Snapshot Report

Bio-based fertilisers

Bio-solids upgrade. Stage 1

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Project Description

The red meat industry can benefit from achieving resource circularity, increasing production efficiency, improving financial prospects, and reducing environmental impacts by using its solid, liquid, and gas by-products to create marketable products. Traditionally, the industry disposed of most of its by-products in landfills. However, AMPC is now considering processing the solid waste stream from red meat processors (sludge) into marketable bio-based fertiliser products.

To assess the feasibility of generating bio-based fertilisers using anaerobic digestate at AMPC member red meat processing plants, a mass balance analysis was conducted to determine potential production capacity, evaluating available processing technologies, and conducting a market analysis to align potential bio-based fertiliser output with demand across Australia. Additionally, the project involved surveying potential off-takers, conducting an in-depth regulatory review, and exploring various business models to fund and operate the facility, including sample contractual agreement documents. A multi-criteria assessment was conducted to evaluate the practicality of implementing bio-based fertiliser facilities at red meat processors.

"By embracing the use of bio-based fertilisers, we not only nourish our soil and crops sustainably, but also close the loop on our waste streams, creating a regenerative circular economy for future generations."

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 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, and the capital and expected operating costs are reasonable and expected to generate a positive return on investment.

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.

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 for product optimisation to suit specific end-users. 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. Several business models for the funding and operation of the bio-based fertiliser facility are available, each with different advantages and risks.

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

Project Content

The red meat processing industry in Australia has been faced with increasing waste management costs for a long time. With the global focus shifting towards sustainability, red meat processors now have an opportunity to tackle these costs and improve their environmental impact by producing bio-based fertiliser products from red meat waste, which can be used in agriculture and other industries. This not only benefits the environment but also helps the industry in establishing circular economy business models.

However, liquid digestate management has been a challenge for the industry as it is more challenging to regulate, transport and store. It heavily relies on state regulations, which can be complicated and costly. Therefore, the implementation of a bio-based fertiliser facility at red meat processing plants is crucial as it offers several benefits. Firstly, it is easier to regulate a solid bio-based fertiliser product than a liquid digestate, and a solid product has better logistics and transport costs than a large volume of liquid digestate. Secondly, storing, handling and selling a solid product is easier to manage. Thirdly, it reduces pathogens and contaminants through a dedicated bio-based fertiliser production facility, which improves the operational flexibility and level of control of treatment.

The Stage 1 bio-solids project was a pre-feasibility exercise to determine potential challenges and the worthiness of the effort to reward. After the completion of stage 1, stages 2 and 3 would develop lab scale and full-scale pilot bio-based fertiliser plants. The outcomes of this stage 1 final report showed 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 proceed.

The mass balance analysis showed that 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 the greatest impact, the project's focus should be on those facilities of scale.

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

There are several dewatering technologies available on the market that are suitable for this application, including decanter centrifuges, rotary presses, KDS multidisc roller systems, and variations of the traditional screw press. Furthermore, three shortlisted re-processing technologies are used to convert the dewatered digestate into bio-based fertiliser, including thermal 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 implementation depending on their strategic goals and resources. One possible model is for the red meat processor to fully own and operate the bio-based fertiliser facility themselves, using the revenue generated from the sale of the fertiliser to offset the costs of waste management. Another model is for the red meat processor to partner with an external investor who has the expertise and resources to finance and operate the bio-based fertiliser facility. This model can provide additional financial and operational benefits to the red meat processor, but may also require them to share some control over the facility and revenue generated. Finally, a third model is for the red meat processor to collaborate with other stakeholders, such as fertiliser producers or end-users, to co-fund and co-manage the bio-based fertiliser facility. This model can lead to greater collaboration and sustainability across industries but may require more complex negotiations and agreements between stakeholders.

Overall, the implementation of a bio-based fertiliser facility at red meat processing plants in Australia can provide significant benefits to both the environment and the economy. By recovering nutrients from waste streams, red meat processors can reduce waste management costs, improve their environmental impact, and establish circular economy, business models. Additionally, the production of bio-based fertiliser can benefit other industries, such as mining, forestry, and municipal resource managers, by providing a sustainable source of fertiliser. While there are challenges and considerations to overcome, such as regulatory frameworks, technology selection, and funding models, the outcomes of the Stage 1 bio-solids project indicate that the effort-to-reward ratio is worthwhile and that further stages of the project should be pursued.

