final report

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Investigating Centralised Co-digestion of Red Meat processing and Municipal Waste

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Abstract

This report evaluates studies into waste treatment options (including anaerobic digestion and composting) for combining paunch and biological wastes from a red meat processing facility (Hardwick's) with residential organics and green wastes from the Macedon Ranges Shire Council (MRSC).

Waste parameters and operational risks associated with waste types and their variabilities were developed. An options analysis and establishment of detailed process streams for the identified options was also undertaken.

Preferred option(s) for waste treatment are presented including viability of solution(s) and potential cost sharing arrangements between the parties. In addition, a commercialisation considerations for a centralised waste treatment facility treating waste are included.

Executive summary

The purpose of this project was to evaluate waste treatment options (including anaerobic digestion and composting) for combining paunch and biological wastes from a red meat processing facility (Hardwicks Meatworks at Kyneton, Victoria) with residential organics and green wastes from the Macedon Ranges Shire Council (MRSC).

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1 Milestone description

The purpose of this project is to evaluate waste treatment options (including anaerobic digestion and composting) for combining paunch and biological wastes from a red meat processing facility (Hardwicks) with residential organics and green wastes from the Macedon Ranges Shire Council (MRSC).

2 Project objectives

The final project outcomes include potential biogas production (or consequent electricity production) for use within Hardwick's plant (or more broadly to external industry if quantities are in excess of Hardwick's requirements), and the production/marketing of an end digestate product for use in surrounding agricultural areas.

The project objectives were to:

- evaluate waste treatment options (including anaerobic digestion and composting) for combining paunch and biological wastes from a red meat processing facility (Hardwicks) with residential organics and green wastes from the Macedon Ranges Shire Council (MRSC);
- understand the quantity, value and quality of potential biogas production for use within Hardwick's plant and/or surrounding facilities;
- understand the production and marketing of digestate product(s) for use in surrounding agricultural areas; and,
- understand the commercialisation strategy for a centralised waste treatment facility treating waste from multiple independent sources.

3 Success in meeting the milestone

The Milestone requirements were achieved.

4 Overall progress of the project

4.1 Investigations to Date

The following investigations and research has been undertaken:

- A site visit was undertaken to Western Composting Technologies ("WCT") at Shepparton on Tuesday August 8th 2017;
- Discussions were held with Hamish Jolly from Biogas Renewables ("BR"), (2nd and 10th August 2017);
- Attendance at the Australasian Waste and Recycling Expo in Melbourne on 24th August 2017;

- Meeting with Technical specialist Laurie Curran (Laurie Curran Water Pty Ltd) ("LCW") in Geelong on 28th August 2017 discussing the initial potential process options to be assessed;
- Attendance at the Renewable Energy seminar at DWELP in Bendigo on 29th August 2017.
- A Gas Master Class run by Sustainability Victoria ("SV") in Bendigo was attended on 12th October 2017. This covered the latest developments in gas technology focussing on sustainability and efficiency, as well as grant programs available to assist in this regard;
- Meeting with Technical specialist Laurie Curran in Geelong on 24 October 2017 and discussed waste parameters and operational risks associated with waste types and variabilities;
- Visit to Midfield Meats ("MM") in Warrnambool on 25 October 2017. Discussions were held with MM in relation to their waste treatment and further plans for this. A site visit was also undertaken to their composting plant at Woolsthorpe north of Warrnambool;
- Attendance at a New Energy Round Table at Shepparton on 26 October 2017 run by SV;
- Further discussions and workshops with Laurie Curran during December 2017 and February 2018 to establish high level costings, risk areas and process stream details;
- Discussions with Laurie Curran at site 22 February 2018 to refine revised options;
- Discussions with EPA regulatory personnel (Melbourne) 28 February 2018 re AD, CAL and composting approvals processes;
- Meeting with EPA Bendigo 15 March 2018 discussing broader approvals process and composting buffer zone requirements;
- Site visit to Yarra Valley Water ("YVW") Aurora Waste to Energy plant at Craigieburn 21 March 2018, and;
- Discussions and information from Kunal Kumar, Business Development Manager for ReNu Energy Limited, in relation to the Southern Meats Biogas project (Goulburn) and ReNu Energy's commercial approach and project appetite (May/June 2018).

4.1.1 Site Visit to WCT:

The site is located at 165 Daldy Road Shepparton. This is on land owned by Goulburn Valley Water ("GVW") associated with the GVW wastewater treatment plant. WCT lease the land area from GVW.

The location was selected by WCT due to the existing buffer zones associated with the WWTP and the existing groundwater monitoring stations in place as well as a 5 metre depth of clay below the site to further ensure environmental impacts are unlikely. The area of the plant is 2 acres.

There was little odour generally at the site.

Main shed, screening and composting tunnels at WCT plant

4.1.1.1 Operations at WCT:

Waste materials processed include:

- Organic waste from a number of Councils kerbside collections;
- Green waste from kerbside collections as well as from transfer stations;
- DAF waste from Herds Geelong (approximately 30% solids content). Presently 30 tonnes per week. Woody waste must be added with this;
- Waste citrus from area farms;
- Waste grains;
- Added woody materials for carbon addition as required.

WCT advise that approximately 30% of the materials must provide a carbon source.
Long term contracts (generally 8 years) with gate fees are in place ($70-$100/tonne). Compost produced is sold at $16 per tonne ex the plant. This mainly goes to large users (fruit growers, dairy producers) and demand outstrips supply. The plant presently processes 20,000 tonnes per year (EPA licence is for that amount), but expansion is planned (2 more tunnels) and the EPA licence amount will be increased.

As far as the overall process is concerned, the operation requires substantial practical knowledge as the incoming waste materials must be mixed and adjusted to ensure the end product is as uniform as possible (nutrients). For example, waste citrus fruit must be added in small batches.
Also, when any new products are processed, trials are undertaken to establish what mixing or water input adjustments are required.

