Snapshot Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Integrated Bioresource Recovery Facility

Novel FEED Study, Stage 2

Project Code	Prepared by	Date Submitted
2024-1019	TESSELE CONSULTANTS	3/10/2024

Abstract

AMPC recently collaborated with Tessele Consultants and ARENA to conduct a thorough feasibility study on establishing an integrated Bioresource Recovery Facility (BRRF) at a red meat facility in NSW. The BRRF aims to maximise the value of by-product streams through wastewater treatment, biogas production, CO_2 recovery, and biofertiliser production. The study included a front-end engineering design (FEED) for each component:

- The Wastewater Treatment Plant (WWTP) processes the facility's wastewater to produce recycled water for irrigation and non-potable uses onsite.
- The Biogas Plant converts red meat processing by-products and WWTP sludge into thermal and electrical energy using Combined Heat and Power (CHP) units.
- The CO_2 Recovery Plant extracts and purifies CO_2 from biogas and CHP unit combustion for food-grade liquid CO_2 used in meat cooling processes.
- The Biofertiliser Plant utilises nutrient-rich digestate from the biogas process to produce biofertilisers.

The project highlighted the renewable energy potential of using red meat by-products for biogas production, estimating a yield of 1.4 GJ per tonne of hot standard carcass weight (HSCW) at a facility capacity of 135,200 t.HSCW/yr. The Combined Heat and Power (CHP) units in the biogas plant generate 2.37 MWh of electrical energy and 2.42 MWh of thermal energy, supplying the BRRF’s energy needs while providing surplus energy to the red meat facility.

Financially, the project promises significant returns, with a Net Present Value (NPV) of $225.3 million over a 25-year lifespan and a payback period of 7 years. It positions the red meat sector as a significant contributor to renewable energy production and exemplifies sustainability and circular economy practices for other industries.

A webinar for the project will be held on September 19th. You can register here.

Acknowledgements

This Study received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Industrial Energy Transformation Studies Program.

The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

Project Description

A beef processing facility in NSW is looking to adopt innovation in the way their wastewater and solid wastes are managed, aiming to (i) improve the removal of nitrogen and phosphorus, maintain an effective nutrient balance on irrigation of crops, (ii) recycle water on allowed operations, (iii) recover bioresources including biogas, biomethane, CO_2, biofertiliser, and (iv) reduce their overall carbon footprint.

In this context, this project aims to develop an Integrated Bio-Resource Recovery Facility Novel FEED Study, Stage 2, to be implemented at the NSW case study facility to inform a technical and economic decision on the way forward for project implementation and the required stages.

The innovative plant design considers aspects such as nutrients (nitrogen, phosphorus) and other compounds recovery from wastewater, with the possibility of irrigation and recycling uses, within compliance limits. Solid streams will be processed onsite for recovering thermal and electric energy as well as food-grade liquid CO_2 from biogas. Moreover, a biofertiliser processing plant adds value to the digestate.

The implementation of a Bio-resource Recovery Facility (BRRF) at the NSW case study facility promises well-managed resource recovery and robust environmental compliance. This initiative not only aligns with circular economy principles but also future proofs their production site, contributing to the red meat sector's commitment to sustainability. Additionally, the facility stands to gain from potential offsets such as treated water, energy, food-grade liquid CO2, biofertiliser, and carbon credits.

The Integrated Bioresource Recovery Facility's Novel FEED Study, Stage 2, builds from the Stage 1 FEED Study, which included the design of a Wastewater Treatment Plant (WWTP). Stage 2 includes biogas production from anaerobic digestion of underutilised solid byproducts and wastewater sludges. The biogas provides thermal and electrical energy to the facility via combustion in combined heat and power (CHP) engines. This approach ensures that the wastewater, biogas, CO_2 recovery and biofertiliser plants can operate self-sufficiently on the renewable energy produced from the biogas. This reduces the NSW beef processing plant's reliance on external fossil-fuel derived energy providers, increasing reliability of power supply, reducing their carbon footprint and mitigating the impact of rising electricity costs. Additionally, the study explores innovative CO_2 recovery of the carbon dioxide produced from the biogas plant, along with CO_2 from the biogas combustion exhaust in the CHP units. The CO_2 recovery plant will purify the captured carbon dioxide gas to food-grade liquid CO_2 which is used as dry ice for storage and transport of the NSW case study facility's final product, processed meat. Producing this valuable resource onsite will generate significant revenue for the facility since the market price for this resource has considerably increased due to market instabilities.