As the project progresses into stages 2 and 3, it will be important to continue conducting detailed assessments and analyses to ensure that the bio-based fertiliser facility is optimally designed and implemented. This includes conducting lab-scale and full-scale pilot studies to evaluate the performance of the selected dewatering and re-processing technologies, as well as assessing the nutrient content and quality of the bio-based fertiliser produced. It will also be important to engage with stakeholders, such as regulators, end-users, and potential investors, to ensure that the facility complies with regulations and meets the needs of all stakeholders involved.

In conclusion, the implementation of a bio-based fertiliser facility at red meat processing plants in Australia has the potential to be a game-changer for the red meat processing industry and other related industries. By recovering nutrients from waste streams, producing a sustainable source of fertiliser, and establishing circular economy business models, this initiative can lead to significant economic and environmental benefits. However, to fully realise these benefits, it is important to carefully evaluate and address the challenges and considerations associated with the implementation of such a facility. With careful planning, collaboration, and innovation, the bio-based fertiliser facility can become a key driver of sustainability and circularity in Australia's agricultural and resource management sectors.

Project Outcome

Red meat processors in Australia are exploring ways to upgrade their lagoon wastewater treatment plants (WWTPs) to comply with stricter environmental regulations. Upgrading their WWTPs not only helps increase the capacity of their processing facilities, which is often limited by their existing WWTPs, but also addresses resource constraints such as the availability of processing water and consistent pricing of energy. Instead of treating WWTP upgrades as an unavoidable expense, these facilities can view them as an opportunity to recover valuable resources by incorporating a bio-based fertiliser processing plant as part of an integrated Bio-Resource Recovery Facility.

Adding a bio-based fertiliser plant to process the 5%TS digestate generated from the anaerobic digestion biogas plant offers several benefits. Firstly, producing a solid bio-based fertiliser product is easier to regulate and sell than a liquid digestate, which can depend on state regulations that may change. Secondly, transporting a denser solid

product is cheaper, results in a lower carbon footprint, and is easier to store, handle, and package. Finally, the solid bio-based fertiliser production facility helps reduce potential contaminants and pathogens, which offers more flexibility and control than solely relying on the anaerobic digestion biogas plant to treat them.

