final report

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Feasibility study In Vessel High Rate Fixed Film Anaerobic Digestion

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Abstract

The focus of this paper is to better understand the waste stream generated by a small family owned country abattoir and how a cost can be turned into a profit by utilising high rate fixed film anaerobic digestion.

The installation will generate considerable amounts of biogas as a source of energy plus the recovery of nutrients such as nitrogen, phosphorous and potassium. By utilising the flow-on benefits of the new digestion infrastructure outside feed stocks to generate positive cash flow will be a significant financial gain to the abattoir

To achieve the objectives the following parameters are discussed:

1. Understand the current waste management facility
2. Determine the nature of the various waste streams
3. Determine the potential for the recovery of energy and nutrients from the waste
4. Understand the financial implications for any proposals or recommendations
5. Identify outside sources of organic waste suitable for digestion
6. Determine design parameters and likely costs of a waste to energy facility

Executive summary

The notion of waste to energy is not new but what is not commonly understood is the amount of energy encapsulated in organic waste. In the case of the Rocky Creek Abattoir located in Far North Queensland it has been established that if a waste to energy facility utilising what is currently regarded as “waste” were established, the business would be close to self-sufficiency in energy needs. To supplement the shortfall in feedstock a number of easily accessible sources have been identified. The advantage of these is that not only will RCA be able to reap the benefit of energy recovered but a gate fee to accept the potential feedstock becomes payable.

An additional and fresh contender for recovery from waste streams are nutrients – primarily nitrogen and phosphorous. As the world reaches peak phosphorous production and the cost of chemical fertilisers rise relentlessly a second dimension to the potential number of dollars to be saved is added. Nutrients recovered as a by-product of anaerobic digestion are also solubilised thus making them more accessible by plants and more economical to use on a weight/weight basis than chemical fertilisers.

Working through the potential gains for RCA and bearing in mind the introduction of external feed stocks it became evident the construction and management of a high rate fixed film anaerobic digestion facility will need to be carefully managed so as not to cause an overload on the existing management capacity. and therefore a separate company with its own management structure would be advisable. RCA would be a member of the new group and gain a monetary benefit from the activities of the business.

Content

The management of Active Research Pty Ltd and the author of this report gratefully acknowledge the assistance of Mr Victor Byrnes, Managing Director, Rocky Creek Abattoir and Mr Daniel Portefaix for their assistance with the collection of data and final presentation.

1 Background

Rocky Creek Abattoir (RCA) is a family owned and operated abattoir and rendering plant near Tolga on the Atherton Tablelands in far North Queensland. Currently blood and paunch is distributed to land and plant wash water pumped to a traditional pondage effluent system.

RCA is faced with high and ever increasing energy costs together with tighter environmental regulatory requirements

A recent visit to the premises indicated that an upgraded waste management system would benefit the company financially through energy recovery and regulatory compliance. The goal was to determine the viability of self -sufficiency for the company in energy requirements however the volume of waste produced internally may be borderline and other external feedstocks would need to be sourced.

As an adjunct to the recovery of energy and water from an anaerobic digestion process is the recovery of nutrients from the digestate. This is a valuable resource estimated by University Queensland, Advanced Water Group, to have a similar monetary value as the energy recovered. A large horticultural market (banana growing) very close by RCA may be a significant market for the recovered nutrients

Most importantly of all, company management is prepared to embrace new economically viable approaches to energy and nutrient recovery along with a pro-active environmental stance. If proceeded with the outcome, it will demonstrate a benefit RCA and the red meat industry at large.

Bearing in mind the readily available sources of biomass, high energy prices and potential markets for nutrients and energy recovered, a logical choice seemed to reflect that a free standing, profit orientated waste to energy facility utilising abattoir and external feedstocks could be justifiable.

2 Project objectives

2.1 To identify the parameters for potential energy and nutrient recovery

To identify the technology requirement for a project to succeed

To establish capital requirements and subsequent sources of funds for a standalone facility

To establish a business model for the construction and operation of a standalone waste to energy facility

2.1.1 The desired outcomes of the above are to:-

To replace current sources of energy with a sustainable and renewable supply,

Reduce energy costs and increase bottom line profits for RCA,

Generate additional cash positive income for RCA and a future stand alone facility,

Extended environmental benefits,

Regulatory compliance.

2.1.2 In addressing the challengers the immediate focus areas were

Current and projected energy costs

The nature of available feedstocks

Integration of feedstocks and appropriate engineering

Promotion and reinforcement of community benefits

2.2 Current Situation

Rocky Creek Abattoir is situated approximately 1½hours drive North West of Cairns, north of Tolga between Atherton and Mareeba. To the east of the abattoir significant areas of bananas are grown.

2.2.1 Annual production

Beef – 3,195,215 kg HSCW

Pork - 761,246 "

Veal - 34,468 "

Goats - 1,474 "

2.2.2 Annual energy cost

Electricity $156,000 @ $200.00 MWh. Supply is regularly interrupted

Black oil $400,000 black oil (used engine oil) 1,800 litres per day, is transported from Brisbane and used as boiler fuel to produce hot water and steam for the abattoir and rendering plant. Apart from the cost of the oil on-road truck time (emissions) from Brisbane should also be considered. Black oil has a tendency to "creep" if spilt, is difficult to clean-up and quickly creates an unpleasant and dangerous work environment.

2.2.3 Abattoir water use

Water for the abattoir is extracted from a bore located on the premises. The bore is metered approximately 130kl/day

- Discharge via a central pit - 86,000 litres/day average over 7 working days. During the test period including weekend's heavy rain was experienced recording flows of up to 97,000 litres per day recorded. The difference between water extracted from the bore and measured discharge is attributed largely to staff showers, toilets, domestic use and stock watering.

- Blood and paunch. Spread on paddocks approximately 48 tonnes per week (4 days)
- Wash water from rendering, abattoir and yards 86,000 litres per day

2.2.4 Collection points

Blood and washwater from killing floor.

Rendering floor wash water including water separated from tallow

Rain and yard water

Waste water including faeces, spilt tallow, blood etc is collected from the above collection points and transferred (gravity) to the central collection pit. From the collection pit the mixed waste is pumped to lagoon 1 – a rise estimated at 4 metres.

2.2.5 Existing Waste Treatment Process

Effluent from the rendering plant, abattoir and yards collected at the central pit is pumped to lagoon 1 from where it progresses to lagoons 2 and 3 before final irrigation to paddock.

Bulk blood and paunch material is collected in a tractor drawn tanker and subsequently spread to paddock. Approximately 2,400 tonnes are dispersed annually in this manner.

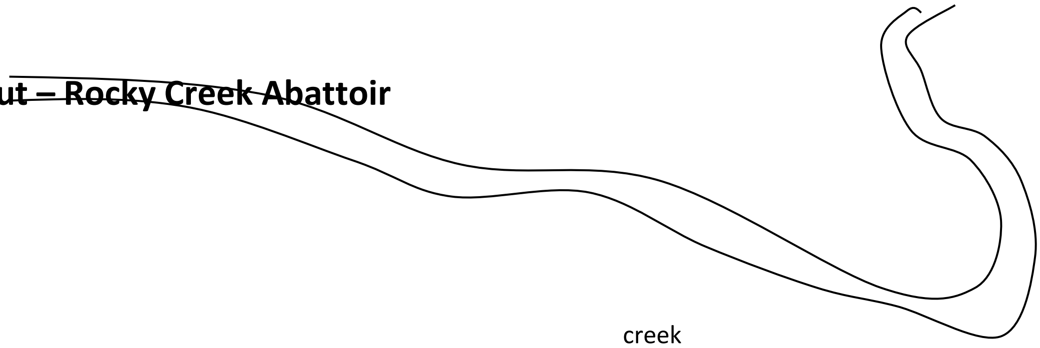
Lagoon 1 is heavily overgrown which reduces fugitive odours however it is more than likely that a build-up of bottom sludge will require excavation.

