final report

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Value from Solid Waste Strategy for South-East Queensland Meat Processors; Final Public Report

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Abstract

Current waste management practices are economically and environmentally unsustainable due to forecasted increases in handling and transfer costs. It is thus critical that effective waste management strategy and business cases are developed. Previous AMPC works suggested that the most economically viable option for meat processors is for a centralised solid waste management facility.

This project investigated a value chain arrangement for the supply of raw materials to create value-added waste products by mapping waste streams and reviewing historical and scientific compositional analysis data for specific red meat waste streams; extrapolating typical volumes, composition, and costs of raw materials; Class 5 level plant design and techno-economic cost benefit analysis of aggregated digestion plant; and development of business cases and models to analyse the overall project economics. The best feedstock for a waste to energy plant are those streams with the highest biomethane potential, or the highest rate of biogas production per tonne of material. This project highlights that not all red meat processing plant wastes are equal and that, after transport costs are taken into account, that dewatered DAF sludges and green stream screenings are of highest interest for waste to energy facilties (i.e. preference is to transport volatile solids and not water). A low capital cost opportunity exists to dewater DAF sludge (and potentially red waste streams) via a hydrocyclone that creates a stream with a high volatile solids concentration, which is a result of the selective recovery of fats and grease.

A centralized facility offers a more sustainable and “greener” waste management solution that is estimated to be approximately “cost neutral” compared to landfilling of organic wastes, excluding state based landfill levies. The presence of a landfill levy improves the economic viability of RMPs utilizing a centralized organic waste processing facility.

This project has significant value to industry. The creation of energy and compost from waste provides an opportunity for the meat processing industry to deal with multiple waste and heat/power related pressures via a single integrated facility. This project bridges the innovation gap by providing objective third party engineering analysis, capital, operating, and revenue estimation, and clear business case development for waste to energy options from the perspective of the meat processing facility and the waste aggregator. Through a proof of concept and commercial viability in an Australian context, this project will ultimately develop and future proof the Australian red meat industry.

Executive Summary

The South-East Queensland red meat industry processes in excess of 1.3 million head of cattle per annum, with associated organic waste generation including paunch, sludges from waste water plants and dissolved air floatation, screened solids and carcasses. Current waste management strategies and practices require continuous review to ensure that economically and environmentally viable options are considered. For example, increases in handling costs, landfill levies and legislative changes mean that it is critical for effective waste management strategies and business cases to be iteratively updated and considered as part of the wider red meat supply chain.

Previous AMPC works suggested that the most economically viable option for meat processors is for a centralised solid waste management facility. Correspondence with industry confirmed that aggregated and centralised digestion is of interest.

This project investigated a value chain arrangement for the supply of raw materials to create value-added waste products by mapping waste streams and reviewing historical and scientific compositional analysis data for red meat processors (RMPs); extrapolating typical tonnages, composition, and costs of raw materials; Class 5 level plant design and techno-economic cost benefit models and sensitivity analysis of an aggregated digestion plant.

It must be noted that this report presents the findings of a concept design of approximately Class 4 to 5 (accuracy ranged estimated at +/- 20 to 40%). The findings of this project at the concept design level are summarised as follows:

- The concentration of RMPs in south east Queensland (SEQ), offers significant opportunity for a centralised co-digester: 66 ktpa of paunch, towards 33 ktpa of DAF sludge and up to 180 ktpa of waste water treatment sludges.
- The design throughput rate for an economically viable anaerobic digester “module” (40 ktpa of organic waste) can be obtained from RMPs as little as 20 km from a suitable site in the Ipswich area (Wood Mulching Industries Pty Ltd (WMI)).
- After utilizing biogas to offset running the anaerobic digester (AD) and providing 50% of WMI vehicle fuel (offsetting diesel use) an excess of biogas can be created, which could be fired in generation sets (gen sets) to export power to the grid, or could be utilized by RMPs or in transport vehicles for the red meat supply chain.
- AD has been thoroughly studied and is extensively utilized throughout the global agriculture and food processing industries. Biogas has been utilized as a transport fuel since the 1970’s.
- Fully installed capital cost estimate (Class 5) for this plant is:
    - AD plant including civil works and tie-ins
    - Engine modifications (for 27 vehicles) and biogas reticulation
    - Biogas cleaning and compression plant
        - Total estimated capital investment: approximate $9 mil
- Total estimated operating costs of $ 1,006,046 per annum
- Net total estimated revenue/cost reduction of $ 1,022,581 per annum
- Base case economic scenario yielded an Internal Rate of Return (IRR) based on the following assumptions:
    - 7% discount rate

- 25 year plant life
- Costs for haulage to site are excluded.
- All available biogas is used to off-set diesel consumed in stationary equipment and on private roads.

Key advantages of a centralized facility include scale, expertise, appropriate approvals for waste management, preference for the more odorous and volatile wastes generated by RMPs, simplification of a RMP's on-site operations, and potential utilization of the digestate. Anaerobic digestion does not end when the biogas is created. The liquid digestate, expected to be about 3% solids, must be managed. The lowest cap ex / op ex scenario is where the digestate is used as a liquid fertilizer and pumped directly to adjacent land for a cropping application, hence waste to energy facilities have limited digestate management options. A value-adding option available to a central facility is to co-compost the digestate with green waste, however this brings with it capital and operating cost as outlined in Section 6.

For the facility to be break-even (i.e. 0.0% IRR over 25 years) a gate fee for the organic waste must be charged. However, it is possible for the facility to achieve a target hurdle rate of ~12% IRR over 25 years at a gate fee that is estimated to be approximately commensurate or slightly below current commercial gate fees for landfilling of organic wastes (state based landfill levies, third party funding including the Australian Renewable Energy Agency (ARENA) and the proposed Biofutures Queensland have not been included in this base case analysis). Hence, a centralized waste to energy facility could offer a much lower cost option for sludges and high fat streams compared to current liquid waste / sucker truck options. For example, a hydrocyclone could be leased or mounted onto a specially designed liquid transporting truck; resulting in an overall reduction in waste management costs for red meat processors whilst providing a highly concentrated waste stream for a centralized waste to energy facility.

There exists a strong economic argument to consider the use of biogas as a transport fuel within the red meat industry supply chain. Re-running the base case analysis but for a scenario where the biogas off-sets diesel used in a heavy vehicle on a public road (including the Australian Tax Office tax credit) the IRR improves, however a gate fee is still required to achieve a hurdle rate of ~12% IRR. Conversely, if the centralized facility is considered a "tolling" facility for converting organics into transport fuel, the facility can generate an IRR of 12% and "free issue" bio-CNG (to offset on-road diesel) for a tolling fee that remains approximately similar to current commercial gate fees for organic waste; this does not include the cost of modifying engines to utilize Bio-CNG (estimated at approximately $10k per engine, less for multiple engine conversions) or the cost of hauling waste to site.

Overall, a centralized facility offers a more sustainable and "greener" waste management solution that is estimated to be approximately "cost neutral" compared to landfilling of organic wastes.

An important point to note is that not all waste is the same. Generally, waste haulage is charged on a $ per cubic metre basis. Table 1 below provides a ranking for RMP wastes that have the highest to lowest biomethane potential (BMP) on a per cubic metre of waste basis. The base case for this project assumed that the AD feed was composed of 36% w/w grease trap waste (similar to Saveall waste), 35% DAF solids (un-dewatered), 13% waste activated sludge (12% solids), 12% paunch (50% solids) and 4% green waste.

Table E1: Approximate biomethane potential per cubic metre for different types of organic waste generated at red meat processing facilities.

Rank	Waste and composition assumptions	Approximate L biogas per m^3 waste
1	DAF sludge – dewatered to 30% w/w solids e.g. via high speed decanter	Up to 235,000
2	DAF sludge – dewatered to 17% w/w solids with higher fat recovery e.g. via hydrocyclone	Up to 230,000
3	Green screenings at 24% solids	97,000
4	Grease trap sludge @ 8.35% solids	66,203
5	DAF float sludge un-dewatered at 7.4% solids (depending upon composition)	29,316 to 69,000
6	Waste activated sludge dewatered via decanter to 20% solids	39,000 - 47,887
7	Paunch mechanically pressed to 50% solids	36,229
8	Fresh manure (11% solids)	32,910
9	Waste activated sludge dewatered to 12% solids	29,929
10	Dried manure (6 weeks with associated loss of volatiles; 30% solids)	26,583
11	Garden waste at 27% solids	24,416

As RMPs experience greater pressure with regards to waste stewardship / limited waste disposal options, rising costs associated with waste management, fuel and thermal heating, and odour management, this project has the potential to provide significant value to industry. A co-product of anaerobic digestion is the digestate existing the main digester tanks and the costs for handling this digestate must be considered. Other than disposal or crop irrigation, one option is to co-compost the digestate with green waste. As outlined in Section 6, the licensing, capital and operating costs for a composting operation are not trivial - hence the cost of handling the digestate must be considered as part of as techno-economic analysis of a waste to energy facility.

The creation of energy and compost from waste provides an opportunity for the meat processing industry to deal with these pressures with a single integrated facility. As stated in the MLA commercialisation principles document (2004) “One of the greatest challenges facing the innovation industry in general is successfully bridging the ‘innovation gap’. This gap represents the crossover from R&D to commercialisation and adoption.” This projects bridges this gap by providing objective third party engineering analysis, capital, operating, and revenue estimation, and clear business case development for waste to energy options from the perspective of the meat processing facility and the waste aggregator. Through a proof of concept and commercial viability analysis within an Australian context, project of this nature can ultimately develop and future proof the Australian red meat industry by shielding against rising waste, fuel and heating costs.

