation required to establish the facility and a cost-benefit analysis with feasibility
- Produce a decision matrix (go/no go) aiming to assess the feasibility of matching supply and demand, with a view to continuing the study into phases 2 and 3

4 Methodology

The methodology for this Bio-based Solids Upgrade Project – Stage 1, included the following:

- Conducting a mass balance of the potential bio-based fertiliser able to be produced at each AMPC member red meat processing facility across Australia.
- Conducting a literature review of available anaerobic digestate dewatering and further reprocessing technologies, to convert the by-products from the red meat processing facilities into valuable bio-based fertilisers.
- An expression of interest process, whereby potential bio-based fertiliser offtakers for case study red meat processing facilities were contacted and surveyed, to obtain market information on the end-user requirements and demand for bio-based fertiliser in various sectors.
- A bio-based fertiliser demand and market analysis, whereby land usages within a 50km radius around red meat processing facilities were identified, quantified and mapped. This activity also involved analysing the demand of the bio-based fertiliser for each identified potential sectoral use, by using required application rates for different sectoral uses, with the adjacent quantity of land utilised in the sector, and comparing this to the potential supply of bio-based fertiliser able to be produced at the red meat processing facilities.
- The anaerobic digestate was characterised via literature review, in addition to pilot studies using anaerobic digestate from a case study red meat processing facility existing anaerobic pond. This sludge was then dewatered using a variety of methods, where the dewatered digestate cake and filtrate were analysed for physico-chemical properties. The dewatered sludge was then further processed via pyrolysis, gasification

and combustion to analyse potential biochar properties, in addition to potential bio-based fertiliser pellet properties of the expected product.

- A cost benefit analysis was carried out, comparing the financial benefit of implementing an example bio-based fertiliser production facility at a case study red meat processing facility (in addition to implementing the required WWTP upgrade and biogas facility to produce the digestate), compared to the base case of upgrading only the WWTP (required) and disposing of the wastewater sludge and existing solid waste from the red meat processing facility.
- A regulatory review was undertaken, to assess the existing regulations related to the production and use of bio-based fertiliser derived from the red meat processing industry. This included a thorough review of the municipal domestic WWTP biosolids regulations and provision of recommendations for the next steps.
- A comparison of the different bio-based fertiliser facility operational models was analysed via desktop review and conversation with potential third-party investors and operators.
- An appendix was provided in previous reports, containing example documents of the various agreements needed for successful funding, construction, operation and maintenance of the facility.
- A decision matrix and multi-criteria analysis, to determine whether the project would be a Go or No-Go, were conducted.
- This final report concisely collated the summarised information from each of the previous milestones, to provide a basis on which to make the decision to go forward with the further stages of the project.

5 Project Outcomes

5.1 Industry drivers and opportunities

Various red meat processors in Australia are looking into upgrading their existing lagoon WWTPs to better comply with increasingly stringent environmental regulations. The additional benefit of upgrading their WWTPs is to have the ability to increase the capacity of their red meat processing facilities, which are often limited by the restricted capacity of their existing WWTPs. Furthermore, some red meat processing plants are constrained by resource availability and reliability, for instance the availability of enough processing water, or reliable and consistently priced energy for production. Regardless of the initial driver behind upgrading the WWTPs at individual red meat processing facilities, rather than perceiving the necessary WWTP upgrades as an unavoidable expense, there is an opportunity to view them as a chance to re-evaluate resource recovery. By incorporating a bio-based fertiliser processing plant as part of an integrated Bio-Resource Recovery Facility, valuable resources can be recovered, providing financial, environmental and social benefits.

The driver to add a bio-based fertiliser plant to further process the 5%TS digestate generated from the anaerobic digestion biogas plant (part of the integrated Bio-Resource Recovery Facility), is for several reasons. Firstly, it will be easier to regulate the production and sale of a solid bio-based fertiliser product than a liquid digestate. Liquid digestate management has been a challenge in the industry, and the use of liquid digestate can depend on state regulations, which may change. Although Europe has been permitted to use liquid digestate directly in soils for some time, and tends to lead the way in this industry (with the USA, NSW and QLD not far behind), they are starting to move away from the direct use of liquid digestate again in order to gain better control over nutrient and contaminant loadings applied to soils. Secondly, the transport costs to take a denser, solid product rather than large volumes of a liquid product from the production facility to the end user will be cheaper, result in a lower carbon footprint, and be easier to store, handle and package. Thirdly, the reduction of potential contaminants and pathogens via a solid bio-based fertiliser production facility allows for more flexibility and control than attempting to control the treatment of pathogens and contaminants solely via the anaerobic digestion biogas plant.

The overall financial, social and environmental benefits of implementing a bio-based fertiliser plant at a red meat processing facility, in comparison with the base case (where there is a WWTP and biogas plant requiring disposal of wet 5%TS digestate), are summarised below. The **$** represents financial benefit, **E** represents environmental benefit and **S** represents social benefit of implementing each processing plant.

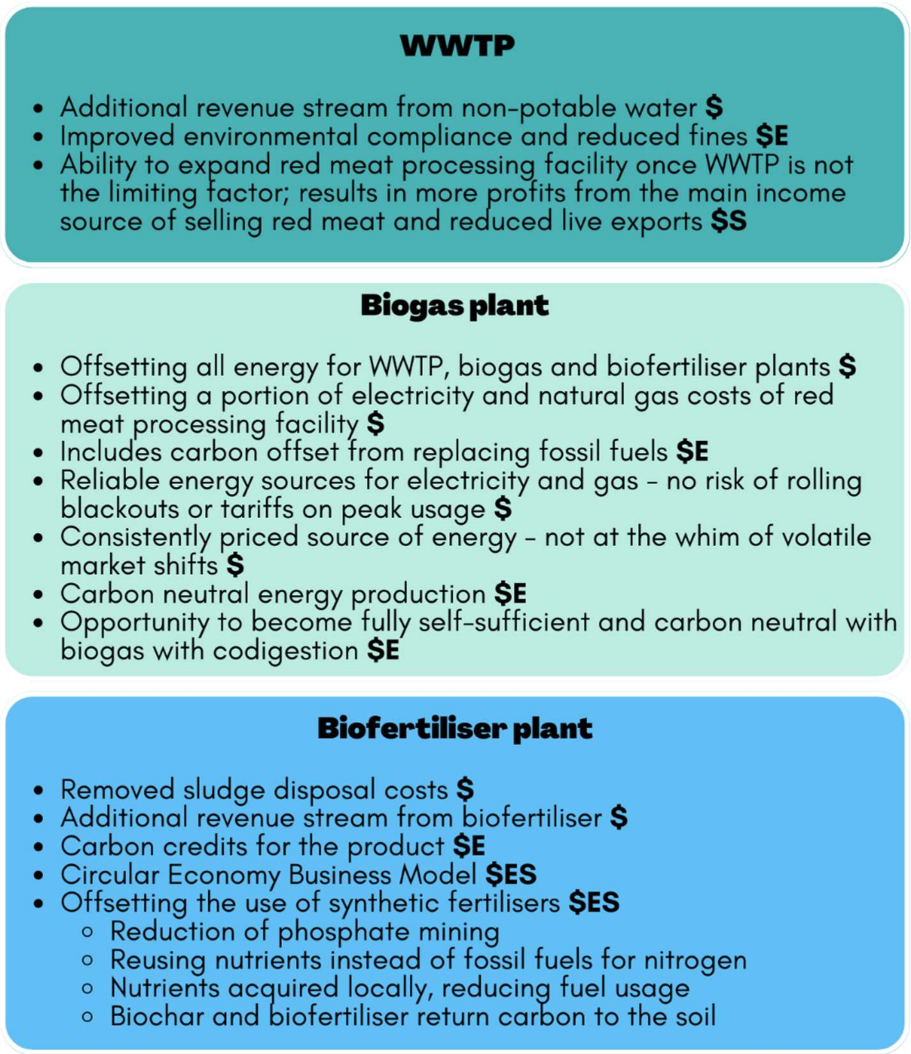


Figure 1: Overall financial, social and environmental benefits of a bio-based fertiliser plant

5.2 Overall mass balance in Australia (availability/demand)

The potential digestate, and subsequently bio-based fertiliser production quantities, were estimated for each AMPC member facility, in order to quantify the bio-based fertiliser supply and demand. These potential production quantities, in conjunction with other criteria such as scale and location of the facilities, were used to establish 11 red meat processing facilities as case studies for further investigation. These case studies were used to determine potential market industries and local off-takers for bio-based products. The estimated production quantity (and quality of product) was compared to the potential demand for using bio-based fertilisers in surrounding areas, and matched with example end-market uses. This formed the basis for a detailed evaluation at each facility which can also be applied to similar red meat processing facilities in Australia.

While the markets for bio-based fertiliser are varied and rapidly developing, a preliminary investigation was undertaken to evaluate opportunities in those sectors which the AMPC does not currently collaborate with, such as mining, forestry, municipal, natural resource management (NRM) and landcare.

5.2.1 Australian red meat processing facilities and case studies

There are 127+ AMPC members across Australia, as represented in the figure below.

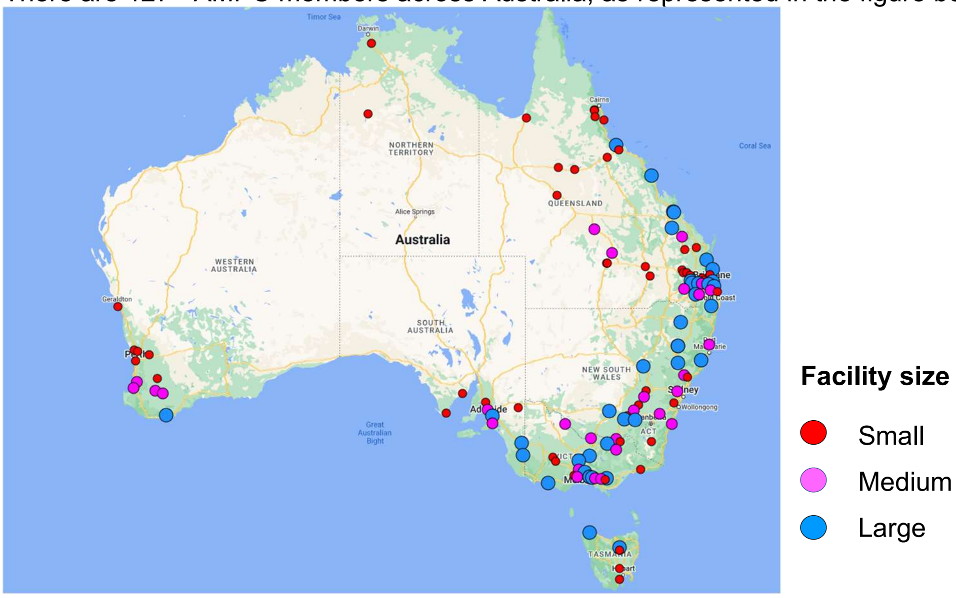


Figure 2: AMPC member facilities map

The 11 example case study facilities, where implementing a Bio-Resource Recovery Facility (including a bio-based fertiliser plant) could be beneficial, are shown in Figure 3 below.

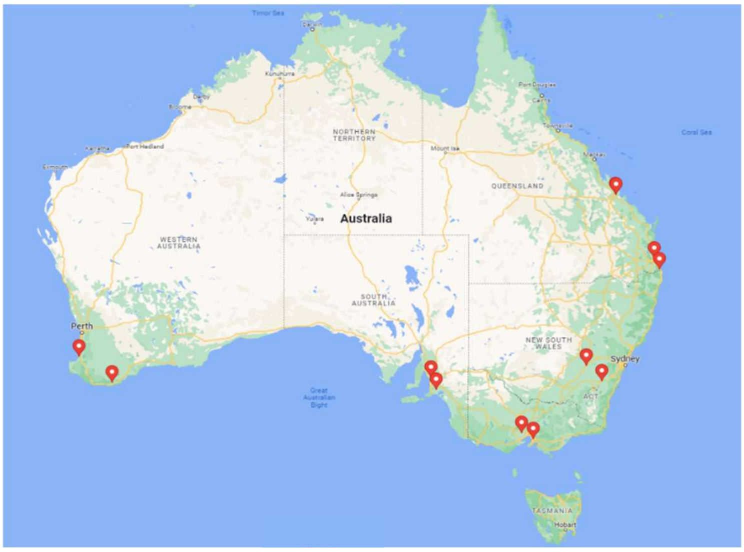


Figure 3: Map of 11 case study facilities for bio-based fertiliser plant implementation

5.2.2 State-wide and Australia-wide bio-based fertiliser production prospects

The graphs show potential bio-based fertiliser quantities that could be produced in each state, if all AMPC red meat processing facilities implemented Bio-Resource Recovery Facilities, including upgraded WWTPs, anaerobic digestion biogas plants and bio-based fertiliser production plants. The graphs display production at the facilities, wastewater production, plus the potential liquid digestate and dewatered digestate cake quantities, dried pellets, and potential biochar production (alternative option). Figure 4 collates the mass balances across Australian states and territories.

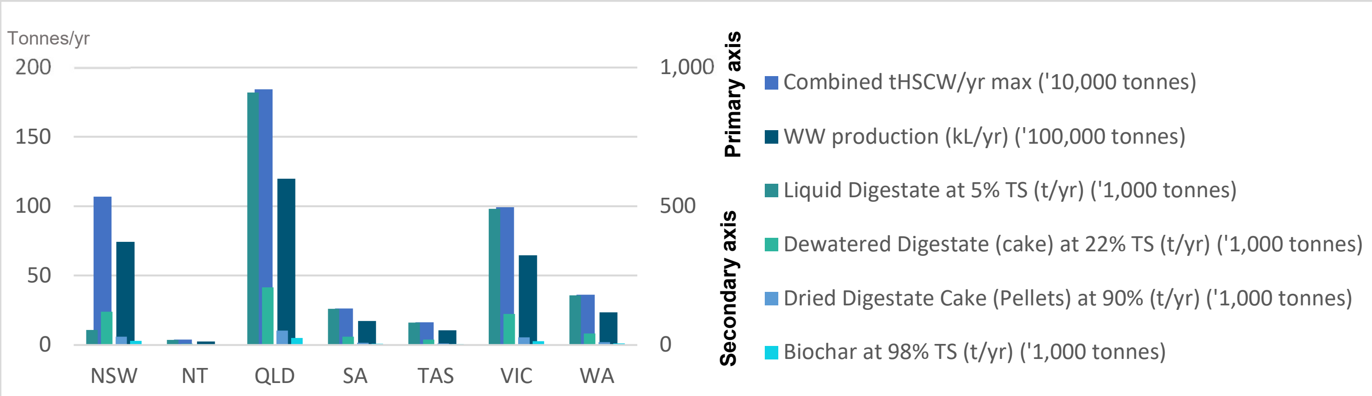


Figure 4: Bio-based fertiliser potential production quantities

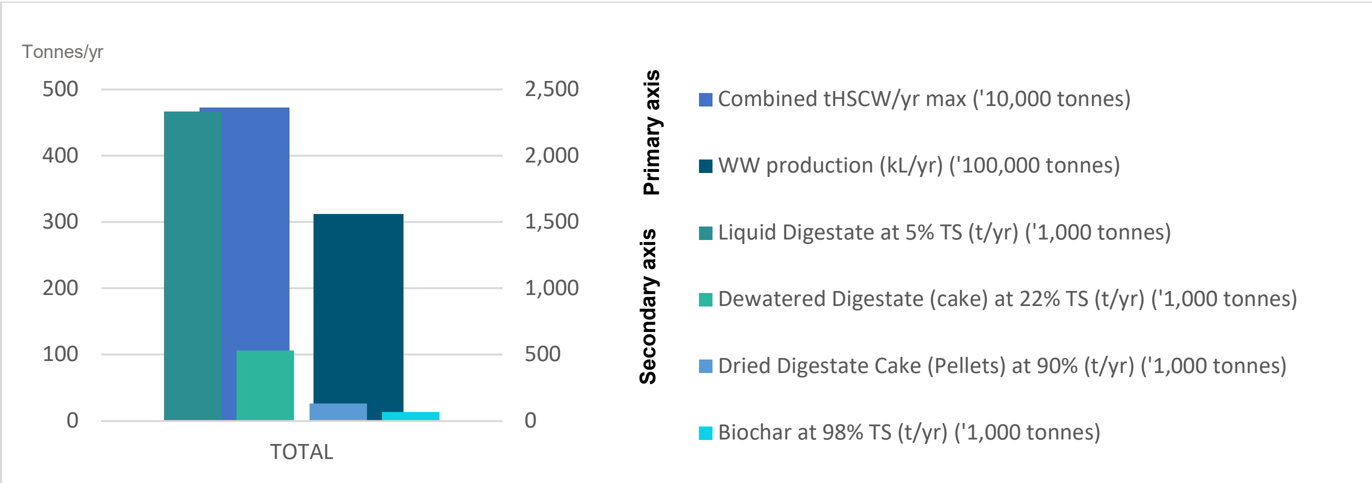


Figure 5: Total potential bio-based fertiliser production quantities

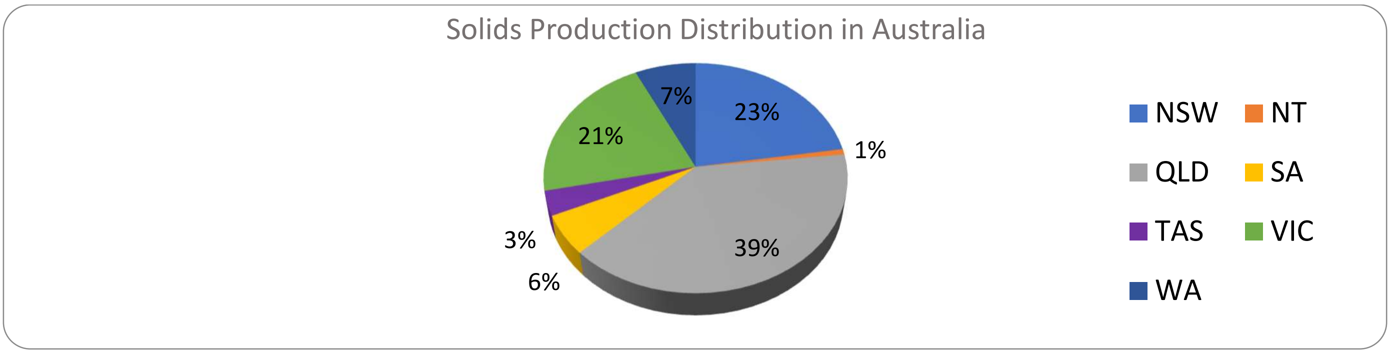


Figure 6: Potential bio-based solids production distribution in Australia. Source: AMPC internal database