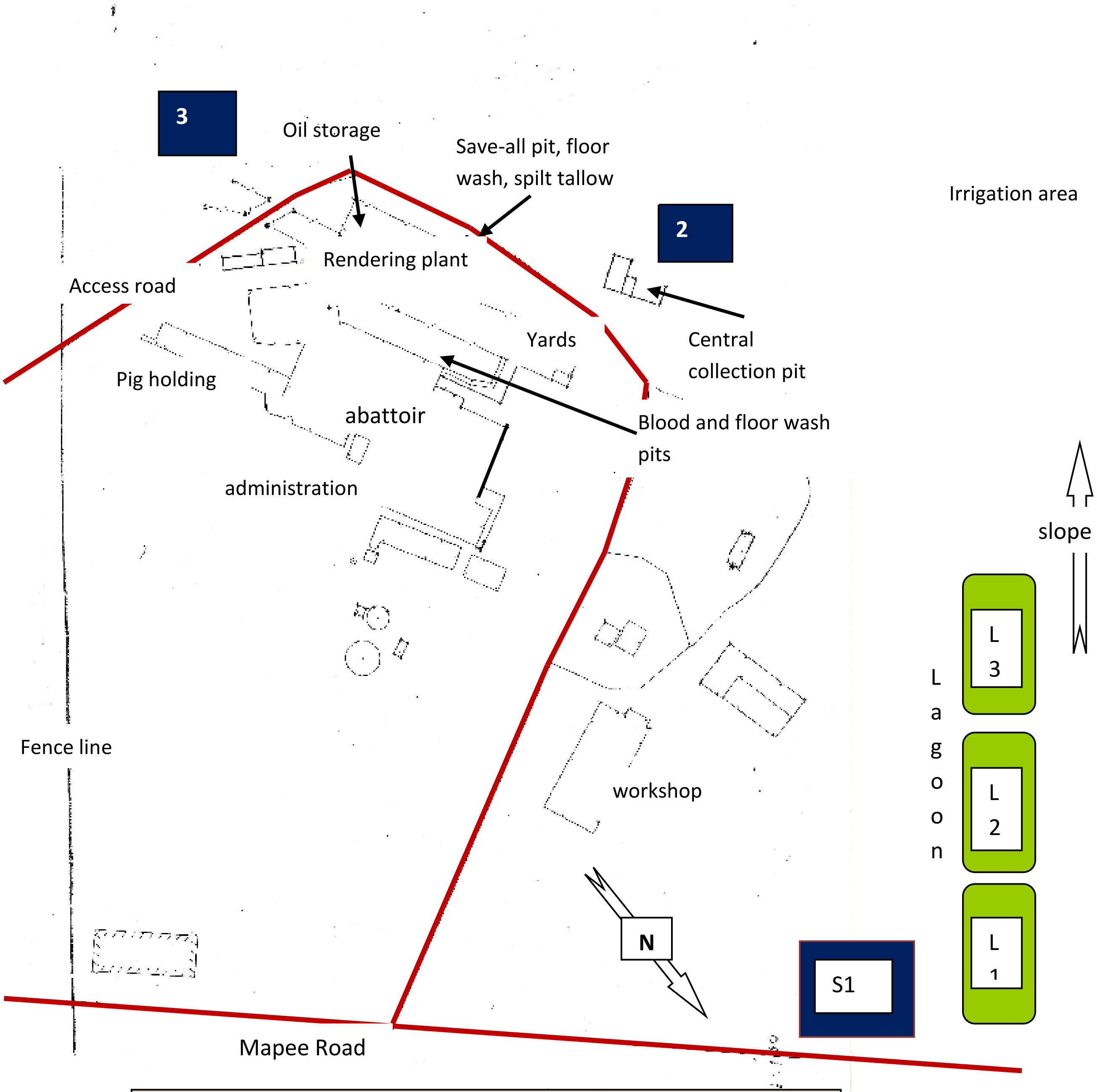
Lagoon 2 only partially overgrown but excessive generation and release of fugitive biogas is clearly evident.

Lagoon 3 not a lot of gas evident – excess water irrigated to pasture from this lagoon.

Schematic 1

Site layout – Rocky Creek Abattoir





Site schematic including potential facility sites S1, S2, S3

2.3 Environmental concerns

Quality of discharge water from save-all to lagoons. The three-lagoon based system of waste water management is emitting large quantities of unregulated methane into the atmosphere. Unless covered or alternative action taken this has the potential to become a legal liability apart from the costs of de-sludging and installing covers. By reducing or eliminating the production of unregulated methane the chances of success in acquiring a Government grant through the Food and Foundries program is enhanced.

Emissions to atmosphere – land spreading organic matter. The practise of spreading blood and paunch material to land has a very limited future because of the risk of contamination to local waterways. Furthermore, a build-up of organic matter in the soil may create anaerobic conditions and eventual methane production. The practise also causes deterioration in soil structure and future productivity.

2.4 Resource recovery

Nutrients for re-use. The process of anaerobic digestion will facilitate the recovery of valuable nutrients NPK as a by-product. These nutrients are in a soluble form and readily taken-up by plants thus reducing volatisation and leaching issues. They are saleable item and good cash flow generator. The quality of phosphate rock currently imported into Australia is reportedly of a low standard and becoming very expensive therefore the opportunity to capitalise is valid.

2.5 Emissions

Current level of emissions generated from energy usage at the site (chart 1). Emissions from the lagoons and disposal of organic matter to land have been identified but not included in calculations.

current emissions/cost snapshot				
Energy consumption pa		**CO2 emissions***	**Current cost** **Jan - December 2011**	emissions not accounted
electricity	771,908 kWh	686,998 kg/CO2	$156,000	transmission loss approx 10%
Diesel	77,507 litres			plus truck time/emissions cartage from BNE
Fuel oil	290,677 litres	1,309,204 kg CO2	$400,000	plus truck time/emissions cartage from BNE
CO2 emissions =		1,996,202 kg CO2 pa	$556,000	plus fugitive emissions from lagoons

(Chart 1) energy consumption and costs as given

As the above chart demonstrates, the operation of the Rocky Creek Abattoir directly generates almost 2,000 tonnes of CO^2 per annum plus indirect generation through transport and fugitive lagoon emissions.

2.6 Opportunity

The opportunity is to establish a standalone business capitalising on readily available onsite and local biomass as a feedstock to produce energy and nutrients. The opportunity exists because the abattoir has a need to legally and responsibly treat process waste thus creating a floor to any future development. The investment required to meet acceptable waste management practises will almost by default create an environment where for relatively little additional capital the value of the business will be enhanced and a new revenue stream created. This is unique.

However, and in recognition of the additional work load created such as sourcing external feedstock and the willingness of third parties to become involved a new standalone business is an obvious path to follow.

Parameters and goals established and community support fostered as the business will bring other business to the area creating employment.

Abattoirs produce a lot of waste which in some instances can be difficult to treat. On the other side of the coin however it is high in energy and with the correct technology this energy can be recovered. All waste streams are different in one way or another and Rocky Creek Abattoir is no exception

Chart 2 demonstrates future emissions reductions by utilising biogas to replace fossil fuels

Proposed facility emissions estimation				
Energy consumption		**CO2 emissions**		**stage 1 year 1**
electricity	771,908 kwh	13,423	(based onMTU Detroit specs)	
diesel	nil			
fuel oil	nil	almost nil CO2 emissions as carbon is		
biogas	300,890m³	derived from renewable resources		
total CO2 emissions from site		13,423kgCO2e	0.067% of current practise	

(chart 2) Emisions as calculated by Aust Greenhouse Office

COD calculation/biogas potential RCA

		COD mg/l	volume L/pa	COD load kg/pa	biogas potential m^3/pa
COD	cattle	291,000	169,346	49,280	17,248
blood	pigs	291,000	31,443	9,150	3,202
	vealers	291,000	2,798	814	285
sub-total			**203,587**	**59,244**	**20,735**
COD	cattle	97,000	575,782	55,850	19,548
paunch	pig	67,000	42,762	12,251	1112.9
	goats	67,000	237	15.88	5.6
	vealers	97,000	12,720	1,234	432
sub total			**631,501**	**69,351**	**21,099**
COD blood & paunch			**835,088**	**128,595**	**41,834**
Abattoir Waste water		8,000	25,872,000	165,120	206,976
FOG		31,000	4,800,000	148,800	52,080
Annual volume			**31,507,088**	**442,515**	**300,890**
				total biogas potential m^3/pa	**300,890**

Chart 3 identifies the potential for biogas production by source and volume – eg. blood, fat, &comparative value

(Source of chart 3: COD and volumes. RA Brooks P/L))

Notes to above chart

- The COD of blood (all species) Dr Ron Brooks
- Paunch refers to paunch and stomach contents less cellulose from cattle
- Abattoir waste water is site specific
- FOG site specific largely due to tallow washing
- Volume is calculated at 13.65 litres/head cattle x 12,517 head, 2.5 litres/head pigs x 12577 head, vealers and goats 2.2 litres head x 1351 head combined.