To close the loop of the bioresource recovery facility and minimise waste disposal, the liquid digestate from the biogas plant can be used as a valuable product for fertiliser or soil amendment application. Through a dewatering, drying and pelleting process, the biofertiliser plant converts the digestate into pelletised biofertiliser. Pelletised biofertiliser retains a higher nutrient content than other product options (such as biochar), and is logistically easier and cheaper to store, transport and apply to land, particularly during winter. The significant agricultural land use in the NSW case study facility region creates a high local demand for biofertiliser, exceeding the NSW case study facility's biofertiliser production capacity, facilitating a favourable market for product offtake. When commercialised, this recovered resource adds meaningful income to the facility.

In addition to Front End Engineering Designs (FEED) for the Bio-resource Recovery Facility components of wastewater, biogas, CO_2 recovery and biofertiliser production plants, the cost analysis of the BRRF was carried out through the evaluation of the capital and operational cost of the plants as well as the revenue from potential offsets such as treated water, energy, CO_2, biofertiliser and carbon credits. Profitability measurements were analysed for various scenarios, considering the implementation of one or more resource recovery plants and staged capital investment, identifying the best investment option.

To source information for the project, a desktop review of relevant documentation and communication via phone calls and emails with the NSW beef processing plant team was undertaken. The design and assumptions were conceived based on the concepts of recovering resources and approaching a circular economy.

Project Content

Wastewater Treatment Plant

The wastewater treatment plant concept design was based on a future average flow rate of 2,520 kL/day for biological and physicochemical processes. Hydraulic components were calculated for a peak flow of 3,024 kL/day (120% of the average). The proposed treatment sequence, shown in Figure 1, combines unit operations to achieve contaminant removal.

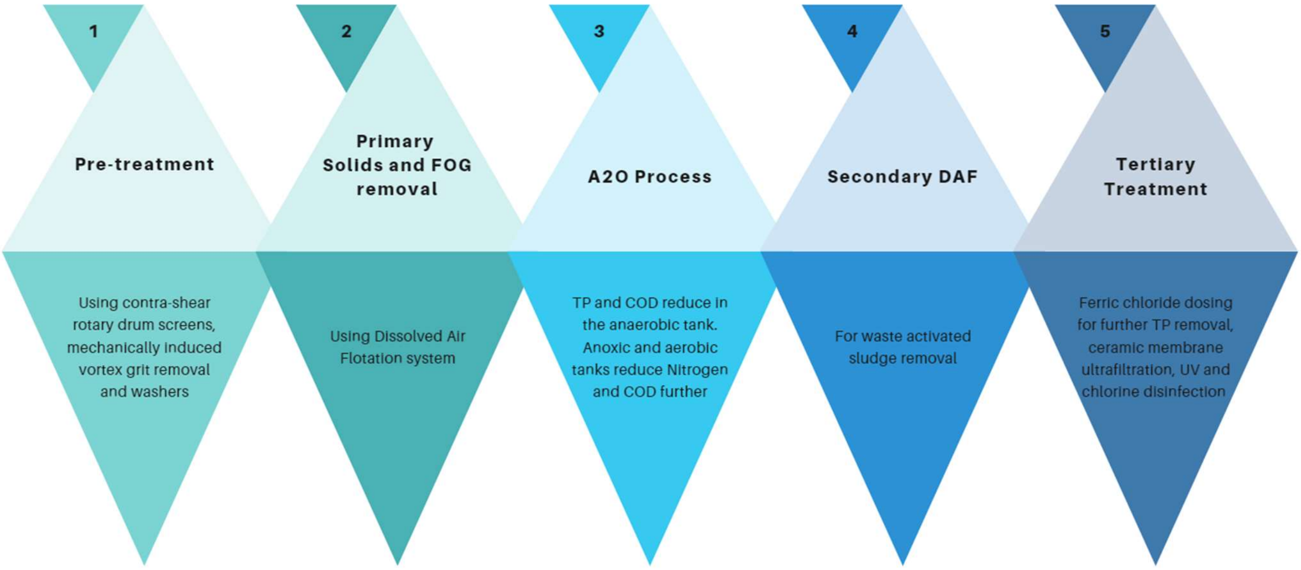

Figure 1. Summary of steps considered in the WWTP concept design.