5.2.3 Potential for bio-based fertiliser production at facilities of scale

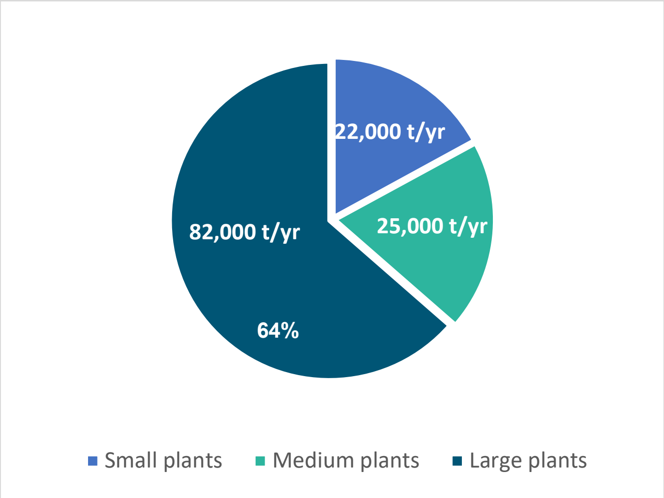


Figure 7: Total sum of potential pellet production across Australia

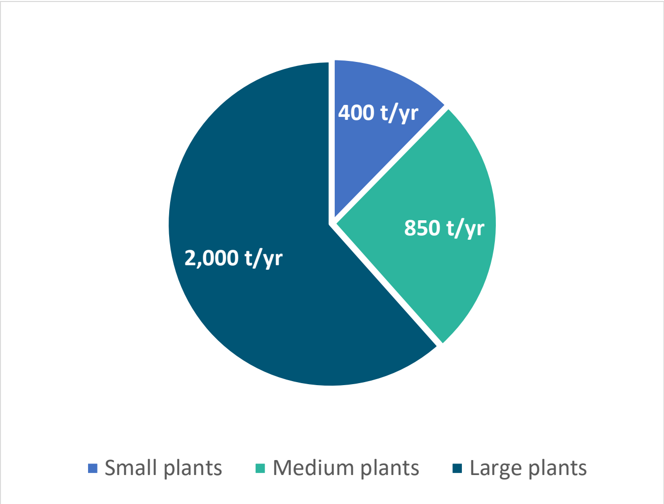


Figure 8: Average potential pellet production per red meat processing plant

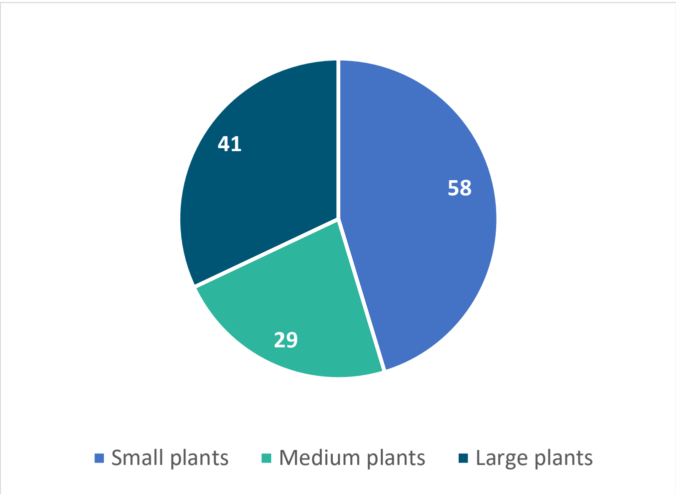


Figure 9: Number of red meat processing plants at various sizes

The pie charts show the mass balance broken down with respect to the facility size. Figure 7 shows the total sum of bio-based fertiliser pellets that could be produced across Australia by all small, medium and large sized AMPC member red meat processing facilities. Figure 8 depicts the average potential production of bio-based fertiliser pellets potentially able to be produced by each small, medium and large red meat processing facility. Figure 9 depicts the number of small, medium and large sized facilities across Australia.

The charts indicate that, despite having fewer facilities (41 large vs. 58 medium), the larger facilities have the capacity to collectively produce 64% of the total red meat derived bio-based fertiliser production in Australia, if bio-based fertiliser production plants were implemented at all AMPC member red meat processors. This is because the larger facilities have capability to produce more than twice as many bio-based fertiliser pellets as their medium-sized counterparts, making them the most industrially significant players in this sector.

5.2.4 Potential bio-based fertiliser production at individual case study facilities

Figure 10 below depicts the potential bio-based fertiliser quantities that could be produced at each of the selected case study facilities if they implemented bio-based fertiliser plants. For comparison, the graphs also show the red meat processing production, disposal quantities that would be offset by a new bio-based fertiliser facility and biochar production quantities (as an alternative to bio-based fertiliser pellet production).

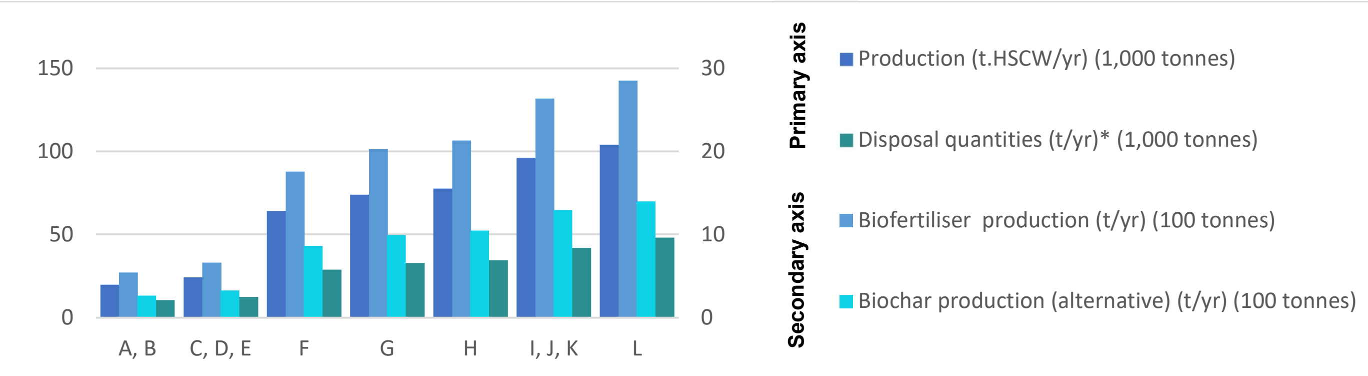


Figure 10: Case study facilities' potential bio-based fertiliser production quantities

*Disposal quantities are the tonnes of total new WWTP sludge and solid waste (such as offals, paunch) requiring disposal in the base case of installing a new WWTP and disposing of 22% sludge and offals (disposal quantities become zero after implementing a bio-based fertiliser facility)

The legend for each of the facilities is below, where certain facilities have been grouped together due to their similar processing throughput and subsequently similar potential bio-based fertiliser production capacity:

Table 1: X axis legend

Case study allocation	Case study location	Case study allocation	Case study location
A	Cowra, NSW04	**H**	Narrikup, WA03
B	Goulburn, NSW22		
C	Strathalbyn, SA03	**I**	Cannon Hill, QLD
D	Two Wells, SA11	**J**	Rockhampton, QLD18
E	Bacchus Marsh, VIC16	**K**	Rockhampton, QLD44
F	Dandenong South, VIC03	**L**	Inverell, NSW03
G	Bunbury, WA11		

5.2.5 Comparative sectoral land availability for bio-based fertiliser use in proximity to facilities

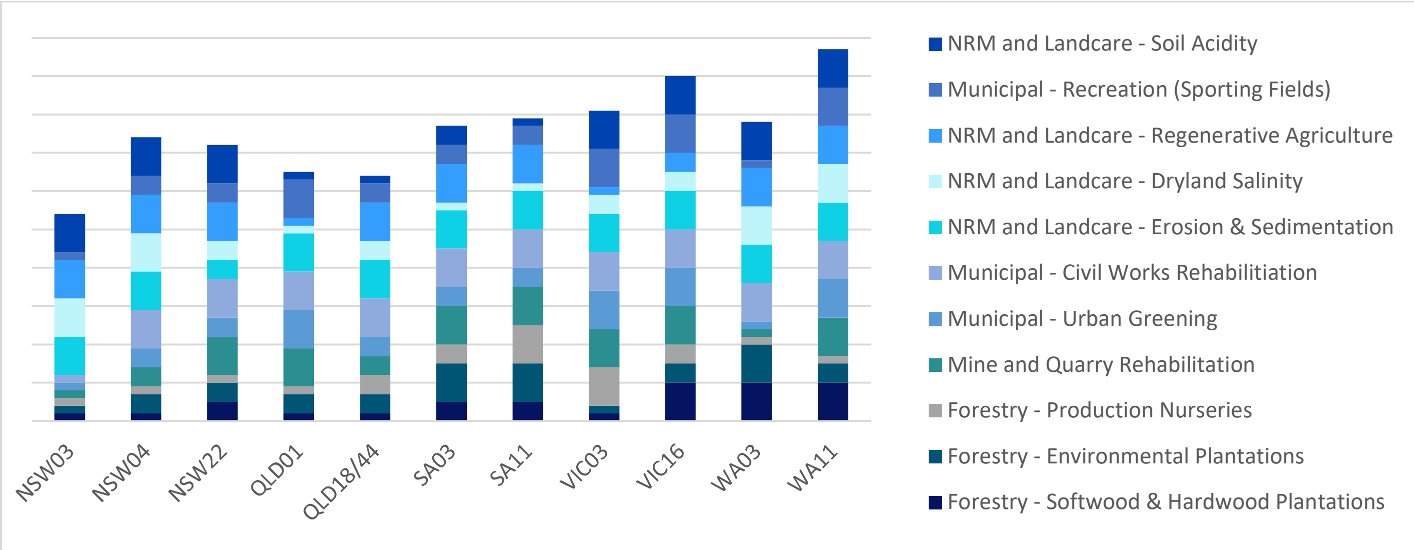


Figure 11: Comparative local land availability for potential bio-based fertiliser application in various sectors

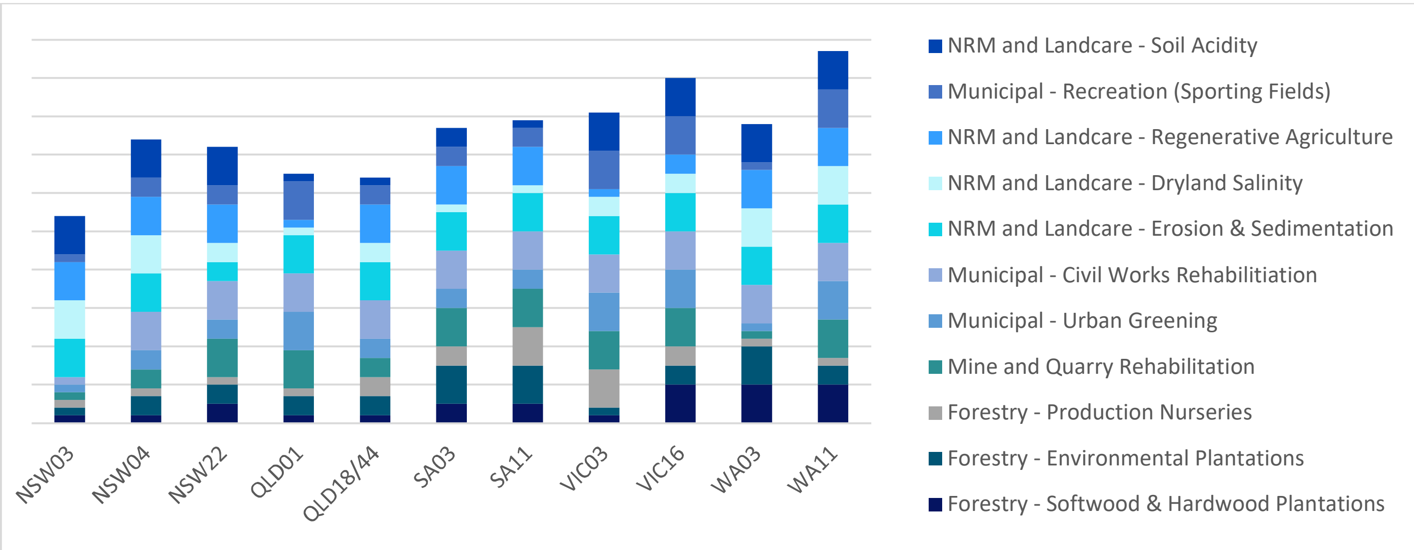


Figure *11* estimates potential use of bio-based fertilisers in different market sectors at selected establishments, based only on local land availability. High potential sectors have large amounts of nearby land, moderate potential sectors have a moderate amount, and low potential sectors have a small amount. The graph indicates strong potential for bio-based fertiliser use in the following sectors near most case study facilities:

- Municipal
  - Civil works rehabilitation
- Natural Resource Management and Landcare
  - Water erosion and sedimentation
  - Regenerative agriculture
- Mine and quarry rehabilitation

There is also a consistent mid-level opportunity for bio-based fertiliser use for the forestry (environmental plantations) and municipal sectors (including recreational land and urban greening) near most case study facilities.

However, the bio-based fertiliser potential use varies depending on the specific case study facility location and should be evaluated individually. In WA case study facilities, forestry has a strong potential for bio-based fertiliser use due to abundant nearby land in those sectors and poor soil nutrition.