The process stream is as follows:

- Trucks enter via a weighbridge. They discharge onto a concrete floor area (totally under roof) and the waste is inspected for contamination (bottles, plastics (non-compostable), etc).
- Where high levels of contamination occur, the material is separated using a loader and placed in a bin to be returned to landfill. Small amounts of contamination are removed manually as much as possible. Some green, woody waste may require shredding first. 24-30tonnes of plastics etc are separated to landfill. Approximately 30% of labour time is spent in decontaminating;
- The loader then transfers the remaining waste materials to a variable speed screening unit which separates the material further and allows manual removal of other contamination from the belt delivery;

Screening equipment at WCT plant.

- The loader can then place the material directly into a composting tunnel (there are three tunnels) mixed as required. Each tunnel holds 450M3;

Inside one of the composting tunnels at WCT plant.

- Once a tunnel is full, the door is closed and composting process begins. Temperature rises to 70 to 80 degrees fairly quickly. Air is pumped through and water is also added (up to 20kl per week in summer is used). (The water system is closed loop and rainwater is collected on site. Very little potable water is required). The air/water amounts are critical to the process. Air enters via gravel drains in the floor and water enters via sprinklers in the roof. Excess water drains through the floor drains back to the storage dam;
- Temperatures are monitored in the tunnels (via probes) as well as water inputs. Gas/air is removed via ducting and discharged via a biofilter (there was no obvious significant odour at the biofilter). The biofilter has a roof over it but WCT thinks it was a European approach (for snow) and isn't really needed ;

Gas/odour removal ducting at rear of tunnels. Biofilter in foreground. (WCT plant)

- Material remains in the tunnel for 5 to 10 days depending on temperature (Australian Standards require minimum 3 days at plus 55 degrees for sterilisation).
- Material removed from the tunnel is then moved to an open windrow area and remains there for 8 weeks (it is turned regularly depending on internal temperature);
- It is then shredded and screened and stockpiled as an end product. End product is relatively odourless (light soil type smell). Good appearance.

Finished compost product at WCT plant.

- Contamination amounts are advised back to Councils and contract cost adjustments apply to drive improvements;
- Monitoring system and data kept is detailed and is critical (used in contact back to Councils to identify problem areas);

Monitoring and control system overview WCT plant

- There is a 30% reduction in volume through the process;
- 7 people operate the plant;
- A stockpile of rejected product (130,000M3) is on site and remains an issue. Possible use is for capping landfill (contains plastics etc but is mainly compost). Quantities have been reducing as Councils better manage collection controls and WCT improve their process. Now operating with about 90-95% final compost with contaminated compost going to stockpile. Some reprocessing from the waste stockpile has been done to obtain some acceptable product but it is expensive;
- Use of compostable bags for organics works well as they breakdown through the process. Ordinary plastic bags are an issue;
- DAF waste is welcomed, meat waste generally assists the process (carbon source);
- Some increased water content is possible (water is added in the process normally anyway). Trials would be required to establish quantities;
- WCT have a tank in place for liquid waste but have not yet trialled the inclusion;
- Water use is closed loop and there is no external discharge;
- Contract arrangements and responsibilities are critical (between Councils, cartage contractors, and WCT);
- Tunnels cost approximately $1M each. To replicate total plant possibly $6-$8M plus land.

4.1.2 Discussion with Hamish Jolly (Biogas Renewables):

- The AD plant BR have in WA for Richgrow is reportedly very cost effective for Richgrow (BR advise that they believe Richgrow have repaid all debt in several years and now have a high ROI);
- Main income is from gate fees ($3M) and power savings from gas generation ($1M);
- Capex was $10M for the AD's (two) and 2.4MW power generation. BR advised that an additional $2M should be allowed for additional maceration if municipal waste is processed. (50,000 tonne per annum capacity);
- Richgrow appear to process mainly waste food from restaurants and large retailers (Woolworths) as well as out of date soft drink, brewery waste, waste grains etc;
- BR says 10,000 tonne per annum design size would be minimum to be cost effective;
- Woody material would cause problems;
- The AD's are not designed to provide full sterilisation so digestate is also composted.
- Waste water goes to trade waste or via aerated lagoon;
- BR advise they have had no problems with the process and they manage the diversity of waste;
- Gate fee around $70/tonne ($3.5M), $500k site power savings, $1.5M power sent to grid, $900K opex; and,
- Product is good and sold to Richgrow markets.

4.1.3 Australasian Waste and Recycling Expo

The expo included a number of manufacturers/suppliers who could offer the latest equipment to assist with removal and sorting of contaminants, as well shredding. Information was obtained from a number of these and retained for further consideration. This included information from:

- Huanchuang (Xiamen) Technology Co. Ltd;
- Steinert Australia Pty Ltd;
- Siveranne Pty Ltd; and,
- DKSH Australia Pty Ltd.

4.1.4 Discussions with Laurie Curran

We discussed what information we would like from Yarra Valley Water in relation to the operation of the AD at Aurora WWTP at Craigieburn. We have advised YVW of these items and obtained some information in return. The information requested from YVW was:

- Actual gas production figures and variation due to ambient temperature;
- Handling of contaminants, (any sorting equipment, any problems, effectiveness etc);
- Overview of the process;
- Any design issues or learnings that would be changed in any future process;
- Any mixing issues or concerns with FOG's;
- What the AD diet is;

- Tonnages handled;
- End product usage (markets, EPA issues);
- Digestate (what quality and where does it go).
- Any other operational advice they could offer.

We discussed with Laurie Curran what we had established to date in relation to potential process flows which could be analysed. (Refer Appendix for Option 1 and 2 diagrams).

The process flows are based on water reuse and irrigation to a Hardwick's site, with alternative flow options should some treatment and irrigation be via Coliban Water.

In further discussions and workshops during Milestone 2, we established and agreed design concepts for both options; what inherent risk issues apply; aspects for further detailed analysis and investigation, and, finalised high level concept costs.