Assuming the treated wastewater will be used for irrigation, cattle wash (other than final wash) and non-potable uses at the facility, treated final effluent quality addressed the requirements according to the Australian Guideline for Water Recycling (Environment Protection and Heritage Council et al 2006) and the Water Reuse Guideline from NSW Food Authority.

Biogas Plant

To identify relevant organic by-products to utilise as feedstock for the biogas plant, the selection of the organic streams considered the anticipated carbon content and substrate availability at the facility, focusing on an operation independent of external substrate additions. In order to obtain a realistic biogas estimate for the plant, the NSW beef processing plant's selected organic streams were sent to a certified laboratory for testing. Furthermore, BMP, TS, and VS values for additional streams like secondary DAF sludge and screened wastewater were derived from values used in similar projects. This approach was taken to accurately estimate the biogas plant's feedstock composition. Figure 2 outlines the process stages of the biogas plant design.

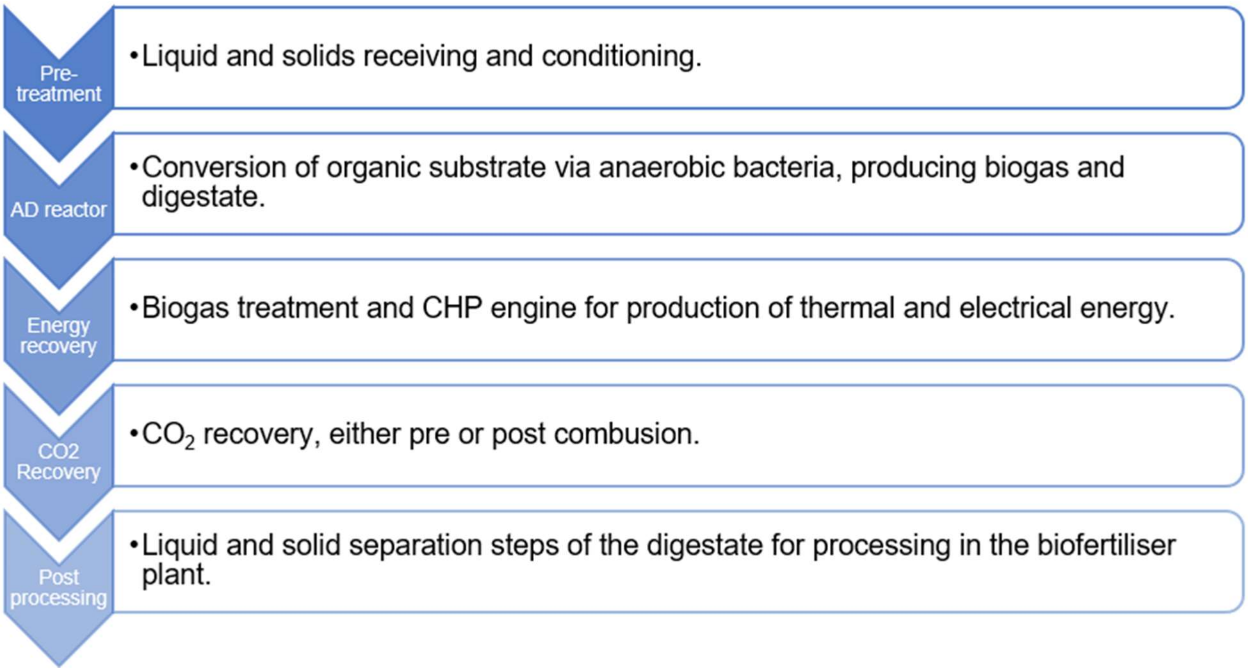

Figure 2. Summary of the process stages of the biogas plant.

