final report

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Investigation into an automated bio-energy and waste water treatment plant (Phase 1)

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Executive summary

The investigation into an onsite waste to energy (W2E) facility has been confirmed. W2E via anaerobic digestion is one of the very limited options for a red meat processor (RMP) to invest in waste management that will deliver a positive rate of return. The design under consideration is unique for RMPs in that it is a concentrated stirred tank reactor (CSTR) processing a concentrated slurry (~10% solids), rather than the more common covered anaerobic lagoons (CALs) that process closer to ~1% solids. CSTRs have much smaller footprints, hence reduced earth works and onsite civil/structural works, can have a modulated (elevated) temperature in comparison to a CAL, are easier to maintain, and are less susceptible to weather events.

Key drivers and requirements for the project include:

- Resource stewardship: reducing fossil fuel usage; organic waste value adding.
- Minimizing power, heating and waste management costs.
- Increasing WWTP reliability via continuous monitoring.
- Full monitoring, data logging and fit for purpose automation of systems.
- Reducing potential odour and visual amenity of WWTP.

It is estimated that in the order of 17% of the site's power load and 10% of the site's thermal energy load can be provided by a biogas fired cogeneration (cogen) system.

A simplified block schematic of an anaerobic digestion waste to energy (W2E) facility is shown in Figure 1 below.

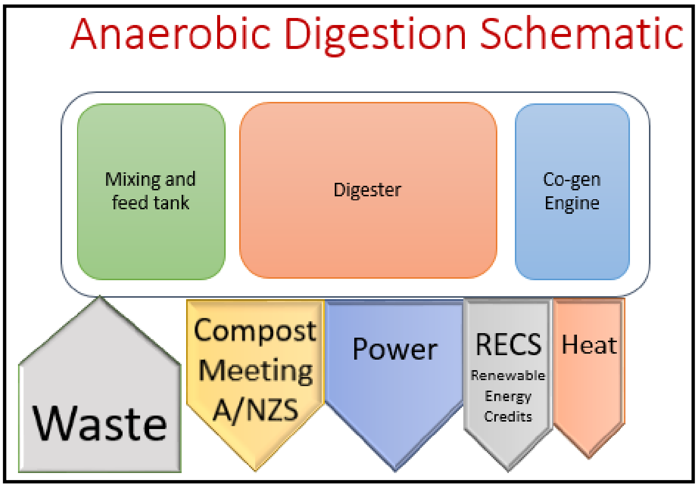

Figure 1: Anaerobic Digestion Waste to Energy Schematic.

The highest risks were considered to be:

- High solids content of the paunch leading to materials handling difficulties,
- Overloading of CSTR when processing material "as received" which would require dilution and hence more digester capacity,
- Low degradability of the mixture leading to not achieving full Biomethane Potential,
- Risk of volatiles remaining on the digestate and thereby not meeting Australian Standard for compost,
- More work to understand impact of new system on WAS composition and tonnage.

Hence, a key recommendation was to drop the solids content in the CSTR to 10% which can be achieved by installing a second digester tank thereby increasing the digester tank volume so that the concentrated feed can be digested. This approach has been confirmed by bench top testing at UQ.

The AD section of the plant (2 digesters) has an estimated simple payback of ~5.6 years for the W2E only for an estimated capex of $7.8 mil. The full W2E and aerated plant shows a ~11.2 yr simple payback for an estimated capex of $13.3 mil, with the opportunity to reduce the simple payback for the full system towards 5.2 years, depending upon third party funding that can be secured.

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1 Abbreviations and Definitions

AD Anaerobic Digestion

AEPL All Energy Pty Ltd

ALARP As low as is reasonably practical

AMPC Australian Meat Processor Corporation

ARENA Australian Renewable Energy Agency

BMP Biomethane potential (m^3 methane / tonne volatile solids)

BOD Biological oxygen demand

COD Chemical oxygen demand

Cogen Cogeneration – a facility for the combined generation of power and heat

DAF Dissolved Air Flotation

EoI Expression of Interest

HAZOP Hazard and Operability Study

hr hour

JHA Job Hazard Analysis

kg kilogram

kPa Kilopascals as unit of pressure (gauge)

kVA Kilo Volt Amperes

kVAr Kilo Volt Amperes reactive

kW Kilowatts

kWe Kilowatts of electrical load / generation

kWh Kilowatt hour

kWt Kilowatts of thermal load / generation

MJ Megajoule

MLA Meat and Livestock Australia Ltd

MW Megawatt

MWe Megawatt electric – electrical power production.

MWh Megawatt hour

MWt Megawatt thermal – thermal power production.

NRV No Return Valve

P&ID Piping and Instrumentation Diagram

PRV Pressure Release Valve

s seconds (time)

SMP Safety Management Plan

SOP Standard Operating Procedures

t Metric tonne (1,000 kg)

tpa Metric tonnes per annum

tpd Metric tonnes per day

tph Metric tonnes per day

tpw Metric tonne per week

W Watts

WAS Waste Activated Sludge

WWTP Waste Water Treatment Plant

yr year

2 Background

Anaerobic digestion provides one of the few options for Australian food companies to simultaneously create renewable energy on-site, improve waste management practices, and increase energy productivity via a net positive return technology. Uptake is limited due to the modest rates of return for waste to energy compared to other "core business" activities and, particularly in Queensland, low waste disposal costs. ARENA funding will assist to improve the economic viability of integrated waste to energy facilities in comparison to competing capital works projects. The proposed renewable energy facility would employ cogeneration engines fired by biogas created from multiple substrates including paunch, sludges, fatty wastes, screenings and volatiles recovered from waste waters.