4.1.5 Discussions with the EPA Melbourne in relation to AD Approvals

Telephone discussions were held with Quentin Cooke, Team Leader, Development Assessments, EPA, on 28 February 2018 in relation to the processes and approvals in relation to the AD facility. This discussion reinforced the situation in relation to the present lack of established EPA approvals processes for a waste to energy AD facility due to the YVW project being the first, and only, unit of this type in Victoria. Quentin described the R&D investigations underway with YVW which are intended to establish approvals in relation to disposal/reuse/sale of the pasteurised digestate.

The YVW project has approvals for the facility in terms of construction and operation, however the management of the final digestate was not included. This obviously places YVW in a risk situation.

The work being undertaken in relation to the YVW plant should however establish the processes and guidelines for any future projects.

4.1.6 Meeting with EPA Bendigo in relation to Overall Project Approvals

Discussions were held with Paul Ratajczyk at EPA Bendigo on 15 March 2018.

We discussed the potential for open windrow composting and he advised significant buffers would be required (as per MM visit advice) and doubted there would be enough distance from houses at Kyneton. "In vessel" composting (well designed) would require less buffer (again as MM advised). However, due to the more closely developed nature of farms around Kyneton, a potential buffer of 500-600 metres may not be available.

He concurred that composting would not be required where anaerobic digestion was used if all items were in the digester (eg: meat waste, MRSC green waste and organics), it was sized appropriately, and final use of the digested sludge was covered in the Works Approval from the start (as per advice from the EPA Development Assessment Team Leader (refer 3.2.6).

4.1.7 Site Visit to YVW Aurora Waste to Energy Plant

A site visit to the YVW plant was undertaken on 21 March 2018. The inspection items noted including discussions with YVW Manager (Damien Bassett), and the Aquatec Maxcon Operations Manager (James Downs), covered the following:

- The food waste etc is delivered at an average of 8 to 10 truckloads per day;
- At present they are taking approximately 140 tonnes per day, 5 days per week (working hrs only). The menu is managed to ensure no shocks to the system should occur and when a new material is added a small quantity is initially used. (They said that they had tried to add DAF sludge but a small quantity caused immediate problems in the AD. DAF sludge may not be a problem if it had been part of the menu from commencement);

Waste collection bays.

- The menu presently consists of food waste (vegetable matter etc), whey, fruit waste, chicken carcases, paunch waste (presently 25t per day), grease trap waste. They do not take green waste or Council organics. They require uniformity in the waste delivered and undertake assessment of reliability and uniformity before advising acceptance. Collection from large commercial operations is where they have found best success in getting product in a fashion which can be suitably fed into the digester. Food waste collection from shopping centres and households from their experience has proven not to be viable. With grease trap waste they take samples of each load as the feed varies. Contaminants in the feed provide significant problems which is the reason they will not accept Council organics. They have no upfront contaminant removal process, nor screening processes within the plant. YVW Manager advised he would have liked to have contaminant removal but a decision was made at the design stage to omit that for cost reasons ($1M+ capital);

- The operators (Aquatec Maxcon) obtain advice from a specialist biologist in Germany (Weltec Biopower) before accepting different waste products;
- All non-liquid feed is macerated to fine sizing (input via shredder-multimix-macerator) and mixed via a Weltec Biopower liquid input system. This system processes fibrous, sticky and soft substrates. The Operations Manager said that maceration to very fine size was critical for operation. There is also a grit removal system for grease trap waste which was in operation when we visited. Liquid feed can be pumped in directly but still goes through grit removal and maceration process (this picks up major contaminant items, if any, but too many would cause major problems/blockages/damage);

Hoppers for solids input with shredder, mixer and macerator in foreground (Weltec Biopower liquid input system).

- The Aquatec Maxcon Operations Manager advised that green waste would be a problem for several reasons. This included woody content and difficulty in reducing Australian materials to small sizes (as distinct from European soft wood waste), contaminants, potential for eucalyptus to upset the process, and longer digestion process. However, the YVW Manager was of the view that trials of green waste would be worthwhile if contaminants could be removed;

Grit removal trap with visual monitoring via a transparent panel (grit removed manually).

- The plant is designed/licenced for 33,000 tonnes per annum. Capital cost was $27.3M. It is presently operating at about 75% capacity;
- The retention time in the AD's is 60 days+ (cf Perth Richgrow plant at 37 days due to different feed (all food waste));
- The 33,000 tonnes is total for solids and liquids. Whey for example comes in at 4%-6% solids and is pumped into the plant. There is no provision or requirement for adding or removing water content. The menu mix is the managing factor;
- They would not provide details of gas production but they were producing at the maximum possible during our visit. YVW Manager said that gas production was exceeding design aims.

The power units can generate 1MW (2 x 530kw engines). When we were there at one point the gas production exceeded requirements and the flare automatically came into operation;

- It was unclear as to what the YVW commercial drivers are. Power production is obviously now a priority at times (depending on power prices) and gate fees for feed also are a consideration. YVW Manager said it was a “balance”. The gas production could be varied dependant on the menu;
- Heating of AD’s (and pasteurisation process) is from engines via heat exchangers. They advised that heating of AD’s only varied in time between summer and winter, not amount of heat. Usually two weeks between heating required in summer, but every two days in winter;
- Direct operating costs are low (3/4 staff, day working hrs only). Major cost is depreciation and longer term maintenance costs (can be substantially impacted by feed products, eg calcium build up in pipework);
- For 100 tonne of feed in, there is 85 tonne of digestate out;
- Wastewater from the process goes to YVW and straight to Western TP (Werribee). Operations Manager said it had low H_2S and low nutrients and Melbourne Water liked the waste as it assisted their operations;
- Reuse or disposal of digestate is still in a trial phase. Otherwise it is either being stored or going to composting. EPA approvals processes are presently time consuming and costly as no processes for approval were in place with EPA in Victoria for these plants (refer notes of EPA discussions above). It was also impacted adversely by YVW having to use waste activated sludge from the YVW WWTP to “seed” the AD’s which came from processed human waste (ex YVW WWTP). The R&D tests are endeavouring to prove pasteurisation is complete and no issues remain with the human waste impacts. Any future waste to energy projects will be much easier to obtain regulatory approval once this one is clear as process will be established, and YVW Manager advised that seeding for any new facilities can come from this plant;
- The digestate is not dewatered (6%-8% solids) and it is expected that end users would undertake dewatering in various processes if they required this (eg: pellets). Otherwise digestate will be injected or sprayed as fertiliser. YVW Manager says he also wants to be 100% satisfied with pasteurisation before they commercially provide the product. (eg: no tomatoes growing when vineyards have been fertilised). Pasteurisation is presently undertaken for 1 hour at 70 to 80 degrees;
- YVW are hoping to have EPA approvals re use of digestate directly to users by late April;
- In the meantime, pending EPA approvals, digestate not being used for trials is being pumped to the adjacent YVW WWTP, mixed with Waste Activated Sludge and piped to the Melbourne Water Sewerage system (eventually to Werribee WWTP);
- Site had very little odour. Odour removal system was extensive;
- The overall plant is very impressive and built to a very high standard.

