MorrisonLow

Southland Region

Energy from Waste Issues and Options Paper

February 2012

achieving **results** in the public sector

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EXECUTIVE SUMMARY

A number of energy from waste options appear to be viable in terms of technology, suitability for Southland wastestreams and available expertise. For example the foodwaste is an ideal feedstock for anaerobic digestion (AD). The majority of organic waste in Southland is from domestic foodwaste and greenwaste. Other forms of organic wastes include commercial, septic and municipal biosolids/sludges, and agricultural wastewater.

The security of a wastestream and the market value(s) of energy and/or end products are critical factors in any waste to energy infrastructure projects.

- There is potential for revenue from the sales of compost products or solid and liquid anerobic digestion (AD) fertiliser products. However, the size and value of the market would require a more detailed assessment, including any lag time for markets to develop.
- The greatest potential product value is the replacement of current electricity or vehicle fuel use with biogas derived alternatives (from AD from Clifton Wastewater Treatment Plant, biodigestors, or landfill), particularly as retail fuel prices continue to increase. This option is particularly attractive for Southland due to its relative remoteness from supply and sale markets and current reliance on fossil fuels for transport. Waste collection vehicles or other transport companies in Southland may offer a scale of demand suited to this opportunity.
- Potential revenue from sales of excess electricity are likely to be low due to New Zealand's low spot pricing and lack of price based incentives for renewable energy alternatives.

However, the biggest barrier for many centralised waste to energy applications appears to be transport costs, due to the largely rural nature of the Southland region.

The relatively modest landfill price that the Councils currently enjoy as part of their long term contract with AB Lime Ltd at Southland's Regional Landfill (SRL) will make waste to energy investments challenging in the short term future as disposal to landfill remains the most cost effective option. However, with the imminent introduction of Emissions Trading Scheme (ETS) charges, this will change as ETS liabilities on the landfill owner are passed on to the Councils. The Councils need to fully establish the impact of any ETS liabilities and expected on-costs to the Councils.

Purely from an energy extraction perspective comparing energy used to energy gained, with no changes to operational practices, means that landfill gas may provide the best option:

- It appears to be the easiest option to implement as there is no requirement on the Councils to do anything different in terms of waste collection.
- Any additional costs of plant etc would be borne by the landfill operator and any benefits to the Councils would be minimal other than the possibility of ETS savings being passed on to customers such as the council.

In terms of waste minimisation, placing organic wastes in landfill represents a lost opportunity to divert a significant element of the waste stream (29%) and gain a beneficial product. With increasing landfill costs due to ETS, other avenues for organic waste may become increasingly viable alternatives.

This report considers composting alongside AD as alternatives to sending organic waste to landfill. There is an increasing global trend for food waste to be collected separately to greenwaste and also for food waste to be treated by AD while greenwaste is composted. Composting is better able to cope with the variations in seasonal tonnages and feedstock compositions associated with greenwaste, and may require less pre-treatment than AD systems. These factors both contribute to composting systems typically have lower operating costs than AD systems. A detailed cost benefit analysis for Southland would be required to compare each of the following scenarios:

1. Separate collections of food and greenwaste for treatment by AD and composting respectively
2. Separate collections of food and greenwaste for treatment by separate AD systems
3. A comingled green and domestic food waste fed AD system

This assessment should give consideration to:

- the method of separation appropriate for the Southland region
- the tonnage and composition of feedstocks
- the location of and type of treatment facilities
- the relative operating and capital costs of these facilities
- the quality of product required

The most obvious opportunity to gather feedstock appears to be a small food waste only collection in urban areas such as Invercargill City, but exploration into the economic viability of extending this into rural areas should also be considered.

The potential to upgrade the digester at the Clifton Wastewater Treatment Plant is perhaps the most promising prospect identified in this paper, as it already utilises AD as part of its process. Indicative information suggests that the total cost of upgrading the facility could cost in the order of $3million, but this investment could payback within 8 years. Significant opportunities for increased feedstock could come from waste streams from commercial operators such as Alliance Mataura, or other new developments. Utilising domestic organic wastes to boost biogas production levels at Clifton may also present an opportunity, particularly if transport costs associated with getting the feedstock are avoided. For example, by encouraging the use of insinkerators.