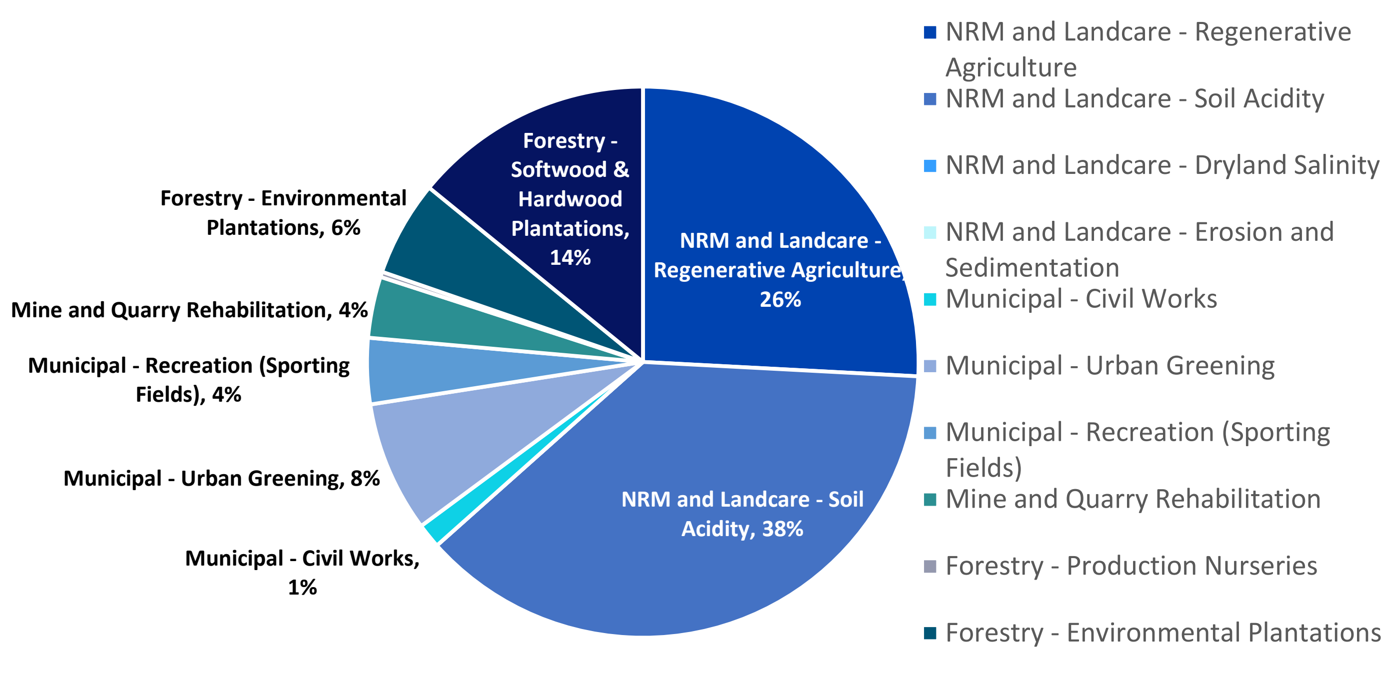


Figure 12: Percentage of land use surrounding AMPC member facilities

*The above percentages are based on the selected sectoral land use within 50km of each AMPC facility, divided by the sum of relevant land uses (excluding irrelevant land uses).

Figure 12 shows that the top potential bio-based fertiliser land-uses in Australia (within close proximity to AMPC facilities) include Natural Resource Management and Landcare (improving soil acidity, regenerative agriculture) and Forestry (softwood and hardwood plantations, urban forestry, and environmental plantations).

5.2.6 Demand vs supply of bio-based fertiliser across various facilities and sectors

Figure 13 compares potential national production of bio-based fertilisers (if all AMPC facilities implemented bio-based fertiliser plants) to current yearly consumption of synthetic fertilisers in Australia. It shows significant market opportunity for bio-based fertiliser use. Note that the bio-based fertiliser nutrient content is more dilute in NPK than typical synthetic fertilisers, so the 3% estimate of total national demand for bio-based fertiliser would be much lower.

Therefore, the graph indicates that there is significant market demand and opportunity in Australia to use the full potential production of bio-based fertilisers from red meat processors.

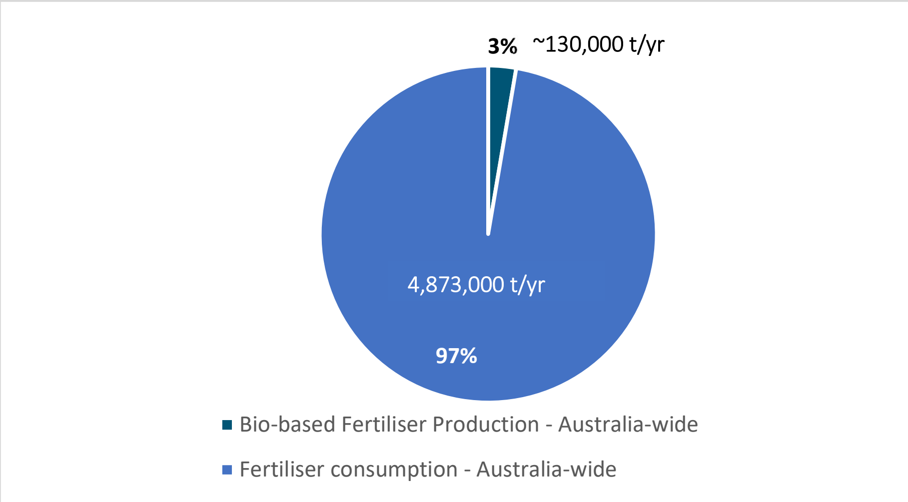


Figure 13: National bio-based fertiliser production vs national synthetic fertiliser consumption. Source: Australian Bureau of Statistics (2017)

Figure 14 depicts the possible utilisation of bio-based fertilisers from selected establishments across various market sectors. The pie charts display the comparative demand vs supply ratios for bio-based fertiliser use in each sector. The pie charts take into consideration the available land in each sector, the bio-based fertiliser application rates required for the specific sectors and the different production quantities expected from each facility. Larger pie charts show a comparatively larger gap between supply and demand, indicating a market demand that is significantly higher than the bio-based fertiliser production quantity. Small segments show where supply can meet over 85% of demand, moderate segments meet between 50% and 85% of demand, and large segments represent a potential supply below 50% of the market demand, indicating the lowest risk of surplus production for one market to off-taker.

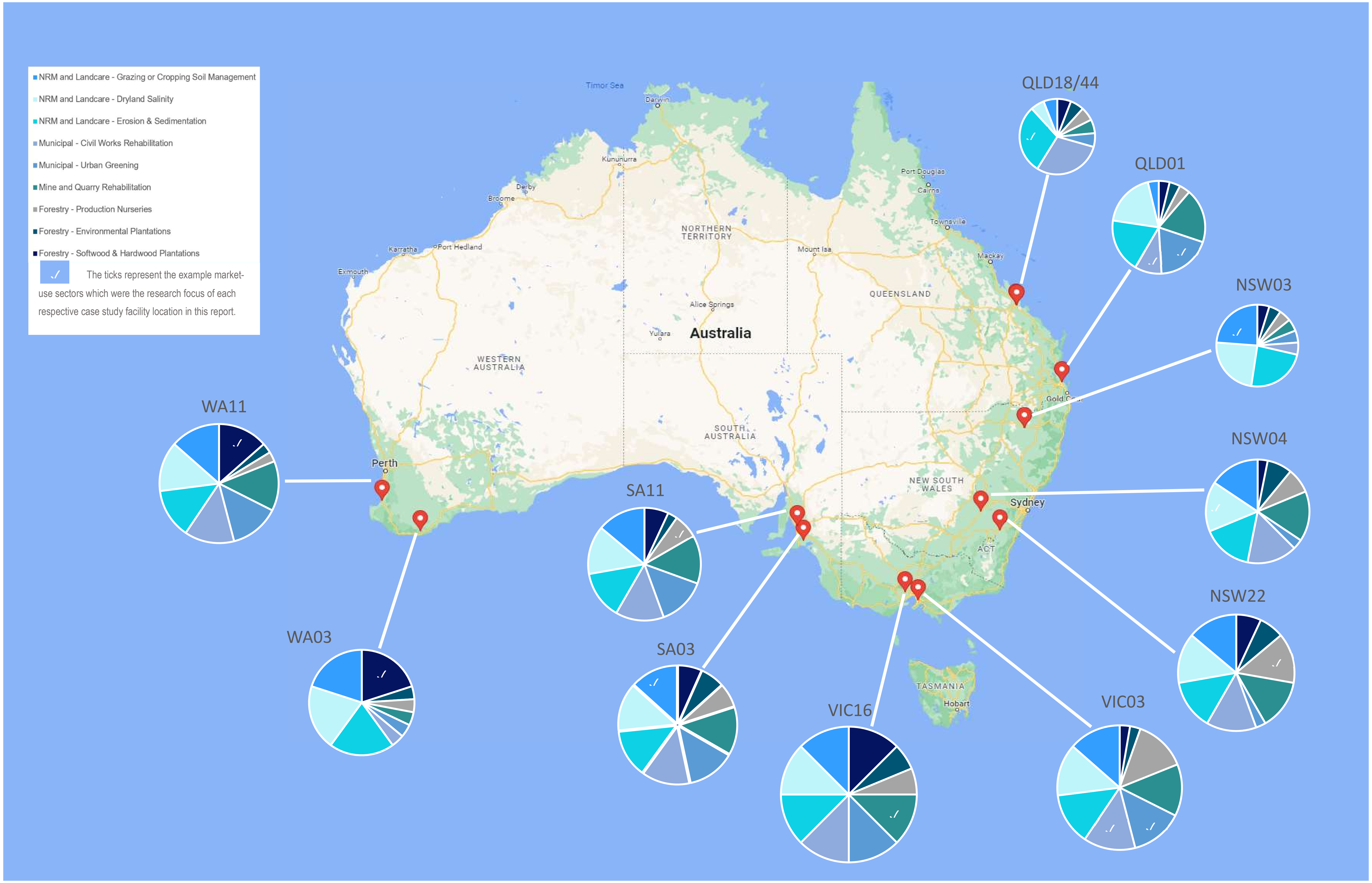
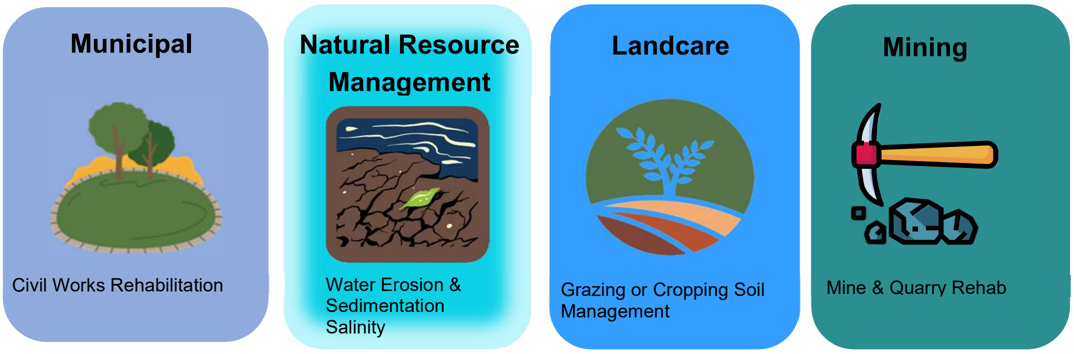


Figure 14: Comparative demand vs supply for bio-based fertiliser use, produced by a range of facilities with differing production and used for various applications

Bio-based fertiliser demand opportunities depend on end-user application rates and nearby land use, whilst the ability to market the entire supply relies on the production capacity in relation to the demand (demand/supply ratio). Figure 14 shows high demand/supply ratios, near most case study facilities, in these sectors:



This indicates a strong opportunity to use the full potential production of bio-based fertiliser from specific case study facilities within these close proximity markets. However, optimal bio-based fertiliser demand varies depending on the specific facility and should be evaluated on a case-by-case basis. For example, the WA11 case study facility showed strong potential demand for all sectors except for production nurseries and environmental plantations.

5.3 Expression of interest – market research of potential end-users

An expression of interest exercise was undertaken, to identify and approach potential off-takers for the bio-based fertilisers to be produced from the future Integrated Bio-resource Recovery Facilities, to obtain an indication of the real market interest. Various potential end-users for bio-based fertiliser, across a range of industry sectors, were surveyed. Refer to Figure 15 for the industry sectors and associated sub-sectors chosen for the EOI process.

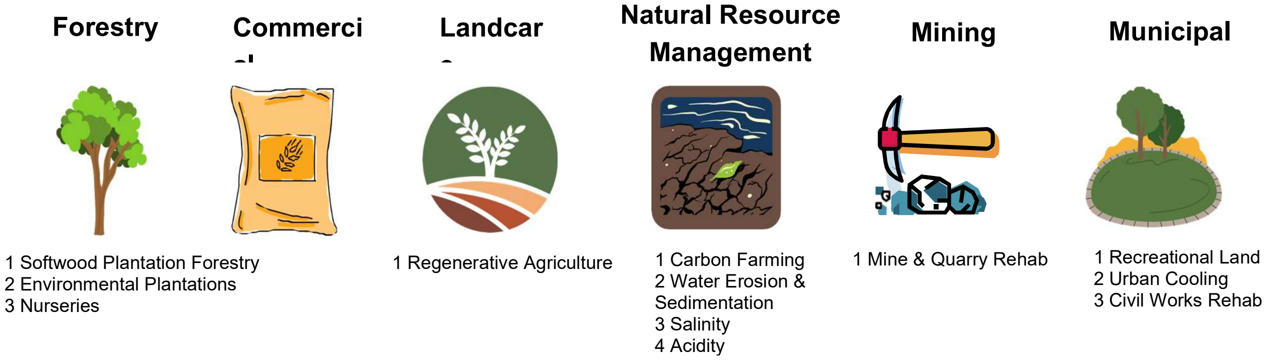


Figure 15: Industry sectors for bio-based fertiliser use

The survey gathered information on potential bio-based fertiliser needs in various sectors near selected example red meat processing facilities. Private companies, government departments and industry stakeholders were surveyed, with results indicating commercial interest in purchasing and using the potential bio-based fertilisers. Figure 16 presents a high-level summary of outcomes from the surveys and interviews, which demonstrated interest and potential for bio-based fertilisers in several sectors near example red meat processing facilities. Most promising sectors included forestry (softwood plantations), commercial off-takers, landcare, natural resource management, and mine rehabilitation. While the municipal sector shows promise, it has lower interest and demand for bio-based fertilisers in the forestry subsectors of native environmental plantings and production nurseries.

SECTOR	SUB-SECTOR	FACILITY	SURVEY OUTCOMES	POTENTIAL
FORESTRY	SOFTWOOD PLANTATIONS	WA11 WA03	Strong potential for local bio-based fertiliser use, with a significantly increasing demand forecast	✓
	ENVIRONMENTAL PLANTATIONS	SA03 WA03	- Low requirement for bio-based fertiliser traditionally - Sandy soil, and carbon offsetting motivation, increases the forecast bio-based fertiliser demand	↑
	NURSERIES	SA11	- Little to no requirement for bio-based fertiliser - Low appetite to trial bio-based fertilisers	✗
COMMERCIAL OFF-TAKERS	COMMERCIAL OFF-TAKERS	SA11 Aus-wide	Keen interest to obtain additional and alternative feedstocks for existing pelletisation and biochar production plants	✓
LANDCARE	LANDCARE	VIC Aus-wide	- High product quantity demand - Specific product quality requirements	↑
NATURAL RESOURCE MANAGEMENT	CARBON FARMING	Aus-wide	- Strong interest and demand - Implementation not well-established	✓
	WATER EROSION AND SEDIMENTATION	QLD18 QLD44	Strong opportunity in the QLD Fitzroy Basin case study area in addition to other bio-based fertiliser uses	✓
	SALINITY	NSW04	Limited opportunity or demand	✗
	ACIDITY	NSW22 SA03	- Strong interest and demand near SA03 - Specific product quality requirements	✓
MINE AND QUARRY REHAB	MINE AND QUARRY REHAB	VIC16 WA11	- Strong opportunity in WA - Dependent on type of land needing rehabilitation	✓
MUNICIPAL	RECREATIONAL LAND	QLD01	- Mid-level opportunity across Australia - Mid-level product quantity demand	↑
	URBAN GREENING	VIC03	- Strong opportunity at VIC03 - Low product quantity demand	↑
GENERAL / ALL	GENERAL/ ALL	Aus-wide	- Strong industry-wide motivation to replace synthetic fertilisers with organics for ESG outcomes - Cost and quality to match synthetic fertilisers - Nutrient content is important	✓

Potential legend:

- ✓ Strong interest
- ↑ Increasing interest
- ✗ Limited interest

Figure 16: Expression of interest summary of results

During the market assessment exercise, most of the stakeholders required further information on the quality of the product. To provide an early indication of the quality of the product to the offtake markets, preliminary testing was undertaken on anaerobic digestate from an existing lagoon WWTP at a red meat processor. The testing included:

- Bench-scale pilot trials to convert red meat processing facility derived digestate into bio-based fertiliser products, including pellets and biochar
    - Analysis on the bio-based fertiliser products to determine and comparison of physical and chemical properties, in addition to nutrient, carbon and contaminant levels

A longer trial including a pilot digester and further processing will add value and robustness to the process, and is planned for proceeding project stages.