- COD removal is expected to be 90 - 95% This figure although high is quite acceptable due to the pre-treatment process and the elevated reactor temperature 40 - 45°C resulting in superior digestion of fats and oils.
- Accepted gross calorific (GCV) value biogas = 28.9MJ/m³ x 300,890m³ = 8,695,721 MJ
- In a report prepared by GHD (December 2003) on behalf of MLA" waste solids processing with energy capture technologies" the GCV of biogas is calculated at 38.8MJ/m³ x 300,890m³ = 11,674,532MJ
- Current annual consumption is 12,714,240MJ pa.
- As the CH4 of the biogas will be around 70% AR have used the higher GCV of 38.8MJ/m³
- (1400l fuel oil burn/day x 0.86 SG = 1204 kg x 44MJ/kg x 240 working days)

2.7 Imported feedstock

In addition to feedstock (waste) produced on-site there is potential to accept suitable material from local external sources, for a gate fee. Products include:

- Dewatered grease trap waste approx. 25 tonnes per week. This material being predominately fat and oil is high in energy (>1,000m³ biogas/ tonne of feedstock)
- Dairy waste, chocolate production waste,
- Energy crops. Potatoes for example will yield 18,000m³ CH4 /ha. The net energy input is 24.2 GJ/ha to yield 349GJ/ha (Data from Cropgen 2011 Murphy and Power 2011)
- Rapidly growing grass is an excellent source of energy and in some cases five harvests per year are possible.
- Approximately 12% of the banana crop is waste and being very high in sugars an excellent source of energy.

2.8 Other income

Considerable opportunity exists for recovered nutrients. The banana industry alone on the Tablelands covers close to 1,000 hectares and on average is fertilised with Nitrogen at a rate between 100 and 200 kg/hectare/annum at an average price equivalent to $1,522 per tonne of N. Leachate of nutrients in the region is a major issue due to the granitic nature of the soil.

The average price of P used for this study is $5.00 per kg and N is $1.40 per kg which is a combined value of $6,000 per tonne or 4 days production at RCA. These are indicative numbers and will need to be confirmed by sampling from actual production.[1]

A distinct advantage of recovered nutrients is that they have been solubilised by the digestion process making them readily absorbed by plants. This means a lower application rate for the same results as chemical fertilisers and without the issues of leaching or volatilisation. (A large pig producer (20,000 sows) in Victoria grows 70% of his feed on-farm utilising digestate and has no need for chemical fertilisers to grow very healthy crops) [2]

Historically concentrations of nitrogen (N) from abattoir waste water are in the order of 260mg/l. This equates to 195kg/N day at RCA from cattle alone. Figure 3 page 3 “Managing Crop Nutrition in Bananas, Daniels & Armour” “Plant crop bunch weight vs nitrogen application rate” indicates an application rate of 100kgN/ha is required to produce a banana bunch weight of 24kg. Therefore, and bearing in mind that because the N from the digestate is solubilised and will not be lost through leaching and volatilisation 30 kg@ 100kg/ha N will provide the same results.. Although this discussion revolves around a horticultural crop, similar benefits will be derived from pasture grass, energy crops etc.

Some basic work in terms of application rates, analysis, delivered costs etc. will need to be undertaken however the technology is accepted in Europe for both horticultural and pasture crops,

Nutrient recovery will minimise downstream removal costs.

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[1] Based on a farm gate cost of $600/tonne for urea, 46%N the actual cost of the nitrogen is 600 ÷ 0.46% = $1,304.00/tonne

[2] Rule of thumb calculation for nitrogen loss is ⅓ volatilisation, ⅓leaching and ⅓ taken-up by the plants

Phosphorous concentration is 60mg/l giving a daily yield of 45kg/P day. Two methods for recovery are available. 1) if Struvite technology is used –.[3] where the process water from the reactor is bubbled through a slightly alkaline solution causing phosphorous crystals to grow and sink to the bottom of the vessel for harvesting. (a Struvite collection system is being constructed to confirm the recovery of this product from the process water on the Active Research pilot plant utilising MHl as the catalyst).

Alternatively and probably more effective in an abattoir environment is the recovery of P from fibrous material in the digestate as a dry solid. Experience at the Berrybank piggery (near Ballarat Vic) over an extended period with the use of a screw press has shown 100% recovery. The advantage of this form of recovery is that it is a "dry" product capable of storage, relatively low transportation costs compared to liquids and easy to spread. The liquor from the press may be returned to head of works or alternatively stabilised and stored awaiting use. The world has almost reached peak phosphorous production; quality is deteriorating in remaining stocks and the price of chemical fertilisers rising accordingly.

The graph below, from a report prepared by Global Environment Corporation Pty Ltd "Total Waste Management System for the Pig Industry" underlines the removal of P results in a commercial environment.

	Volume (m3)	BOD5 (mg/L)	TDS (mg/L)	TKN (mg/L)	Total P (mg/L)	SS (mg/L)	pH
Primary Effluent	340	6000	8000	1520	150	7200	
After HDAF	196	1800	1600	860	27	170	
After Digesters	124	700		7301	-----		7.7
After Dewatering	10	1000					7.8
After Irrigation[2]		270	360	160		170	

Note:

- All above values as milligrams per litre, volume as m3.
- 1. By calculation from nitrogen removal in sludge.
- 2. By calculation from assumed 80% BOD5 & TKN reduction, 70% TDS reduction during irrigation.

[3] Extrapolated on a per head basis as concentration will vary according to waste water dilution

3 Technology Selection

3.1 Background

A hierarchical approach to technology selection was adopted giving first priority to the waste stream generated by the abattoir followed by potential imported material. As could be expected the stream is highly varied from low strength wash water to paunch material (high cellulose content) and fats. Given this variation it is not unreasonable to expect selected external feedstocks to fit into the system relatively easily.

Within the above framework the planned system must first and foremost cater for the abattoirs' energy requirements and therefore to determine the demand evidence of existing energy usage including power bills and purchases of fuel oil was collected. Secondly sources of waste i.e. killing floor, tallow washing and so on was identified and sampled for COD as a starting point so as to match demand with supply. (please refer to site schematic)

The hardware must be capable of receiving, pre-treating, digesting and post digestion demands such as water for re-use and nutrient recovery.

The plant will need to be relatively maintenance free, require minimal management time and be capable of being remotely monitored. Energy needs to operate the plant will need to be parasitic to minimise operating costs and as short hydraulic retention time as possible to minimise footprint and capital cost.

Operating a digester to maximum efficiency has been described as essentially a farming project. in that livestock – microbes are involved. By providing the microbes with the best environment possible including food, warmth and movement they will work very hard. Whatever happens within the system absolute care must be taken to avoid conditions which may adversely affect the microbial population.

The reactor or digester is essentially the heart of the process. To maximise efficiency include minimum hydraulic retention time within the reactor the following technology is utilised:-

- Prepared substrate is pumped into the bottom of the heated vessel where it is constantly mixed with existing material by means of a mechanical mixer mounted within the bottom cone of the reactor. The mixing process can be constant or timed.
- A heat exchange is situated within the lower section of the vessel.

- To prevent wash-out of the microbes due to pump speed, an attached polythene web known as fixed film provides the microbes with an anchor point,
- Floating in-organic material, for example small pieces of plastic are collected within the top of the reactor and discharged,
- High rate refers to the speed of digestion.

3.2 Description of technology

The principle technology to be utilised is In-Vessel High Rate Fixed Film Anaerobic Digestion assisted with ultra sound for cell lysis, which results in increased gas yield (refer to 3.2.1 Sonication). An elevated operating temperature of 40 - 45º C and controlled agitation to ensure organic matter is readily available to the microbes and eliminates blockages where fats and oils are involved. The overall technology includes a pre and post -treatment phases.

3.2.1 Sonication

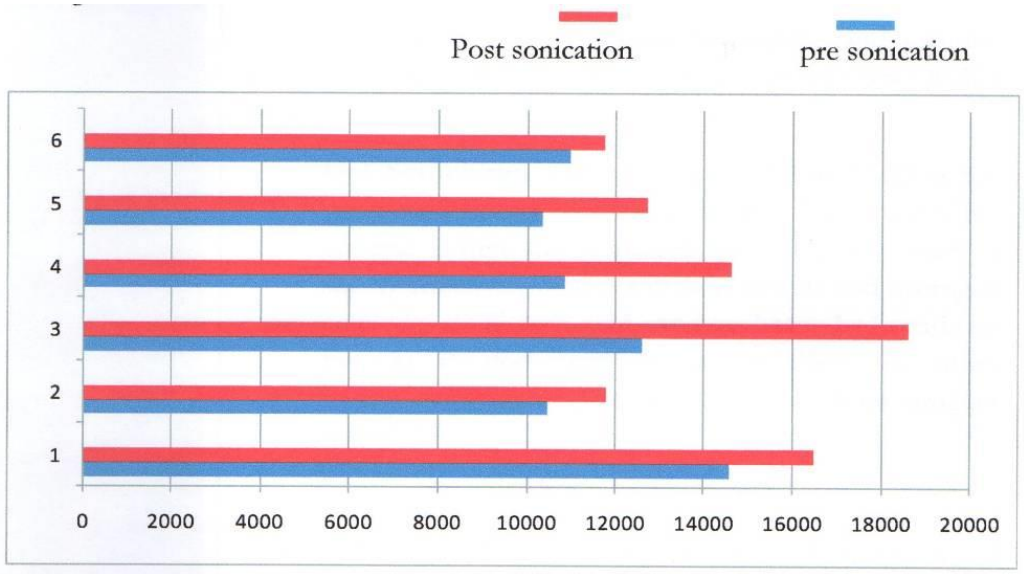
The function of the ultrasound unit (sonication) is to destroy the cell structures such as cellulose to facilitate digestion. Ultrasound or sonication involves the transmission of radio waves at 20Khz.and forms an important role in the production chain. When organic matter is exposed to ultrasound the effect is to crack open cell structures allowing immediate access y the microbes to the contents. This helps reduce hydraulic retention time, reduce bottom digestate and importantly causes very small organic matter to remain in suspension for extended times. Digestion is faster and gas production increased.