The development of AD using agricultural waste is a proven technology in New Zealand and overseas, for example in the UK the National Farmers Union has estimated that by 2020 over 1000 farm waste AD plants will be operational[1]. Historically, New Zealand's low energy prices and high transport costs have made it unviable for centralised AD for farm waste. However centralised AD may become more viable as energy prices continue to rise. There are high technology options for AD, such as enclosed biodigestors, and low technology options which may have lower set up costs, such as covered pond systems. It is recommended that further investigation is undertaken into low technology AD covered pond options on farms (eliminating transport costs), potentially in collaboration with NIWA. The benefits of AD of agricultural wastes are not only in energy savings, but include:

- carbon reductions
- energy security
- the <u>reduction</u> of odours
- associated benefits for farmers meeting resource consent conditions etc.
- reduced pollution of waterways through increased capture of manure
- reduced use of costly synthetic fertilisers (i.e. where replaced by digestate fertiliser)
- reduced pathogens contained in manures (i.e. destroyed, at least in part, by AD processes)

[1] http://www.waste-management-world.com/index/display/article-display/4203595670/articles/waste-management-world/waste-to-energy/2011/08/What_s_Stopping_AD_Supplying_1__of_UK_s_Power_.html?cmpid=EnlWMW_WTEAugust42011

The volume of timber waste currently disposed of to the landfill could provide further opportunities, particularly if it was sorted at source and segregated at transfer stations. Although any gasification plant is expensive, additional volumes of woody biomass or forestry waste could enhance this opportunity further.

While it is the Councils that will make the final decision, based on the waste hierarchy, waste management operational considerations, proven technology and potential for energy capture combined with useful end products, it is recommended that the Councils give further consideration in list order to:

- anaerobic digestion opportunities (on farms, at Clifton Wastewater Treatment, at centralised or district collection points)
- landfill gas collection with energy capture
- further exploration of wood waste opportunities

In addition further consideration should be given to commercial scale composting organic waste. Although composting does not have a captured energy component it would still be preferable to landfilling organic waste from a Waste Minimisation Act (WMA) perspective.

A range of opportunities exist to obtain further assistance to develop waste to energy opportunities from both the waste sector and energy sector. The type of assistance may vary from advice and information, to funding assistance such as grants for feasibility studies, implementation and crown loans. A range of resources and useful websites has been included for future reference.

1. INTRODUCTION

As part of the joint waste assessment process for Gore District, Invercargill City and Southland District Councils (SDC) (the Councils) that deliver waste services under the collective banner of WasteNet Southland (WasteNet) and energy strategy related work Venture Southland is doing, research was undertaken into possible issues and options to secure energy from waste. This report considers a range of issues and options (at a high level) pertaining to energy from waste. It has considered the most likely available opportunities by looking at particular wastestreams. Where waste to energy opportunities looked feasible after initial scoping and research, some further work and high level modelling has been carried out. Where opportunities were considered unviable at an early stage this has been noted and further research discontinued, in order to prioritise resources. The results of this investigation are presented in the following chapters as an issues and options paper.

Table 1-1 Acronyms used in this report

Acronym	Name
AD	Anaerobic Digestion
CEF	Community Environment Fund (Ministry for the Environment)
DAF	Dissolved Air Filtration
DEFRA	Department for Environment, Food and Rural Affairs (United Kingdom)
EECA	Energy Efficiency Conservation Authority
ETS	Emissions Trading Scheme
EWI	Environmental Waste International
GDC	Gore District Council
ICC	Invercargill City Council
ICI	Industrial/ Commercial/ Institutional
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilo Watt hours
MBT	Mechanical Biological Treatment
MfE	Ministry for the Environment
MJ/kg	Mega Joules per kilogram
MWh	Mega Watt hours
MSW	Municipal Solid Waste
NCV	Net Calorific Value
NIWA	National Institute Of Water & Atmospheric Research
NZWS	New Zealand Waste Strategy
OECD	Organisation for Economic Co-operation and Development
PNCC	Palmerston North City Council
RDF	Refuse Derived Fuels
RTS	Refuse Transfer Station
SDC	Southland District Council
SRL	Southern Regional Landfill
SWAP	Solid Waste Analysis Protocol
T/pwk	Tonnes per week
T/pa	Tonnes per annum
WMA	Waste Minimisation Act 2008
WMF	Waste Minimisation Fund (Ministry for the Environment)
WMMP	Waste Management and Minimisation Plan

2. EXISTING SERVICE

Currently a large proportion of waste in the Southland region is disposed of to the Southland Regional Landfill (SRL) which is managed by AB Lime Ltd under an exclusive contract with the Councils. Under the Waste Minimisation Act 2008 (WMA) councils have a responsibility to promote effective and efficient management and minimisation of all wastes within their districts. They are also required to have regard to the waste hierarchy when making plans for waste management and minimisation. As a result waste to energy opportunities have been given some consideration as recovery sits above disposal in the waste hierarchy.