Whilst the creation of bioenergy from liquid wastes is becoming common place, organic solid wastes have not been utilized extensively within closed anaerobic digester vessels in Australia, whilst the high moisture contents (50 to 99% moisture) make these organic waste streams from abattoirs unsuitable for traditional thermal combustion systems. The proposed plant provides a disruptive route for creating bioenergy from a wider range of solid organics and sludges. Within south-east Queensland alone, it is estimated that wastes from beef processing facilities could generate 3.8MW of power, or towards 40% of on-site power demand. Conversion of solid and liquid food processing wastes into energy via a closed vessel system would provide inspiration and an innovative pathway for the uptake of renewable power and thermal heat by Australia's food manufacturing industry.

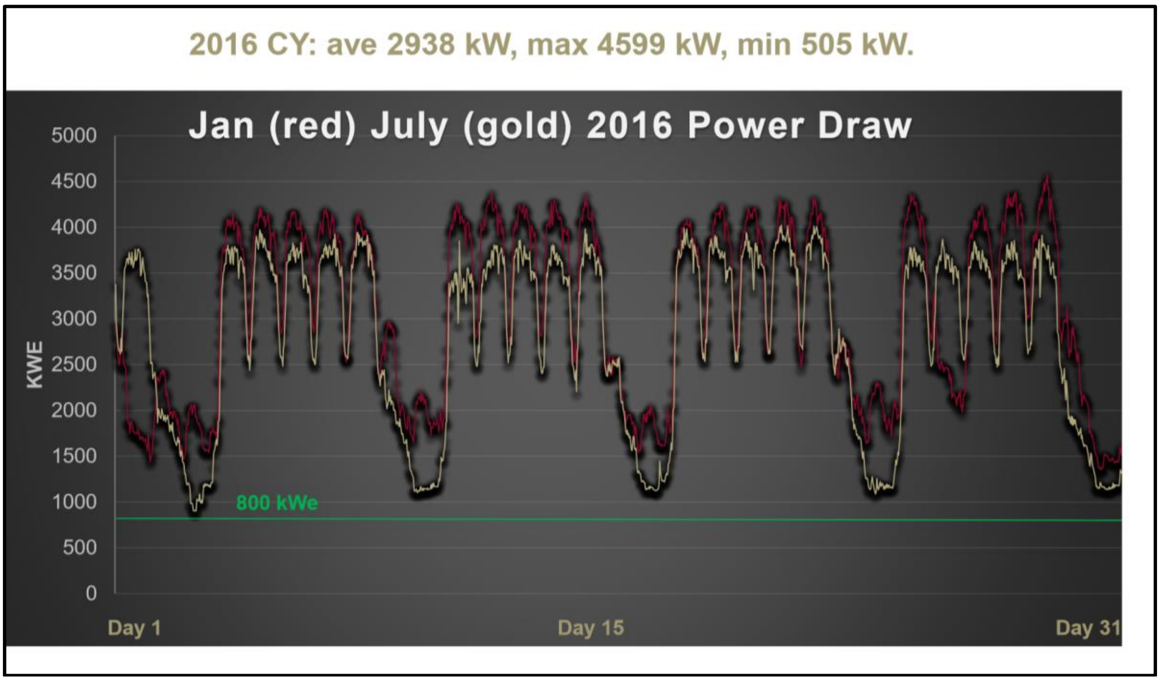


Figure 2: Site power load during summer (red) and winter (gold).

This bioenergy technology can then be rolled out to other sites.

When analysing the "Total Addressable Market" for reported bio-waste to energy projects within the red meat industry (feed lotting and process plants), it is estimated that approximately 101 to 147 MWe of power could be generated from organic wastes. However, documented power generation is sat at less than 1% of this potential. Why? The use of covered anaerobic lagoons generating biogas at relatively low overall efficiency and/or the availability of boilers at these sites means that if biogas is generated it is generally seen as a by-product of the waste management process (and hence flared or simply combusted within a boiler) rather than seen as an opportunity to off-set power costs. The use of CSTR technology is required to take bio-energy to the next generational level by efficiently generating power and heat from more concentrated bio-waste streams, rather than the use of lower efficiency covered anaerobic lagoon (CAL) systems.

3 Project objectives

The overall objective of this project is to conduct a general feasibility review of an automated bio-energy and waste water treatment plant at an Australian beef processing operation. The specific objectives of the project include:

1. Selection of digester location including specifications and detailed drawings.
2. Submission of a full proposal to ARENA.
3. Independent third party technical review of an automated bio-energy and waste water treatment plant; Further test works: Biomethane testing to enable an ARENA EoI; Evaluation of volatile solids removal testing through stream sampling for WWTP with the proposed new clarifier and DAF.
4. Refinement of mass and energy balance and stream table.
5. Development of environmental documentation to assist council and state level approvals.
6. Development of ex ante cost benefit analysis, business case, and reporting on the innovative elements of an integrated WWTP facility at a red meat processing facility.

4 Methodology and Results

4.1 Digester Location and Detailed Drawings

The following layouts form the basis of the DA submission. Where two digester tanks are required, the feed tank can be located within the building envelope and a second digester installed. As part of the project due diligence, a site visit was conducted of the laboratory and commercial facility. Detailed discussions were held on pilot vs lab testing; equipment inclusions and exclusions; site layout; performance guarantees; and timing.