The preliminary results were shared with several potential offtakers, including two fertiliser production companies and a tree-planting company. The fertiliser manufacturing companies indicated interest in off-taking the quantity of bio-based fertiliser that could be produced across Australia. One fertiliser company expressed potential interest in off-taking the dewatered digestate cake without further processing, which is promising.

5.4 Literature review of digestate dewatering and reprocessing technology

To obtain an indication of the feasibility of producing bio-based fertiliser from the red meat processing industry by-products, a literature review of processing technology was undertaken. After the anaerobic digestion process, the liquid digestate can be dewatered and further processed to produce bio-based fertiliser. The review considered technology for dewatering digestate, and further processing technologies to process the dewatered digestate cake.

The below schematic summarises the high-level reprocessing technology options to produce bio-based fertiliser. The following tables, Table 2 and Table 3, summarise the comparison characteristics of the most suitable pre-selected dewatering technologies and the most suitable pre-selected further digestate processing technologies. A more comprehensive analysis, including eliminated technologies, were detailed in Milestone 3 report of the 2022-1081 Project.

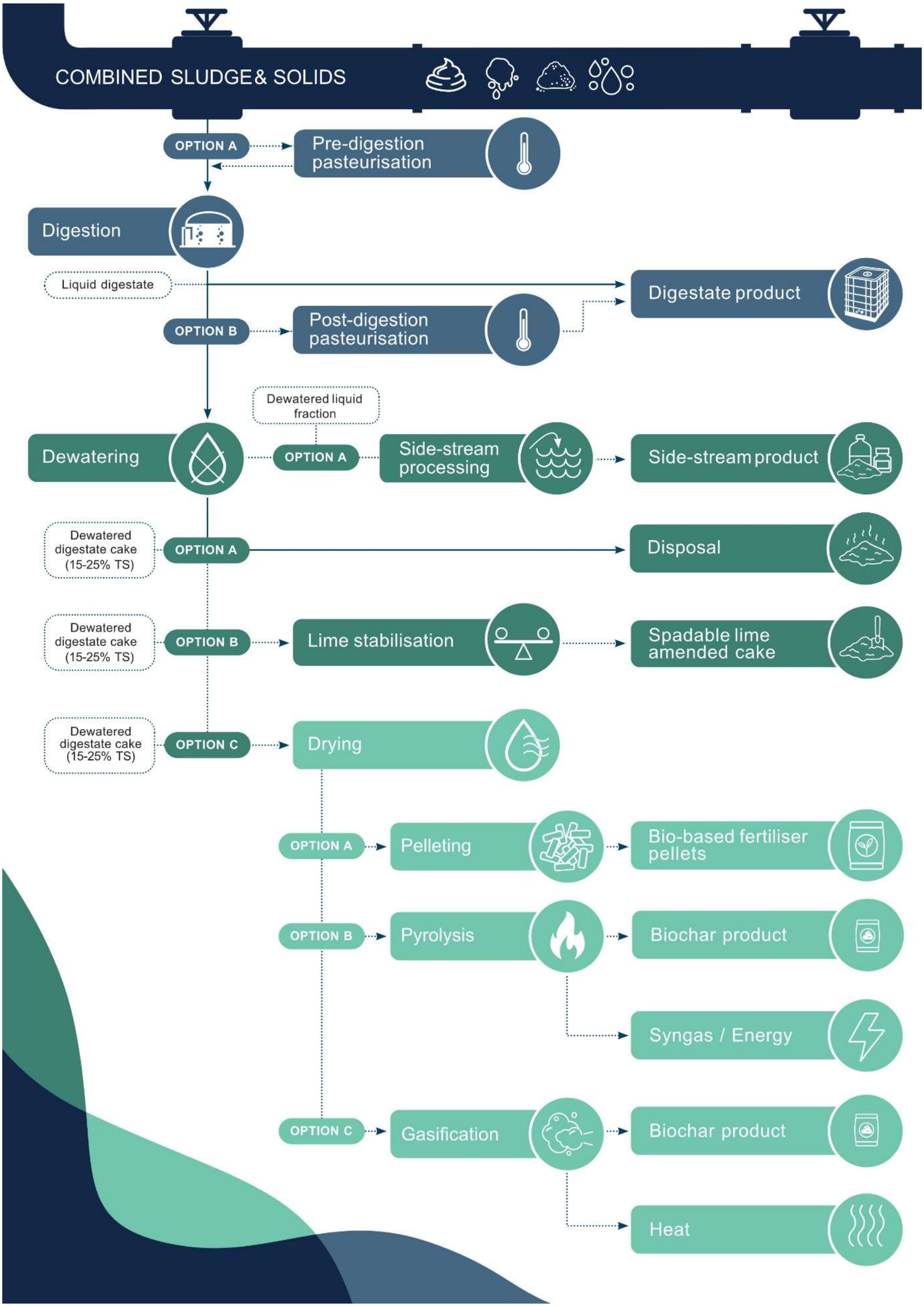


Figure 17: Summary of further processing technology options

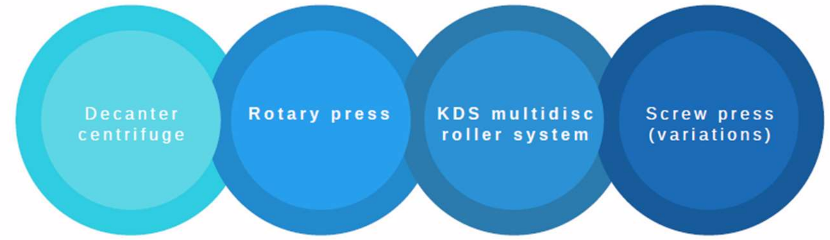
Table 2: Preferred dewatering technologies - summary

Technology	Benefits	Disadvantages	TRL	Cost	Energy Use	Footprint	Combined Rating
Decanter Centrifuge	- High dewatering level (up to 30% TS) - Handles varied sludges - Can dewater small volumes without chemicals - Large processing range	- High CAPEX and OPEX - High power consumption	9	High	High	Low	10
Rotary Press	- Low maintenance - Low OPEX, power and process water requirements - Low odour - Simple operation and low labour - High product %TS - Large processing range (1-60kL/hr)	- Polymer required	8	Low	Low	Low	10
KDS Multidisc Roller System	-Product from WAS (15-18% TS); product from cattle manure (25-35%) - Low noise and vibration - No washwater required - Self-cleaning; handles oily and fibrous material - High solids capture in solids stream - Very low energy use - Low operator and maintenance attention - Small footprint	- Designed for smaller to medium sized applications, throughput of 1kL-15.5kL/hour at 2%TS	8	Medium	Low	Low	10
Screw press (variations of traditional)	- High dewatering level (15-70%TS) - Low energy use - Handles varied sludges and high fibre content - Large capacity, 1kg to 1326kg DS/h - Reduced CAPEX and OPEX	- Flocculant usage recommended - Process water required - May have issues handling small particles	9	Medium	Low	Low	8

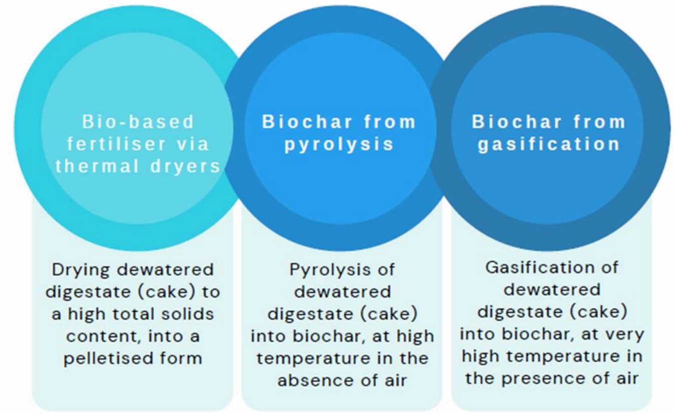
Table 3: Preferred digestate processing technologies - summary

High Level Option	Technologies	Benefits	Disadvantages	TRL	Overall CAPEX & OPEX	Energy Use	Footprint	Combined Rating
Bio-based Fertiliser Products	Thermal (non-solar) Dryers	-Heat recoverable -Energy recoverable from other parts of process (digester biogas) -Low volume of product for transport and reuse -Product retains nutrients	-High energy requirement -Relatively high OPEX -Relatively high CAPEX	8	High	High	Medium	8
Biochar from Pyrolysis (Absence of Air)	Biochar from Pyrolysis	- Simple operational procedure - Volume reduction - High quality final product well accepted by buyers, with potential for a variety of end uses - Proven soil amendment properties and carbon sequestration - Produces gas, which can produce and recycle heat and electricity, and biochar	- High temperature (and power) demand (500 – 800 ºC) - High CAPEX AND OPEX -Reduced nutrient content in end product - Reduces a liquid by-product which will need treatment, re-use or disposal options	8	High	High	Medium	8
Biochar from Gasification (Presence of Air)	Biochar from Gasification	-- Volatiles can be used as heating fuel for the process - More homogeneous properties from a variety of raw biomass -Produces gas, which can produce and recycle heat and electricity, and biochar -No liquid by-product produced	-More scrubbing of flue gas required - Very high heat and energy requirement (800-1200ºC) - A less common technology with suppliers	8	High	High	Medium	8

The most suitable pre-selected dewatering technologies, detailed in Table 2, are summarised as:



The most suitable pre-selected dewatered digestate further processing technologies, detailed in Table 3, are summarised as:

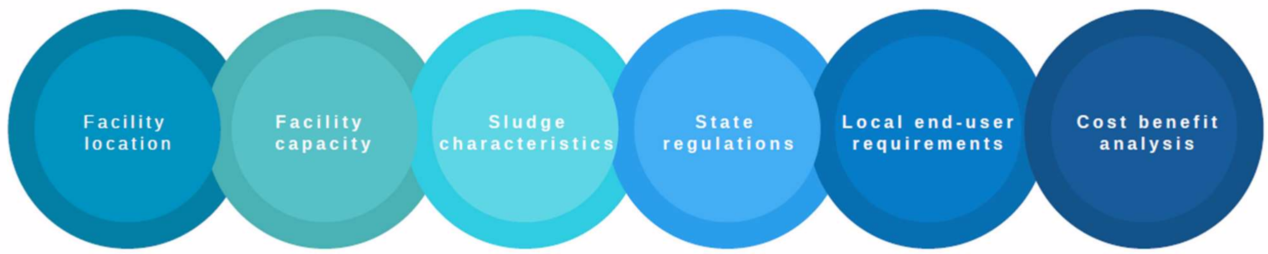


Reviewed technologies, including established and novel options, were evaluated for cost, energy consumption, footprint, Technology Readiness Level (TRL), and overall suitability. Table 2 summarises the four shortlisted dewatering technologies with a high TRL, low footprint, low energy requirements, and relatively low costs (except for the centrifuge). These technologies produce high total solids content cake and have good automatic operation.

Table 3 shows the three shortlisted further processing technologies with high combined ratings, high TRL, relatively high costs and energy requirements, and a medium footprint. The resultant high-quality product is expected to provide an attractive return on investment and enable a wide range of applications. The two biochar technologies destroy more pathogens and potential contaminants, likely allowing regulatory approval for a wide variety of uses. The bio-based fertiliser pellets retain more nutrients and is more valuable to some end users. All three processes have heat and energy recycling components to offset operational costs.

Recommendations include:

- Assess the above pre-selected dewatering and further processing technologies for each red meat processing facility implementing a Bio-Resource Recovery Facility.
- Select one final dewatering technology and one final further processing technology for each facility based on specific criteria as follows:



5.5 Characterisation of red meat processor derived bio-based fertiliser

5.5.1 Digestate characterisation methodology summarised

After the digestate has been processed using reprocessing technology mentioned in the previous section, characterisation of the bio-based fertiliser product can provide an indication of its worth. Characterisation of anaerobic digestate was undertaken, to quantify the amount of nutrients and potential contaminants that may be in the final product. This exercise helped to assign financial and market value to the potential product and fed into the financial analysis and conversations with potential product off-takers and equipment suppliers.

AD sludge from a red meat processing facility in Bunbury was dewatered via bench-scale tests and characterised. Three different tests were used and the samples of dewatered cake and filtrate were analysed for nutrients, organics, metals, pathogens and contaminants. Results were used to determine whether side-stream treatment would be needed for the filtrate and to assign financial value to the bio-based fertiliser. The dewatered digestate cake was also analysed for thermal stability, and yields for potential biochar production. The characterisation of the cake was used to gain confidence in the reuse possibilities and provide information to potential end-users on the marketability of the product.

5.5.2 Bio-based fertiliser nutrient profile and comparison with commercial fertilisers

A high level summary of the difference between bio-based fertiliser pellets and biochar are outlined in Table 4.

Table 4. Comparison between typical bio-based fertiliser pellets (dried digestate) and biochar

Parameter	Bio-based pellets	Biochar
Carbon Content	Medium	High
N	High	Medium
P	High	Medium
K	Low	Low
Dryness	90%TS	98%TS
Porosity Properties	Low	High
Volume reduction	Medium	High

The below figure summarises the positive outcomes regarding the NPK ratio of the dewatered anaerobic digestate, when compared to typical commercial fertilisers.

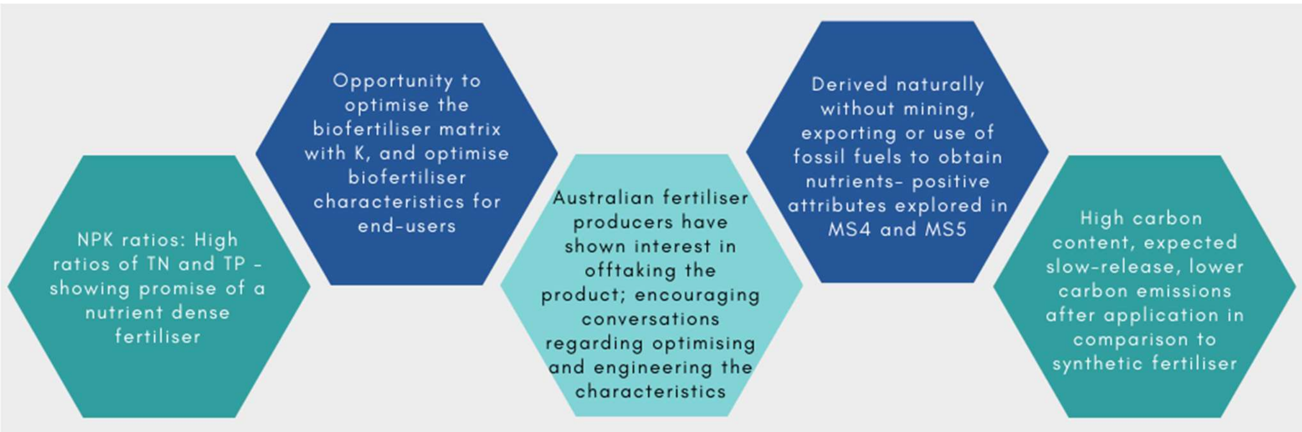


Figure 18: Positive outcomes of NPK ratio of dewatered AD

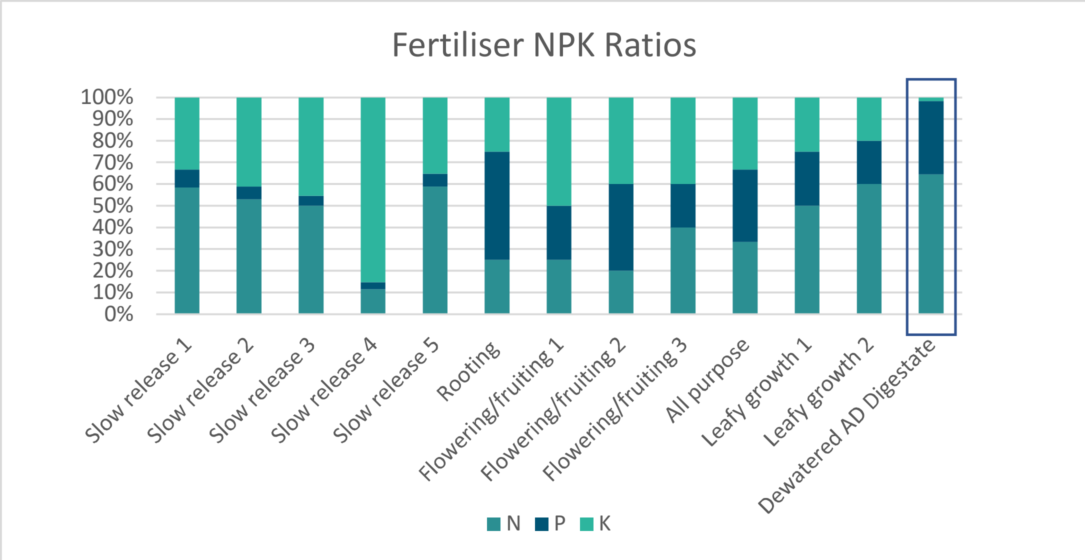


Figure 19: NPK ratios of synthetic fertilisers vs dewatered AD. Ratios derived from: (Bunnings Australia, 2023) and (Montreal Space for Life, 2023)

Figure 19 represents the typical NPK ratios of slow release and general synthetic fertilisers, compared with the NPK ratio of the dewatered AD derived from the red meat processing industry. Figure 20 shows the overall nutrient composition comparison between bio-based fertiliser and typical organic fertilisers. A typical example of organic fertiliser nutrient composition is in Figure 21.