The red meat industry requires a game plan on how to decouple its energy requirements from fossil fuels. Waste to energy and renewable energy can limit exposure to international energy prices and improve the “clean and green” image of the RMI. For example, it is estimated that around 40% of thermal energy for RMPs is exposed to natural gas pricing whilst around 85% of all energy is obtained from fossil fuels (coal, natural gas, grid power and other liquid fuels). Whilst not all sites are able to install a waste to energy facility, the first step could be selection of wastes with the highest biomethane potential per tonne (i.e. dewatered, fatty sludges) for transport to a central facility, thereby offering the potential to reduce waste management costs and/or reduce loading on waste treatment plants.

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1 Background

1.1 Project Background

South-East Queensland (SEQ) is an area with a great deal of meat processing tonnage. There exists the opportunity for red meat processors and associated waste producers to partner with a third party waste processor in a co-located, aggregated, and centralised business model to optimise the creation of energy and compost from the solids generated at meat processing facilities.

SEQ processes in excess of 1.3 million cattle per annum, hence total solids waste generated is estimated to be towards 140 kilotonnes per annum (ktpa), providing sufficient scale for sustainable waste to energy projects. Current waste management practices of toll waste removal from red meat processors in SEQ are economically and environmentally unsustainable due to likely price spikes in handling and transfer costs, particularly if Queensland waste regulatory requirements and fees align with other eastern states over the next couple of years. It is thus critical that alternative waste management options and business cases are evaluated continuously as the technical, social, and political environment changes. This project investigated a value chain arrangement for supply of raw materials processed through a centralised waste processing site located at Wood Mulching Industries Pty Ltd (WMI) in SEQ to create additional value to help facilitate long term supply and demand of value added waste products.

MLA recently funded the project P.PIP.0454, the aim of which was to determine the technical viability and estimate the associated economics for pelletizing paunch and aerobic sludge to off-set coal usage (Meat and Livestock Australia; Australian Meat Processor Corporation, 2015). Key findings from this project were that aerobic sludge had too high a moisture content but that paunch pelletising, when incorporating innovative process and waste heat recovery, could achieve a 5 – 6 year payback. A rapid scan of alternative options highlighted how anaerobic digestion and sludge decanting could provide shorter payback periods than paunch pelletisation.

An AMPC project (not yet published) clearly demonstrated that in comparison to on-site high rate digestion and on-site composting, the most economically viable option for meat processors is for a centralised solid waste management facility, in order to exploit economies of scale. Discussions with industry operators (personal communication with All Energy Pty Ltd) confirmed that off-site and centralized waste management is the most economically viable option compared to on-site composting.

Optimal Alternative Waste Technology (AWT) performance relies on a range of organic material inputs to provide an optimal diet for the digester. Sourcing local materials reduces transportation costs enhancing financial viability. From a recent report on Australian waste (Ritchie, 2016) :

- Unlike all other Australian States and Territories (except NT), Queensland does not currently charge a waste levy and the landfill price is unsustainably low. The previous introduction of a waste levy resulted in an immediate spike in recycling activity and reduction in landfilling. The state based waste levy was reduced to $0 / tonne on 1 July 2012 (Queensland Government, 2013).
- The average garbage bin contains 60% organic material waste. The bulk is food (40%) and garden waste (20%). The introduction of food/garden organic bins in

many council areas will go a long way to achieving the targets for the household sector.
- Queensland has the lowest levels of recycling in Australia.
- New technologies in composting and anaerobic digestion will accelerate organics diversion.
- Many councils are also contracting alternative waste technologies (AWT) to sort through the garbage bin, to recover recyclables and convert the organic component into low-grade compost. These will continue to grow.
- Recycling in Queensland remains immature, placing it at odds with the rest of Australia (except NT).

The overall objectives of this project were to conduct an analysis of the opportunities for a centralised co-located facility to aggregate meat processing waste for a waste to energy plant. This project provides input into the most economically viable organic waste management strategy for red meat processors by evaluating specific waste processing options.

1.2 Project Partner Background

Established in 1993, Wood Mulching Industries (WMI) is owned by the North family with operations based in Swanbank, Queensland, Australia. The 70-hectare facility is managed to the strictest environment controls and is equipped with state of the art technology for processing and manufacturing. Founder John North maintains his vision on how WMI can continue to evolve transforming waste into beneficial, safe, and fit for purpose products.

WMI supplies a wide range of high quality landscaping, horticultural and civil works products including composts, soil conditioners, mulches, garden & lawn blends, erosion control products and storm water treatment media. Products conform to the appropriate Australian Standards including AS 4419 and AS 4454. WMI owns and operates extensive plant and equipment for processing recycled organics and offers a contract shredding and removal service.

WMI employs over 20 staff, processes over 200,000 tons of materials per annum (including waste and non-waste streams) and is a leader in Australian Recycled Organic Processing. Apart from recycled organics, WMI also produces washed sand and aggregates.

Currently WMI operates a recycled organics facility in Swanbank featuring:

- 70 ha site approved under the Queensland State Government's Environmentally Relevant Activities (ERA) 33 (Crushing, milling, grinding or screening material: >5,000t/yr) and 53 (Composting and soil conditioner manufacturing: 200t/yr or more).
- Approval to take up to 100,000 tons of green waste per annum.
- Demonstrated processing capability of 100,000 tons of total waste per annum.
- Demonstrated sales of 100,000 tons of finished product per annum.

- All required infrastructure, systems, processes and ability for industrial scale recycled organics processing and finished product distribution.

WMI understands the waste management environment is changing creating opportunities and challenges. To meet future challenges and maximise opportunities for the next twenty years plus, WMI is developing an innovative organic recovery system by:

- Redeveloping its current site at Swanbank,
- Project development, business case analysis and commencement of associated approvals and safety requirements for a new Alternative Waste Treatment (AWT) facility,
- Enhancing existing markets, developing existing markets and markets with synergistic industries for optimal resource recovery.

2 Project Objectives

2.1 Purpose and Description

This project involved a review of available solid wastes from SEQ facilities including red meat processors and other similar waste generating companies and the development of a business case for an aggregated centralised waste to energy facility. In principle, support was provided by several processors in SEQ to participate in this feasibility of alternative business models. The detailed waste stream mapping and compositional analyses of specific red meat processor(s) and other targeted companies were used to extrapolate typical volumes, composition, costs of raw materials allowing for seasonal variabilities in an economically viable range of a SEQ waste processing plant. The outcomes of the project were to present business case options to red meat companies and seek their participation and long term contracts in a value chain approach to waste management of specific waste streams. The business case will also be utilised by the waste management value adding company to design and implement waste value adding technologies, engage with end users, regulators and utilities suppliers and secure long term contracts for raw materials. The primary purpose was to evaluate alternative business cases to create additional value through economies of centralised processing and engage red meat processors in alternative waste processing options.

2.2 Value of Project

2.2.1 Value Proposition for Industry

Meat processors are experiencing pressure to change traditional practices due to increasing waste stewardship / limited waste disposal options and rising costs associated with waste management, power and thermal heat. Pressure for the industry to change is coming from a range of stakeholders: clients, competitors (with a lower cost of business and / or reduced waste and energy cost risks), product end users / consumers, state level environmental permitting authorities, councils, and internal staff.

The creation of energy and compost from waste provides an opportunity for SEQ operators, as it does for the wider meat processing industry, to deal with these multiple pressures via a single integrated facility. The NKP rich by-product sludge may be returned to farmers for use as an effective fertiliser, closing the nutrient loop, minimising carbon footprint, and supply chain costs.

Anaerobic digestion is one of the few options available for processing the waste in a manner that is close to cost neutral. An attractive feature of anaerobic digestion is the freedom to choose the utilisation of the produced biogas. This project’s aggregated waste processor, WMI expressed interest in offsetting heavy vehicle fuel usage at their Swanbank, Queensland site with CNG from biogas. The key parameters affecting the economic viability of such operations were determined so that other geographic areas can consider whether this is a suitable option.

A key innovation of this project was to review the highest value of the biogas. For example, stationary power generation for onsite use, compared to compression for transport vehicles versus creation of power for electric vehicles. The proposed facility will comprise the first documented biomass to biogas as a transport fuel at a commercial Australian facility, displaying best practice organic waste management.

2.2.2 Commercialisation and Adoption

As stated by MLA in the document "MLA's commercialisation principles", 2004: "One of the greatest challenges facing the innovation industry in general is successfully bridging the 'innovation gap'. This gap represents the cross over from R&D to commercialisation and adoption." (Meat and Livestock Australia, 2004). This project aimed to bridge this gap by providing objective engineering analysis, cap ex / op ex estimation and a clear business case for waste to energy options from the perspective of the meat processing facility and the waste aggregator. WMI's bio-loop strategy for incorporating alternative waste technology for converting waste into a fuel that can be utilised in vehicles to offset diesel use is shown below in figure 1. The red box shows the section of the strategy that formed the basis of this project.