4.1.8 Discussions with ReNu Energy Ltd (Southern Meats Biogas Plant)

During May and June 2018, a number of discussions have been undertaken with Kumal Kumar, Business Development Manager for ReNu Energy Ltd (“ReNu”) in relation to ReNu’s corporate position on biogas energy projects. ReNu is an ASX listed public company (ASX:RNE) refer, renuenergy.com.au.

ReNu have a number of projects which have recently been completed, including one at the Southern Meats site at Goulburn NSW which has been undertaken using a “Build/Own/Operate/Transfer” (BOOT) approach. This project had a capital cost of $5.75M with grant funding support from the Australian Renewable Energy Agency totalling $2.1M. This facility produces approximately 4000 MWH per year of electricity from 2 x 800kW generators, processing 22ML of waste per annum. It incorporates a CAL design. The processed waste quantity is similar to what the Hardwick’s/MRSC co-digestion project involves, however the substantially reduced capital cost reflects the nature of the waste from Southern Meats and the consequent lack of requirement for major waste handling and contamination removal facilities associated with processing municipal green and organics wastes.

ReNu Energy have indicated a strong interest in investigating this Hardwick’s/MRSC project to add to their portfolio.

The approach which has been discussed, is similar to that used at the Southern Meats site. The basic commercial position at Southern Meats is summarised as follows:

- The facility is owned by ReNu for a 20 year period, with an agreed transfer back to Southern Meats ownership after that at a nominal amount. This is a typical BOOT approach widely used in Government infrastructure projects over the past 20+ years. (The writer has specific experience in commercial management of BOOT projects);
- The site is on Southern Meats land and ReNu have a licence to operate on the land from Southern Meats;
- The interface points are at the DAF discharge point from Southern Meats (inlet to ReNu facility), with the discharge effluent point being from the ReNu facility to the Southern Meats disposal lagoons;
- ReNu as owner of the facility takes all operating and regulatory risks; and,
- Power produced from the gas is sold directly to Southern Meats under a long term contract, however ReNu can also provide power to the grid on a second priority basis.

For this Hardwick’s/MRSC co-digestion project, additional technical complexities are involved due to the difficulties associated with green waste and organics from MRSC. However it is considered worthwhile undertaking further discussions with ReNu. It is expected that other parties may also be interested in a BOOT delivery (eg: Biogas Renewables) which will provide a competitive position.

4.2 Projected Quantities for Process Concept Analysis

Quantities/volumes of potential waste streams, both existing and projected (15-20 years) are presently summarised as follows:

Material/Waste	**Source**	**Estimated Present Tonnage/Volume**	**Projected Future Tonnage/Volume (15-20 years)**	**Constituents (Averages)/Comments**
Wastewater	Hardwick’s	600kL per day average (220ML per year). Assume solids of 330 tonnes per annum (dry) based on SS quantity. Assume 6600 tonnes @3% w/w.	1000kL per day average (365ML per year). Assume solids of 330 tonnes per annum (dry) based on SS quantity. Assume 11000 tonnes @3% w/w.	COD 5000mg/litre Salinity (EC) 1750 uS/cm SS 1000mg/litre P 45mg/litre N 250mg/litre PH 7-7.5
Paunch Waste	Hardwick’s	1250 tonnes per annum	2100 tonnes per annum	Based on long term growth to 1000kl per day waste volume
Green Waste ex Transfer Stations	MRSC	3000 tonnes per annum	5000 tonnes per annum	Assumes 2.5% growth in services per annum

Green waste (kerbside)	MRSC	3300 tonnes per annum	5500 tonnes per annum	As above
Recoverable Organics (from kerbside)	MRSC	2300 tonnes per annum	4000 tonnes per annum	As above
Kyneton Saleyards organics (manure)	MRSC	750 tonnes per annum	750 tonnes per annum	Assume no further growth at this site
TOTAL		**Present Combined Hardwick's/MRSC waste 17,200 Tonnes per annum**	**Assume 30,000 Tonnes per annum design capacity**	

These quantities and volumes may change as further analysis is completed. However, they are intended to be used for initial conceptual analysis only (not detailed design should the project proceed to implementation).

4.3 Initial Investigation Outcomes

To date, the study has established the following:

4.3.1 Composting:

- Incorporation of contamination in organics and green wastes provides difficulties if it is not managed at source. The resultant unusable by-products of the composting process are building up at a number of sites and a solution to their further refining or disposal is an issue;
- Large woody waste can be processed but involves shredding and re-processing of large items;
- Location of a composting site needs to consider EPA licence requirement and, if an open process is used in lieu of closed vessels, this may require 1 to 2 kms clear buffer from any housing. An "in vessel" operation may be possible within 500-600 metres of housing. The site requires hard standing, catchment and management of stormwater runoff, and monitoring bores in relation to groundwater impacts;
- There is a requirement for green waste in the process and this requires surety of availability;
- A market for end use of the compost should be in place prior to proceeding, although this should not be an issue. Market value is minimal at ($10-$20) per tonne. Processing costs for a composting plant are between $50 and $80 per tonne; and,
- For our project, the process would suit MRSC green and organic waste in conjunction with Hardwick's and MRSC saleyards yard wastes and paunch wastes (ex-Hardwick's). DAF waste inclusion ex Hardwick's would also be appropriate if this is more attractive than sending to rendering, or renderer's refuse to accept this waste.