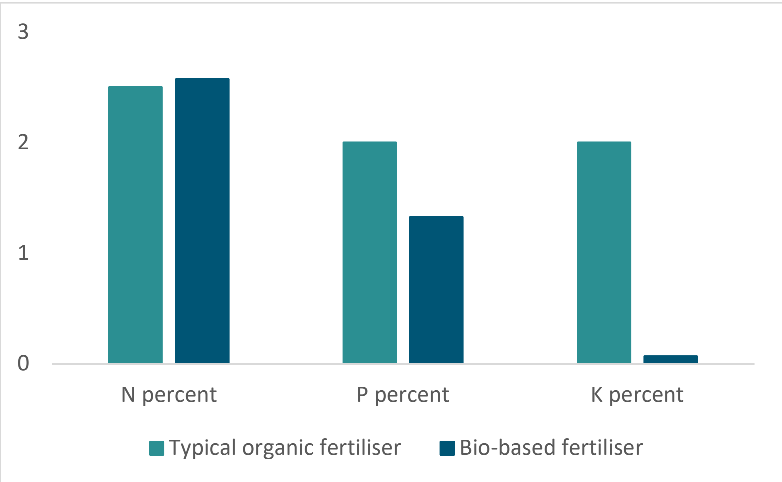


Figure 20: NPK of bio-based fertiliser vs typical organic fertilisers (Salamat et al, 2022)

NPK	
Typical Analysis	**% w/v**
Total Nitrogen (N) as blood, bone and flesh	5.4
Phosphorus as water soluble	0.09
Phosphorus as citrate soluble	1.5
Phosphorus as citrate insoluble	2.41
Total Phosphorus (P)	4
Potassium as potassium sulfate	0.4
Potassium as blood, bone and flesh	0.6
Total Potassium (K)	1
Sulfur as sulfate	0.3
Sulfur as blood, bone and flesh	0.5
Total Sulfur (S)	0.8
Total Calcium (Ca) as Bone	8
Iron (Fe) as organic and iron sulfate	0.24

Figure 21: Example of commercial fertiliser content (Source: Bunnings Australia, 2023)

The dewatered AD digestate from the red meat processing facility sample has a higher NP ratio than commercial synthetic fertilisers (refer to Figure 19). Regarding the low potassium content, additional potassium sources can be added to optimise its nutrient composition for end-users. The total nutrient composition (Figure 20) in terms of nitrogen and potassium, is comparable to organic fertilisers, and additional digestate feedstock (such as paunch, offals and fats (refer to 2023-1019 MS3 Waste Characterisation Report, 2022)) is expected to result in a product with higher carbon and nutrient density.

5.5.3 Bio-based fertiliser characteristics - complying with reuse regulations

The characteristics of dewatered AD sludge from a red meat processing facility were compared to the municipal biosolids guideline limits as a preliminary benchmark. The comparison showed that the product has the potential to be used for almost unrestricted use, similar to a C2P2 municipal biosolids classification. Furthermore, there is potential for it to be classified at an even higher quality, with a contamination grade of C1 and a stabilisation grade of P1. The Australian national biosolids guidelines used as a contingent comparison, were stricter than those used in the USA, NSW and QLD. The bio-based fertiliser plant will include a pasteurisation step to remove pathogens. Regulations relevant to the use of red meat processor derived bio-based fertiliser are explored more in MS7 of the 2022-1081 project and summarised in section 5.6.

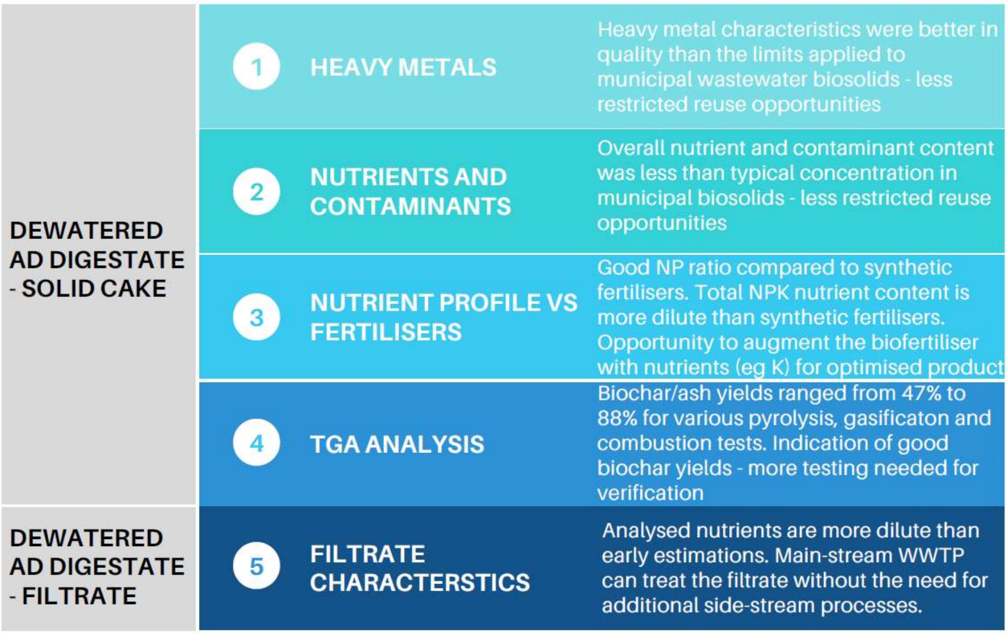


Figure 22: Bio-based fertiliser characteristics summary

5.5.4 Bio-based fertiliser characteristics - conclusion

The findings from the digestate characterisation are summarised as:

Redefining Waste:

This report redefines 'waste' as 'by-product'. In this case study, waste should be considered as a valuable resource and a by-product of the current red meat industry process. Redefining wastes as valuable resources and by-products of existing industries supports the transition to a circular economy by shifting mindsets.

5.6 Unlocking investment barriers – desktop review

A desktop review was undertaken, of the immediate barriers to investing in re-processing technology required for producing bio-based fertilisers from Australian red meat processor by-products. The review was needed to understand whether Australian regulations would realistically allow the bio-based fertiliser product to be beneficially used. The review included researching barriers to investing in technologies which are innovative in Australia, to produce bio-based fertiliser pellets or biochar. The following schematic depicts the general investment barriers to overcome, from regulatory, technical, social, economic and behavioural perspectives.

Figure 23: Unlocking investment barriers

An extensive literature review was undertaken, to find guidelines for the use of solid wastes from the red meat industry and to understand investment requirements from regulatory, technical, social, economic and behavioural perspectives. The review analysed regulations from South Africa, Great Britain, Europe, Canada, USA, New Zealand and every State and Territory in Australia.

It was found that Australia lacks regulations controlling the use of by-products from red meat processing facilities and that these by-products are generally classified as ‘waste’ requiring disposal. However, NSW and Queensland are moving towards resource recovery orders and exemptions and end of waste codes, to provide better opportunities for resource recovery of by-products.

The characteristics of red meat processing facility dewatered digestate were compared to municipal biosolids, and it is recommended that the biosolids guidelines are used as an example framework to develop regulations for bio-based fertilisers. The biosolids guidelines provide guidance on application rates for various soil types and nutrient requirements of various crop types.

The recommended next steps to unlock the investment barriers are shown in Figure 24 below.

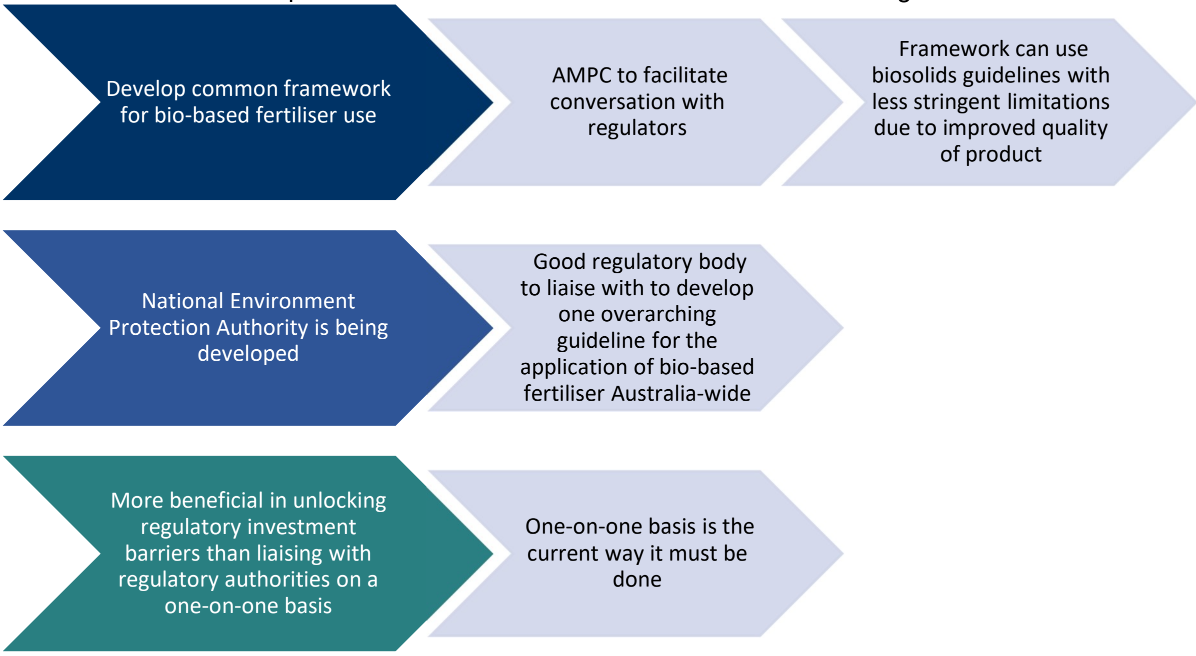


Figure 24: Next steps to overcoming investment barriers

The absence of regulations for the use of red meat processing facility derived by-products provides an opportunity to establish guidelines acceptable to regulators. It is recommended that AMPC develops a draft set of guidelines based on the available biosolids guidelines and a clear understanding of the product's composition.

To better understand the product quality, samples from various locations should be analysed for consistency. The recommended analysis includes testing for nutrients, bacteria, viruses, antibiotics, other pathogens, and other potential contaminants such as herbicides, pesticides and heavy metals.

The guidelines should consider the level of treatment required based on soil capacity, pathogen removal, and required nutrient levels for the end-user. It is expected that obtaining approval to use the product based on agreed guidelines will be achievable, particularly with early and collaborative discussions with regulators.

5.7 Initial sectoral cost benefit analysis

To provide investors with the confidence to implement a bio-based fertiliser plant at AMPC member facilities, a cost benefit analysis needs to be undertaken and ideally show a positive financial result. The cost benefit of implementing a bio-based fertiliser plant at a red meat processing facility was analysed using the net present value methodology. The analysis compared the cost benefit of disposing of 5%TS liquid digestate from the biogas plant (base case) against the scenario of implementing a bio-based fertiliser pelleting plant. Research was conducted into the market value of various income streams, and the prices were averaged across Australia for use in net present value calculations. Operational costs were estimated based on experience and current market conditions. A sensitivity analysis was carried out to understand the robustness of investing in a bio-based fertiliser plant, the outcome of which produced a net present value, return on investment, annualised return on investment and payback period. The summary of the bio-based fertiliser income and cost assumptions have been summarised below.

5.7.1 Cost benefit analysis - income and costs assumptions

Adopted values – biofertiliser

$110/tonne biofertiliser pellets (90%TS)

- Market price of N component in Urea, and P component in DAP
- $ value per tonne of N&P applied to the analysed AD dewatered cake to estimate pellet value

Adopted values – biochar

$1800/tonne biochar

- Average biochar price for biochar as reported by users across Australia* (Joseph.S et al 2022)

* The quoted prices by users ranged from $100 to $6,750 per tonne of biochar.

The adopted value for the biofertiliser pellets was derived from bulk fertiliser prices. The fertiliser could sell for much more if it was commercialised in small packages targeting domestic public use.

Figure 26. Biochar price ranges in Australia (2022 - 2023)

Carbon credits

The carbon credit market is currently very volatile, with pledges for Australian companies to hit net zero emissions by 2050 or even earlier, causing changes in the market. The current spot price as of January 2023 is **~$40/tonne**, which has been used for the base case of this cost benefit analysis. Refer to Figure 25 for the recent trends in Australian carbon credit spot prices.

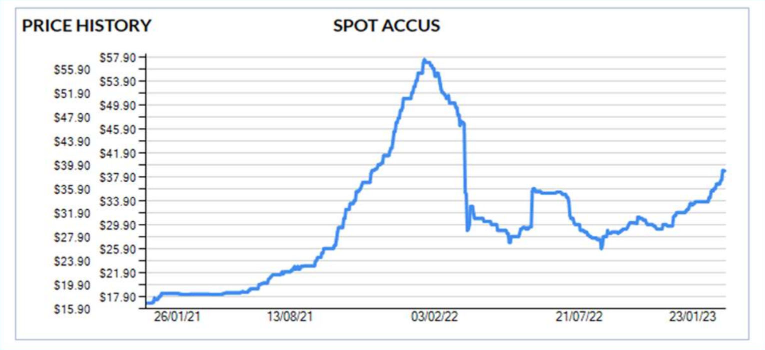


Figure 25: Australian carbon credit price (AUD). Source: Jarden Australia Pty Ltd (2023)

A sensitivity analysis was carried out, including European carbon credit values (currently ~$130AUD/tonne), as their market is more developed than Australia and can provide a prediction for Australian forecast carbon credit prices.