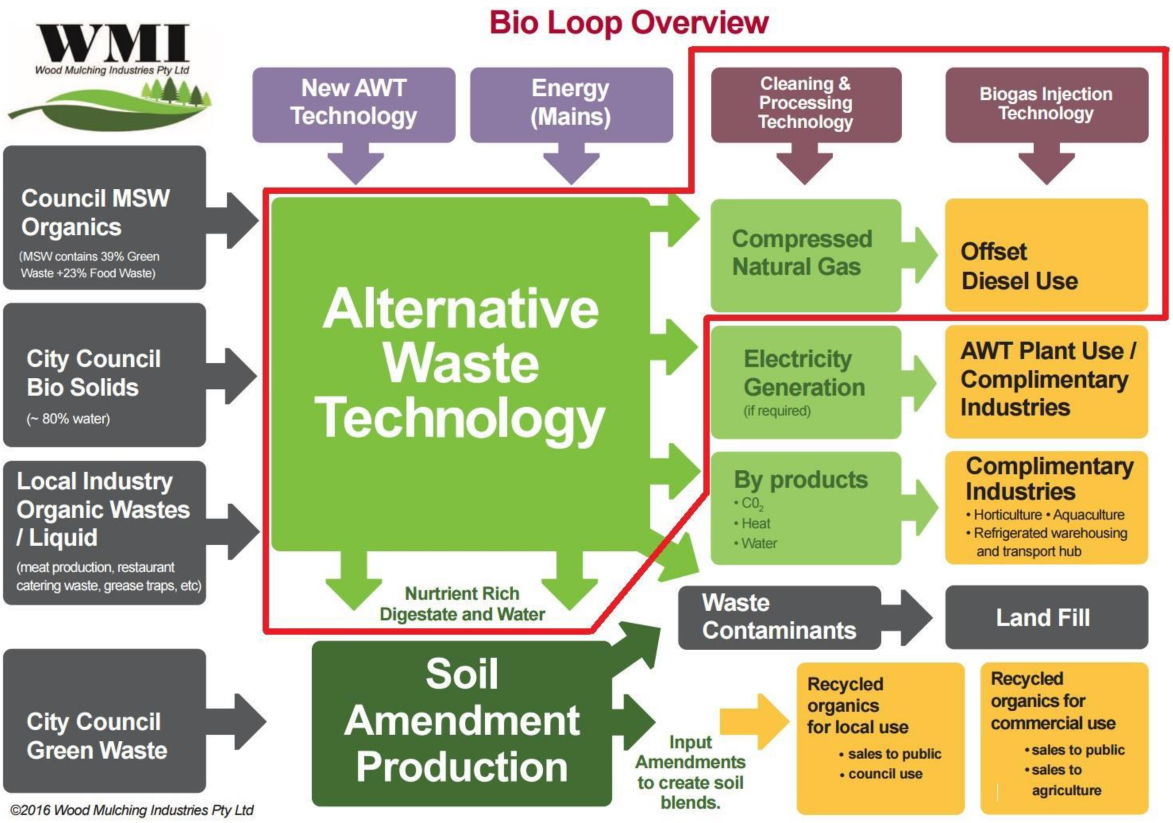

Figure 1: WMI Bio Loop Overview. The red line indicates the section of the operations within the scope of this report.

2.2.3 On-site Capability Building

The business case took a forward looking approach and considered future impacts on the waste management industry. The works increase the knowledge of the streams generated by sites and options for creating value from waste, with the aim being to provide feasible alternatives to landfilling that can "future proof" the industry in the case of rising state government based landfill levies and other legislative changes. Appropriate meat processing facility staff were involved in the data gathering / interviewing process to determine the "business as usual" case and to test the findings of the business case.

3 Methodology

3.1 Stage 1

The first phase of this project involved a high level concept analysis of aggregation of specific waste streams. Red meat processors in SEQ were engaged during this phase, in order to maximise specificity and accuracy. Using industry heuristics regarding organic waste generation, waste streams were extrapolated to generate a heat map of SEQ red meat processors. A review of scientific and industry data pertaining to compositional analyses of specific waste streams was performed in order to verify information. Finally, using the red meat processors engaged with and the aggregated waste processor, plant operating cost and revenue / savings were estimated based on a completed mass and energy balance.

3.2 Stage 2

The second phase of this project was a high level concept analysis of the technologies for value adding organic waste and available solid waste tonnages. Scientific literature was reviewed regarding AD as a broad process and case study commercially successful operating plants were investigated. A vendor long list was then developed, before dissemination of a technical specification based on the completed mass and energy balance as a request for submissions. From this, concept level engineering and associated class 5 level capital cost estimates for AD, gas cleaning and compression, and vehicle conversion were obtained.

3.3 Stage 3

In the final project phase, an economic cost benefit analysis for an aggregated waste processing facility was completed, including capital cost, plant operating cost, and revenue / savings estimation. A review of available funding sources was performed to identify alternative business models to aid in project delivery and maximise success. The final outcome of this project was to meet with prospective stakeholders (including processors, companies, and / or end users) to present business case options and seek companies long term contracts to participate in a value chain approach for specific waste streams.

4 Results

4.1 High Level Mapping Analysis of Organic Waste Streams

A scan of red meat industry literature was performed in order to generate a list of large processors located in South East Queensland (SEQ). Citing the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), the consulting firm GHD's *Central Highlands Meat Processing Plant Feasibility Study* listed the following facilities in SEQ (GHD, 2015): JBS Dinmore, Teys Beenleigh, JBS Beef City, John Dee Warwick, Stanbroke Grantham, ACC, Churchill Co-op, Kilcoy Pastoral.

To estimate scaled waste production of these sites, the following relationships of a typical 625 head per day (hpd), 250 operating days pa facility were used from MLA project P.PSH.0768:

- 4 ktpa paunch solids
- 11 ktpa aerobic sludge or waste activated sludge (WAS)
- 2 ktpa DAF float solids (after fats, oil and greases (FOGS) removed)

Then, considering the radial distance from WMI to each site, Table 1 below was generated. It is noted that some sites use anaerobic ponds rather than aerated systems as their primary method for waste water treatment, hence the waste activated sludge (WAS) tonnages listed will be lower for facilities utilizing anaerobic ponds. Anaerobic ponds still generate a settled sludge which requires periodic removal (e.g. every 3 to 5 years or more).

*Table 1: Summary of SEQ Red Meat Processor (RMP) Waste Producers. *Note: some facilities utilize anaerobic digestion for on-site waste treatment thereby reducing the tonnage of sludge generated from waste water treatment activities.*

Within Radius from WMI	Aggregated head per day	Paunch ktpa	WAS* ktpa	DAF ktpa	Total* ktpa
20 km	4350	28	77	14	118
50 km	2553	16	45	8	69
75 km	870	5	15	3	23
100 km	2612	17	46	8	71

The heat map shown in figure 2 was generated from the data contained in table 1. WMI is located at the centre, with concentric circles drawn at 20km, 50km, 75km, and 100km radii.

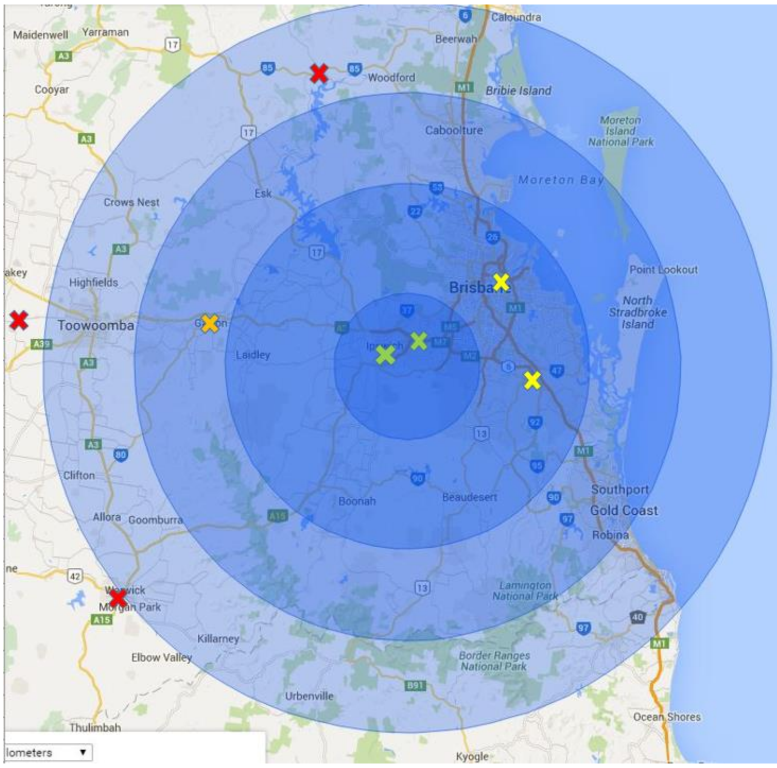

Figure 2: Heat Map of SEQ Red Meat Processors.

It can be seen that even if waste were to only be received from the two closest abattoirs (and thus lowest transport cost options), the feed design specification (40 ktpa) could be achieved. Feedstock can also include any available, clean organic material including chipped green waste and grease trap waste, which are both currently received at WMI. There exists an infinite number of feedstock combinations to achieve a 40 ktpa feedstock rate for the proposed anaerobic digester facility, with one scenario presented in Table 2. These throughputs formed the "base case" for completion of an estimated mass and energy balance of the plant, with a preference for DAF float solids and grease trap waste which are well suited for processing through an anaerobic digester as they are pumpable, contain a range of components suited to supporting microbial populations, and are more odorous and have high densities hence command a high cost per cubic metre for waste management and/or landfill disposal.

Table 2: Concept Design Feedstock Throughputs

Stream	Throughput (ktpa)
Green Waste	1.6
Paunch	5.0
DAF Float – 7% Solids	14.0
WAS	5.0
Grease Trap Waste	14.4
TOTAL	**40.0**

At the specified throughputs, an additional 1.3 ktpa of top-up water is required to maintain operation at a target slurry solids concentration of 20%. In practice, a recycle loop can be utilized to reduce the need for top-up water. Further, low quality water (e.g. brackish, saline, bore water, reverse osmosis water reject, run-off water, etc.) is often acceptable for use as top-up water.