When radio waves are transmitted through the feedstock an acoustic pressure is built up causing cell structures to implode and finally explode violently thereby releasing the contents of the cells facilitating immediate access to the contents by the microbes. This results in faster digestion and additional gas recovery.

Paunch material pre-sonication

The same paunch material post sonication has largely settled to the bottom of the vessel 1 hour after processing.

Above, the effect sonication on underflow from a DAF unit at a rendering plant in Melbourne. Work was undertaken by Active Research January 2009



Graph. COD improvement with sonication COD mg/l

influent pre treat	14570	10480	12610	10850	10350	10950		Average 11,635
influent post treat	16460	11790	18620	14600	12720	11740		Average14,321
	19-11	20-11	21-11	24-11	25-11	26-11		Average increase 23%

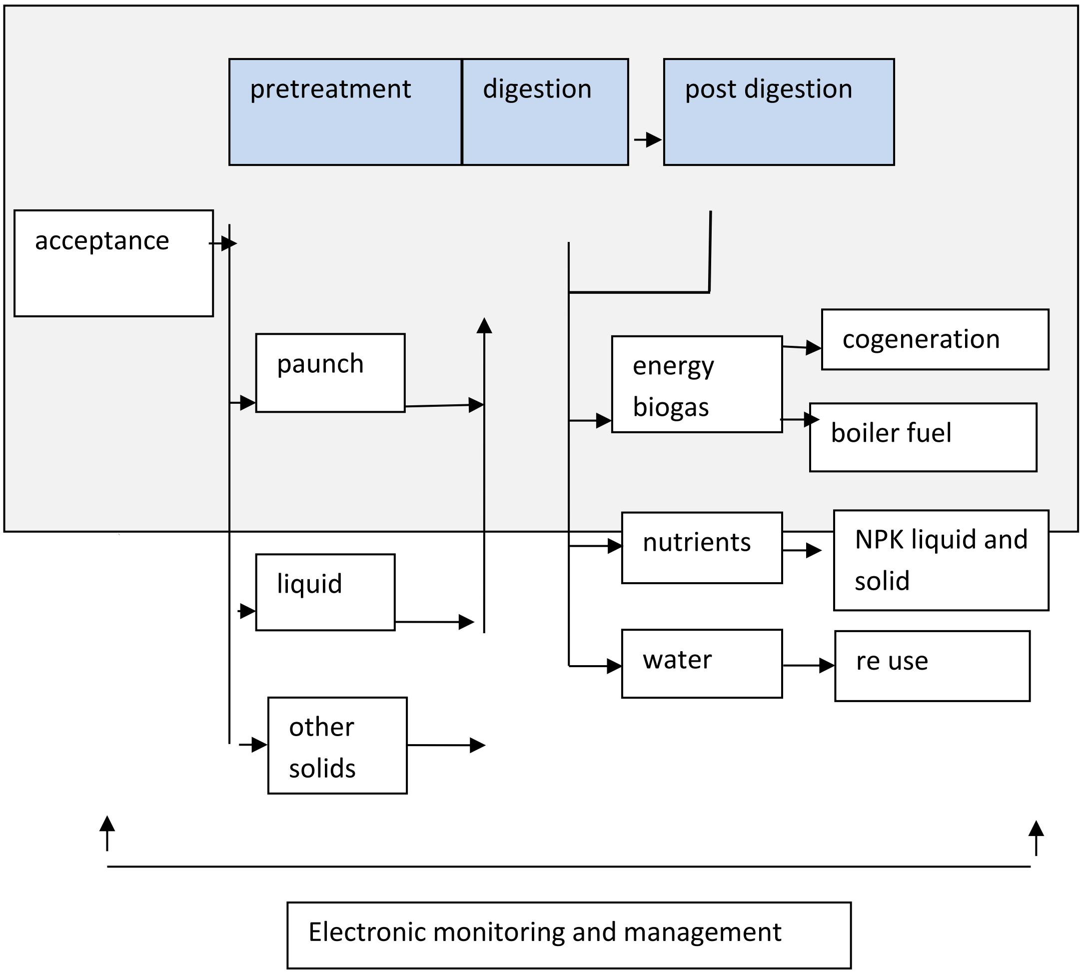
Table 3 Sonication effect on COD analysis.

3.3 Process

The process falls into three distinct zones, pre-treatment of the feedstock, digestion and post digestion.

Schematic 1 below indicates the three phases, pre-treatment, digestion and post digestion for the recovery of energy, nutrients and water from organic matter.

(Schematic 2) Overview of process



Schematic 2 provides a view of the process from acceptance of the untreated biomass to the end product.

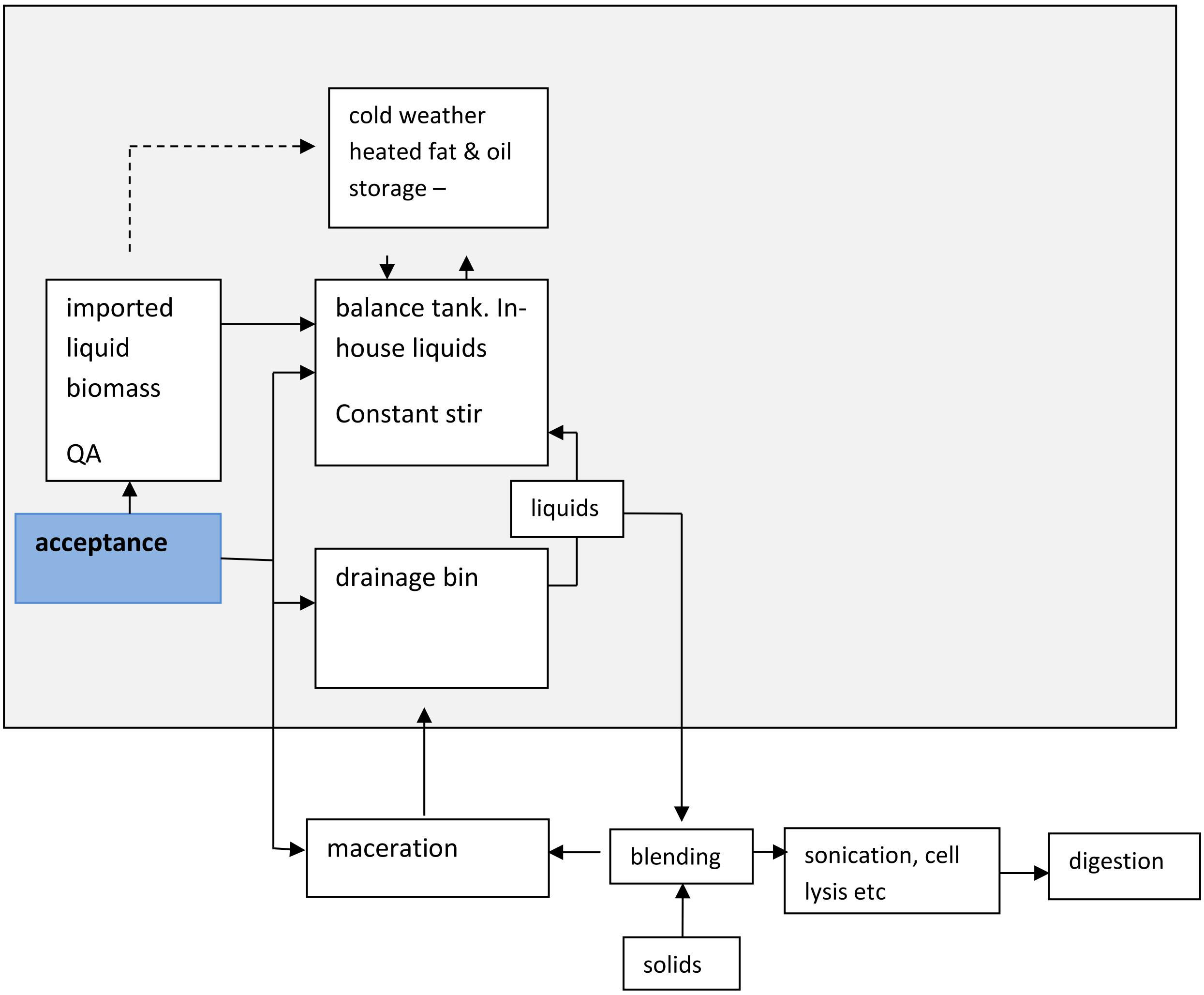
It is an advantage to have all items of equipment on legs or stands and off the floor as this provides for easier wash down and cleaning thus reducing opportunity for build-up of organic waste and odours.