Sludge disposal costs

Wastes include spadable (>15%TS) sludge from WWTP ponds and other solid wastes currently disposed of (such as inedible offals, fats and save-all). The relevant controlled waste gate fees in regions with red meat processing facilities identified as potential case study facilities, is averaged at **$295 per tonne** of waste. A realistic transport factor of $50/tonne per 100km of waste transported via truck was added, resulting in an average total disposal cost of **$345/tonne** / 100km

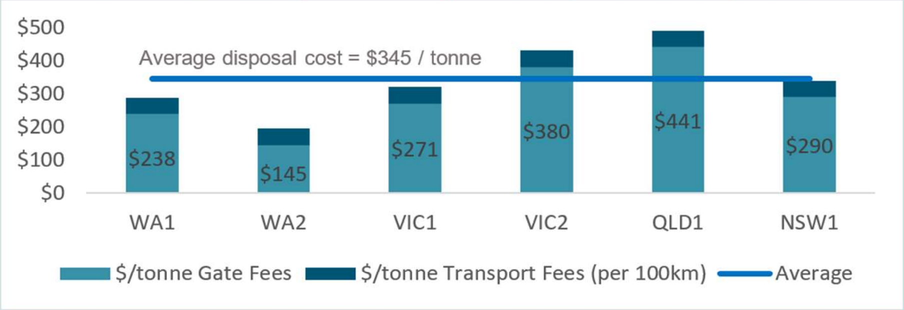


Figure 27: Sludge disposal fees. Fees derived from (EMRC, 2022), (Cleanaway, 2023a), (Cleanaway, 2023b), (Rockhampton Regional Waste & Recycling, 2022), (Goulburn Mulwaree Council, 2022), (Cleanaway, 2023c)

5.7.2 Mass balance for cost benefit analysis

The reduction of mass/volume of the digestate for disposal, via dewatering, drying and pelleting it into bio-based fertiliser pellets or conversion into biochar, is a significant factor in the cost benefit analysis. Refer to the figure below to observe the mass reduction across the process for an example case study facility.

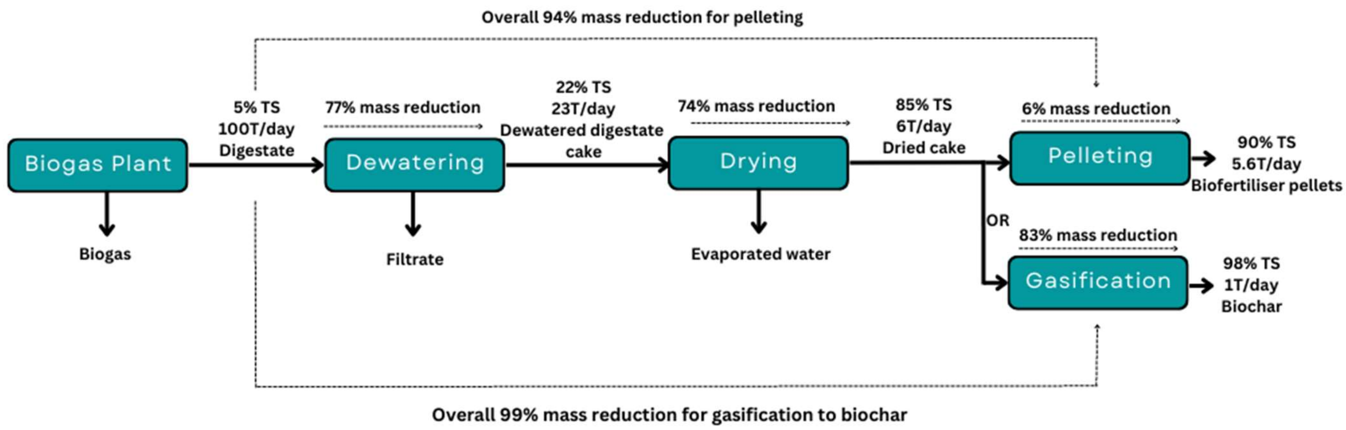


Figure 28: Mass balance showing mass reduction across the process. Source: gasification figures derived from values provided by IQ Energy

5.7.3 Cost benefit analysis results

The cost benefit analysis compared the capital expenditure (reported in 2023-1013 MS7 report), operating costs based on a percentage of Capex (inclusive of gas and electricity consumption) and estimated incomes (presented in section 5.7.1 above) for implementing a bio-based fertiliser plant at an example case study facility. The summary of the cost benefit analysis is presented in Table 5. The outcome was positive, with a net present value of $80M over the 25-year total project life, a payback time of approximately 6 years, and an annualised ROI of approximately 3.3% (Table 6). For every $1 invested, $2.20 is returned.

However, it is advised to conduct a more thorough economic assessment and potentially increase the contingency to 15% to 20% in the final business case. Due to the impact of Covid-19 and the conflict in Ukraine, which occurred during the development of this project, inflation is now higher and there are increased labour costs and interest rates to consider.

Table 5: Cost benefit analysis inputs and outputs

Inputs	Variable	Price	Quantity/year	$/design life
Income	Biofertiliser	$110/tonne	2030 tonnes	$6M
	Non-potable water	$2.12/kL	432 ML	$24M
	Electricity	$0.31/kW	9,636 MW	$78M
	Gas (thermal)	$26/GJ	33,000 GJ	$22M
	Carbon credit	$40/tonne	14,400 tonnes	$15M
	Alternative - Biochar	*$1,800/tonne*	*360 tonnes*	*$17M*

Inputs	Variable	Price	Quantity/year	$/design life
Income Total				**$145M**
Capex	WWTP	$10M	N/A	N/A
	Biogas plant	$12M	N/A	N/A
	Biofertiliser plant	$3M	N/A	N/A
Capex Total				**$15M**
Opex	WWTP (6%*Capex)	$600k/yr	N/A	$16M
	Biogas plant (6%*Capex)	$720k/yr	N/A	$19M
	Biofertiliser plant (6%*CAPEX)	$194k/yr	N/A	$5M
	Alternative 1 - do nothing case – disposal of 5%TS digestate	*$345/tonne*	*36,500 tonnes*	*$327M*
	Alternative 2 – disposal 22%TS digestate	*$345/tonne*	*8,290 tonnes*	*$3M*
Opex Total				**$39M**

Table 6: Cost benefit analysis summary of results

Financial Metrics	Values for the Base Case
NPV	$80M
ROI	125%
Annualised ROI	3.3%
Cost Benefit Ratio	2.2
Payback time	~6years

5.7.4 Sensitivity analysis

The results of the sensitivity analysis, shown in Figure 29 and Table 7, indicate that all scenarios tested produced a positive net present value when income streams were adjusted to zero, 0.5 times, and 1.5 times the average market prices. This is in contrast to the base case of disposing of digestate, which produced a negative net present value.

These findings suggest that the investment in the bio-based fertiliser plant will be able to withstand fluctuations in market prices and remain robust even in volatile market conditions, and provide a net financial gain over time.

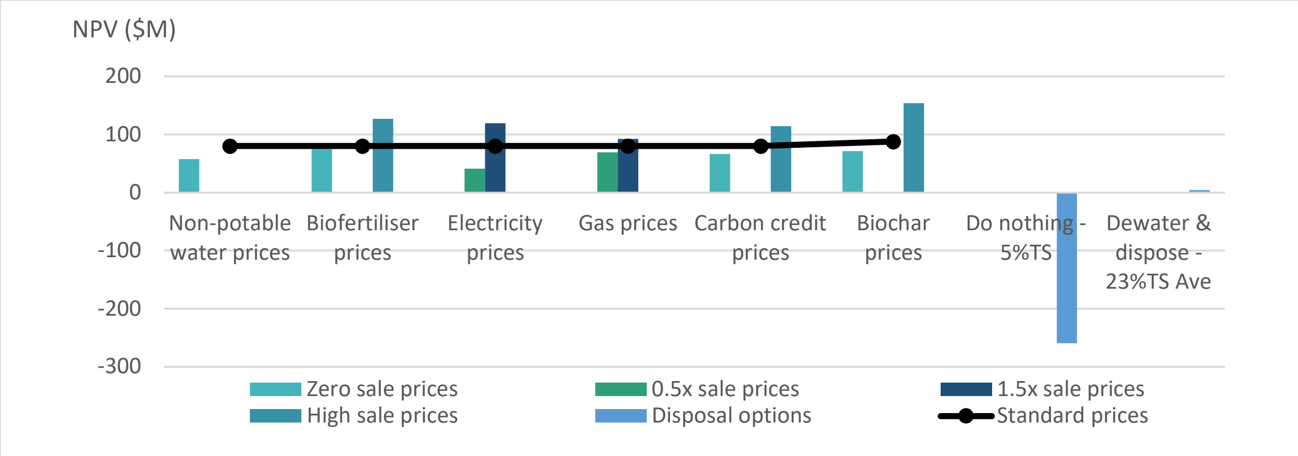


Figure 29: NPV sensitivity analysis with various price changes

Table 7: Sensitivity analysis ROI and payback times

Variables	Prices	ROI (%)	Annualised ROI (%)	Payback time (years)
Base case	Biofertiliser plant, standard prices	125%	3.3%	6
Non-potable water prices	$0/ML	88%	2.6%	8
Biofertiliser prices	$1,000/tonne	197%	4.5%	4
	$0/tonne	116%	3.1%	7
Electricity prices	$0.16/kW	64%	2.0%	10
	$0.47/kW	185%	4.3%	5
Gas prices	$13/GJ	107%	3.0%	7
	$39/GJ	142%	3.6%	6
Carbon credit prices	$130/tonne	177%	4.2%	5
	$0/tonne	101%	2.8%	7
Alternative - Biochar prices	$1,800/tonne	127%	3.3%	6
	$8,900/tonne	223%	4.8%	4
	$0/tonne	103%	2.9%	7
Alternative - Disposal Options	Base Case - 5%TS digestate disposal	-68%	-4.4%	-2
	Dewater & dispose (ave of 3 technology options)	3%	0.1%	22

5.7.5 Cost benefit analysis conclusions

The findings from the cost benefit analysis have been summarised in the figure below.

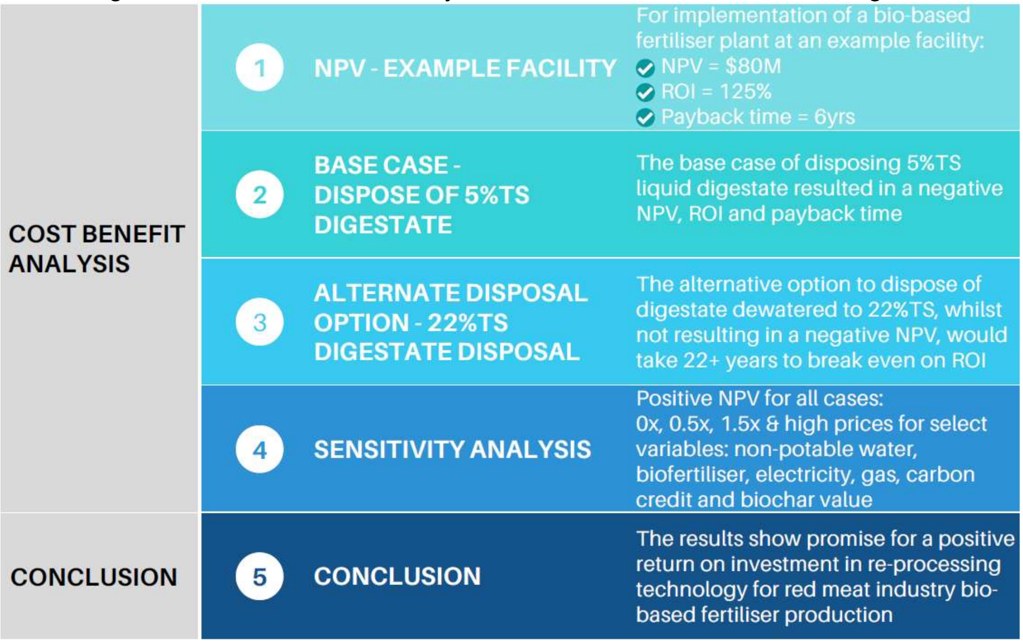


Figure 30: Cost benefit analysis summary of findings

The findings of the cost benefit analysis show that implementing a bio-based fertiliser plant as part of an integrated Bio-Resource Recovery Facility results in a positive net present value and increased profits, along with environmental and social benefits. The sensitivity analysis demonstrated that it is worth implementing the plant at even the smallest scale possible (with no income from the sale of bio-based fertiliser), as it still results in a positive return on investment. This is due to the volume/weight reduction of digestate which no longer requires disposal, and other income streams from the integrated Bio-Resource Recovery Facility such as non-potable water, offsetting gas and electricity costs and new carbon credits.

Therefore, it is recommended to carry out the next steps to implement the bio-based fertiliser plant at the chosen case study red meat processing facilities. The next steps and recommendations are summarised in the below figure:

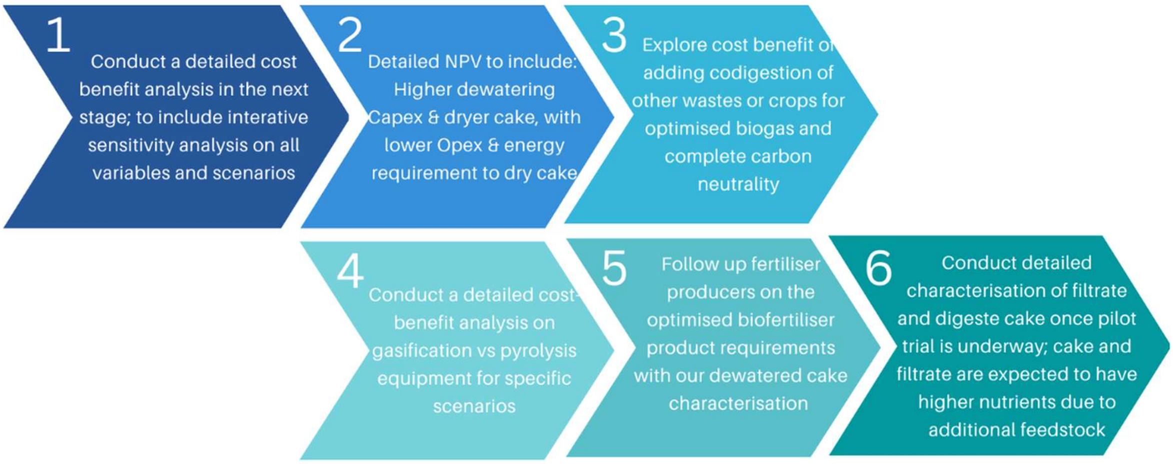


Figure 31: Recommendations and next steps

5.8 Model of materials handling and facility operation

A review of possible business models, to fund and operate the bio-based fertiliser plant, was undertaken. This provides the possible paths forward for red meat processing plants, from which they can choose what model works best for them and their priorities. The following provides the advantages and disadvantages for the two main business models, private vs shared ownership, of the bio-based fertiliser production plant.

Model	Advantages	Disadvantages
1) Private Ownership	• Owner has complete control • Owner can quickly respond to market/industry changes without stakeholder consultation • Greater profit potential / don't need to share earnings with other parties. • Potential for greater business structure and operational flexibility - streamlining processes and increasing efficiency	• Expensive - owner bears full costs of O&M • Limited access to other resources and expertise - limited ability to innovate or expand • Higher risks as owner is solely responsible for losses and setbacks • Private ownership may be seen as less transparent or accountable compared to shared ownership models.
2) Shared Ownership	• Wider range of resources, expertise, and capital. • Spread risks and costs of O&M across multiple parties, reducing financial burden • Encourages collaboration, innovation, and shared decision-making, leading to more sustainable and equitable outcomes • Greater transparency and accountability; each owner has a stake in the facility's success	• Increased complexity; multiple parties to agree on decisions and management • Requires coordination and communication between owners; slower decision-making • Legal agreements and documentation required to govern the partnership; can be time-consuming and costly • Potential for conflicts between owners if there are differences in priorities or values

Of the above two options, private or shared ownership, there are several subcategorised business models that can be used to implement a waste management facility in the red meat industry, summarised below.

	OPERATIONAL MODELS	CHARACTERISTICS
BOOM	**BUILD-OWN-OPERATE-MANAGE** Third-party builds, owns, operates and manages the bio-based fertiliser facility. The red meat industry pays a fee to use the facility to dispose of its byproducts.	• Allows the red meat industry to outsource the management of byproducts, which can minimise complexity and cost • Red meat industry has reduced control of facility operation
BOOT	**BUILD-OWN-OPERATE-TRANSFER** Third-party builds, owns, and operates the bio-based fertiliser facility for a specified period before transferring ownership and operation to the red meat industry or a designated entity.	• Allows the red meat industry to access financing for construction • Reduces the red meat industry's risk • The red meat industry has reduced control of operation during the own and operate phase
JV	**JOINT VENTURE** The red meat industry partners with a third-party to build, own, and operate the bio-based fertiliser facility.	• Both parties share the costs, risks and returns. • Allows the red meat industry greater control of facility operation • Finding a suitable partner and negotiating the terms of the partnership are critical
COOP	**COOPERATIVE** Farmers come together and pool resources to create a biofertiliser production unit. Objective: produce biofertilisers for farms and gardens, reducing synthetic fertiliser use and promoting sustainable agriculture.	• Allows farmers to share the costs and risks of producing bio-based fertilisers • Collect organic waste from farmers and local communities to produce high-quality biofertilisers. Biofertilisers will be sold to farmers and gardeners, providing income for the cooperative members.
FOM	**FULL OWNERSHIP MODEL** The red meat industry builds, owns, and operates the bio-based fertiliser facility itself.	• Allows the industry to have full control over the facility's operation and disposal of byproducts. • Industry bears the full cost and risk of the project

Figure 32: Summary of possible business models to operate a regional bio-based fertiliser facility

The advantages and disadvantages of each of the shared business models are summarised below.