4.2 Waste Stream Composition Data

The following waste stream composition data has been drawn from previous MLA, AMPC, industry and scientific literature.

4.2.1 Green Waste

4.2.1.1 Biomethane Potential

The biomethane potential (BMP) of green waste is vague and varies according to many factors, including species, location, mixing, and age. It was thus decided that a literature scan of green waste would likely not be performed as it would not yield suitable information; and the BMP of the green waste stream specific to WMI as outlined in the basis of design as 343 m^3/t VS would be used. However a scan of literature did report a BMP for green waste (unfortunately with no further clarification of specific composition) of around 280 m^3/t VS (Chen, Yan, Sheng, & Sanati, 2014), which was deemed similar enough to validate the basis of design value.

4.2.1.2 Composition

For the purposes of characterising the composition of green waste (a very ambiguous term – as already mentioned), the assumption of homogeneity was made; then using the composition of plant matter reported by the New Zealand Institute of Chemistry (NZIC, 2008), the elemental balance (considering macronutrients) of this substrate is shown in table 3.

Table 3: Green Waste Approximate Elemental Balance

Substrate	Dry Weight (DW) tpa	Component	Fraction (% DW)	tpa
Green Waste	54	H	6	3.2
		C	45	24.3
		O	45	24.3
		N	1.5	0.8
		K	1	0.5
		Ca	0.5	0.3
		Mg	0.2	0.1
		P	0.2	0.1
		S	0.1	0.1
		Cl	0.01	0.01

4.2.2 Paunch

4.2.2.1 BMP

A scan of scientific literature produced a range of paunch BMPs as presented in Table 4.

Table 4: Paunch BMP from Published Literature

Source	Mean BMP (m^3/t VS)
(Jensen, Sullivan, Carney, & Batstone, 2014)	380
(Browne, Allen, & Murphy, 2013)	238
(Navaratnam, 2012)	250
(Nkemka, Marchbank, & Hao, 2015)	300

4.2.2.2 Composition

The compositional analysis of paunch was conveniently found and taken directly from AMPC/MLA A.ENV.0111 *Pilot testing pyrolysis systems and reviews of solid waste use on boilers* (Bridle, 2011). Table 5 presents this information.

Table 5: Paunch Approximate Elemental Balance

Substrate	DW tpa	Component	Fraction (% DW)	tpa
Paunch	313	H	6	18
		C	48	148.7
		O	39	122.1
		N	1	3.7
		K	0.02	0.1
		P	0.2	0.5
		S	0.3	0.8

The values reported in table 5 are also corroborated by a cross reference with AMPC/MLA A.ENV.0106 *Use of dewatered paunch waste and DAF sludge as a boiler fuel* (Bridle, 2012)

4.2.3 DAF Solids

4.2.3.1 BMP

The BMP of dewatered DAF sludge is also highly variable from plant to plant and day to day, depending on the operation at the time. For this reason, the basis of design, guided by RMI literature such as AMPC/MLA A.ENV.0111 *Pilot testing pyrolysis systems and reviews of solid waste use on boilers* (Bridle, 2011) figure of 698 m^3/t VS was used.

4.2.3.2 Composition

The compositional analysis of DAF solids was also found and taken from AMPC/MLA A.ENV.0111 *Pilot testing pyrolysis systems and reviews of solid waste use on boilers* (Bridle, 2011). Table 6 shows the elemental balance for DAF solids.

Table 6: DAF Solids Approximate Elemental Balance

Substrate	DW tpa	Component	Fraction (% DW)	tpa
DAF Solids	123	H	11	13.5
		C	73	89.2
		O	6	6.8
		N	0.4	0.5
		K	0.01	0.01
		P	0.1	0.2
		S	0.5	0.6

4.2.4 Waste Activated Sludge (WAS)

4.2.4.1 BMP

The BMP of dewatered waste activated sludge is also highly variable from plant to plant and day to day, depending on the operation at the time. For this reason, the basis of design figure of 387.5 m^3/t VS was used until test work can be completed.

4.2.4.2 Composition

Compositional analyses of activated sludge and clarifier waste specific to RMPs was based upon general waste water treatment heuristics thus the chemical composition (concerning C, H, N, and S only) as outlined in Table 7 was used.

Table 7: WAS Approximate Elemental Composition

Substrate	DW tpa	Component	Fraction (% DW)	tpa
WAS	78	H	5	3.9
		C	31	24.2
		N	3	2.3
		S	1	0.8

4.2.5 Grease Trap Sludge

4.2.5.1 BMP

Finally, the grease trap and clarifier sludge is the most variable stream of all, so definitive industry or scientific literature was unable to be found. The BMP informed by MLA testing of 1010 m^3/t VS is then used.

4.2.5.2 Composition

Likewise with regard to the high variability of the grease trap sludge stream, certain approximations and assumptions were required to be made in order to determine its composition. It was assumed as a result of (Yilmaz, Karakaya, & Aktas, 2010) that the composition of the lipid fraction of this stream was 25% palmitic acid, 22% stearic acid, 37% oleic acid, and 2% linoleic acid, with the remaining 14% being made up by water. The elemental compositions of each fraction are shown in table 8.

Table 8: Elemental Composition of the main Oils in Grease Trap Fractions

Fraction	% C	% H	% O
Palmitic Acid	74	13	13

Stearic Acid	76	13	11
Oleic Acid	77	12	11
Linoleic Acid	77	11.5	11.5
Water	0	11	89

The elemental composition of the grease trap sludge stream is then shown in Table 9.

Table 9: Grease Trap Sludge Approximate Elemental Composition

Substrate	DW tpa	Component	Fraction (% DW)	tpa
Grease Trap	60	C	66	39.6
		H	12	7.3
		O	22	13.4

4.2.6 Estimated Feedstock C:N Ratio

From initial analysis of specific feedstock compositional data, the ratio of biological C to total N is calculated at 45. The literature reports an optimal C:N ratio for anaerobic digestion of approximately 30 (United Nations Food and Agriculture Organisation, 1992); should significant deviations from expected results or operational problems prove this feedstock composition prove to be inadequate, the C:N ratio may be adjusted up or down by additional green waste or additional protein containing substrates, respectively.

4.3 Plant Operating Cost and Revenue/Savings Estimation

4.3.1 Red Meat Processor (RMP) Waste Management

RMPs have a range of waste management practices from direct land application where a third party (e.g. crop farmer) may collect the organics, through to paying for haulage costs, through to paying for haulage and landfilling.

It is estimated that to transport organic waste 20 km from a RMP to a centralized facility would cost approximately $12 / tonne for transport only; rising to around $23 / tonne for a 60 km distance from the RMP to centralized facility for transport only[1].

The collection and disposal of organic waste in south-east Queensland is estimated at around $50 to $200 / tonne depending upon the composition and volatility / odour of the waste (i.e. less for paunch and more for fatty sludges). The Brisbane City Council listed commercial waste fee is $125.10 / tonne, Gold Coast City Council lists regulated waste disposal at $96.90 / tonne[2], whilst Logan City Council lists low hazard regulated waste as $164 / tonne. Commercially operated landfills can offer lower cost per tonne landfilling costs under longer term, higher tonnage contracts. Detailed waste management and transport costs were not considered as part of the model, but rather only a gate fee at the centralized facility was modelled.

[1] http://www.freightmetrics.com.au/Calculators/TruckOperatingCostCalculator, ACCESSED 26 July 2016.
[2] http://www.goldcoast.qld.gov.au/environment/landfill-disposal-fees-24055.html, accessed 26 July 2016.

4.3.2 Waste Processor

As the digestate needs to be processed further before it can be utilized, a cost per tonne of digestate was estimated based on capital and operating costs associated with a composting business.

4.3.2.1 Biogas Generation

A mass and energy balance completed by AEPL estimates that for the design feedstock composition given in Table 2, approximately 2.4 million Nm^3 of biogas at 60% methane may be produced. At an assumed biogas LHV of 22.3 MJ/Nm^3, this is equivalent to approximately 54,000 GJ pa (approximately 608 kW electrical power assuming 30% engine efficiency, 8000 hours per annum operation).

4.3.2.2 Diesel Saving

Towards 1.59 mil L per year of diesel fuel equivalent could be generated by the facility. In order to estimate diesel fuel savings, an audit of equipment on site at WMI was performed in order to establish the "average" diesel burn rate for the site.

As a base case, it has been confirmed by the engine conversion technology provider, GasMastor, that a substitution of diesel with bio-CNG of 50% is definitely possible. As an optimistic estimate, substitution may be increased to as high as 60 – 70%. The value of the bio-CNG hinges upon the amount of diesel that can be offset either via direct use on-site for rotating equipment, diesel displacement in vehicles or sold to third parties. Along with monetary savings, CO_2 emissions will be offset by the substitution of diesel with bio-CNG.

At 70% substitution of on-site use, there remains biogas to sell to third parties or to generate electrical power, thereby providing an opportunity for on-site power generation for further monetary savings.

Diesel has an energy density of around 35 MJ / L[3], with CNG or bio-CNG at 200 bar at around 9.3 MJ / L[4] and natural gas at around 0.037 MJ/L. Taking a hypothetical scenario as an example, if a vehicle is able to operate for 12 hours on one tank of CNG or bio-CNG at 200 bar, then compressing biogas at 60% methane to only 10 bar would provide approximately half an hour of run time. Compressing CO_2 above 35 Bar at approximately 0 ^oC results in the formation of liquid CO_2. To avoid the formation of liquid CO_2 and to enable vehicles to run for long periods of time without the need to refuel, biogas first needs to be scrubbed (to obtain towards 99% methane) and then compressed into a bio-CNG (e.g. to 200 bar).