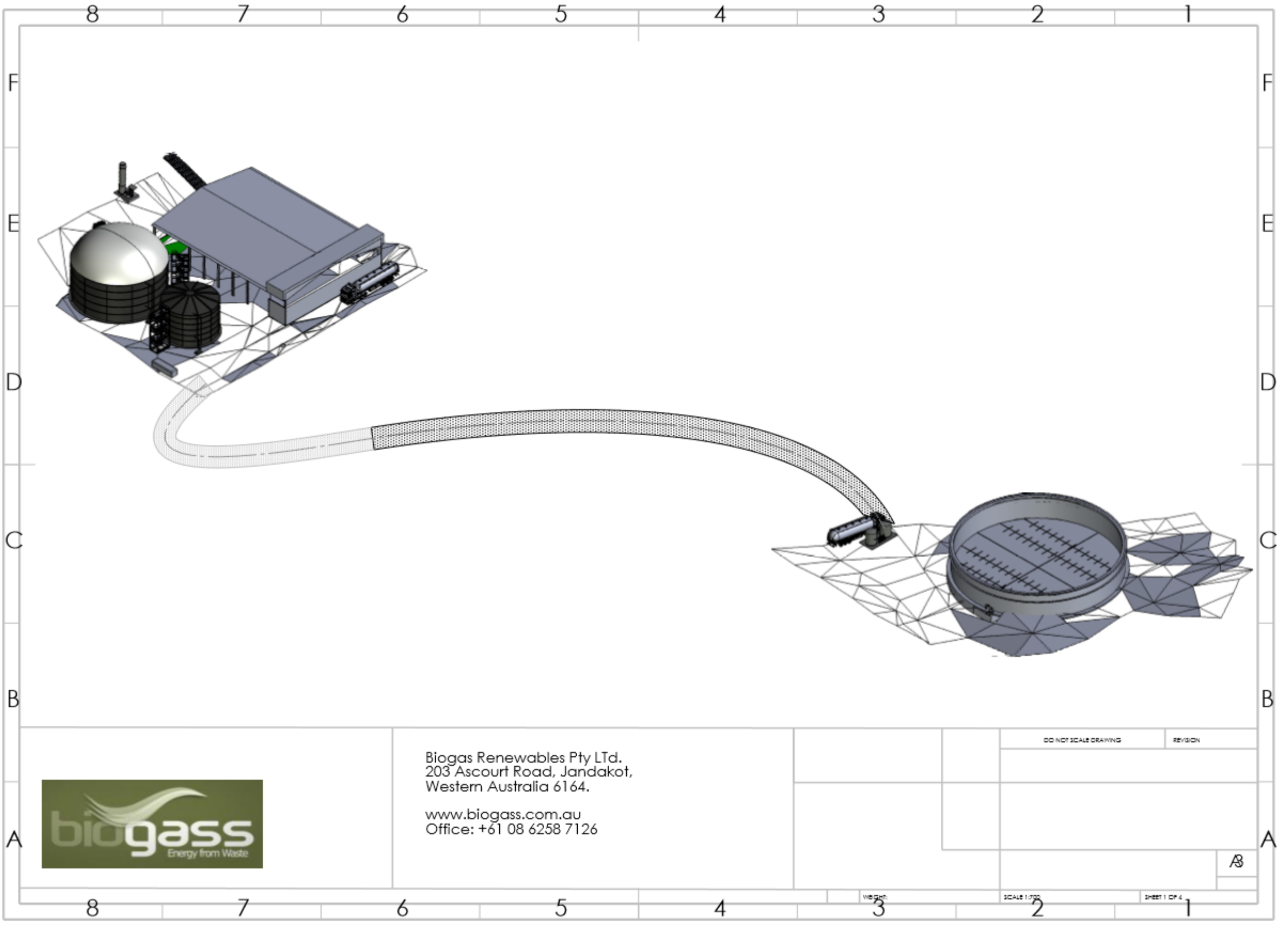


Figure 3: W2E and aeration plant layout.