The biogas plant design, validated by information obtained in the solids streams audit and BMP testing, incorporates modular units to enhance redundancy and supports future expansion, with an energy production capacity of 1.4 GJ per t.HSCW. The generated energy reduces onsite gas and electricity consumption, contributing to environmental stewardship and financial efficiency. The solid streams audit and BMP used to validate the biogas plant design are shown in Figure 3 below.

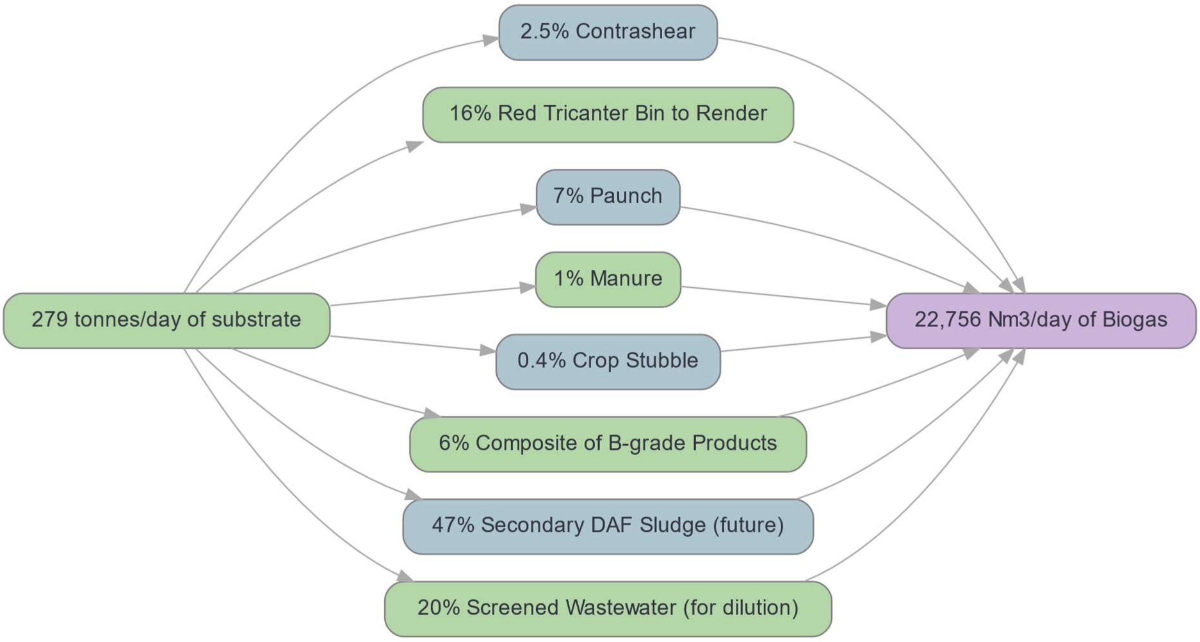

Figure 3. Solids stream audit and BMP test results output.

CO_2 Recovery Plant

CO_2, primarily used in the red meat industry as dry ice for preserving and transporting products, has faced supply challenges in Australia in recent years, due to global supply chain disruptions, increased demand, and production facility closures. This has caused higher costs and product assurance issues, leading some red meat processors, such as the NSW case study facility, to look into alternative CO_2 supply chains. The CO_2 recovery plant concept design was conducted by using the estimated biogas production, where it is assumed that 40% of the biogas is comprised of CO_2.

A renowned company in CO_2 recovery equipment, Evo Energy Technologies, was engaged in the CO_2 Recovery Plant design to identify the best process in obtaining food-grade liquid CO_2 from the biogas by-product gas stream. According to Evo Energy Technologies, amine scrubbing is the recommended option, which will be used for post-CHP engine flue gas, due to its ability to capture the 40% CO_2 content in biogas in addition to the CO_2 produced during biogas combustion in the CHP engines. Amine scrubbing is proven and widely used in CO_2 production plants globally.