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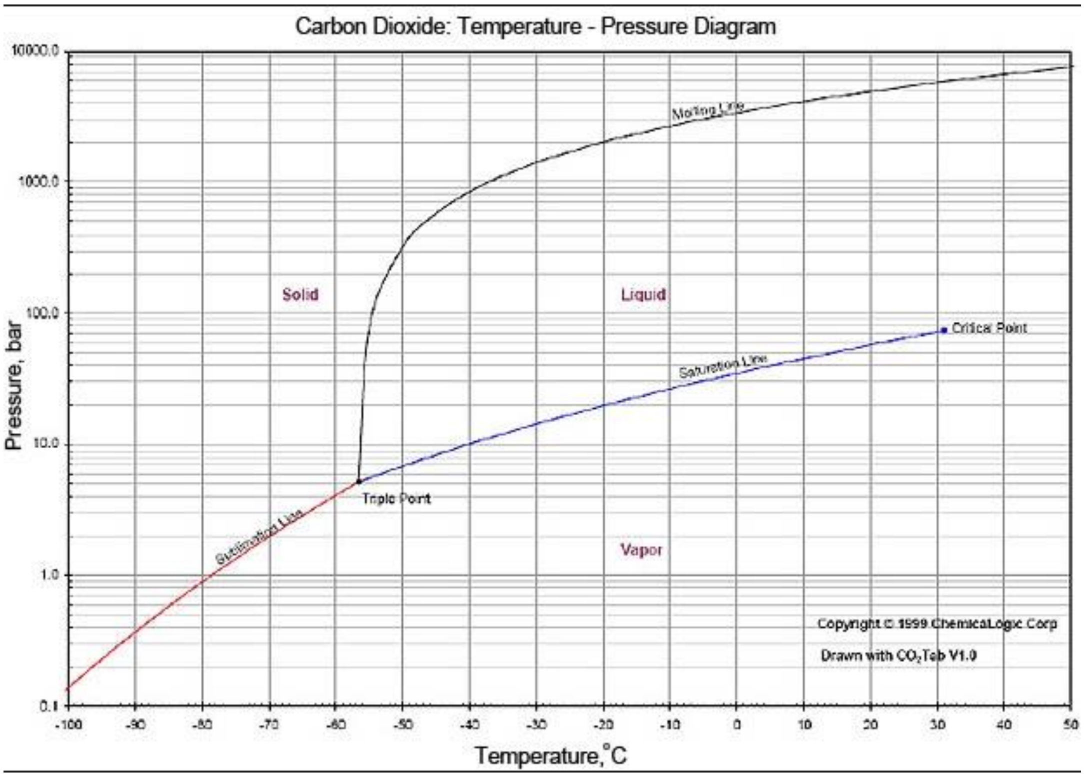
[3] Alternate Fuels Technology Inc., https://www.propanecarbs.com/propane.html

[4] http://www.cngcenter.com/wp-content/uploads/2013/09/UnitsAndConversions.pdf



4.3.3 Power Saving and REC LGC Credits

There exists the potential to feed a genset of capacity 300 kWe; a system of this size is capable of generating approximately 2400 MWhe per annum. This quantity of electricity could would not be used by a central facility, hence the majority of the power would need to be exported to a third party.

At a LGC spot price of $75 / MWh (Green Energy Markets, 2016), this quantity of renewable electricity generation is eligible for approximately $180,000 in REC LGCs. Shown in Figure 3 is the market performance of LGCs as of first Quarter 2016; this should be monitored closely and updated when performing economic analyses of such projects as it provides a significant opportunity for additional revenue. Due to the low power usage on-site and cheap grid power, there exists little motivation to generate power from biogas that is exported to the grid (IRR of ~3%).

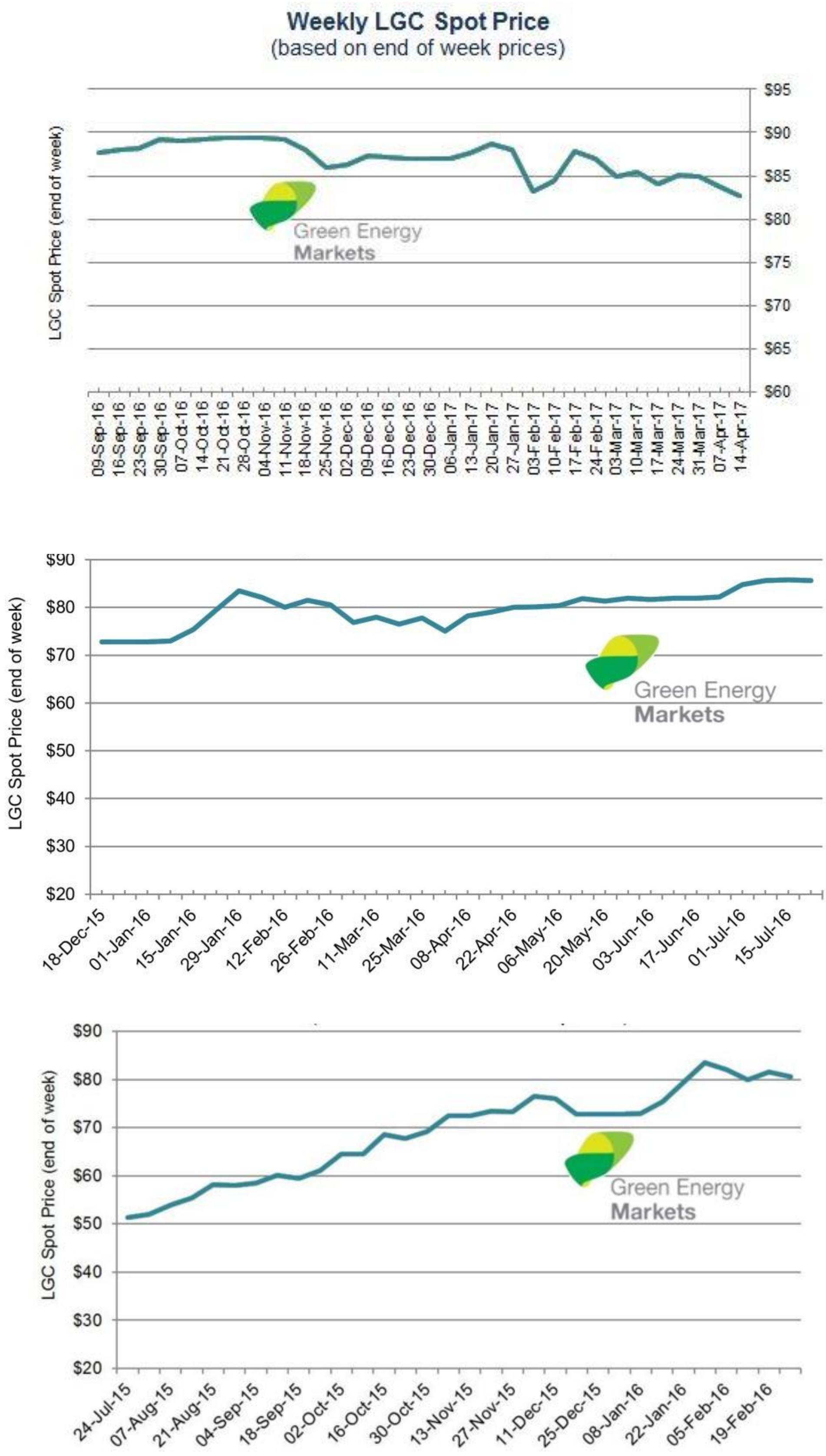


Figure 3: Weekly LGC Spot Price[5].

[5] http://greenmarkets.com.au/resources/lgc-market-prices, accessed 26 July 2016.

4.4 Technology Options

4.4.1 Technology Readiness Level (TRl) and Commercial Readiness Level (CRL)

From an Australian perspective, a TRL ranking of 7 reflects the large amount of development that has occurred in Europe, North America, and Australia for anaerobic digestion systems, however there has been limited commercial investment and no documented full-scale demonstration of this technology in Australia for the creation of transport fuel.

From an Australian perspective, a CRL of 1 has been selected. Note that the TRL and CRL levels have no correlation with the class of capital cost estimation outlined in this milestone (class 5). Table 14 presents a long-list of AD OEM technology providers. Biogass Renewables Pty Ltd was selected due to the suitability of their continuous stirred tank reactor (CSTR) technology that is technically suitable for processing the wastes under consideration, acceptable capital costs for a delivered plant, and previous experience of this company with the proposed site.

Table 14: Long List of AD OEM Vendors

Company	Technology
Biogass Renewables Pty Ltd	**Wet AD**
OWS (Dranco Farm System)	Plug Flow AD
Bioferm	Solid AD
Erigene	Solid AD
DVO Inc	Wet AD
BEKON	Dry AD
Zero Waste Energy	Dry AD
Anaergia	Wet AD
Eagle Green Energy	Dry AD
Tamar Energy	Wet & Dry AD
Anaeco	Wet AD
AP BTC	Batch AD
SeaB	Small scale AD
Quantum Power	AD (preferably BOOM)
RCM International	AD
CST Wastewater Solutions	Water treatment solutions
Aquatech Maxcon	Water treatment solutions
BioConversion Solutions	AD
Utilitas	AD
Centre for Solid Waste Bioprocessing	Solid AD

As a proof of concept, a number of commercially operating plants worldwide were identified that process mixed wastes by anaerobic co-digestion, with the produced biogas utilised as a vehicle fuel. A summary of these are given in table 15.