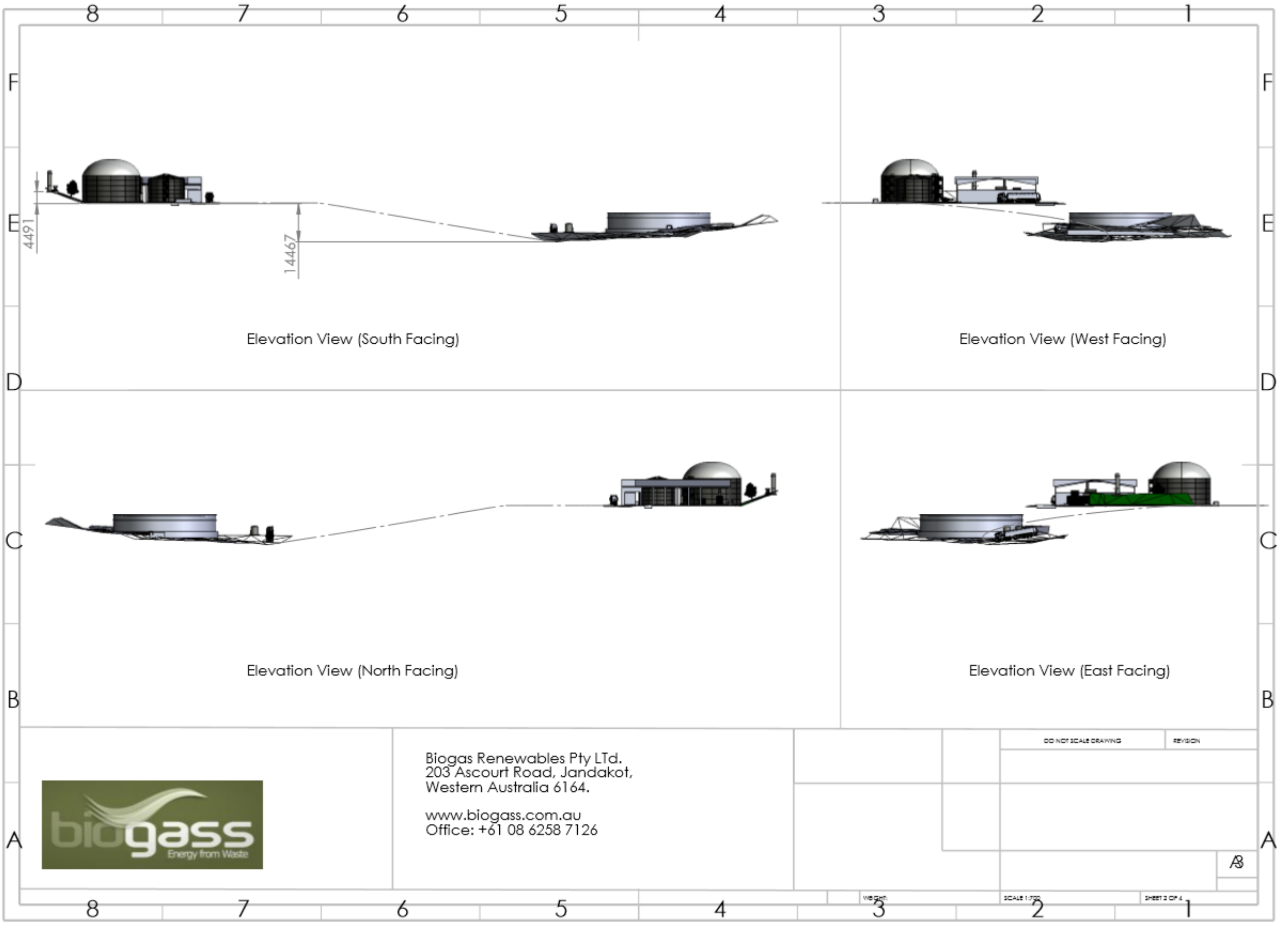


Figure 4: W2E and aeration plant elevations. .

4.2 Full ARENA Submission

A full ARENA submission has been lodged. Formal technical review has been completed and the ARENA Review Panel found that the project is:

"Potentially of high merit and recommended to the Board for funding approval, subject to the conditions outlined below:

Submission of a finalised business case document and feasibility assessment that confirms:

- EPC pricing for delivery of the solution;
- full analysis of project revenues and avoided costs compared to BAU;
- project management arrangements and responsibilities;
- optimised Project delivery timetable that does not have finance as a limiting factor, and thereby;
- the final quantum of ARENA grant request."

A Merit Assessment Report will then be created for the board for a decision on funding.

The proposed project will meet the following Advancing Renewables Programme objectives:

- reduction in the cost of renewable energy: by converting organic wastes that currently attract a waste management and landfilling fee into power and thermal heat and by focussing on technology efficiency, cost improvements, balance of system and intelligent integration of plant, and structuring of business cases for optimal operational and maintenance costs.
- solid and liquid, multi-substrate digestion. Utilization of a range of feedstocks increases the understanding of how renewable energy can be created from a wider range of feedstocks.
- increase in the value delivered by a integrated plant by reducing the amount of aeration required for on-site waste treatment,
- maximizing the value of the power via the use of an Energy Management System that ensures that all power is utilized "behind the meter": this means that the power that is generated has a higher value by off-setting higher cost power rather than being sold into the grid at a low value and also reduces the capital outlay by not requiring grid exporting infrastructure.
- improvement in technology readiness and commercial readiness of renewable energy: staged project delivery utilizing a modular approach to the creation of a full scale system thereby proving the economic viability at multiple scales.
- reduction in or removal of barriers to renewable energy uptake: dissemination of the economics of the process at increasing scale; dissemination of dry fermentation technology using multi-substrates.
- increased skills, capacity and knowledge relevant to renewable energy: upskilling of staff and contractors.

The proposed biomass to biogas to combined heat and power facility meets the following priority areas under ARENA's investment focus:

- Integrating renewables and grids: the project will show how a biogas system can be used for distributed energy. It will address the knowledge gaps for integrating renewables into a grid-parallel non-exporting system.
- Renewables for industrial processes: demonstrates the application and economic benefits of using renewable energy within an industrial setting by displacing fossil fuels in the form of grid-power and coal, providing an example for other industrial settings thereby reducing the perceived technical and commercial risks associated with integrated renewable energy systems.

- The activity will displace fossil fuels used for heat and power generation, namely coal, with renewable biogas. This will have the benefits of greatly reduced gross emissions of greenhouse gases, with drastic reduction in NOx and SOx emission, reduced operating cost, lower safety and environmental hazards from reduced need to store finely pulverised coal, and lower emission of particulate matter.
- Advancing the commercial development of renewable energy and enabling technologies
- The project will demonstrate creating electricity and heat from biomass to meet a specific local demand, provide a pathway for utilizing biomass that has not previously been considered extensively in Australia (solids and liquids) with associated feedstock management.
- Financial viability improved via reduced waste costs
- Automated and remote monitoring and control with associated public availability of real time and archived data.
- Grid-parallel, non-exporting integrated industrial installation at proof of commercial scale.

The use of an inflatable, double layered roof structure enables a finite amount of storage of biogas, hence a "bio-battery" is achieved where some storage of biogas can occur so that the cogeneration engine can generate a maximum power output during peak times. This increases energy productivity as the highest value is then achieved for the biogas. Further advantages of energy security and a more reliable energy source are also achieved.

4.3 Independent third party technical review and further test works

Independent third party technical review and further test works were undertaken. The table below summarizes the findings of the laboratory analysis contributing to the updated mass and energy balance. The key detailed findings are presented in the appendix.

Lab Analysis	Lab
Time Series Paunch and Paunch press water - 5 days	Eurofins - Water/solids analysis Water/solids analysis
Salsnes testing: volatiles recovery from green and red streams	
Time series screened green and post-DAF red	
Paunch mono-digestion	UQ - BMP (all BMPs tests are completed in duplicate)
WAS mono-digestion - Winter	
DAF skimmings mono-digestion	
Red solids Mono-digestion	
Mixture	
Composite 1 – DAF at 8% of solids (similar to expected levels)	
Composite 2 – DAF at 30% solids	
Composite 3 – DAF at 50% solids	
WAS mono-digestion - Summer	
Continuous #1 - proposed CSTR feed; 120 days; includes digestate analysis.	UQ - Continuous
Digestate (UQ testing on Biogass Renewables Pty Ltd digestate)	UQ

The Milestone 4 works included an Independent technical review of the waste to energy project.