4.3.2 Covered Anaerobic Lagoons (CAL's):

- Lower capital cost than AD but require a larger footprint. Operational and maintenance risks may be higher than for AD's;
- There should be an available site adjacent to Hardwick's, or this may involve discussions with Coliban Water in relation to building on their existing WWTP site;
- Could incorporate MRSC organics (subject to low levels of contamination) but green waste may be difficult unless highly macerated. Therefore, for comparison purposes, the CAL concept design incorporates heating, mixing/chopper pumps, contamination removal and

maceration, and piped/pumped digestate removal. It is effectively an in ground AD and provides high rate digestion. A traditional low rate CAL without mixing and heating or contamination and maceration facilities is not considered suitable for the co-digestion of green and organics wastes;

- On removal, sludge has been digested and there should be a market for disposal/sale as for the AD, and,
- It may be possible to incorporate floating solar panels as a cover for a CAL.

4.3.3 Anaerobic Digestion:

- Higher capital cost than CAL's, but require a smaller footprint and could be installed within the present Hardwick's site, or on adjacent land or Coliban Water WWTP site (as for CAL above);
- MRSC organics and green waste can be processed in the digester. Handling and sorting areas would be required involving external transport and a larger site. Contamination could be an issue. Further advice from specialists or pilot plant trails may be required in relation to incorporation of Australian sourced green waste as European green waste is substantially different. There may also be impacts in relation to climatic impacts on Australian green waste causing large variations in nitrogen for example;
- Woody waste would need to be sorted and excluded and processed separately;
- The technology in Australia is less proven than CAL and the volume of gas output is less sure; and,
- Operational risks are higher than CAL due to fats, oils and greases potentially providing an issue. The feed "menu" is very critical and requires specialist advice on an ongoing basis. DAF sludges will need to be assessed for suitability.

5 Options Analysis

5.1 Options Considered

A number of previous studies have been undertaken by Hardwick's, all of which involved Hardwick's waste streams only. This project builds on the knowledge gained during those projects and is investigating whether a more cost effective solution can be achieved by combining municipal wastes via partnering with a Local Authority (MRSC), which provides both increased scale and the potential for improved technical solutions for both parties.

Previous studies undertaken by Hardwick's include:

- *"Options Analysis for Wastewater Management". Author Peter Elliott, September 2014.*
- *"Feasibility Study for the use of Anaerobic Digestion and Biogas Energy Generation at a Meat Processing Facility". P.PSH.0704, Authors, Peter Elliott and Laurie Curran, March 2015).*
- *"Potential Wastewater Treatment for Hardwick's". Author Peter Elliott, June 2017.*

In summary, the following conclusions and recommendations, resulted from these studies:

5.1.1 Option for Total Wastewater Solution:

This potential solution for Hardwick's waste treatment was driven by restrictions and increased costs being imposed by the present service provider, Coliban Water. The preferred solution was for a new Lagoon Treatment System to be installed by Hardwick's with disposal/reuse to a new Hardwick's owned site. This involves the construction of a new lagoon treatment plant either adjacent to Hardwick's plant or at a new farm site; a pipeline from the site to the farm (up to 5 kilometres); a winter storage (approximately 180ML) and irrigation system on a farm of up to 200 acres. This solution provides an "in house" facility where the services costs required by Coliban Water are excessive (higher NPC). The process included:

- Contrashear screening as per existing plant;
- Aerated oxidation lagoon; and,
- Facultative lagoon.

5.1.2 Revised Total Wastewater Solution Option Including the addition of Anaerobic Digestion

This involves the ongoing consideration of Treatment via an AD, with final effluent transferred to Hardwick's new farm site. This includes the benefits achieved in using biogas within Hardwick's meat processing plant.
The developed process flow included pre-screening (coarse) and maceration, high rate anaerobic digestion and clarification, with sludge treatment via either belt press dewatering, or centrifugation; with trickling filter treatment and clarification of wastewater downstream of the high rate anaerobic digester.

Each of these reports have been reanalysed on the basis of combining Hardwick's waste stream with the various organic and green waste streams from MRSC, with water reuse and final solids products being managed by Hardwick's and MRSC as appropriate. The potential for Coliban Water to be a part of any potential solution has also been retained. The extent of Coliban Water involvement and what aspects of treatment they may be involved in are the subject of continuing negotiations.

5.2 Developed Options for this Study

Incorporating the outputs from the previous studies detailed in section 5.1, two process flow options were developed during Milestone 1 which were further analysed. In addition, since those initial studies were completed, Hardwick's have purchased an area of farmland (88Ha) immediately to the north west of their processing plant (and abutting the present Coliban Water Waste Water treatment Plant ("WWTP")).

As noted in Section 2 above, the initial two identified process flow options have been revised to exclude composting following digestion in AD's or CAL's, with all wastes (Hardwick's and MRSC) being processed via those processes.

The summary of process inputs and outputs for these revised options are as follows:

5.2.1 Process Flow Option 1

- Screening and maceration;
- DAF treatment;
- An activated sludge process (to reduce nutrients), with Class C water produced for irrigation or further treatment for reuse to Class B or A if required or cost effective. Irrigation will require a large winter storage and up to 70Ha of irrigation. Alternatively, some aspects may be carried out at the adjacent Coliban Water WWTP (potentially trickling filtration, aerated lagoon treatment and winter storage of treated wastewater) subject to a satisfactory commercial arrangement being reached;
- Treatment of the resultant sludge's from the DAF and activated sludge process, and addition of MRSC wastes via CAL, with gas produced used by Hardwick's processing plant, potentially some sold to third parties;
- Pasteurising and dewatering of CAL digestate; and,
- Sale of final fertiliser material.