Model	Advantages	Disadvantages
BOOM Build-Own-Operate-Manage	**Control:** Investor retains facility control throughout the project life. Investor can make decisions on the facility operation and take advantage of market opportunities. **Flexibility:** BOOM model is flexible, allowing the investor to adjust facility operation to suit changing market conditions or to take advantage of new opportunities. **Profit sharing:** Investor retains all profits from bio-based fertiliser sales, providing potential for higher returns.	**Long-term responsibility:** Investor takes responsibility for facility operation over the long term, which may be challenging and require significant resources. **High risk:** High risk placed on the investor, as project success depends on the investor's ability to operate the facility efficiently and effectively. **Limited access to financing:** Investor's access to financing may be limited, as lenders may view the project as high risk due to the long-term nature of the investment.
BOOT Build-Own-Operate-Transfer	**Risk transfer:** Investor bears risk of facility construction and operation. After construction and operation phases, the facility is transferred to the designated entity, and the investor's risk is reduced. **Long-term returns:** Provides long-term returns for the investor as the investor is contracted to operate the facility for a specified period. Returns may come from the sale of bio-based fertiliser and the disposal of the facility to the designated entity. **Access to financing:** Provides an avenue for investors to access financing for the construction of the facility. This is because the designated entity is often willing to provide or guarantee financing for the project.	**Limited control:** Investor has limited control over the facility as the designated entity takes over ownership and control after construction and operation phases. **Dependency on partner entity:** Investment success depends on the willingness and ability of the designated entity to take over ownership and control of the facility after the contract period. **High initial investment:** Requires high initial investment from the investor to construct and operate the facility. This may limit the number of willing investors willing to participate in the project.
JV Joint Venture	**Shared Resources:** JV can pool resources, including funding, expertise, and technology. JV can combine the knowledge and resources of the red meat processing plant with those of the fertiliser production company for a more efficient and cost-effective operation. **Access to New Markets:** Companies involved can gain access to new markets and customers that otherwise may not have been available to them. This leads to increased revenue and growth opportunities for both companies. **Reduced Risk:** By sharing the costs and risks of the project, a joint venture can provide a lower-risk approach to entering a new market or pursuing a new opportunity. This is important in the case of producing bio-based fertiliser, as it involves significant capital investment and regulatory hurdles.	**Lack of Control:** When multiple companies are part of a JV, it can be difficult to control the operation. **Conflicting Interests:** Companies involved in the JV may have different goals and objectives; leading to conflicts of interest. **Complex Legal and Regulatory Requirements:** Involves complex legal and regulatory requirements. This can lead to delays and extra costs as the companies work to comply with various regulations and obtain necessary permits. **Sharing Profits:** Profits are shared among the partners according to the terms of the agreement. This limits the potential returns for each individual company compared to pursuing the opportunity independently.
COOP Co-operative	**Collective ownership and decision-making:** The co-op is owned and operated by its members, who have equal voting rights and decision-making power. **Resource pooling:** Co-op members pool resources, including capital, land, labour, and expertise, to create the biofertiliser production unit. **Social, financial and environmental benefits:** Value is created by transforming organic waste into a valuable resource for soil improvement, fertility and crop yields. The co-op is driven by a shared goal to reduce farmer's environmental impact, improve soil fertility and create additional income. It fosters a sense of community amongst members. **Market focus:** The co-op produces biofertilisers for the local market, targeting farmers and gardening enthusiasts who are looking for natural and sustainable fertilisers.	**Complex decision-making, governance and legalities:** When multiple members are involved, it can be difficult to control the operation. Decision-making can be time-consuming and complex to reach a consensus. The co-op needs to be registered with the relevant government bodies and comply with legal requirements. **Limited access to financing:** Raising capital may be challenging for individual members to source. **Liability and Risk:** Members share liability and risk, leaving individual members personally liable for debts, liabilities, or legal issues if the risks are not managed. **Sharing Profits:** Profits are shared among the members according to the co-op's governing documents. This limits the potential returns for each member compared to pursuing the opportunity independently.
FOM Full Ownership Model	**Control:** Red meat industry retains facility control throughout the project life. Red meat industry can make decisions on facility operation and take advantage of market opportunities without stakeholder consultation. **Flexibility:** FOM model is flexible, allowing the red meat industry to adjust facility operation to suit changing market conditions or to take advantage of new opportunities. **Profit sharing:** Red meat industry retains all profits from bio-based fertiliser sales, providing potential for higher returns.	**Long-term responsibility:** Red meat industry takes responsibility for long-term facility operation, which may be challenging and require significant resources. **High risk:** High risk placed on the red meat industry, as project success depends on the red meat industry's ability to operate the facility efficiently and effectively. Access to in-house expertise, to manage all aspects of the facility, may be limited. **Limited access to financing:** Red meat industry may have limited resources to invest in the facility ; lenders may view the project as high risk due to the long-term nature of investment.

Figure 33: Advantages and disadvantages of various business models

In conclusion, selecting the best business model between BOOM, BOOT, joint venture, cooperative or full ownership for producing bio-based fertilisers requires a comprehensive and systematic approach that considers various factors, such as feasibility, financial viability, social and environmental impact, and project objectives. By conducting a thorough analysis and evaluation of each option, stakeholders can make informed decisions that result in the most appropriate and sustainable choice for the project.

Both the BOOT and BOOM models have their own advantages and disadvantages. The choice of business model will depend on the investor's objectives, risk tolerance, and access to financing. The BOOT model may be suitable for investors who prefer a lower-risk investment with access to financing, while the BOOM model may be suitable for investors who prefer greater control and flexibility over the facility.

A joint venture for producing bio-based fertiliser from red meat processing plants involves a partnership between a fertiliser manufacturer and a meat processing company. By combining their resources and expertise, the two companies can develop and produce a valuable product while reducing waste and creating a sustainable business model.

A cooperative for producing biofertilisers is a sustainable business model that benefits both the environment and the community. By working together, farmers can reduce their environmental impact, improve soil fertility, and create a new source of income.

The full ownership model for producing biofertilisers is involves full responsibility, investment and profitability for the red meat industry. It is a higher risk option with the potential for higher rewards; the red meat industry retains full control of the facility and decision-making and has the potential to benefit from the full profits.

5.9 Example documents that would be required to establish agreement

The production of biobased fertilisers from dewatered digestate obtained from red meat processing plants requires careful consideration of several factors to ensure safe and efficient operation of the facility. Ultimately, the success of the facility relies on the commitment of all parties involved to work together towards the common goal of producing high-quality biobased fertilisers that contribute to a more sustainable and environmentally friendly agricultural industry. The responsibilities are summarised below:

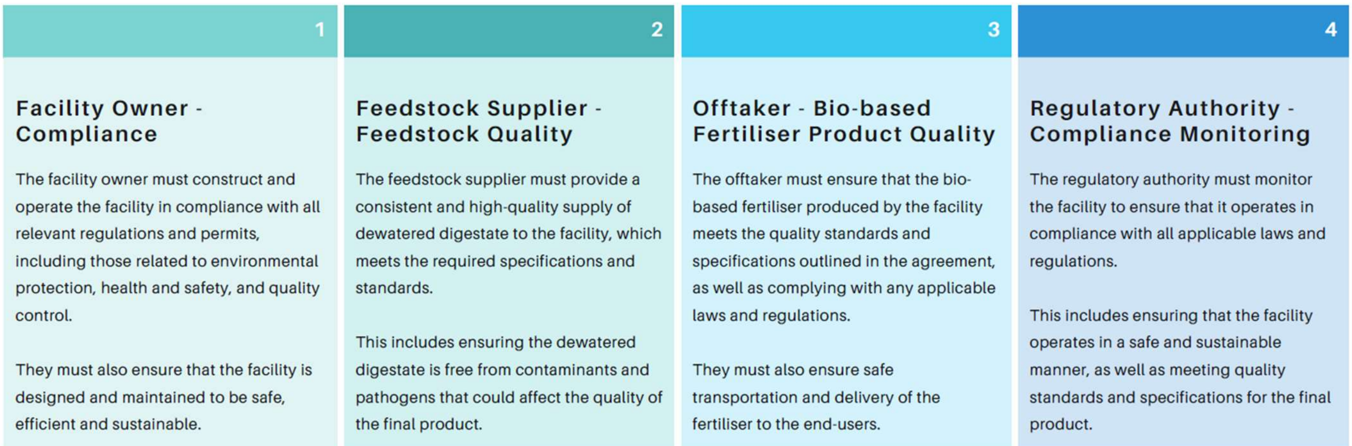


Figure 34: Stakeholder responsibilities

The example documents that would be required to establish a facility agreement are summarised below:

Figure 35: Example documents summary

5.10 Multi Criteria Assessment (go/no go) and planning for Phases 2 and 3.

A multi-criteria assessment is required to indicate whether it is worth continuing to investigate the project to implement a bio-based fertiliser plant at red meat processors. Therefore, a multi-criteria assessment for implementing the bio-based fertiliser plant, as part of an integrated Bio-Resource Recovery Facility, was carried out. The main considerations for implementing a bio-based fertiliser plant at a red meat processing facility, as determined in the multi-criteria assessment, are summarised below.

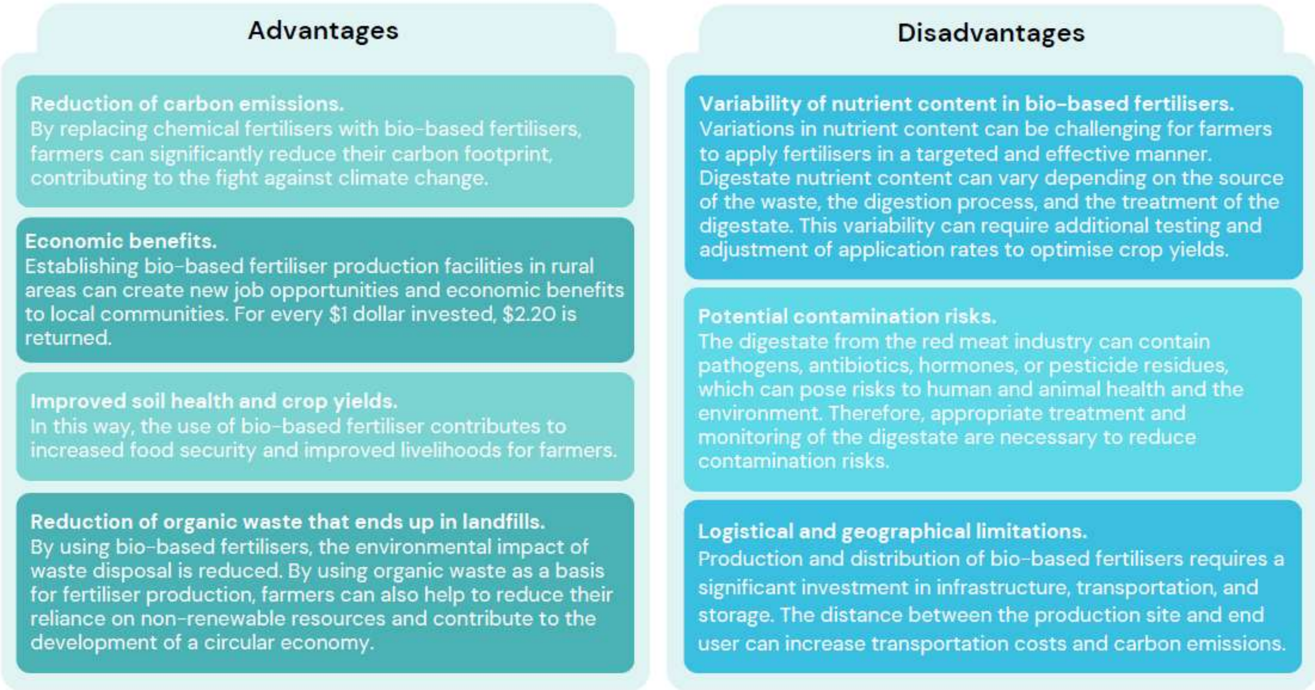


Figure 36: Advantages and disadvantages of a bio-based fertiliser plant

The following multi-criteria assessment in Figure 37 aims to evaluate the potential benefits, limitations, and risks associated with the production of bio-based fertilisers using digestate from the red meat industry. The assessment considers a range of factors, including environmental, economic, and social impacts, as well as regulatory requirements and technical feasibility. The summary above has highlighted the high-level potential advantages and disadvantages of implementing a bio-based fertiliser plant, including the reduction of carbon emissions, the variability of nutrient contents in fertilisers, contamination risks, and the potential for job creation and social impact. Additionally, the discussion has emphasised the importance of a risk management strategy and a two-year pilot trial to test the concept and reduce associated risks.

CRITERIA DESCRIPTION		IMPACT
DIGESTATE MANAGEMENT	• Disposing of AD can be problematic due to high nutrient and potential contaminent content - may cause pollution • Lack of regulation for the use of digestate as a fertiliser or soil conditioner • Significant transportation costs to move the material to disposal sites • Responsible management of AD is a complex issue that requires careful consideration of environmental and economic factors	HIGH
QUALITY ASPECTS	• Bio-based fertiliers from waste materials can have significant variability in nutrient content ◦ Due to feedstock differences and waste processing • Bio-based fertilisers from red meat processing may have suitably high nitrogen and phosphorus ratios but low levels of other key nutrients, such as potassium • Co-digestion of waste streams can lead to variability in nutrient content, depending on the source	MEDIUM
ENVIRONMENTAL IMPACT	• Switching from chemical fertilisers to bio-based fertilisers can help prevent environmental damage • Chemical fertilisers require significant resources and energy, causing greenhouse gas emissions and other negative impacts • Bio-based fertilisers are made from organic waste, which reduces the environmental burden of waste disposal • Slow nutrient release of bio-based fertilisers reduces the risk of pollution causing leaching and runoff • Improves soil health and biodiversity by encouraging beneficial microorganisms and reducing soil damaging synthetic inputs	HIGH
ECONOMIC FEASIBILITY	• Generates revenue from waste that would otherwise require costly disposal • Reduces the cost of chemical fertilisers and improves crop yields, which can increased farm income • Enhances soil quality, reducing the need for costly soil remediation. • Local bio-based fertiliser production reduces transportation costs and supports local businesses • Economic feasibility depends on factors such as the local market, production costs and government incentives	MEDIUM
CARBON EMISSIONS	• Bio-based fertiliser production using AD digestate requires less energy and emits fewer greenhouse gases than synthetic fertilisers • Slower nutrient release reduces the frequency of applications that require energy-intensive production and transportation • Improve soil health, which can increase carbon sequestration in the soil	HIGH
REGULATORY COMPLIANCE	• In Australia, the regulatory framework for bio-based fertilisers is still evolving, varying between states and territories • There is currently no national standard for the use of AD digestate-based fertilisers • This lack of clarity can create challenges for producers and farmers seeking to use these fertilisers, including uncertainty around quality control, labelling requirements, and certification processes. • There may be local regulations or restrictions on the use of certain types of waste materials as fertilisers, which can impact the viability of AD digestate-based fertilisers	LOW
SOCIAL IMPACT	• Employment opportunities created at the bio-based fertiliser facility, particularly in rural areas near red meat processors • Economic development and promoting social equity • Use of bio-based fertilisers can create greener public spaces, which can improve the well-being of residents • Social impacts such as noise and odour issues should be considered with community engagement and consultation	MEDIUM
GEOGRAPHICAL ASPECTS AND LOGISTICS	• High transportation costs and short shelf life can increase expenses and reduce the effectiveness of digestate. • Nutrient content of digestate can vary, leading to challenges in producing high-quality fertilisers • Local regulations and public perception towards using animal by-products in agriculture can limit the use of the product	MEDIUM
TAILOR MADE PRODUCTS	• Potential to enhance bio-based fertiliser with macro and micro nutrients to meet specific crop requirements • Allows farmers to tailor the fertiliser product to suit their specific application needs • This enhances the overall efficiency of the fertiliser application, leading to increased crop yields and better soil health • Tailoring bio-based fertilisers to specific crop requirements can reduce wastage and save costs for farmers	HIGH
RESOURCE AVAILABILITY	• Potential availability of AD digestate from red meat processing plants across Australia could be up to 726 million tonnes of dewatered digestate potentially available per year in total • Actual availability of digestate will depend on a range of factors, including the capacity and efficiency of individual processing plants, as well as the market demand for bio-based fertilisers	MEDIUM
MARKET DEMAND	• Demand for bio-based fertilisers as a replacement for chemical fertilisers is increasing globally • Growing awareness of the environmental and health impacts of chemical fertilisers • Benefits of bio-based fertilisers compared to chemical fertilisers include reduced carbon footprint, improved soil health, and increased nutrient efficiency. • Support of a circular economy by repurposing organic waste streams and reducing reliance on non-renewable resources • Challenges include regulatory and logistical barriers, variability in nutrient content, and the need for more R&D for optimisation	HIGH

INNOVATION POTENTIAL	• Applicable innovation techniques include:
	  ◦ Development of efficient and novel processing and distribution technologies
	  ◦ Optimisation of nutrient content and consistency and integration of other 'waste' streams
	• Benefits of such innovation include:
	  ◦ Improved soil health and crop yields
	  ◦ Reduced greenhouse gas emissions
	• Supporting the circular economy and reduce reliance on synthetic fertilisers derived from non-renewable resources
		HIGH

EMPLOYMENT GENERATION	• Significant potential for creating new jobs and generating socio-economic benefits
	• Employment opportunities include:
	  ◦ Production
	  ◦ Processing
	  ◦ Distribution
	  ◦ R&D
	  ◦ Marketing and sales
		MEDIUM

OTHER BENEFITS	• Supporting regional economic development • Reducing dependence on imports of chemical fertilisers • Creating opportunities for local production and supply • Supporting sustainable agriculture and environmental stewardship, improving soil health, reducing greenhouse gas emissions, and promoting biodiversity	HIGH

Figure 37: Decision matrix describing the multicriteria assessment of various project drivers and their impact on the production of bio-based fertilisers as a new industry practice.