The highest risks were considered to be:

- High solids content of the paunch leading to materials handling difficulties
- Increased WAS
- Low degradability of the mixture leading to not achieving full Biomethane Potential
- Risk of volatiles remaining on the digestate

Hence, a key recommendation was to drop the solids content in the CSTR to 10% which can be achieved by installing a second digester tank thereby increasing the digester tank volume so that the concentrated feed can be digested at around 5 kg COD / m^3 / day, which is towards the upper bound of CSTR systems.

4.4 Comparison of Lab Results

4.4.1 BioMethane Potential

	Lab 1 - March 2017. Adv. Water Management Centre						Lab 2 - March 2017. Biogass Renewables Pty Ltd						Lab 3 - Aug 2015. Centre for Solid Waste Bioprocessing			
	Ave. of duplicate.						Average of duplicate.						Ave. of duplicate			
	TS%	VS%	BMP	Me-thane	Biogas	Deg-radability	TS%	VS%	BMP	Me-thane 30 days	Biogas	Deg-radability	TS%	VS%	BMP	Me-thane
			L methane / kgVS	m^3/t	m^3/t	Fraction			L methane / kgVS	m^3/t	m^3/t	Fraction			L/ kgVS	m^3/t
Paunch	24.8%	23.0%	226	52.1	80.2	0.45	24.5%	22.6%	261.5	59.2	91.0	76.2	16.7%	14.6%	184	26.65
WAS Sludge	10.9%	9.2%	210	19.3	29.7	0.34	11.5%	10.1%	267.2	27.0	41.5	75.8	11.3%	9.6%	232.5	20.5
DAF	4.6%	4.3%	740	31.8	48.9	1	7.5%	7.0%	607.7	42.5	65.4	99.0				

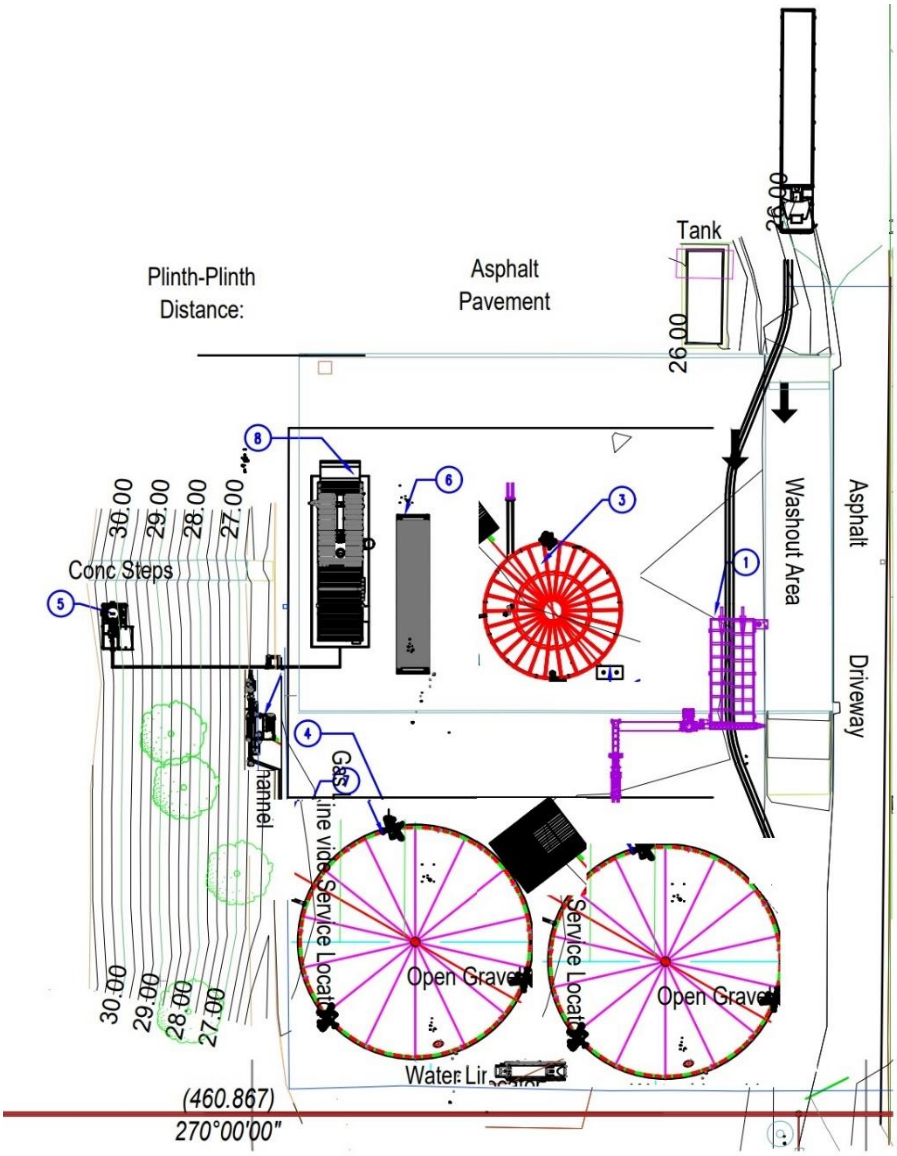
4.4.2 Organic Streams Composition

Composition	Biogass Renewables Pty Ltd Findings			ARENA M&EB – Based on earlier sampling results		
Sample	Solids	Volatile solids %	KGVS / tonne	Solids	Volatile solids %	KGVS/tonne
Green screens	24.45%	22.6%	226.3	25%	21.5%	214.2
WAS sludge	11.51%	10.1%	100.61	12.5%	9.5%	95.4
DAF float	7.54%	7.0%	70.05	8.8%	8.3%	82.31

The above analysis confirms that the MEB presented in the ARENA submission has strong correlation (~1.8% variation) with the Biogass Renewables Pty Ltd testing data for the above substrates.