The NSW case study facility currently has a snow horn system that produces dry ice snow from liquid CO_2 as a method to flash freeze their product. According to the amount of liquid CO_2 that will be recovered in the CO_2 plant (assuming a design stage of 135,200 t.HSCW/yr), the demand for liquid CO_2 is approximately 50% of the produced amount, resulting in a 50% surplus. It is known that a solid dry ice system can be implemented to enhance the surplus percentage. While the snow horn system requires 4.5 kg of liquid CO_2 to produce 1 kg of dry ice snow, the solid dry ice system requires 2.2 kg of liquid $CO_{2,}$ if a recovery system is implemented, the intake of liquid CO_2 decreases to 1.3 kg. Thus, the surplus rates would be approximately 70% and 80%, respectively. Although the NSW case study facility is focused on producing food-grade CO_2 for internal use, it is important to note that offering the CO_2 surplus to their other facilities as well as commercialising it may provide additional income to the NSW beef processing plant.

Biofertiliser Plant

The digestate's characteristics and quantifications at the NSW case study facility are shaped by the substrate type and biogas plant operation schedule, respectively. It is known that the biogas plant will process 279 kL of feedstock per day (under a 24/7 operation schedule). It was assumed that the digestate volume after the anaerobic digestion is equal to the substrate amount fed to the process. Given that the biofertiliser plant will operate 5 days a week, the inlet stream of the plant comprises 392 tonnes per day.

Before advancing with the biofertiliser plant design, it is crucial to understand relevant regulations and their impact on process design and final product application. A regulatory review found no existing regulations for biofertiliser from red meat digestate in NSW, suggesting the use of municipal biosolids guidelines as a framework. Analysis of the dewatered sludge from an anaerobic pond of a red meat facility located in the Australian southwest indicated that red meat digestate-derived biofertiliser could achieve a pathogen and contaminant level comparable to domestic biosolids Grade B, potentially reaching Grade A with pasteurisation.

Various technologies have been evaluated for potential integration into the bio-based fertiliser plant, with each option requiring thorough analysis to align with the project's sustainability and environmental objectives. Selection criteria for the digestate and filtrate processing have been compared in Table 1 below.

Table 1. Selection criteria of digestate and side stream processing technologies applied to the NSW case study facility.

Processing Option	Details	Environmental	Social	Capex + Opex
Digestate processing	Liquid digestate (pasteurised or unpasteurised)			
	Pelletised bio-based fertiliser			
	Biochar from gasification			
	Biochar from pyrolysis			
Filtrate processing	Mainstream WWTP			
	Struvite recovery			
	Annamox			

Out of all the processing technologies assessed, the most favourable alternative identified in the feasibility study involves dewatering, drying, and pelletising the bio-based fertiliser. This option boasts a small volume of product, simplifying transport and reuse besides keeping most of the nutrient content in the final product. Additionally, it is recommended that the filtrate side stream be directly returned to the initial stage of the WWTP due to ease of application and reduced cost, energy, and area requirements.

Project Outcome

An economic analysis was undertaken including different alternatives, encompassing full and partial BRRF implementation in single and double stages. It encompassed the plants' capital expenditure costs combined with operational costs at 6% of CAPEX, and revenue from recovered bioresources (treated water, energy, food-grade liquid CO_2, biofertiliser and carbon credits).

Out of all economic scenarios analysed, implementing a full Bio-resource Recovery Facility (BRRF), including wastewater, biogas, CO_2 recovery, and biofertiliser plants in one stage, offers the highest return on investment, helping offset energy consumption and support carbon neutrality. The economic outcomes for a full BRRF implementation in one stage are shown in Figure 4 below.

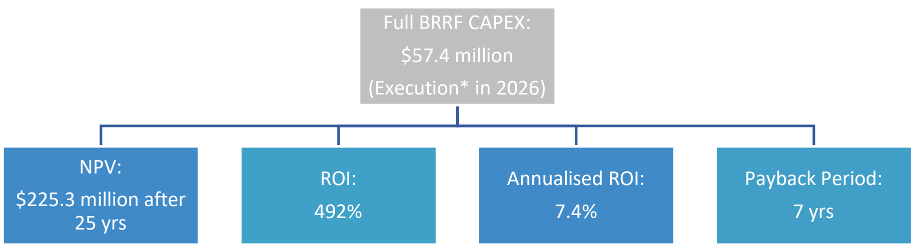

Figure 4. Economic outcomes for implementing a full Bio-resource Recovery Facility (BRRF) in one stage.