5.2.2 Process Flow Option 2

- Screening and maceration;
- DAF treatment;
- An activated sludge process (to reduce nutrients), with Class C water produced for irrigation or further treatment for reuse to Class B or A if required or cost effective. Irrigation will require a large winter storage and up to 70Ha of irrigation. Alternatively, some aspects may be carried out at the adjacent Coliban Water WWTP (potentially trickling filtration, aerated lagoon treatment and winter storage of treated wastewater) subject to a satisfactory commercial arrangement being reached;
- Treatment of the resultant sludge's from the DAF and activated sludge process, and addition of MRSC wastes via AD, with gas produced used by Hardwick's processing plant, potentially some sold to third parties;
- Pasteurisation and dewatering of digestate; and,
- Sale of final fertiliser material.

HoSt Waste to Energy plant in the Netherlands visited by Laurie Curran. A similar AD layout is envisaged for this project.

For both of the above process options, more detailed analysis may lead to the exclusion of an upfront DAF process with the waste entering directly into the AD or CAL.

6 Site Identification

There are three sites which provide potential sites for various aspects of the options under consideration:

- Hardwick's meat processing plant has sufficient area to enable the siting of some treatment processes on that site. Planning approvals may be required. The screening, DAF (if required), CAL or AD, and activated sludge processes would preferably be located here to reduce distances for transfer of wastes, sludge's, and gas. There would also need to be access and storage and handling areas for MRSC organics and green waste.
- The existing Coliban Water WWTP site which is immediately north-west of Hardwick's site is presently limited in providing further land, due to demands on storage as well as the irrigation area. These demands will be significantly reduced if irrigation is applied to the adjacent land now owned by Hardwick's. There is therefore potential for the Coliban Water site to be incorporated for some aspects of the treatment process, winter storage, or a share of irrigation. Buffer distances should be possible to achieve.

- The new farming land acquired by Hardwick's has been initially assessed in relation to suitability for sustainable flows for wastewater irrigation. The preliminary assessment and report by specialist irrigation and reuse consultants (Kelliher and Wallace, RMCG, March 2018) with experience in the area indicates the area will be suitable. This area may also provide sufficient area to locate any composting facility, with sufficient buffer zones, although buffers may be minimal and planning issues may arise.

All of these sites will involve consideration of the need for EPA works approvals and MRSC planning approvals.

7 Risk Analysis

7.1 Anaerobic Digestion

Risks associated with an Anaerobic Digester were identified and analysed in a previous study for the MLA (Elliott and Curran, March 2015). At that stage, the risks noted included the following:

- A failure of the biological process due to the adverse impact of accidental chemicals (eg: a large quantity of chlorine or cleaning agent used in the processing facility). Although this risk is considered to be extremely low, in any final design the use of two digesters (which is the approach suggested for this Processor) could involve the treatment of separate waste streams in order for potential emergency backup being provided by one digester for a short term whilst the biological failure is overcome in the other unit. It may also be prudent to negotiate an emergency arrangement with any downstream service provider if that is possible, or consider the use of buffering storage upstream of the digester;
    - Digester over loading – large "dumps' from the processing facility;
    - Digester under loading – eg: after a Christmas shutdown;
    - Mechanical failure of heating or mixing systems;
    - High levels of FOG's (in excess of design and mixing capabilities);
    - Prolonged power outage;
    - Under-performance of the settling process;
- Operator error. (eg: One municipal digester failure was reportedly caused by an operator leaving a tap running – the digester received a large volume of cold water and so stopped working); and,
- The propensity for FOG's to solidify and gradually find their way to the top of the digester, aggregating to form a crust on the surface of the digester. Not only does this provide operational problems, but it deprives the process of a source of carbon. This is particularly related to the mixing system provided for the digester and its ability to break up material which accumulates on the surface. This is a similar problem to "foaming" in municipal digesters which is generally addressed by including a "spill and fill" system consisting of a weir at surface level where surface material is wasted.

The further analysis undertaken during this study has resulted in additional operational risks being identified. For a cogeneration facility involving municipal (green and organic waste) as well as meat processing wastes (paunch material, screenings and DAF sludge's), issues have been raised in site inspections and operational discussions in relation to:

- The suitability of Australian green waste which includes eucalyptus and other native plant matter for the digestion process;

- Variability and volume of gas produced;
- Handling of woody wastes;
- EPA approvals processes for use of processed digestate;
- The suitability of DAF sludges for digestion;
- Whether contamination inherent in municipal green and organic wastes can be adequately managed; and,
- Operator capability.

7.2 Covered Anaerobic Lagoon

In summary, the risks associated with a CAL generally include all those associated with an AD as identified above, and have additional risks including:

- Lack of operational control (temperature, mixing control, sludge removal);
- Risk of damage to membrane cover, expected life of membrane cover;
- Geotechnical risk (leakage of clay liner);
- Risk of scum formation and removal;
- Odour control risk; and,
- Operator capability.

7.3 Composting

Risks associated with the construction and operation of a composting facility are summarised as follows:

- The extent of contaminant levels in the Municipal waste;
- Buffer zone distance required;
- Handling/disposal of contaminated final product;
- Mechanical failure or prolonged power outage; and,
- Operator capability.

At this preliminary stage, it is considered that for this area any composting facility would need to be an “in vessel” type with odour control due to the potential location involving proximity to houses.

8 Markets for Digestate

Site visits and discussions with operators in relation to both composting operations and digesting operations indicate that markets are readily available, subject to an attractive, contaminant free product being produced, and all regulatory requirements being met.

The process in Victoria for approvals associated with digestate are still being developed by the EPA for the YVW Aurora waste to energy digestate. However, this has been adversely impacted by YVW having to use human sewage waste sourced waste activated sludge to initially “seed” their digester. Once YVW and the EPA finalise arrangements at the Aurora site the EPA processes will have been established.