Table 15: Summary of Case Study Proof of Concept Plants

Plant, Location	Biomass ktpa	Feedstock	Approx. Biogas	Approx. Methane	Power	Fuel pa	Fleet fuelled
Quasar, Columbus OH	90	Biosolids, food and beverage waste, FOGs	3600 GEG per day		1 MWe	3.4 mil L	Min 25 garbage trucks
BioCNG, Sacramento CA	6.25 - 25	Food waste	450 – 1350 GEG per day		NA	1.3 mil L	Garbage trucks, buses, third party users (unknown number)
SSFSC/Blue Line Transfer, San Francisco CA	11.2	Food and green waste			NA	Estimated at 2.4 mil L	18 collection trucks
Fair Oaks Dairy, USA.		Dairy cattle manure		216250 MMBtu	NA	5.7 mil L	42 milk delivery trucks

4.4.2 AD OEM Technology Provider

Biogass Renewables Pty Ltd has been selected as the anaerobic digestion OEM. Biogass Renewables is a bioenergy enterprise taking the lead in bringing commercially viable anaerobic digestion plants to the Australian commercial, manufacturing and resources industries. Commerce and industry demands certainty, and Biogass only focuses on proven, mature technology which has been standardised through use in the Northern Hemisphere where anaerobic digestion is already widely integrated into industry. Biogass designed, installed, and operates a biomass to biogas with cogeneration facility in Perth, Western Australia. The facility is designed for processing 35,000 – 50,000 tonnes per annum of food waste in an anaerobic digestion plant at Richgro Garden Products and is designed to produce over 2 MWe capacity electricity, with 1.7 MWe being sent to the grid. Figures 4 and 5 show this plant.

Figure 4: Biogass Renewables Pty Ltd Richgro Garden Products AD Plant.

Figure 5: Biogass Pty Ltd Richgro Garden Products AD Plant

4.4.3 Vehicle Conversion Technology Provider

GasMastor is an Australian patented “one system, multi-fuels” technology to safely inject flammable gases such as LPG and natural gas into diesel engines in a precisely controlled manner to offset dirtier fuel usage. Installation is non-invasive and does not involve any additional modifications to the engine. Figure 6 shows a schematic of the GasMastor system.

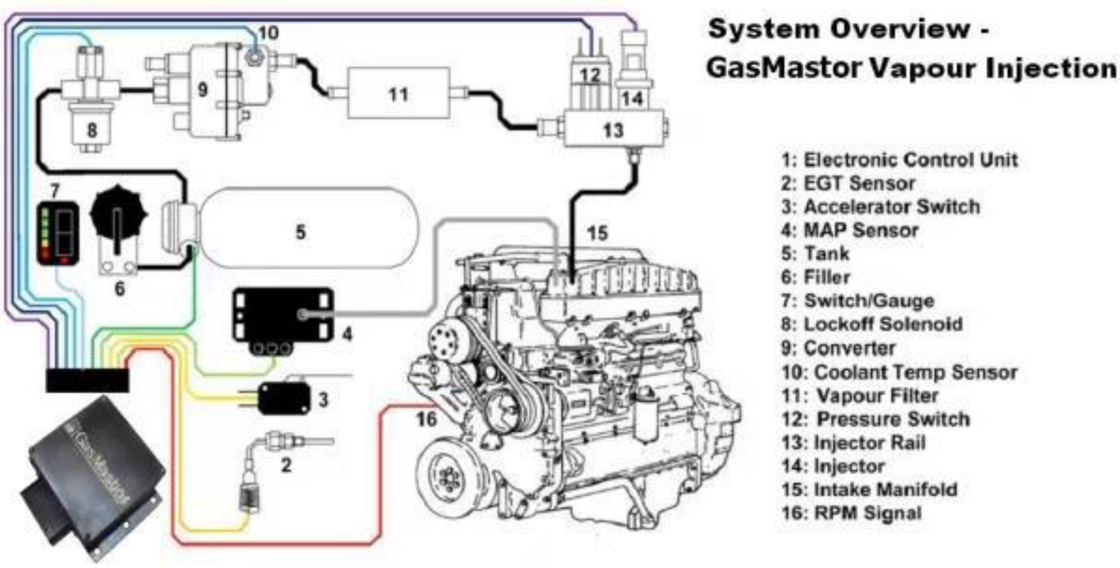


Figure 6: Schematic of Patented GasMastor Engine Modification

4.5 Class 5 Capital Cost Estimation

4.5.1 AD Plant and Vehicle Conversion Capex

Fully installed Total Capital Investments (TCI) obtained from vendor submissions are presented below in table 16.

Table 16: TIC for AD Plant and Vehicle Conversion

Phase	Itemised Capital Investment		Capital Estimate
1	Digester Plant	Feedstock handling: acceptance, storage, pre-processing, walking floor, hammer mills, sensors, and controls	
		Digester feed tank – 500 m^3.	
		2500 m^3 digester, sensing, control, mixers, pumps, platform	
		Control room, vapour/exhaust gas handling, exhaust and safety flare (including treatment)	
		Programmable electronic control system for automated and unattended operation, instrumentation, control room; utilities (all facility electricals, compressed air, cooling water, heat exchangers etc.)	
	Civil works		
	800 amp connection to mains power (783m cabling, transformer, and switchgear)		
	Water connection		
2	Engine modifications x 27; biogas reticulation to stationary equipment – 100m of gas polypipe (PE gas pipe Y/S SDR21 PE100; 40mm ND): supply, trench, laid in trench, electrofusion joints, commission		
3	Biogas upgrading and compression; 2500 cum digester		
Total Estimate			**Approx $9 mil**

5 Class 5 Cost Benefit Analysis

The financial data presented in this document is preliminary in nature and is expected to be refined as the capital cost estimation error of margin is reduced as the project progresses from an American Association of Cost Engineering (AACE) Class 5 to Class 3 and associated operating and revenue estimates are updated.

It is assumed that the facility will be operated by WMI with appropriate technical input by project partners (i.e. OEMs) and contracting / consulting personnel as required (e.g. cogen engine maintenance under a bilateral service contract).

Key assumptions:

[1] Capital equipment estimate error of >+/- 20% accuracy. The equipment costs will be estimated to "fixed and firm, lump sum" as part of the full proposal.
[2] CPI escalation assumed at 1.8% per annum.
[3] Overnight capital. No capital escalation for future years.
[4] 7.0% discount rate
[5] A flat electricity price has been applied which takes into account the kWh and capacity/demand charges for electricity as of Q1 2016.
[6] Internal rate of return (IRR) calculated over a 25 year life of equipment.
[7] Refer spreadsheets for further assumptions

5.1 Opex and Revenue/Cost Reduction Estimates

Table 17: Itemised Operating Cost Estimates for AD Plant

Opex		$ pa
Personnel		
Plant maintenance and repair – AD		
Plant maintenance and repair – balance of plant		
Electrical load (kW)		
Parasitic load – AD + biogas		
Sub-total electricity		
Biogass Renewable Pty Ltd – technical assistance retainer		
Cleaning		
Potable water for cleaning		
DERM ERA Environmental Fee – 52		Excluded
Total estimated annual operating expenses per annum		**$1,006,046**

Table 18: Itemised Expected Revenue Sources of Project

Revenue/Cost Reduction	Units	$ pa
Value of digestate		
Diesel		
Feedstock gate fee		
Total estimated revenue/cost saving per annum	$ p.a.	2,028,627
Net revenue/cost savings	**$ pa**	**1,022,581**

5.2 Sensitivity Analyses

From inspection of the operating cost and expected revenue estimates, the key parameters impacting the economics of the project, in order of relative impact, are:

1. Feedstock gate fee
2. Diesel price

At time of writing (18/07/2016), diesel terminal gate price was on an unsustainable downward price trend. It is thus sensible to consider the effect on project economics when historical prices are again realised. Pertinent to the subsequent waste transfer contracts and business models, the critical feedstock gate fee and effect of variations was also determined.

Figure 7 shows project economics sensitivity to variations in the gate fee able to be contracted for feedstock acceptance, and the market price of diesel. It can be seen that variations below the prices assumed in the base case model have significant negative effect on the 25 year internal rate of return, while significant variation above the base case feedstock and diesel prices would need to be realised before the project can be said to be viable with a high degree of certainty without funding assistance or innovative business delivery models.

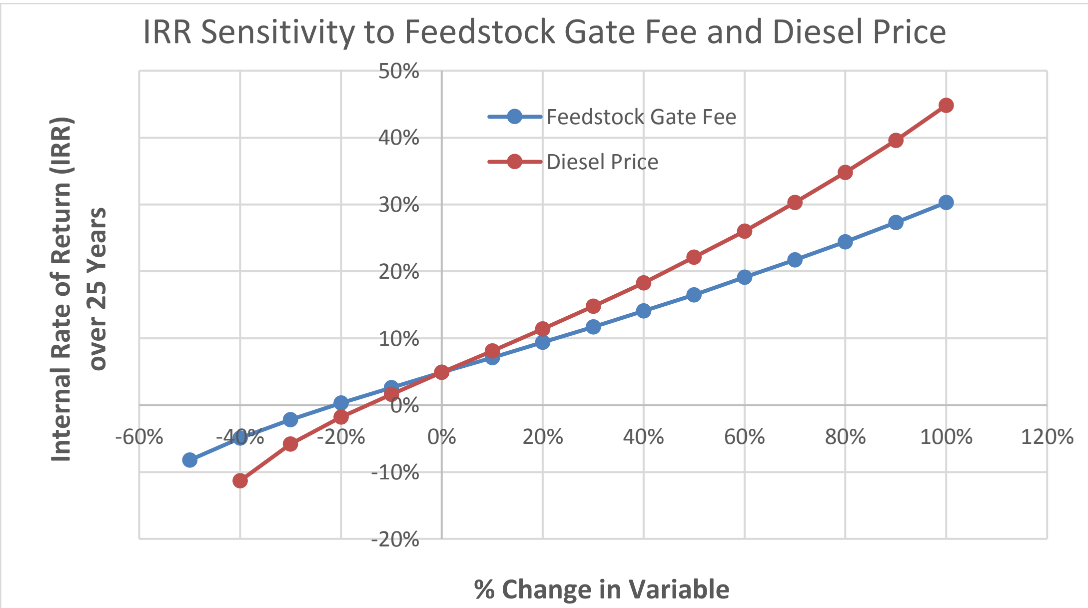


Figure 7: Economic Sensitivity of Project to Variations in Feedstock and Diesel Price

Holding all other variables constant, it is calculated that the feedstock gate fee cannot go below a critical value (at the lower end of current commercial landfilling costs) or diesel price below $0.75/L before project IRR becomes 0%.