* Where execution date is the selected financial modelling date however the NSW case study facility currently has no plans committed to delivering the project on this date.

It is recommended to include sensitivity analyses in further project stages to optimise recovered resources quantities and prices, enhancing financial viability. Ongoing BMP tests and participation in RACE to 2030 anaerobic digestion trials are recommended to refine biogas, CO_2 recovery and biofertiliser component process designs and improve outcomes. Implementing flowmeters and a comprehensive sampling campaign, in addition to reassessing the assumptions provided for the wastewater treatment plant, are recommended to refine the wastewater treatment plant component for further project design stages. Refer to Figure 5 below for a summary of the outputs for each stage of the process.

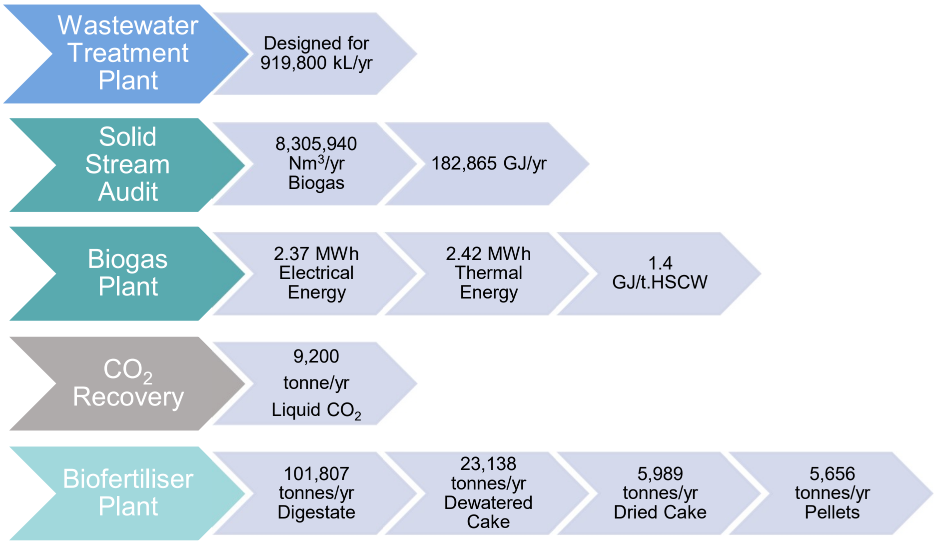

Figure 5. Bio-resource Recovery Facility summary and key values.

Overall, implementing a Bio-resource Recovery Facility at the NSW case study facility transforms the necessary wastewater treatment plant upgrades, that would otherwise be a financial burden, into a profitable venture. It offers a positive return on investment by adding bio-resource recovery components that recycle high-quality non-potable water, produce thermal and electrical energy from biogas, recover food-grade liquid CO_2, and produce value-adding biofertiliser. This initiative produces carbon offsets, fosters environmental stewardship, improves regulatory compliance, and promotes a circular economy. The design offers social, economic, and environmental benefits, reinforcing the rationale for advancing to the next phases of the project.

Benefit for Industry

Based on the technical and economic outcomes of this project, the implementation of the Bioresource Recovery Facility at the NSW case study facility will result in:

- An integrated bioresource recovery facility that is self-sufficient in power, fully powered by biomethane. Additionally, surplus thermal and electrical energy is available for use by the red meat processing facility.

- Revenue from recovered resources will offset both capital expenditures (CAPEX) and operational expenditures (OPEX), with a projected annual return on investment of 7.4%, a significant improvement compared to the traditional cost (negative ROI) associated with waste and wastewater management.

- The facility will avoid external reliance on food-grade liquid CO_2 by producing this commodity on-site sustainably.

- The implementation of the BRRF will contribute to carbon offsetting, supporting the NSW case study facility's sustainability initiatives. It will future-proof the NSW beef processing plant, establishing it as an exemplar of sustainability and circular economy practices in the red meat sector.