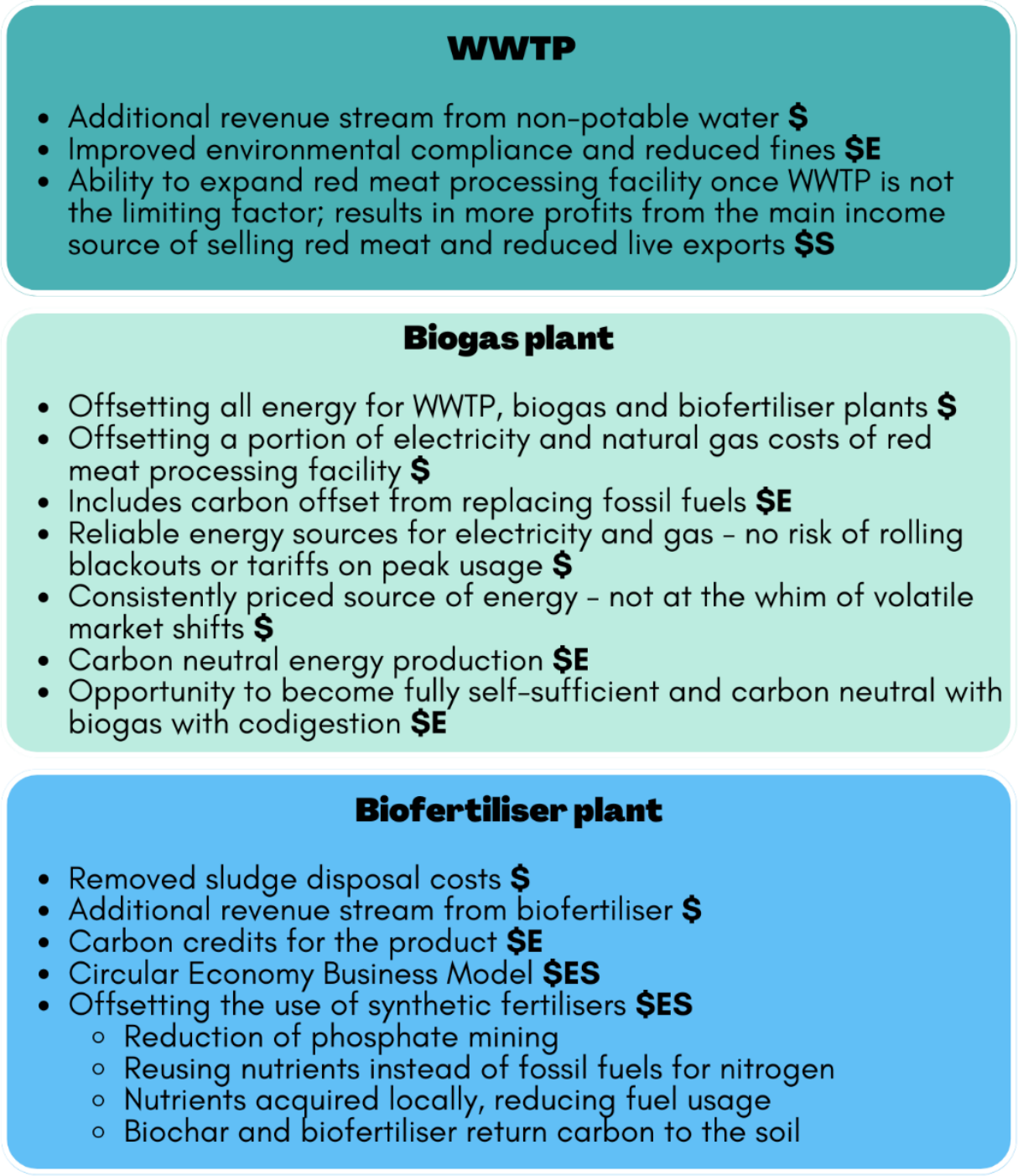

Figure 1: Overall financial, social and environmental benefits of a bio-based fertiliser plant

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 a financial benefit, E represents the environmental benefit and S represents the social benefit of implementing each processing plant.

Benefit for Industry

The production of bio-based fertilisers from anaerobic digestate at red meat processing facilities has enormous potential to benefit the industry, the environment and various other sectors. To determine the feasibility of this project, an investigation was carried out which included a mass balance study, technology analysis, market research, and characterisation study. The investigation found that if all facilities implemented an anaerobic digester and bio-based fertiliser plant, there would be enough digestate available to interest commercial fertiliser companies. The Natural Resource Management, forestry, commercial sale, and mining sectors showed great potential for bio-based fertiliser use. The bio-based fertiliser produced was of higher quality than municipal biosolids in terms of contaminants and pathogens, and regulations do not pose any significant barriers. The implementation of a bio-based fertiliser facility at a red meat processing plant has low energy requirements and costs, making it a viable option. The graphic below provides a summary of the main impacts of implementing the bio-based fertiliser project in the red meat industry.

In addition to reducing waste management costs, producing bio-based fertilisers can also help the red meat industry establish circular economy business models and contribute to the global shift towards sustainability. The investigation has shown that there is significant potential for the production of bio-based fertilisers from anaerobic digestate at red meat processing facilities.

The mass balance study indicated that a large amount of digestate is produced during the red meat processing, and the implementation of anaerobic digesters can help recover this waste. The bio-based fertilisers produced from this digestate can potentially fulfil up to 3% of the total fertiliser demand in Australia. The analysis of supply and demand also showed that there is a growing interest in bio-based fertilisers among various sectors, including the municipal, Natural Resource Management, landcare, and mining sectors.

The characterisation study revealed that the bio-based fertilisers produced from the digestate were of higher quality than municipal biosolids, making them a more attractive option. In terms of regulations, the review showed that there were no significant barriers, and guidelines for the use of municipal biosolids can be used as a base framework for the bio-based fertilisers. Moreover, the implementation of bio-based fertiliser facilities has low energy requirements and costs, making it a viable option for the red meat industry.

The market research also revealed that there is a significant opportunity for the use of bio-based fertilisers in various sectors. The Natural Resource Management, forestry, commercial sale, and mining sectors showed great potential for bio-based fertiliser use, and the potential off-taker expression of interest process showed the greatest opportunity for the bio-based fertiliser use in these sectors.

The production of bio-based fertilisers from anaerobic digestate at red meat processing facilities has several benefits for the red meat industry. The investigation has shown that there is significant potential for the production of bio-based fertilisers, and the implementation of such facilities has low energy requirements and costs, making it a viable option. By producing bio-based fertilisers, the red meat industry can not only recover costs but also contribute to the global shift towards sustainability and establish circular economy business models.

The graphic below summarises the main benefits and their impact, generated by implementing bio-based fertiliser production units associated to red meat processing plants.

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