3.3.1 Pre-treatment

This is a very important function as it prepares the feedstock in a way which makes the sugars, carbohydrates, lipids and proteins easily accessible by the microbes and minimisation of digestion time. Feedstock may be liquid or lumpy and contain fat, cellulose and solid vegetable pieces.

Imported biomass, particularly liquids must be isolated on receipt and checked for problems such as the inclusion of motor oils or disinfectants which may create a problem in the reactor – at worst kill the microbial population or jam/break mechanical parts such as impellers on pumps

Schematic 3 Pre-treatment



As fat will be involved there is a likelihood of it solidifying in cold weather experienced on the Tablelands. Solidified fat was observed in the save-all pit thereby causing pumping problems and a deterioration of the product. Some form of parasitic heating may be required.

The faster the feedstock, i.e. solids and imported material can be pre-treated and transferred to the balance tank the less the likelihood of odour creation.

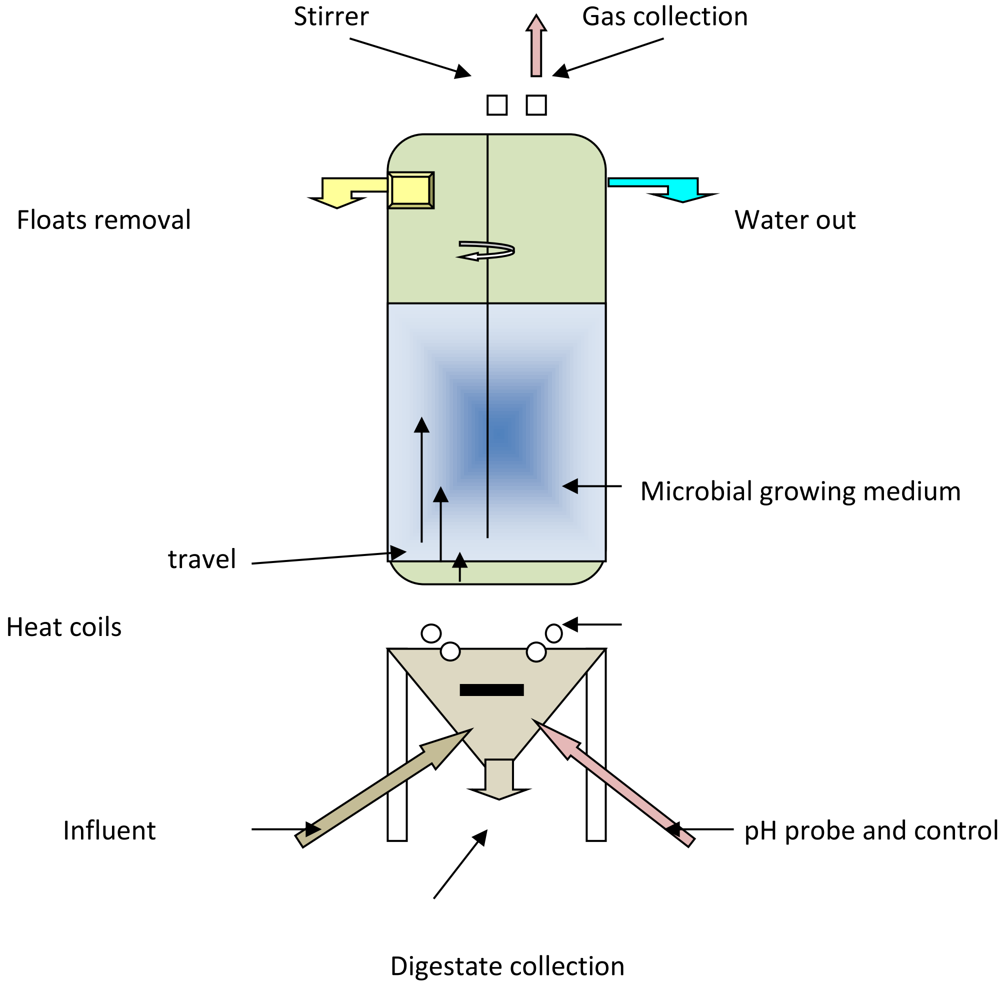
Where substrate received is a mix of liquids and solids – say undigested cellulose from paunch, it is advisable to separate the liquid fraction and send it, the liquids, straight to the balance tank

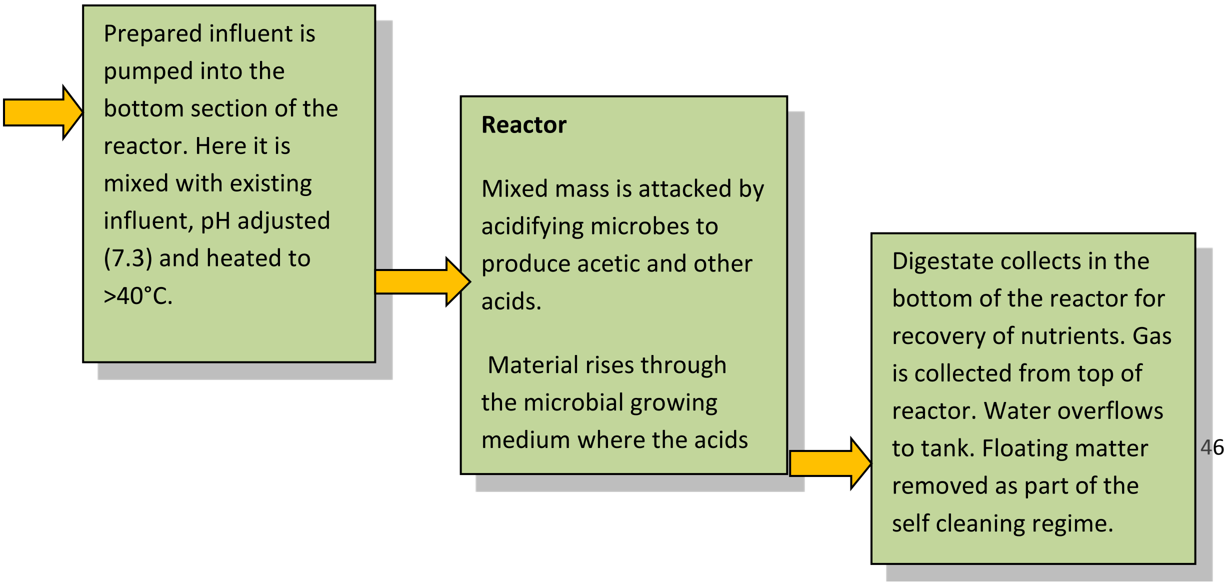
Sonication will crack open cellular structures increasing gas production and reducing digestion time (HRT). . In addition to reducing the particle size, the particles will remain in suspension for extended periods up to 24 hours also assisting digestion.

3.3.2 Digestion phase

(Schematic 4) Typical cross section of a reactor designed by Active research.