There exists the opportunity for a centralized facility to offer a "tolling" service for converting organics into transport fuel. The facility can generate an IRR of 12% and "free issue" bio-CNG (to offset on-road diesel) for a tolling fee within the bounds of current commercial organic waste land filling costs per tonne received. This does not include the cost of modifying engines to utilize Bio-CNG (estimated at approximately $10k per engine) or the cost of hauling waste to site.

The overall economics of such a facility would be improved via third party funding such as via the Australian Renewable Energy Agency (ARENA) or the proposed Biofutures Queensland initiative.

6 Fully integrated waste to energy and composting operation

Anaerobic digestion does not end when the biogas is created. The liquid digestate, expected to be about 3% solids, must then also be managed. The lowest cap ex / op ex scenario is where the digestate is used as a liquid fertilizer and pumped directly to adjacent cropping land. A value-adding option is to co-compost the digestate with green waste, however this brings with it capital and operating cost as outlined below.

6.1 Main capital requirements for a composting operation

- Weighbridge
- Grinding
- Screening
- Windrow turners
- Heavy vehicles for transporting materials on-site
- Heavy vehicles for load out
- Water trucks for dust suppression
- Liquid handling: costs for water storage, pumps, piping and irrigation
- For soils: mixing with sand and other materials.
- Administrative and supporting infrastructure.

6.2 Main operating cost requirements for a composting operation

- Facility state and council permits
- Administrative and management fees
- Weighbridge operations - Receival
- Greenwaste Transport
- Greenwaste tip off
- Greenwaste Contaminate cleaning (time based cost)
- Contaminate Disposal Costs (i.e. non-organic materials)
- Greenwaste Grinding
- Mulch load-out into truck
- Mulch Transport to mixing bay
- Liquid handling (i.e. pumping costs)
- Mulch & Liquid Mixing 1
- Move Mulch Mix to Holding
- Mulch Mix Holding Shrinkage
- Windrow Formation
- Windrow Turning
- Windrow Watering
- Windrow Quality Assurance
- Transport to screening area
- Compost Stockpile Commencement
- Pre mix to recipe
- Screening Operation

- Remove Oversize/Contamination
- Stockpile of finished product
- Product Loading (Truck and Dog)
- Loading shrinkage
- Weighbridge operation - dispatch

7 Innovative Funding Sources for Bioenergy Facilities

A primary barrier for the uptake of renewable energy and waste to energy projects is the large initial capital outlay. A RMP (also referred to as the project proponent or the project developer) considering a waste to energy or clean tech project can access a range of different third party funding sources to support the creation of such facilities, as summarized below:

- ARENA: Australian Renewable Energy Agency. Projects must be innovative and the information shared widely. Funding available as grants paid in arrears. Submissions for "Expressions of Interest" are first made followed by an invitation for a "Full Submission". Refer to: http://arena.gov.au/

- Equity funding: can be high net worth individuals, international companies or fund managers looking for "clean tech" projects with longer term income propositions. The equity provider will look to make a return on the initial investment over a period of 6 to 20 years, depending upon the contractual agreement. Potential advantages of equity funding can include:

    - The company / funder will bring experience of multiple similar projects and can provide project specific expertise and due diligence (legal, technical, insurance, risk) to ensure that the project is technically and commercially sound.

    - "Skin in the game" hence may take a keen and active interest in the project development, construction, operation and project management.

    - Longer term and stable biomass offtake and energy costs for the project proponent.

    - Cost / time overruns can be managed via the equity agreement.

    - The equity partner may request security over the project revenue and assets of the project only, rather than security over other assets of the RMNP / project proponent.

    - Options can be negotiated for the equity funder to be "bought out".

  Some potential disadvantages may include: that a special purpose vehicle (SPV) be created that operates as a separate business with its own board and management thereby whilst the RMP / project proponent may retain the majority of the equity, absolute control over all SPV decisions may not be possible due to the equity partner retaining minority shareholder protections. Equity groups may look for a higher rate of return due to the high risk of funding a project through the construction phase.

- "Rent-to-buy" where the equipment costs are paid over a longer period of time. This reduces the large initial capita outlay, whilst the site owns the facility after an agreed period of time.

- Technology / vendor / equipment partners: Companies that are able to offer low cost funding (e.g. low interest to no interest loans; structured payments). Examples include engine manufacturers, digester manufacturers and other equipment providers.

- Build-Own-Operate (BOO), Build-Own-Operate-Transfer (BOOT) and Build-Own-Operate-Maintain (BOOM) proponents. An example includes Quantum Power Limited (http://www.quantumpower.com.au/).
- "On-bill financing": A company provides the capital with the installments matched via the energy cost savings. Examples include large energy retailers.
- Clean Energy Finance Corporation (CEFC): can assist with low cost loans and mobilizing capital investment in renewable energy, low-emission technology and energy efficiency in Australia. Refer to: www.cleanenergyfinancecorp.com.au
- Lending institutions: Examples include merchant, investment and commercial banks. Some of these banks have agreements in place with the CEFC.
- Equipment financing and leasing groups.
- Superannuation funds (normally from North America for these types of projects).
- For Queensland: Advance Queensland (specifically the "Business Development Fund"; refer to: http://advance.qld.gov.au/industry/business-development-fund.aspx) and Biofutures Queensland funding (details of scheme still to be announced).

Australian companies have started to utilise "build-own-operate" (BOO) and "build-own-operate-transfer" (BOOT) models to deliver projects. An example of a very common plant delivered under this model is PV solar facilities, where a third party owns and operates the PV solar array so that there is no risk to the main business, no large capital outlay and no on-going management requirement. Delivery of plant that is outside of core business via a BOO / BOOT scheme tends to be advantageous for both parties as the main business / proponent has minimal track record and/or interest in the construction and operation of such equipment, whilst the BOO / BOOT proponent routinely has a high level of expertise in ensuring that the plant is technically and economically viable.

Taking PV solar as an example, the equipment is sized so that the plant will always consume the maximum amount generated by the BOO plant as the BOO operator often requires a "take-or pay" contract to be in place; that is, that the company must take a certain agreed amount of power (e.g. X kWh per day) at an agreed rate ($Y/kWh) over an agreed period of time (e.g. Z years). As long as the company always consumes Y kWh per day and the $Y/kWh is below the current utility payments, then the BOO scheme is likely to result in acceptable terms for both parties. Z years is normally a sufficiently long period of time to enable the BOO proponent to reach its hurdle rates in terms of rate or return or net present value. A "build-own-operate-transfer" (BOOT) model is where after Z years the ownership of the facility is transferred back to the company.

BOO and BOOT schemes can reduce or eliminate energy costs whilst requiring no or minimal deposit in order to overcome the hurdle of the initial capital outlay. A key element is the contract under which the BOO/BOOT scheme is delivered. This may take the form of an Energy Services Agreement (ESA), where immediate cost saving can be achieved compared to current energy costs. The BOO or BOOT proponent brings expertise in designing, constructing and operating such facilities which offers advantage over the traditional project delivery model. Such projects can be 'off book' thereby not impacting the balance sheet of the main business, its borrowing capabilities or future financing options.

8 Discussion of Advantages of a Centralized Waste to Energy and Compost Facility

8.1 Licensed Disposal

Organics, waste water/liquids and sludges that have not been processed appropriately are restricted items, which means they can only be managed by approved facilities or processes.

8.2 Licensed Facilities

There are a limited number of facilities, which can legally process RMP wastes. Just like running a meatworks, quarry or electricity station, these facilities provide an essential service to the community – but no one wants them in their back yard. These sites need development approval from Local Government and an Environmentally Relevant Activity (ERA) approval from the State Government.

As such, the approval process to demonstrate the suitability of a site, minimal environmental and social impacts with two government bodies is significant. If approval is granted, it is subject to a vast range of operating conditions once again dictated by two government authorities (sometimes contradictory).

The approval process is costly and time consuming as is maintaining site conditions and compliance with conditions. These types of sites may be remote and not have basic services like power and water, roads etc.

8.3 Supporting Infrastructure

To implement facilities such as hectares of impermeable composting pads, mixing bays, storm water leachate management and systems requires extensive civil construction.

The plant equipment required such as weighbridges, heavy loaders (5 cubic meter buckets), windrow turners, Moxy trucks, screening machines, water carts, administration facilities etc.

Recycled organics processing is not a common industry with few skilled operators and managers. Training staff without nationally recognised formal and or vocational courses requires considerable time and effort. Retention of staff in an industry which is not highly paid or attractive is also difficult.

The development of quality systems and standards requires overcoming the same barriers as above.