Should this project proceed, the initial Works Approval will include the final digestate usage incorporating the processes developed for the YVW project. In addition, YVW have indicated that their Aurora materials will be made available to seed our digester which avoids the need to use human waste based waste activated sludge.

Other operators of both composting and digestion facilities are providing product to a wide range of users with indications of pricing of $10-$16 per tonne ex the plant. (Orchards, wineries, worm farms, general fertiliser and gardening products). The value of the end product is driven by competition from other fertilisers.

9 Benefits/NPV Analysis

The process flows detailed in the Appendices cover the complete digestion system inclusive of the digestion/energy generation facility. Other external factors are also relevant to the design and operational costs/revenues associated with the waste to energy aspects, and also impact the overall considerations of Hardwick’s capital spend.

For this study, the benefits and NPV analysis are restricted to the specific waste to energy facilities. In addition, further analysis of a composting only solution has not been included as that solution does not produce energy. We understand that a stand-alone composting facility may be of interest to a commercial operator due to the closeness to Melbourne although buffer zone requirements may provide difficulties. WTC, for example, have indicated an interest in establishing their own facility if land was made available for lease. The comparative costs of transferring waste to compost (transport and gate fees) can be assessed by each of the parties (Hardwick’s and MRSC) as options external to this study.

The factors included within the NPV analysis include the following:

- Estimated capital and operating costs covering all aspects of the facilities including handling areas, storage and pre-digestion equipment (decontamination, maceration etc), AD’s/or CAL’s, and pasteurisation, including all required buildings and associated works;
- Provisions for maintenance and replacements over a 25 year NPV period which incorporate considerations associated with risks such as equipment damage (eg: CAL covers);
- Gas production, including processing and equipment modification costs and benefits to Hardwick’s for gas use within their operations (production of electricity from the gas has not been included as Hardwick’s are large gas users and use of gas directly within their process is considered more efficient. However, in any final design if excess gas was produced over that required by Hardwick’s then electricity production would be considered. Alternatively, as is noted in the HoSt facility at Waalwijk (NL) (refer Section 6 above), any surplus gas could be purified to “natural gas” quality and returned to the external reticulation system);
- Impacts on either of the digestion processes from upstream or downstream treatment and disposal/reuse costs or benefits;
- Sale of digestate (assumed at $15per tonne ex the gate); and,
- No gate fees for other wastes have been included as it is assumed Hardwick’s and MRSC will share capital and operating costs, and may restrict the operation to their wastes only in order to control contaminants and the process menu. Should any additional external wastes be accepted, gate fees would apply but no allowance has been made for this at this time.

The high level costings have been based on work undertaken in the previous studies and have been further updated and developed in conjunction with specialist adviser Laurie Curran using information provided by HoSt, and information from site visits and stakeholders.

The costs have been reviewed during Milestone 3 but no amendments have been made and estimates remain as per those established during Milestone 2.

Capital costs are based on the following:

- AD: Insulated steel construction (Elliott and Curran, March 2015) (costs updated by Laurie Curran));
- CAL: Clay lined and geotextile covered with sludge removal system via low point (continuous to suit composting process).

The potential for staging of capital expenditure has been further considered because the shorter term financial viability is compromised when growth capacity is included within the base concepts. However, due to the increased unit costs of the major items a staged approach resulted in a significant increase in capital costs and pay-back periods for both options and has been disregarded.

Based on concepts to date, financial support from Government will be critical for Hardwick's to proceed with the project, as the payback periods for both options are well in excess of an acceptable industry position. However, the project is considered potentially viable if assessed as a longer term energy or waste project, and it may be attractive to MRSC, Coliban Water or other third parties.

Option 1: AD

Item		Concept Estimates @full capacity, 30,000 tonnes per annum	Concept Estimates @ start up 17,200 tonnes per annum
1.	Anaerobic Digester (incl. contamination removal and dewatering)	$12,000,000	$12,000,000
2.	Operation and Maintenance	$600,000 per annum	$450,000 per annum
3.	Gas cost offset (savings on gas purchases) less gas used to heat AD)	$550,000 per annum	$330,000 per annum
4.	Sale of Digestate	$350,000 per annum	$220,000 per annum
5.	Savings in disposal charges for undigested Hardwick's sludge (to external composting)	$320,000 per annum	$190,000 per annum
6.	Savings to MRSC for alternative waste processing.	$1,100,000 per annum	$650,000 per annum
	NPV	**$14.6M**	**$3.0M**
	Payback period	**6 Years**	**11 Years**

Option 2: CAL

Item		Concept Estimates @full capacity, 30,000 tonnes per annum	Concept Estimates @ start up 17,200 tonnes per annum
1.	Covered Aeration Lagoon (incl. contamination removal and dewatering).	$11,000,000	$11,000,000
2.	Operation and maintenance	$700,000 per annum	$550,000 per annum
3.	Gas cost offset (savings on gas purchases) less gas used to heat CAL)	$350,000 per annum	$130,000 per annum
4.	Sale of Digestate	$350,000 per annum	$220,000 per annum
5.	Savings in disposal charges for undigested Hardwick's sludge (to external composting)	$320,000 per annum	$190,000 per annum
6.	Savings to MRSC for alternative waste processing.	$1,100,000 per annum	$650,000 per annum
	NPV	**$10.9M**	**($0.9M)**
	Payback period	**7 Years**	**14 Years**

10 Potential Cost Sharing Arrangements

There are a range of potential cost sharing arrangements which could be considered by both Hardwick's and MRSC. Many variations are possible, however they can be grouped into several major options as follows:

- Hardwick's 100% ownership;
- MRSC 100% ownership;
- Shared ownership; and,
- Ownership via a specialist external party.

10.1 Hardwick's 100% Ownership

This option would be unlikely without financial support from Government. Hardwick's (as for other meat industry operators) utilise their capital on "core business" projects or investments which directly impact their production and which have a relatively short pay-back period.