Reactor Schematic





3.3.3 Post digestion

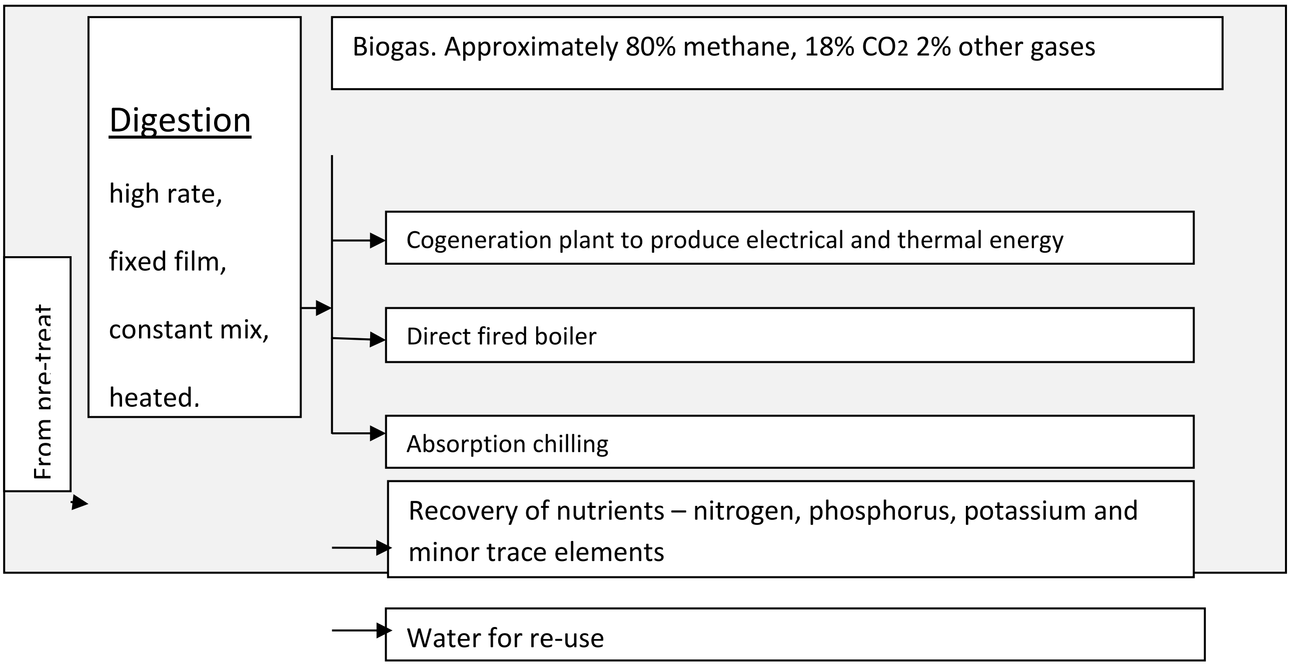
Biogas recovery

The biogas collected at the top of the reactor will be a wet gas because of the reactor temperature. After leaving the reactor it will be chilled to condense the water which is normally returned to head of works. Hydrogen sulphide may need to be removed if concentration level is regarded as in excess of final use specifications. The gas can then be stored before re-use as boiler fuel or to power a co-generation plant.

3.3.4 Nutrients

Nutrients recovered from the bottom of the reactor will be passed through a screw press to produce a dry spreadable product capable of storage. Substrate from the screw press will be returned to head of works. Liquid phase from the top of the reactor (process water) may be stored as a liquid for future agriculture applications or further treated to other use standards.

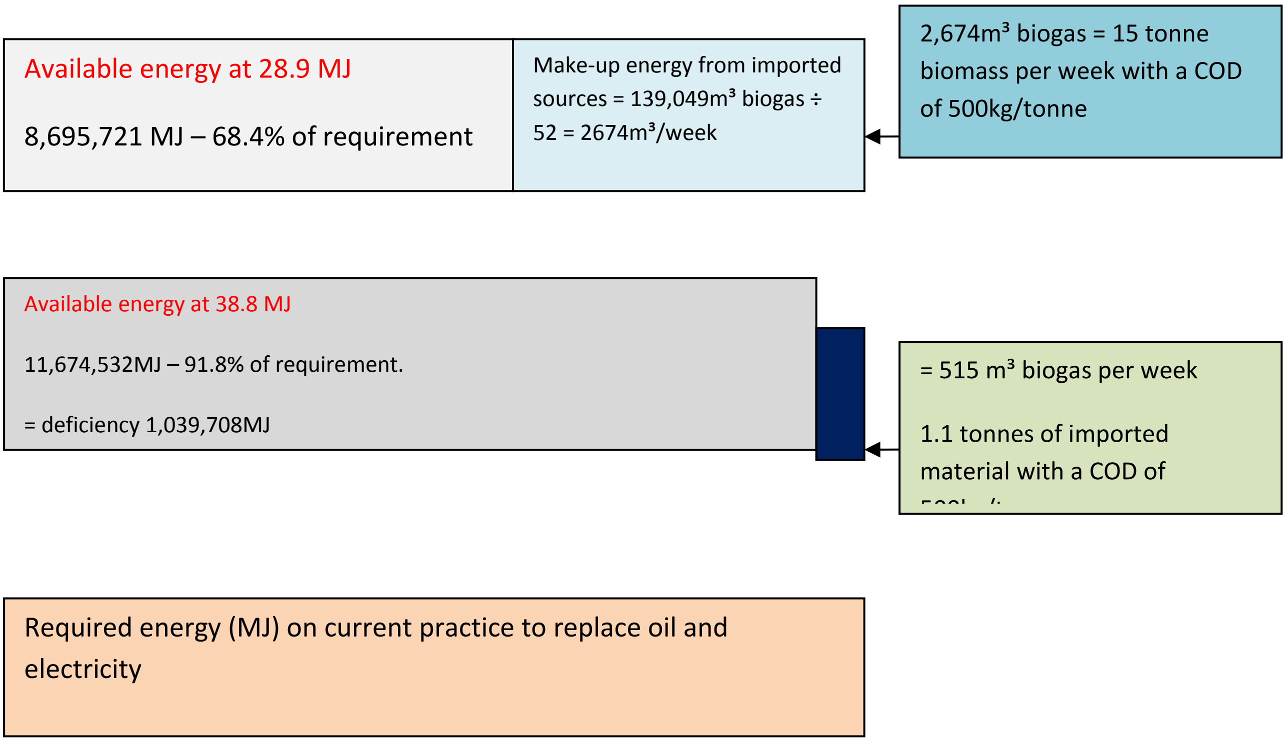
Schematic 5 Post digestion



Final specifications for the co-generation plant/boiler/chillers will need to be assessed as actual needs are determined.

3.3.4 Energy recovery/usage.

The available biogas recovered may vary according to feedstock and for that purpose the following chart is devised as an indication of the likely volume of external feedstock required if there is insufficient for self-sufficiency by RCA.



Based on the above graph the worst case for self-sufficiency is biogas with a GCV of 28.9MJm³. It is expected the Active Research technology will produce biogas with a CH4 value around 80% making the second example, 38.8MJ/³ most likely. Plant efficiencies achieved may remove the need for imported feedstock or alternatively the cogeneration plant supplies power to the abattoir during times of peak demand when energy costs are at their highest and low cost off-peak is purchased at other times. 66% of the energy used by the abattoir is for refrigeration.

The variable calorific value is attributed to the % of fats and oils in the feedstock.

Gas produced will be stored and used as required. It is usual for gas to be monitored and flared during early phase commissioning to provide site specific flow rates, gas analysis and GCV information.

This being the case, it is reasonable to design the facility in such a way that stage 1 caters for the needs of RCA exclusively and once this is operating at maximum efficiency a second reactor and co-generation plant be added to produce electricity to sell into the grid – stage 2. This is an economical way to proceed as plumbing changes are minor, the electronics, management systems, pre-treatment hardware and so on will allow for expansion and therefore remain untouched. An energy audit will be required to better understand peak loadings and determine best suited engine(s) capacity. A secondary benefit is that should there be problem at start-up, the fewer the differing feed stocks the easier it is to isolate issues.

An alternative to converting the existing oil fired boilers to gas or even replacing them is to use the heat generated by the cogeneration plant to produce steam. The exhaust temperature of a largish cogenerator is around 850°C and allowing for some parasitic energy to keep the engine warm conversion efficiency is still around 90% (electrical and thermal)

The commencement of stage 2 will depend on a number of parameters including commissioning of stage 1 and the hydraulic loading rate achieved. The plant is designed around a loading rate of 10 - 12 kg/m^3 however 19kg/m^3 may be possible. This means that additional feedstock may be imported and converted into saleable products without the need for a second reactor.

In a situation such as RCA two smaller cogeneration plants rather than one large one will provide peace of mind in terms of continuous supply during servicing requirements and unexpected breakdowns.

3.2.6 Cost and benefit

Although indicative the price is realistic based on current information including equipment supplier budget pricing, an estimate of capital cost is $1,300,000 against current energy costs of $556,000 and with other income it is anticipated the investment will be recovered in 2.4 years. Additional income through gate fees, nutrient sales and REC's of $238,800 the return on investment will be further enhanced.