4.5 Updated Layout

The attached shows an option for 2 x 2500 m^3 digester tanks, with 1 x 500 m^3 feed tank located within the existing “hay shed” envelope.



4.6 Mass and Energy Balance

Presented below is an updated mass and balance on the updated lab and analysis information. These results show that the pressed paunch, DAF sludge and concentrate from the red and paunch press liquid are the highest sources of biogas. Further, the biogas to tonnes ratio shows that WAS is “occupying

Estimated for:	6400	**hpw**											
Basis: Average weekly kill rate 3/1/17- 2/7/2017	**5823**	**hpw**											
Rev C 2017 Jan-Jun Data Extrapolation to 6400 head per week (from 5823)													
Organic waste generation - PER ANNUM				Solids	Solids	Volatile Solids	Volatile Solids		BMP	Biogas @85% BMP	Biogas	Biogas to tonnes ratio	Energy
Current	Volume	Density	tonnes per annum	%	Tonnes pa	% TS	Tonnes per annum	Tonnage Fraction	L methane / kgVS	m^3 pa	% total		GJ pa (assuming 60%
Dewatered Paunch	20,333	0.400	8,133	23.3%	1,895.63	88%	1,668	0.289	226	534,087.89	33%	66	11501
WAS Sludge	13,717	0.721	8,212	11.2%	917.5	86%	788	0.292	210	234,452.57	14%	29	5049
DAF sludge	5747	0.895	5,144	6.6%	337.8	94%	316	0.183	740	331,323.15	20%	64	7135
Red + paunch press liquid concentrate from Salsnes Screen	12245	0.400	4898	10%	489.81	97%	475	0.174	470	315,941.19	19%	65	6803
Red screenings	1374	0.721	991	25%	247.64	97%	240	0.035	470	159,733.39	10%	161	3439
Green screenings	1374	0.5	687	24.8%	170.08	88%	150	0.024	226	47,920.64	3%	70	1032
Quarterly bottoms pump-out	100	0.400	40	5%	2	59%	1	0.001	210	353.99	0%	9	8
TOTAL – current solids and future concentrated streams			**28,105**	**14%**	**4,060**		3,638			1,623,812.81		58	34969
Residence time (days) for AD capacity of	**2500**	**kL**	**32**										
Residence time (days) for AD capacity of	**5000**	**kL**	**65**										
TOTAL – current solids and future concentrated streams			40,604	10%	4,060		3,638			1,623,812.81			34969
Residence time (days) for AD capacity of	**2500**	**kL**	**22**										
Residence time (days) for AD capacity of	**5000**	**kL**	**45**										

At 21.536 MJ/m^3 and 40% electrical efficiency, 486 kWe and 422 kWt would be produced for 8000 hours per annum. In practice, the engine would be throttled to around 75 to 100% load during peak power pricing periods then back to 50% load or turned off during off-peak times.

4.7 Cost Benefit Analysis

The following cost-benefit analysis was present to ARENA as part of the final submission. In summary, the AD section of the plant (Phases 1 and 2) has an estimated simple payback of 5.6 years for the W2E only, with the full W2E and aerated plant showing a 11.2 yr simple payback (with the opportunity to reduce the simple payback for the full system towards 5.2 years, depending upon third party funding that can be secured).

Total Capital Investment – Updated Vendor Comparison Aug 2018:

6400 head per week red meat processing plant AD system	BRPL - D&C	BRPL - D&C	BRPL - D&C	GHD - EPCM	Energy 360 - D&C	ReNu - EPC	ReNu - BOOM
	2 AD tanks, use existing ponds; Fixed and firm	1 AD Tank Fixed and firm; Aligned with GHD	2 AD Tanks Fixed and firm; Aligned with GHD	DVO Digester	Prelim	Estimated from available data	CAL: BOT; Energy system: BOOM
Digester Volume + Feed tank	5360	2860	5360	4510	3614	35,000	35,000
Cogen rating	800kWe	800kWe	800kWe	806kWe	550kWe	1600kWe	1600kWe
kWh pa	4,475,280			6,448,000	4,000,000	10,043,822	10,043,822
CAL						$4,894,800	$ 4,894,800
Digester #1 and all materials handling including all civil/structural requirements, paunch conveyor system from rendering area to feed tank, WAS sludge/DAF/screenings conveyor system from WWTP area, all piping and tie-ins, control room, flare, feed tank and materials receival, bunding, all mech and elec within bunded	4,020,088	4,020,088	4,020,088	5,614,262	2,293,000		
Digester #2 including all materials handling for Digester #2 (not including detailed design)	940,088	NA	940,088	NA	Not quoted	NA	NA
Cogen - containerized 800 kW with heat recovery	951,000	951,000	951,000	2,675,000	895000	1,902,000	-
Anaerobic Digester (digester and cogen)	5,911,176	4,971,088	5,911,176	8,289,262	3,549,376	6,796,800	4,894,800
Paunch conveyor system; WWTP solids conveyor system; Piping and tie-ins		1,299,398	1,299,398	Included	1,296,398	1,299,398	1,299,398
Tie-in to MCC Power cabling; REC metering	361,376	361,376	361,376	299,000	361,376	361,376	361,376
Sludge / liquids Decanter (WAS decanter)	509,050	509,050	509,050	206,000	509,050	Included	Included
Hydrocyclone for red	348,000	348,000	348,000	NA	348,000	NA	NA
870kW Plate Heat Exchanger (Allied Heat Transfer)	7,000	7,000	7,000	Included	7,000	7,000	7,000
Salsnes screen for red and green plus associated equipment. (SF4000)	306,250	306,250	306,250	Included	306,250	NA	NA
WWTP DCS Automation	309,966	309,966	309,966	50,000	309,966	309,966	309,966
SUBTOTAL W2E section	**7,752,818**	**6,812,730**	**7,752,818**	**8,844,262**	**6,687,416**	**8,774,540**	**6,872,540**
Closed aerated tanks - 6400 hpw Aquatec; or N/P removal GHD	-	3,950,000	3,950,000	4,700,000	3,950,000	3,950,000	3,950,000
ESTIMATED CAPITAL COST - ELIGIBLE ARENA EXPENSES	***7,752,818***	***10,762,730***	***11,702,818***	***13,544,262***	***10,637,416***	***12,724,540***	***10,822,540***
ARENA Submission	11,712,526	11,712,526	11,712,526	11,712,526	11,712,526	11,712,526	11,712,526
AD and cogen only - Estimator's number. EPCM AD and engine only (does not include n/P handling system)				$ 1,153,000.00			
W2E Detailed design BRPL; or prelim design GHD	89,400	89,400	89,400	250,000	94,000		
Aquatec detailed design and project management	-	370,000	370,000		370,000		
Balance of MLA "Detailed Design" not incl. GHD project management at ########	421,260	421,260	421,260	271,294	421,260		
SUBTOTAL MLA "Detailed Design"	1,125,539	1,564,315	1,564,315	1,674,294	1,564,315	1,564,315	1,564,315
ESTIMATED TOTAL CAPITAL INVESTMENT	**8,878,357**	**12,327,045**	**13,267,133**	**15,218,556**	**12,201,731**	**14,288,855**	**12,386,855**
ACC costs assuming 75% MLA/AMPC and 50% ARENA funding	**4,157,794**	**5,772,444**	**6,242,488**	**7,190,705**	**5,709,787**	**6,753,349**	**5,802,349**
kW - continuous equivalent	559	515	640	806	550	1341	1341
kW - net (minus parasitic load)	491	447	572	685	495	1147	1147
Power $ pa (0.14 - 0.025; or BOOM at $0.11)	495,046	450,308	576,233	690,170	498,663	1,155,040	301,315
Waste reduction $ pa	1,006,653	1,006,653	1,006,653	1,006,654	1,006,655	1,006,653	1,006,653
RECS $ pa @ $60	294,026	270,684	336,384	423,634	289,080	704,830	-
Heat @ $4/GJ	73,416	73,416	73,416	73,416	73,416	175,990	175,990
Revenue / cost savings	1,869,141	1,801,061	1,992,686	2,193,873	1,867,814	3,042,512	1,483,958
Op ex	485964	700164	700164	700164	700164	700164	700164
Simple Payback W2E only	5.61	6.19	6.00	5.92	5.73	3.75	8.77
Simple Payback TOTAL	6.42	11.20	10.26	10.19	10.45	6.10	15.80

Operating cost / revenue and cost savings

OPERATING COST ITEM	Value $ pa
Personnel (@ 2.0 FTE)	$ 203,056
Plant Maintenance and repair @ 5% rotating equipment cap ex	$ 210,222
Electrical load - assume all power free-issued from cogen	$ 0.00
Biogass Renewable Pty Ltd - Technical assistance retainer	$ 72,000
Aerated plant alum and caustic; or additional N,P,SS & Volume QUU Charges	$ 214,200
Reclaimed water	$185
DERM ERA Environmental Fee	N/A
TOTAL ESTIMATED ANNUAL OPERATING EXPENSES p.a.	**$ 700,164**

COST SAVING / REVENUE ITEM	Value $ pa
Reduced landfill - paunch	$ 288,915
Reduced landfill - sludge	$ 376,289
Reduced landfill - decanted DAF float (FOGS removed)	$ 341,448
Peak power off-set	$ 252,066
Off-peak power off-set	$ 67,949
RECS	$ 324,491
Heating	$ 84,608
TOTAL ESTIMATED REVENUE / COST SAVING Per Annum	**$ 1,708,154**

Estimated Earnings and Net Profit After Tax Report (Ryan Harvey McEnery):