If this option was proposed, waste from MRSC (or any other third parties) would be processed under contract via a gate fee or similar arrangement. Long term contract(s) with MRSC and other waste suppliers would be required to support the initial investment.

The location of the facility under this option would preferably be on Hardwick's site, however it could be located on the adjacent Coliban Water WWTP site if that was a more attractive alternative.

10.2 MRSC 100% Ownership

MRSC investment decisions are based more on the basis of best service/best cost for the ratepayers and longer term investments are assessed on a priority basis. In addition, MRSC (like other Local Authorities) are presently faced with increasing costs and risks associated with the disposal of green waste and organics. This project may therefore potentially provide a solution for their waste issues and full ownership may be considered.

As with 10.1 above, waste from Hardwick's or other third parties would be processed under a gate fee or similar arrangement, with gas (or electricity) purchased by Hardwick's. Again, long term contracts would be considered necessary. The facility could still be located at Hardwick's (or on the adjacent Coliban Water site) with the site provided under a licensing arrangement.

10.3 Shared Ownership (Hardwick's/MRSC)

This option could involve a joint venture arrangement with varying levels of ownership. This option would be complex considering the different investment policies of both of the parties, and the varying risks associated with handling substantially different wastes and variations on volumes over time. However, it is considered potentially viable with an appropriate joint venture agreement.

Potentially, Coliban Water could also be involved in this option.

10.4 External Ownership by a Specialist Operator

Recent developments in the Australian energy market have opened up the potential for this option. For example, the biogas plant has recently begun operation at Southern Meats in Goulburn NSW. This facility has been completed under a BOOT contract with ReNu Energy Ltd, an ASX listed company as detailed in Section 4.1.9 above.

Discussions have been held with ReNu Energy who have indicated they are interested in investing in further energy facilities in the meat industry. It is expected that other parties may have an interest in this area.

Another potential approach could be for Coliban Water to own and operate the facility on their adjacent WWTP site.

These solutions would be driven by the competitiveness of any proposed gate fees/gas/power costs with other options.

11 Commercialisation Options

11.1 Commercialisation Vehicle/Business Structure

To take this project forward, the parties will need to determine a preferred approach to ownership, and how legal rights to any IP will be held and conveyed during commercialisation. The commercialisation vehicle or business model refers to this manner of conveyance and relates to practical considerations broader than legal issues.

As noted in Section 10 above, there are 4 cost sharing/ownership arrangements which have been broadly identified. Hardwick's and MRSC (and Coliban Water) will need to consider independently their preferred positions and any specific arrangements which would be required (eg: a special purpose vehicle).

Following the establishment of each parties preferred position, further negotiations can then proceed to agree on project team membership and a process to develop any necessary agreements, licenses etc.

11.2 Funding Requirements

Once the preferred business model has been agreed, the funding requirements will be known and a process to finalise requirements can be established. The requirements for any of the ownership/shared costing approaches may involve:

- Investigation of funding support available from State or Federal Governments and their agencies; and,
- Establishment of budget provisions and financing sources including external financing parties/bank approvals where necessary.

In the case of a BOOT option, the preparation of an "Expression of Interest" for the bidder market will be necessary with both parties involved in its preparation. Consideration will need to be given to risk apportioning and expected outputs of the project.

11.3 Delivery

This process will be dependent on the ownership model adopted. However, Hardwick's, MRSC and Coliban Water all have experienced project management skills in-house to deliver such a project. Specialist design, engineering and legal/commercial advisory assistance will however be required. Due to the performance risks associated with project, any contract arrangement should include performance drivers or guarantees. A medium term operating component (5 years+) with performance related payments is suggested as the minimum requirement.

A BOOT model will require increased specialist commercial and legal advice, however the engineering and design aspects will, in the main, be the responsibility of the BOOT provider. In addition, an experienced Project Director will be necessary to manage the delivery via this method. Hardwick's have ongoing support available from a long term service provider for this. Coliban water also have experience with delivery of BOOT projects. This model will provide significantly increased performance surety than the traditional construction contract approach noted above as all performance risks are taken by the third party owner over the 20 year life of the project.

12 Conclusions/recommendations

At this stage, there appear to be no potential catastrophic issues with any of the processes outlined. All of the risks can be managed/mitigated during detailed feasibility and design. A pilot plant operation would be recommended to establish design criteria and operational management prior to final feasibility and detailed design, should further analysis and a commercially appropriate solution be established. Under a BOOT delivery scenario, any pilot plant studies or investigations would potentially be the responsibility of the bidders. Therefore the ownership and delivery arrangements need to be agreed in principle initially.

Laurie Curran is also discussing the inclusion of Australian sourced green waste with technical experts at HoSt Bio Energy Systems in Holland. LCW are the Australian agents for HoSt. This information will be incorporated in any further feasibility assessment.

There is some research available in relation to the incorporation of DAF sludge and paunch waste from a meat processor in the anaerobic digestion process (Othman and Woon, 2011) which concluded that, in a laboratory situation, both DAF sludge and paunch wastes have a good potential for gas production. In addition, information provided by HoSt on gas production from various waste materials has assisted the gas production estimates. ReNu Energy have also indicated that they would advise on the options for inclusion (or not) of a new DAF unit, in relation to the potential energy production or FOG considerations with a CAL.

Further site visits can be undertaken if necessary to obtain more information in relation to Australian waste to energy sites. South Australian Water's Glenelg biogas plant may be of benefit particularly in relation to further confirming expected gas production, the maximisation of which will be critical in the feasibility of this project. The SA Water plant has added a co-digestion system to an existing wastewater digester and increased biogas production by 50%. The increase in biogas yield from co-digestion plants in Australia is also noted in another study (Simmonds and Kabouris, 2012) who note that the most effective waste streams for biogas production have a high energy content which includes abattoir wastes.

Construction and operation of either an AD or a CAL solely for Hardwick's waste streams would remove the risks associated with the handling and maceration of MRSC wastes (and particularly the removal of contaminants), and these options remain to be assessed outside of this study.

13 References

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