Indicative capital cost comprises

Receiving and pre-treatment eqpt.	75,000
Digestion system, pumps plumbing.	780,000
Discharge incl. nutrient recovery	78,510
Sundry items	20,000
Instrumentation	42,000
Design	58,100
Installation and commissioning	74,320
Technology transfer	196,400
Total	**$1,324,330**

With the possible assistance of the Food and Foundries program (50%) and Clean Energy Futures the capital investment by shareholders in the facility will be minimal. It is not unreasonable that at the expiration of two years the facility will effectively be generating energy essentially free of charge to RCA together with a positive cash flow from nutrient and energy sales.

The Australian Energy Market Commission (AEM) 2013-2014 report forecasts electricity price increases in Queensland of up to 42% in nominal terms 2013-2014. The report is flagging a potential retail price increase in Queensland for electricity of 6.67 c/kWh which if extrapolated to RCA (%) represents an increase of $65,520 from $156,000 calendar year 2011 to $221,520 2013-2014 - an increase of $16.42 per tonne of HSCW.

Energy cost savings:

Nil importation of energy – savings based on Year 2011 expenditure		556,000
Renewable energy credits at $40.00 MWh x 772 hours		30,800
Nutrients	excluding own use, estimated sales	200,000
Gate fees	say 10 tonne per week at start-up x $60/tonne x 50 weeks	30,000

The capital cost has been calculated using schematics 2,3,5 as a reference point to identify specific items of equipment to perform required tasks – for example pumps, macerator, ultrasound, plumbing, telemetry, electrical, instrumentation, reactor(s), other vessels, materials handling, forecast cost of engineering specifications, expected regulatory approvals, contingencies, construction time (20 weeks) OH&S certification, insurances, transport and so on.

Running costs will be in the order of 1¢ per kWh energy produced - $11,400 pa in this case plus one man's wages. (The provision for R&M of a reciprocating engine to generate electricity is 4¢ /kWh) The projected R&M for this study is slightly above that for a high use engineering facility of 1/16th capital cost over 10m years.

Above only outlines cost, what are the benefits and the value associated to that for RCA? How much can they save/recover/produce etc on a weekly/yearly basis?

Projected operating costs at today's prices of the projected facility are:-

(R& M over 20 years @ 12.5% of capital cost) $1,300,000 x 12.5% = $162,500 ÷ 20 years = $8,125 PA (say $10,000)

Energy (parasitic) 15% of production (foregone sales) $556,000 x 15% = $83,400

Wages and on-costs, 1 man full time @ $100,000pa + 30% = $130,000

Motor vehicle costs	$20,000pa
Rates and charges	$13,000pa
Travel	$25,000pa
Legal	$15,000pa
Administration	$35,000pa
Unforseen	$20,000pa

Estimated running costs ... $349,525 pa

Projected income

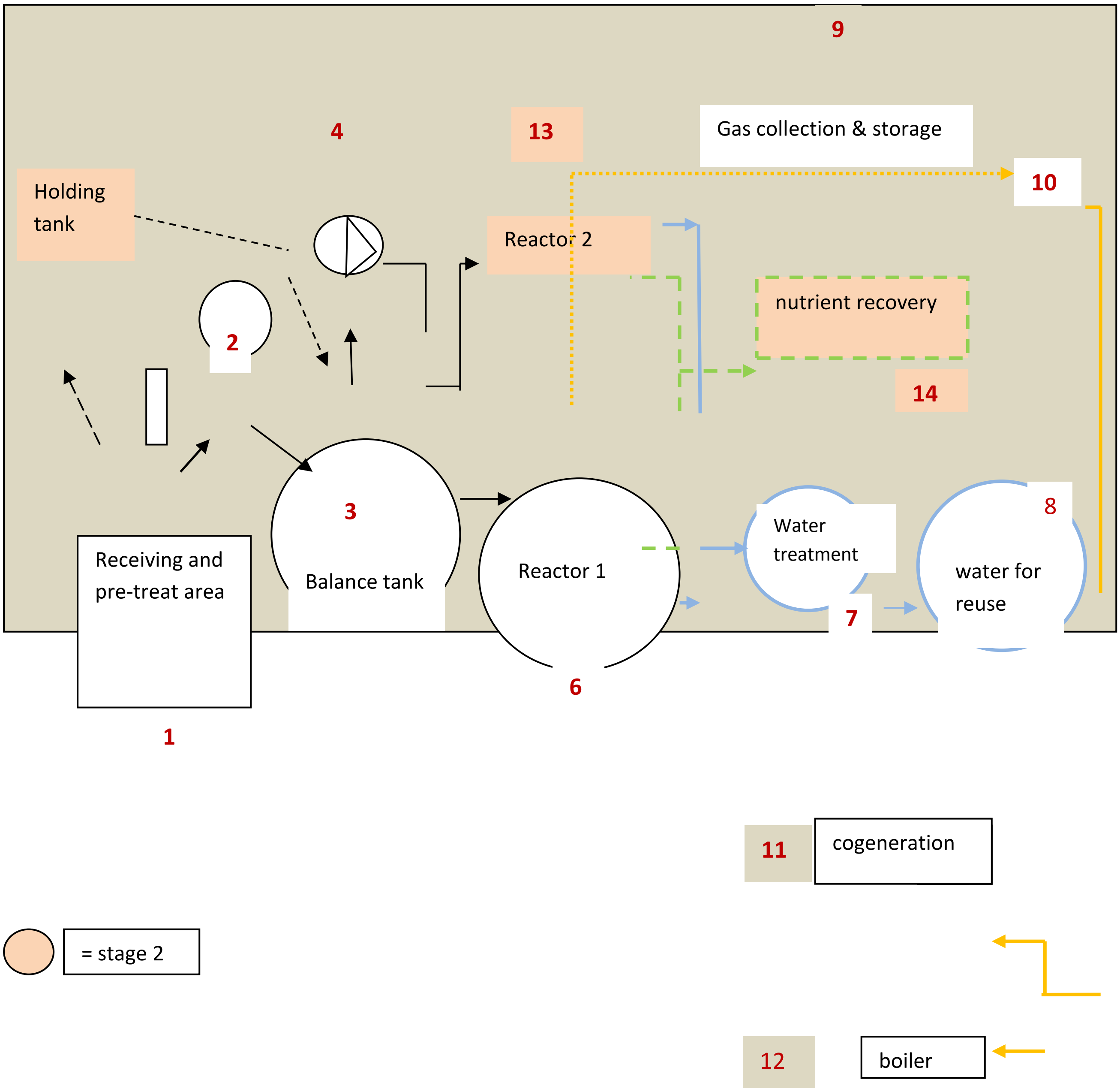
Sales to RCA energy	$472,600
Nutrients	200,000
Renewable Energy Credits	30,800
Gate fees	30,000
Total	**$733.400**

3.4 Location

This schematic looks at a potential layout plan for the facility on the plan and considered:

- Proximity to point of generation of feedstock and where the recovered energy and water will be utilised – the bulk.
- Gravity feed of liquids – the bulk, to the receiving area
- Supervision and security
- Current infrastructure
- Ease of access for equipment servicing
- Site 1 on plan. Has an advantage for delivery of imported feedstock combined with separation of visitors from the abattoir however pumping material up the hill and then sending treated water, electricity and gas down the hill for re-use is a cost.
- The lagoons are not suitable as an alternative to the balance tank,
- The existing pipe infrastructure to the dam will be maintained to allow for material to be transferred to the lagoons as a back-up in case of a major breakdown.

Schematic 6   Facility layout



1	receiving and pre-treat, includes bin for solids, macerator and pumps
2	ultrasound
3	balance tank
4	balance tank
5	transfer pump to reactor
6	holding tank for imported liquids
7	reactor – heated, fixed film, constant mix
8	optional water treatment equipment depending on final use of water
9	water for re-use storage
10	gas collection and
11	gas storage
12	cogeneration
13	boiler
14	additional reactor stage 2
15	nutrient recovery stage 2

4 Results and discussion

The commissioning of the facility will bring many benefits to RCA due in part to cleaner production. For example, black oil tends to creep if spilt and is difficult to clean-up which apart from the aesthetics creates a potential for slipping injuries and cross contamination of other products such as tallow. Decommissioning the oil fired boilers and converting to biogas removes the above risk.

Productivity will be enhanced by providing a cleaner work environment and improved working conditions with the added benefit of reduced potential for rodent and insect infestation.

There is also potential for higher skills training for employees interested in the waste to energy process.

4.1 Existing lagoons

It is expected the existing lagoons will remain in-situ firstly to “burn-off” existing loading but more importantly could be utilised as a holding facility in case of emergency.