The production and use of bio-based fertilisers using AD digestate from red meat processing plants present a promising opportunity for sustainable agriculture in Australia. However, there are several challenges that need to be addressed to ensure the feasibility of this approach.

One of the key challenges is the variability in nutrient content in the fertilisers produced from waste materials, including those derived from red meat processing and co-digestion. This variability can make it difficult for farmers to apply fertilisers effectively and may require additional testing and adjustment of application rates to optimise crop yields.

Another challenge is the contamination risks associated with using AD digestate from the red meat industry as a basis for bio-based fertilisers. These risks include the presence of pathogens, medicines, and other contaminants that may be harmful to crops and the environment. Appropriate treatment and quality control measures are necessary to mitigate these risks and ensure the safety and effectiveness of fertilisers.

Despite these challenges, there are significant benefits to producing and using bio-based fertilisers from AD digestate. These benefits include reducing waste and greenhouse gas emissions from the red meat industry, improving soil health and fertility, and potentially reducing the reliance on chemical fertiliser, in addition to the financial benefits.

To fully realise these benefits, further research and development are needed to optimise the production and use of bio-based fertilisers. This includes exploring the potential for enhancing bio-based fertilisers with macro and micronutrients to tailor the product for different applications and markets.

In addition, the establishment of a pilot plant would be a crucial step in developing this technology. A pilot plant would provide an opportunity to trial the process and produce sufficient samples of bio-based fertilisers for field trials, ensuring that the fertilisers are effective and safe for use.

Moreover, the establishment of a pilot plant would also contribute to the socio-economic benefits of this technology. The production and use of bio-based fertilisers from AD digestate would create new jobs and support the growth of regional communities.

In summary, the production and use of bio-based fertilisers from AD digestate present a promising opportunity for sustainable agriculture in Australia. While there are challenges associated with this approach, such as the variability of nutrient content and contamination risks, the benefits are significant and warrant further research and development.

6 Discussion

The purpose of this project is to determine the potential for producing bio-based fertiliser from anaerobic digestate at AMPC member red meat processing facilities. The reason for developing the project is to understand whether there are insurmountable limitations which would affect the project success, to effectively implement and operate bio-based fertiliser plants at red meat processing facilities.

There are several criteria which are critical to project success, one of which is whether there is enough digestate potentially available to achieve the required critical mass for the bio-based fertiliser facilities, as well as the market demand in various sectors for bio-based fertiliser. Understanding whether there is real interest from potential off-takers to receive and utilise the bio-based fertiliser product, in addition to the suitability of reprocessing technology that is available on the market, are also criteria which affect the project feasibility. The cost benefit analysis and status of regulations affecting the use of bio-based fertiliser products derived from the red meat industry, are important elements for project success. Choosing the right business model for the red meat processing facility which will implement the bio-based fertiliser plant, is vital to project success, as are the stakeholder contractual agreements. It is important to undertake a multicriteria assessment to evaluate the advantages and disadvantages of implementing a bio-based fertiliser facility at a red meat processing plant, to make the decision on whether the project should go ahead. To investigate the critical criteria outlined above, several investigatory tasks were undertaken as follows.

A mass balance was conducted to estimate how much bio-based fertiliser could potentially be produced at each AMPC member facility across Australia, and whether that quantity is enough to be of marketable interest. The mass balance proved that if all facilities implement an anaerobic digester and bio-based fertiliser plant, there would potentially be enough digestate available to be of interest to commercial fertiliser companies to integrate into their product selection.

An analysis of various processing technology was undertaken, to identify what types of suitable equipment is available on the market. The suitable dewatering technology which red meat processes can select from includes decanter centrifuges, rotary presses, a KDS multidisc roller system, or variations of the traditional screw press. These technologies had high Technology Readiness Levels (TRLs) as they were deemed to be the most effective options available for the type of digestate which will be processed (derived from the red meat industry). Except for the centrifuge (which was selected due to its likely high suitability and performance for this type of feedstock), these shortlisted technologies have a low footprint and energy requirements, and relatively low costs.

To improve the accuracy of findings, 11 case study red meat processing facilities, strategically positioned across Australia, were selected to undertake detailed market research and analysis. This potential production quantity was compared to the market demand, in each relevant sector, for bio-based fertiliser use in adjacent areas to the red meat processing facilities. The analysis of supply/demand and market research showed that the municipal, Natural Resource Management, landcare and mining sectors show great potential for the 11 selected case study facilities.

A selection of potential bio-based fertiliser offtakers were surveyed, from various markets including mining, forestry, municipal, resource managers and landcare enterprises, to obtain their level of interest and market demand and requirements for bio-based fertiliser products. From the potential offtaker expression of interest process, the greatest opportunity for bio-based fertiliser use was in the Natural Resource Management, forestry (softwood plantations), commercial sale and mining sectors. Of the national fertiliser use, if all AMPC member facilities implemented bio-based fertiliser plants, they could collectively fulfil up to 3% of the total fertiliser demand in Australia. This is a positive outcome, as it means there will be an abundant market demand for producing the local bio-based fertiliser products.

The shortlisted further processing technologies included the options of thermally drying the dewatered digestate and producing bio-based fertiliser pellets, drying and pyrolysing or gasifying the dewatered digestate into biochar. These options also have a high TRL, but with a medium footprint and relatively high costs and energy requirements. The two biochar technologies, whilst being able to destroy more pathogens and potential contaminants than drying and pelleting option, will result in a product with a lower nutrient composition. The choice between these technologies chiefly depends on the individual red meat processing plant and the market demand and end-user requirements for the bio-based fertiliser product.

A characterisation study was undertaken, to better attribute a financial value and market demand for the bio-based fertiliser. The characterisation study was firstly conducted via desktop, then secondly via a bench-top analysis. Hereby, anaerobic digestate from an existing red meat processing facility was tested and analysed. The results showed that the likely characteristics of the bio-based fertiliser may potentially be higher in quality (in terms of contaminants and pathogens) than municipal biosolids, which could open the use to almost unrestricted use. In terms of nutrient content and comparison to typical organic fertilisers, the percentage of nitrogen and phosphorus were comparable, with the opportunity to optimise the product to suit specific end-users with added feedstock or fertiliser augmentation with potassium sources. The characterisation exercise is highly dependent on the samples, so representative sampling and analysis should be undertaken across several facilities to refine the analysis.

Regulations were reviewed to understand how much of a regulatory barrier would need to be overcome for project success. The regulatory review, both global and across all states and territories in Australia, showed that there are no existing regulations for bio-based fertiliser derived from the red meat industry. However, it is suggested that the municipal biosolids guideline be used as a base framework to develop suitable regulations. It was noted that Europe and the USA, with QLD and NSW following behind, are leading the way by considering by-products as valuable resources to be utilised rather than as waste products for disposal, and so their biosolids guidelines and similar regulations (such as End of Waste Codes) should be used as inspiration for the bio-based fertiliser discussions with regulators.

A cost benefit analysis was carried out, to examine the financial inputs and outputs and understand if the project would result in a net financial gain. The capital and expected operating costs were reasonable and are expected to generate a positive return on investment. For every $1 dollar invested, $2.20 will be returned. The NPV after a 25 year design life was estimated to be $80M, with a 125% ROI and a payback time of 6 years.

Various business models, for facility funding and operation, were analysed and presented. The presented options included BOOM (build-own-operate-manage), BOOT (build-own-operate-transfer), JV (joint venture), Co-operative and FOM (full ownership model). The choice between the business models is up to the individual red meat processing facility, to evaluate their specific priorities, risk profiles and other dependent variables. A selection of example contractual documents was provided in a previous milestone report, which could be used to set up the stakeholder agreement for the final selected business model.

A multi-criteria analysis was undertaken to help AMPC decide whether to proceed with the next stages of the project. The multi-criteria assessment demonstrated that the project should go ahead. The analysis showed that the project will deliver a high positive environmental impact, high potential for carbon abatement, positive social impact, great potential to produce tailor made products, market demand, high innovation potential, employment creation and be economically feasible. Therefore, there is potential for a positive business case for the implementation of bio-based fertiliser facilities at red meat processing plants.

The report utilised a variety of literature and preliminary sampling and analysis data to draw conclusions, which relied on a vast number of assumptions. Particularly, the specifics for each red meat processing facility will differ, causing variability in the digestor feedstock and resultant bio-based fertiliser characteristics. The market demand for the bio-based fertiliser will also differ from location to location. The establishment of a pilot plant is a crucial step to refine the assumptions to further develop this project to move towards sustainable agriculture and regional development.

7 Conclusions / Recommendations

Red meat processing plants in Australia traditionally have significant waste management costs. In addition to costs, with the global shift to focus on more sustainable operations, red meat processors have the opportunity to recover costs and improve their environmental impact by producing red meat derived bio-based fertiliser products for beneficial use. Furthermore, by operating in an optimised commercial manner, the red meat processing industry can collaborate and improve the sustainability of other industries, such as mining, forestry, municipal, resource managers and landcare enterprises. The implementation of such bio-based fertiliser projects at red meat processing facilities enables positive environmental and social outcomes, improved resource recovery rates and establishment of Circular Economy business models.

The driver to add a bio-based fertiliser plant to further process the liquid digestate (which would be produced as part of the integrated Bio-Resource Recovery Facility) is for various reasons. It is easier to regulate a solid bio-based fertiliser product than a liquid digestate. Liquid digestate management has been a challenge in the industry and heavily depends on state regulations. Logistics and transport costs for a denser, solid product will be better than for large volumes of liquid digestate, resulting in less transport and the associated financial and carbon footprint benefits. Additionally, storing, handling and selling a solid product will also be easier to manage. Reducing pathogens and contaminants via a dedicated bio-based fertiliser production facility will also improve the operational flexibility and level of control of treatment than attempting to meet certain product criteria solely via the anaerobic digestion biogas plant.

The findings of the Stage 1 bio-solids project are presented in this report, which is chiefly a pre-feasibility exercise to determine the potential challenges which would need to be overcome, and whether the effort to reward is worthwhile. After the completion of stage 1, stages 2 and 3 will take things further by developing lab scale and full-scale pilot bio-based fertiliser plants.

The outcomes of this stage 1 final report show that there are many potential advantages to implementing a bio-based fertiliser facility at red meat processing plants in Australia, and all things considered, the further stages of the project should go ahead.

The mass balance analysis shows there would potentially be enough digestate available if all facilities implemented an anaerobic digester and bio-based fertiliser plant, spread in strategic areas in Australia, to support a more sustainable fertiliser production in collaboration with fertiliser producers. With 64% of the total potential bio-based fertiliser production from red meat processors being able to be provided by the large-size facilities, it is suggested that to achieve greatest impact, the project focus should be on those facilities of scale.

Of the 11 case study facilities, the sectors with the greatest demand for the potential available supply are the municipal, Natural Resource Management, Landcare and mining sectors. The survey results from the potential off-takers showed that the highest potential for bio-based fertiliser demand would be the forestry (softwood plantations), commercial, Natural Resource Management and mining sectors. There was a level of interest in market sectors which previously had little demand, but now have rising demand due to a range of factors such as climate change and increased global environmental focus. These rising stars include forestry (environmental plantations), Landcare and municipal (recreational land and urban greening).

There are several dewatering technologies available on the market which are suitable for this application, including decanter centrifuges, rotary presses, KDS multidisc roller system and variations of the traditional screw press. Furthermore, there are three shortlisted re-processing technologies to convert the dewatered digestate into bio-based fertiliser. These technologies include thermally drying and pelleting the dewatered digestate, pyrolysing it into biochar or gasifying it into biochar. The ultimate selection of these technologies should be made for each individual red meat processing facility that will implement the bio-based fertiliser project using the criteria of facility location, capacity, specific sludge characteristics, state regulations, local end-user requirements and specific cost benefit analysis for that location.

The digestate characterisation exercise showed a good NP ratio compared to commercial fertilisers, with a total nitrogen and phosphorus nutrient content comparable to that of typical organic fertilisers. There is an opportunity to optimise the product with additional potassium sources, and other nutrients as required, to tailor a product to suit specific end-users. In terms of pathogens and contaminants, preliminary testing has shown the product will likely be of a better quality than typical municipal biosolids, which should result in almost unrestricted possibilities for beneficial reuse of the bio-based fertiliser.

The regulatory review showed that no existing regulations exist for the production and use of bio-based fertiliser derived from the red meat industry. However, it was found that Europe and the USA, in addition to NSW and QLD, are more ahead than other states in Australia with respect to considering by-products as valuable commodities for use rather than waste. It is recommended that the municipal biosolids guidelines be used as a framework on which to base bio-based fertiliser regulations, and early discussions with regulators should proceed.

The cost-benefit analysis showed that the investment in bio-based fertiliser facilities will be robust against market volatility, resulting in a positive NPV for all sensitivity analysis cases. The standard NPV is $80M after a design life of 25 years, a payback time of 6 years, a 125% ROI and a return of $2.20 for every $1 dollar invested. It is recommended that a more detailed cost benefit analysis is done for specific red meat processing facilities who plan to implement a bio-based fertiliser facility, as the cost variables will change depending on location and other criteria.

There are several business models, for funding and operating the bio-based fertiliser facility, that red meat processors can choose from. These models include BOOM, BOOT, JV, a co-operative and FOM, and each of these should be evaluated with the specific red meat processing facility in mind, taking into consideration their individual priorities, risk profiles and other related variables. The example contractual agreements provided in a previous milestone report can be utilised to put the final stakeholder agreement together for the business model.

The multi-criteria assessment shows that the project should go ahead. This analysis was based on the high positive environmental impact, high potential for carbon abatement, positive social impact, great potential to produce tailor made products, good market demand, high innovation potential, employment creation and positive economic feasibility. It is expected that a positive business case can be made for the implementation of bio-based fertiliser facilities at red meat processing plants in Australia.

Establishing a pilot plant is a critical step to develop this technology and realise the full potential for red meat processors to contribute to sustainable agriculture and regional development. The pilot trial should be undertaken in the next stage of the project, and will be used to confirm assumptions and provide surety for investors.

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