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
Revenue/Receipts												
	ARENA Grant Capital	1,242,249	512,207	1,171,435	782,071	86,897	-	-	-	-	-	-
	ARENA Grant Operating	-	16,274	195,289	195,289	195,289	-	-	-	-	-	-
	RECS	-	-	324,491	324,491	324,491	324,491	324,491	324,491	324,491	324,491	324,491
	Total revenue	1,242,249	528,481	1,691,215	1,301,851	606,677	324,491	324,491	324,491	324,491	324,491	324,491
***less* Additional Expenditure**												
	Staffing Costs	-	16,921	206,711	210,432	214,220	218,076	222,001	225,997	230,065	234,206	238,422
	Repairs & Maintenance	-	17,519	214,006	217,859	221,780	225,772	229,836	233,973	238,185	242,472	246,836
	Technical Assistance Fees	-	6,000	72,001	73,297	74,616	75,959	77,327	78,719	80,136	81,578	83,046
	Chemical	-	17,892	218,565	222,499	226,504	230,581	234,731	238,956	243,258	247,636	252,094
	Other Expenditure	-	15	188	192	195	199	202	206	210	213	217
	Total expenses	-	58,347	711,471	724,278	737,315	750,587	764,097	777,851	791,852	806,106	820,616
***add* Cost Savings**												
	Waste Expenditure	-		1,024,772	1,043,218	1,314,812	1,338,478	1,362,571	1,387,097	1,412,065	1,437,482	1,463,357
	Electricity Expenditure - Peak	-		252,066	256,603	261,222	265,924	270,711	275,584	280,544	285,594	290,735
	Electricity Expenditure - Off-Peak			67,949	69,172	70,417	71,685	72,975	74,288	75,626	76,987	78,373
	Heating Expenditure	-		84,608	86,131	87,682	89,260	90,867	92,502	94,167	95,862	97,588
		-	-	1,429,396	1,455,125	1,734,133	1,765,347	1,797,124	1,829,472	1,862,402	1,895,926	1,930,052
EBITDA		1,242,249	470,134	2,409,139	2,032,698	1,603,495	1,339,252	1,357,517	1,376,112	1,395,041	1,414,311	1,433,928
Depreciation												
	Phase 1	-	18,348	220,182	220,182	220,182	220,182	220,182	220,182	219,862	216,346	216,346
	Phase 2	-	-	9,868	118,418	118,418	118,418	118,418	118,418	118,418	118,418	118,418
	Phase 3	-	-	-	-	133,832	401,495	401,495	401,495	401,495	401,495	401,495
	Total Depreciation	-	18,348	230,050	338,600	472,432	740,095	740,095	740,095	739,775	736,259	736,259
EBIT		1,242,249	451,786	2,179,089	1,694,098	1,131,063	599,157	617,422	636,017	655,266	678,052	697,669
Interest												
	Phase 1	103,674	129,593	120,785	111,978	103,171	94,363	85,556	76,749	67,954	59,301	50,647
	Phase 2	-	16,829	42,072	37,335	32,598	27,861	23,125	18,388	13,651	8,914	4,178
	Phase 3	-	-	72,521	137,790	145,043	128,983	112,923	96,863	80,803	64,744	48,684
	Total Interest	103,674	146,421	235,378	287,103	280,811	251,208	221,604	192,000	162,409	132,959	103,508
Net Profit brefore Tax		1,138,575	305,365	1,943,711	1,406,995	850,251	347,949	395,819	444,017	492,857	545,093	594,160
Taxation		***341,572***	***91,609***	***583,113***	***422,098***	***255,075***	***104,385***	***118,746***	***133,205***	***147,857***	***163,528***	***178,248***
Net Profit		797,002	213,755	1,360,598	984,896	595,176	243,564	277,073	310,812	345,000	381,565	415,912
Capital expenditure	Phase 1	3,834,101	958,525	-	-	-						
	Phase 2	-	622,360	933,540	-	-						
	Phase 3	-	-	2,682,000	2,413,800	268,200						
	Total capex	3,834,101	1,580,885	3,615,540	2,413,800	268,200						
Sources of funds	National Australian Bank	2,591,852	1,068,678	2,444,105	1,631,729	181,303						

Rate of Return with No Funding		Cost Base	11,712,526			2.08%	2.37%	2.65%	2.95%	3.26%	3.55%
Rate of Return with Funding (subtracting the funding from the cost of the asset)		Cost Base	7,917,668			3.08%	3.50%	3.93%	4.36%	4.82%	5.25%
Annual Average Rate of Return with No Funding over 25 years	5.43%										
Annual Average Rate of Return with Funding over 25 years	8.04%										

4.8 Risk Review

A Risk Matrix was created by Dr Paul Jensen, which was then work shopped by the PCG on Wed 5 July. The results of the PCG workshop are in the appendices.

4.8.1 Safety Assessment

A safety assessment was completed for the potential pilot plant, which served as a good introduction to the requirements for running a biogas facility.

4.8.1.1 HAZOP Nodes

The plant was separated into two distinct nodes for HAZOP analysis, the gas node, including the flare, safety vent, and condensate transfer; and the digester node, including feeding, primary and secondary digestion tanks, digestate storage, and loadout. The two P&IDs that were worked from were "Uniflare Dwg #1092-3001" and "Biogass Dwg #102-002".

4.8.1.2 Gas Node

Due to the flammability and lack of odour or colour of biogas, the gas node was determined to be the node of highest hazard. Below is a summary of important safeguards; refer to the appendix for the full HAZOP tables.

- Pressure testing
- Odourised biogas
- Over/under pressure PRV
- Failsafe on flare
- Surge protection on flare
- Protection of vent from elements and ingress of contaminants

4.8.1.3 Digester Node

The high moisture content and non-toxicity of the feedstocks and digestate mitigate many of the health and safety hazards identified in the gas node. Additional safeguards include:

- Liquid seal in feed tank to prevent ingress of air
- NRV on feed tank
- Inlet on secondary tank lower than outlet of primary tank
- Break and weir to drain secondary tank to prevent siphoning
- Screen for large solids prior to feeding

4.8.1.4 Revised P&IDs

Consequent from the above safeguards and recommendations, the initial gas and digester node P&IDs were updated by their respective designers.

5 Conclusions/recommendations

There is sufficiently strong technical and economic viability to progress the project to the detailed design stage.

A key advantage of the CSTR system is that it is modular: where the organics load is low due to low production rates, or use of substrate for other purposes, then a single digester can be installed. Where the first digester is overloaded, a second digester can then be installed. In the future, where too much biogas is being generated for a singe engine, a second engine can then be procured as required.

The AD section of the plant (2 digesters) has an estimated simple payback of ~5.6 years for the W2E only for an estimated capex of $7.8 mil. The full W2E and aerated plant shows a ~11.2 yr simple payback for an estimated capex of $13.3 mil, with the opportunity to reduce the simple payback for the full system towards 5.2 years, depending upon third party funding that can be secured.

6 Appendix

6.1 Independent third party technical review and further test works – UQ

6.2 Draft Development Application

6.3 Risk Review Findings

6.4 HAZOP Table