8.4 Finished Product Sales

Gate fees for waste acceptance is supplemented by sales of finished products. The market for finished product is immature, unbranded, has minimal standards and historically offered little protection from unlicensed operators. The end result is little product differentiation with no recognition for quality and little reward for value adding.

Continuing negative pressures on the value of finished products places pressure to maintain gate fees.

In AS4454-2012: Composts, soil conditioners and mulches, there is discussion of pathogen pasteurisation which references 40 CFR Part 503, Appendix B to Part 503 - Pathogen Treatment Processes. “Significant Reduction” of pathogens is achieved by anaerobic digestion (treatment in the absence of air for 15 days at 35 to 55 °C). Further Reduction is achieved where the temperature is maintained at 70 degrees Celsius or higher for 30 minutes or longer.

Hence, anaerobic digestion meets the AS4454-2012: Composts, soil conditioners and mulches requirement for “significant reduction”.

8.5 Waste Management

Recycling of organics has significant environmental and social benefits which are yet to be fully exploited by the RMI. A recent survey of Australians showed 87% were either composting, wished they could or thought it was a great idea. Until compost becomes more widely used and finished materials become established as products of choice, it continues to be a waste regardless of potential value.

Volatile organic materials are highly odorous and must be handled with extreme care. With continued urban encroachment closing in on waste management facilities, sites are encountering increased regulatory pressure to reduce their impact – particularly odours. As such highly odorous materials continue to represent a higher risk material requiring specific attention to processing.

WMI provides a service of legal waste management, a recycling which is a higher order of waste management (in the hierarchy of waste) than landfill and provides greater social and environmental benefits than direct land application.

The use of raw poultry manure is banned in several shires and city councils in Western Australia, as it provides a breeding ground for stable flies, which are a serious pest to animals and humans. Regulations governing the movement of raw poultry manure are detailed in the Biosecurity and Agricultural Management (Stable Fly) Management Plan 2013. Poultry manure is permitted for use only if it has been composted to Australian standards or treated in another approved process so it is does not breed stable flies[6].

Organic waste will continue to be a restiricted item into the foreseeable future and be required to be managed by licensed facilities. Indeed, as evidenced by legislated changes to waste management resulting in the restriction of practices and further processing (such as

[6] Western Australian Department of Agriculture and Food, https://agric.wa.gov.au/news/media-releases/raw-poultry-manure-invites-stable-flies, accessed 16 August 2016.

managed composting) required for agri-business waste, it is anticipated that options available to the RMI

Sending waste to a facility like this delivers full triple bottom line benifits for financial, societal and environmental outcomes.

8.6 Financial Advanatges - Immediate

Swithching to disposal at a facility like this is expected to be approximately neutral compared to current market rates for gates fees for waste of this type. This does not include transpot costs.

Dealing directly with the end disposal site (i.e. anaerobic digestion facility operator) should remove handling / middle man costs which may currently not be adding value to the process.

8.7 Financial Advantages - Longer Term

Longer-term benefits will become apparent with increased certainty of costs, the ability to sign longer term off-take agreements and a reduction of environmental and operating risk.

8.8 Waste Levies

The introduction of any market based waste schemes (levies, bans etc), will increase the cost of waste management. Queensland is the only Australian State not to have such an instrument, however it is anticipated that a state based landfill levy will be re-introduced into Queensland at some time in the future to prevent dumping of NSW and Victorian waste in Queensland and to bring environmental policies in line with other juristictions.

Conversely, Federal and State governments are providing financial incentives to build facilities like these.

8.9 Risk

Financial risk of self-management of waste is vast including: a diversion of focus from primary business activity, exposure to issues resulting in potential problems, tying up land and capital in non-core activities.

On-site waste management may not be compatible with a site that produces high value food.

8.10 Transport Fuel Opportunity

Operating a waste to energy facility at scale results in the ability to generate a transport fuel (compressed biogas), as opposed to a smaller site based waste to energy plant which cannot achieve econmies of scale. Arrangements including fuel supply can provide energy security to offset inevitable fossil fuel price rises. As an example of scale, it is estimated the for the first approximately 30 ktpa of organic waste processed, biogas can be generated at a total cost over the life of plant at $13.92 / GJ. Increasing throughput to 60 ktpa can result in biogas production at a cost of $ 7.97 / GJ.

8.11 Market Diversification

With a significant % of animals being considered waste along with the large amounts of water used to process, the RMI is in the waste game whether or not they want to be. The potential for investment in a project like this allows for the potential to value add from waste whilst remaining at arms length.

8.12 Societal: Consumers and Customers

This project aligns and builds on the "*clean and green"* image of the Australian RMI. In an age where consumers want to know the story about how and where things come from and go, this provides the RMI with a great environmental and social message

Especially in light of consumers who are demanding (and paying) for:

- Cage free, barn laid or free range eggs.
- RSPCA approved chicken meat.
- Sow stall free pork.
- PRC placing a carbon dioxide target for processed pork.
- Dolphin friendly tuna is now industry standard.
- Rainforest Alliance Coffee at McDonalds.
- Orangutan Certified Palm Oil.

Consumers expect a story and "branding propositions" when selecting red meat with examples including steakhouses offering a description of the breed, location, feed and explanation of the cut of meat; McDonalds promote meat paddy's as Angus; Woolworths premium meat is branded MSA; Coles brands their meat as "*Hormone Free*"; large restaurant placing "zero landfill" requirements throughout supply chains.

8.13 Improved Water Way and Reef Outcomes

Rising sediment and nutrients loads from land-based runoff are one of the few threats that can be tackled and managed with immediate positive impact via domestic Australian initiatives[7]. The "Reef 2050" plan aims to have reduced nutrients by 50% and sediments by 20% and have 90% of the sugarcane production area operating under best management practices by 2020. Food and garden organics (FOGO) waste management can contribute to preventing run off to waterways and reef waters. Declining water quality is recognised as

[7] Brunton, V. and Ritchie M. "Local organics action to help the Great Barrier Reef", MRA Consulting, 2016.

one of the greatest threats with land runoff of suspended sediment (SS) and nutrients with the associated crown-of-thorns starfish (COTS) outbreaks roughly account for 37% of reef damage[8]. It is estimated that the 2.6 million people living in coastal areas generate 1.7 million tonnes of FOGO with effectively all of the council collected FOGO going to landfill, resulting in green house gas emissions and the potential for creation of leachates. Alternatively, this waste could be use to create towards 40 to 60 million litres of diesel equivalent and, after composting digestate with green waste, around 2.0 million tonnes of compost to substitute for the mineral fertilisers used in agriculture. As an example, this volume of composted FOGO would replace towards 70% the nitrogen (N) and all of the phosphorus (P) requirements in sugarcane production.

The value for the reef in substituting mineral fertilisers with organic forms is that the organic forms are 50% less likely to leach into water ways as demonstrarted by Dougherty (2014)[9]. In addition, the organic matter itself helps bind soil and prevent erosion with significant erosion prevented via the use of composts, with compost blankets reducing gully erosion by 90%[10].

[8] Webster, A.J. et al., 2012. Reducing dissolved inorganic nitrogen in surface runoff water from sugarcane production systems. *Marine Pollution Bulletin*, 65(4-9), pp.128–135

[9] Dougherty, W.J. & Chan, K.Y., 2014. Soil Properties and Nutrient Export of a Duplex Hard-Setting Soil Amended with Compost. Compost Science & Utilization, 22(1), pp.11–22.

[10] Brooks, A. et al., 2012. Protecting the Great Barrier Reef from sediment pollution. Griffith University.

9 Conclusions/Recommendations

9.1 Conclusions and Key Messages

This project reviewed organic waste generation by SEQ RMPs in order to frame a concept level cost benefit analysis and business model development for a centralised and aggregated anaerobic digestion plant operated by a third party waste processor. Numerous European and North American case studies prove AD to be a technically feasible technology, however some work is still required to increase uptake in Australia. The objective of this was to aid in the development of responsible and sustainable organic waste management systems to future proof the Australian RMI, and contribute to existing knowledge of anaerobic digestion and encourage uptake and adoption by proving commercial applicability.

This project showed that there is more than sufficient organic waste available in South-East Queensland due to large scale red meat processing in a concentrated geographical area; and that this organic waste provides an ideal substrate for co-digestion. An aggregated and centralised facility offers a long term solution to exploit the beneficial economy of scale and reduce marginal operational costs and capital expenditure. At a gate fee that is competitive with current commercial organic waste landfilling costs (excluding transport costs), a centralized facility offers a solution to organic waste management.

The overall economics for a centralized facility can be improved from the perspective of a RMP where a “tolling” arrangement with a centralized facility is put in place for organics to be converted into bio-CNG for on-road use and/or where a state based landfill levy is introduced. Further, the economics will be improved by targeting the more concentrated wastes (e.g. dewatered materials, DAF sludges, grease trap / Saveall sludges) that have higher associated waste management costs rather than transporting dilute materials containing water and/or low concentrations of volatile solids. A low capital cost opportunity exists to dewater DAF sludge (and potentially red waste streams) via a hydrocyclone that creates a stream with a high volatile solids concentration, which is a result of the selective recovery of fats and grease.

The future stages of this project are to present business cases to prospective stakeholders (red meat processors, companies, and/or end users) to seek long term agreements for supply of organics and/or off-take of bio-CNG. Support of RMPs would assist with obtaining third party funding thereby improving the overall economic success of the project.

Red meat processors should continuously and iteratively develop and refine their organic waste management and energy strategy, realising the two are intimately linked, as legislative, social, economic, and environmental factors change. This will help shield against rising costs of fuel and waste management, and increase the overall profitability and sustainability of the Australian red meat industry.

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