4.2 Biosecurity

Anaerobic digestion particularly when combined with ultra sound technology will provide added biosecurity particularly in relation to preventative action to minimise spread of pathogens and weed seeds when organic matter is spread to land. One of the features of ultrasound is the destruction of cell structures and experience within the waste water industry has confirmed that cryptosporidium and Guardia are destroyed with this technology. The discontinuation of spreading blood and paunch to land will dramatically reduce these risks and localised pollution to waterways

5 Conclusions and recommendations

5.1 Mixed feedstock

The study examined the available opportunities leading to the successful design, construction and operation of a cradle to grave energy and nutrient recovery facility utilising the waste stream from Rocky Creek Abattoir as a catalyst. The work is a convergence of a broad range of opportunities with the potential to be replicated at other locations.

It is acknowledged further work will be required to better understand for example the application of process digestate to horticultural and broad acre crops under tropical conditions. Contact has been made with the relevant personal at the Queensland DPI to consider a development program for this valuable resource.

The less water used at the abattoir the heavier the solids content of the substrate, the smaller the required capacity and therefore reduced capital cost. A water map including water movements and volume would be beneficial. For example to divert rainwater and maybe some of the very low strength wash water away from the facility would be advantageous.

The establishment of this waste to energy facility once commissioned should be widely publicised to the public in general. The outcomes expected are good news stories for the red meat industry, the local community and an inspiration to other generators of organic waste to think broadly about how they may improve their business. Wide spread publicity sponsored by the MLA and the operators is recommended.

One of the biggest hurdles in technology development is getting science into the hands of users. The establishment of a facility as outlined will open the door to other income streams such as nutrient, carbon dioxide and water recovery.

The successful operation will demonstrate a paradigm change in the way waste is managed over a wide canvass of opportunities.

Expected results clearly indicate the benefits – environmental, social and fiscal to recommend the establishment of a high rate anaerobic system at Rocky Creek and to that end discussions have been initiated between the three principle parties involved with this project to establish a greenfield facility.

During the course of this study three potential sites were considered and rated according to proximity to the source of feedstock (abattoir), logistics to relocate feedstock from point of generation to point of processing, vehicle and visitor movements, energy and nutrient exports and all weather 24 hour access. If the facility was for the exclusive use of the abattoir location 2 stood out however when the total concept is considered location 1 met all criteria.

5.2 Social and environmental benefits

The environmental benefits are obvious:- reduced fugitive gas emissions, reduced leaching of nutrients to waterways, reduced odours, reduced numbers of flies and rodents and in some situations reduced noise.

The social or community benefits will include reduced on-road truck time, fewer exhaust emissions and less wear and tear on roads. Less stress on existing poles and wires and so on.

Regulatory compliance problems are eliminated or significantly minimised

5.3 Facility development

Bearing in mind the management skills and time required to:-

- operate the abattoir,
- manage the waste to energy facility
- provide technological expertise
- co-ordinate outside feedstock as well as sales of energy and nutrients a consortium approach is considered the most likely to succeed and therefore an appropriate business model is being investigated.
- Expected capital cost is $1,300,000

Attachment 1 Current process

Existing central collection pit

Paunch and blood transport to paddock


Tallow mix, save-all, rendering area floor wash


Pump from central collection pit to lagoons
Project flow monitor


lagoon 1
Mapee Rd
Site 1
abattoir


Site 2

Appendix 2 Data collection

Cairns Regional COUNCIL
Water and Waste

Client: **Active Research Pty Ltd**

Project No: **058780**
Report ID: 752
Date Issued: **11-Apr-2012**
Page 2 of 2

LRN: 13172
Sample A
Date Sampled: 04-04-2012 1:00pm
Received at Lab: 04-04-2012 04:09pm

	Method	Analyte	Result	Date Started
	Physical Properties			
13175	Oil and Grease	Oil & Grease	160000 mg/L	05-04-2012

LRN: 13173
Sample B
Date Sampled: 04-04-2012 1:00pm
Received at Lab: 04-04-2012 04:09pm

	Method	Analyte	Result	Date Started
	General Chemistry			
13176	Chemical Oxygen Demand		57000 mg/L	05-04-2012

LRN: 13174
Sample C
Date Sampled: 04-04-2012 3:00pm
Received at Lab: 04-04-2012 04:09pm

Please Note:
Note that the nature of the sample is outside the scope for the COD method. Results are indicative only.

	Method	Analyte	Result	Date Started
	General Chemistry			
13177	Chemical Oxygen Demand		540000 mg/L	05-04-2012

Explanatory Notes for this Project

Responsibility for sampling lies with the CUSTOMER. Samples analysed as received.

Daily flow monitoring and lab reports

	Time of reading	No of Litres	usage during day (in lts)	usage during night (in ltrs)	HSCW (in Kg)
Saturday, 14 April 2012	1800	0			
Sunday, 15 April 2012					
Monday, 16 April 2012	0600	107800			
	1800	178796	70996		
Tuesday, 17 April 2012	0600	211611		32815	
	1800	344294	132683		
Wednesday, 18 April 2012	0600	367250		22956	
	1800	439185	71935		
Thursday, 19 April 2012	0600	458825		19640	
	1800	526568	67743		
Friday, 20 April 2012	0600	526719		151	
	1800	555864	29145		
Saturday, 21 April 2012	0600	558554		2690	
	1800				
Sunday, 22 April 2012	0600				
	1800				
Monday, 23 April 2012	0600	740496	181942		
	1800	841962	101466		
Tuesday, 24 April 2012	0600	843118		1156	

	1800	974030	130912		
Wednesday, 25 April 2012					
End of data Tuesday midnight		974177			
sub total of daily usage without week end			604880		
sub total of night usage and week ends				369150	
average per working day over 7 days recorded			86411		
average per 24 hours inc w/e and nights		97418			
from Monday 16 to Friday 27 hot standard carcase weight in kg					146521
average per day (/8)					18315
note fridays are non-killing days only boning occurs					
Figures for Monday 16th – Mon 23rd April					
Beef - 358 Head 92209.6 kg		92209.6			
Pork - 573 Head 35887.6 kg		35887.6			
Veal - 36 Head 1068.6 kg		1068.6			
		129165.8			
average gross weight daily over 5 killing days		25833.16			

SGS

CLIENT: Active Research
PROJECT: Biogas - RCA - Active Research

Laboratory Report No: CE77625

LABORATORY REPORT

-------- Our Reference Your Reference Type of Sample	Units	CE77625-1 Rendering Water	CE77625-2 Abattoir Water	CE77625-3 Abattoir Water
Date Extracted		19/04/2012	19/04/2012	19/04/2012
Date Analysed		19/04/2012	19/04/2012	19/04/2012
Chemical Oxygen Demand	mg/L	20,000	890	[NA]
Oil & Grease	mg/L	[NA]	[NA]	3,300

→ Excluding blood & faeces

CLIENT: Active Research Pty
PROJECT: Biogas - Active Research - Daniel Portefaix **Laboratory Report No:** CE77405

LABORATORY REPORT

Our Reference Your Reference Type of Sample Date Sampled	Units	CE77405-1 Sample A1 Water 4/04/2012	CE77405-2 Sample B1 Water 4/04/2012
Date Extracted		5/04/2012	5/04/2012
Date Analysed		5/04/2012	5/04/2012
pH	pH Units	6.9	[NA]
Electrical Conductivity @ 25°C	µS/cm	2,700	[NA]
Bicarbonate Alkalinity	mg/L $CaCO_3$	970	[NA]
Carbonate Alkalinity	mg/L $CaCO_3$	<5	[NA]
Total Alkalinity	mg/L $CaCO_3$	970	[NA]
Chloride, Cl	mg/L	240	[NA]
Sulphate, SO_4	mg/L	87	[NA]
Chemical Oxygen Demand	mg/L	42,000	[NA]
Total Suspended Solids	mg/L	26,000	[NA]
Total Dissolved Solids	mg/L	5,800	[NA]
Total solids	mg/L	32,000	[NA]
Total Kjeldahl Nitrogen (as N)	mg/L	1,100	[NA]
Total Phosphorus	mg/L	230	[NA]
Nitrite (NO_2) (as N)	mg/L	<0.1+	[NA]
Total Oxidised Nitrogen as N (NO2+NO3) #	mg/L	0.94	[NA]
Nitrate (LIMS Calc)	mg/L	0.94	[NA]
Ammonia Nitrogen NH_3 as N	mg/L	69	[NA]
Calcium, Ca	mg/L	21	[NA]
Magnesium, Mg	mg/L	8.1	[NA]
Iron, Fe	mg/L	3.8	[NA]
Sodium, Na	mg/L	420	[NA]
Potassium, K	mg/L	140	[NA]
Oil & Grease	mg/L	[NA]	22,000 — pit

— = Same as B
Regional -
57000
↓
pit
81000