3. WASTE TO ENERGY OVERVIEW

Waste to energy broadly speaking takes one of two forms:
- biological or biochemical energy conversion processes;
- thermal energy conversion process.

A number of examples of waste to energy opportunities are listed below in Table 3-1under these broad headings.

Table 3-1 Waste to Energy Opportunities

Biological/Biochemical	Thermal Energy Conversion
Anaerobic Digestion (e.g. biogas from farm or food wastes)	Pyrolysis (e.g. waste tyres, biomass from algae)
Fermentation (e.g. ethanol from waste crops)	Gasification (e.g. wood waste)
Algae production (e.g. butanol from algae)	Combustion (e.g. waste incineration or landfill gas collection with energy capture)
	Municipal waste processing (e.g. synfuel from Fischer–Tropsch Synthesis)
	Autoclaving (mechanical heat treatment)
	Plasma Gasification/Pyrolysis

There are a large number of proprietary technologies for thermal treatment of waste streams. Many of these technologies claim to be unique processes. However, while they may have unique characteristics, they are generally variations or combinations of principal technologies in the table above. There is one technology which does not easily sit under either biological or thermal energy conversion, that is Reverse Polymerisation[2]. Technical overviews of anaerobic digestion, advanced thermal treatments and Reverse Polymerization are provided in Appendix B. Under each of the technologies, a high level explanation of their suitability for the treatment of organic wastes is discussed, and subsequently only Anaerobic Digestion (AD) and gasification are further discussed in this report.

[2] 'Reverse polymerization' is a patented technology developed by a Canadian company, Environmental Waste International (EWI). It is a microwave-based technology that works by applying the microwaves in a nitrogen atmosphere directly to any organic material that contains a hydrocarbon base.

4. ORGANIC SOLID WASTES

Organic waste has significant potential with respect to energy from waste applications. It also makes up a significant proportion (29%[3]) of waste to landfill in the Southland region. The majority of organic putrescible waste is food waste, which is an ideal feedstock for AD. For the purposes of this report AD and a food waste collection have been considered alongside more traditional opportunities such as composting. Although composting is not energy from waste, a resource is still recoverable and many of the implications around collection are similar. This report discusses composting in the context of commercial scale composting. It is assumed some level of home composting will continue to take place despite any organic waste collection system, and continued education programmes for effective home composting are likely to continue to be an important council initiative for waste minimisation. It is prudent to therefore compare commercial scale composting to AD rather than treat it in isolation as the subject of a further report at some later time.

Landfill gas collection has also been considered and is discussed under section 12.

4.1 Organic wastes generated in Southland

There are a number of sources of organic wastes within the Southland region, including:

- Domestic garden wastes
- Domestic food wastes
- Commercial food wastes (from cafes and restaurants, supermarkets etc.)
- Septage wastes
- Municipal biosolids/sludges
- Dairy farm wastes
- Dairy factory wastes/sludges
- Piggery wastes
- Animal processing wastes (from meat works, fisheries etc.)

The key wastes that are currently being disposed of to landfill are domestic garden and food wastes. Some dairy factory and animal processing wastes may also go to landfill, although it is expected that much of the solid matter from those sources is collected within a wastewater stream for treatment on or off-site. It is understood that some commercial food wastes, for example from restaurants, are collected for stock feed, if separated at source. Manures, if collected, are disposed of on-farm (i.e. to land or within effluent ponds).

Although on farm disposal methods can add nutrients back into the soil, problems can also arise from the uncontrolled pollution of waterways and the creation of odour and greenhouse gas emissions. These methods result in a lost opportunity to potentially convert farm wastes to compost or to energy (heat and biogas). Where economically viable, biogas can be converted to electricity or even to liquid fuels. Liquid and solid by-products from biogas production also carry potential value as fertiliser products.

The Alliance Group is a major meat processer in Southland, producing approximately 2,400 to 2,900 T/pa of sheep and beef waste solids (paunch wastes, grit and screenings etc.) and around 17,000 T/pa of Dissolved Air Filtration (DAF) sludge and 800 to 1,000 T/pa of solids from the treatment of pelt processing wastewater. The sheep and beef waste solids from the

[3] Southland Waste Assessment (2011), Morrison Low.

Mataura and Makarewa sites are currently composted, while the 1,000 T/pa from the Lorneville facility are currently retained on-site (previously also composted). DAF sludge is applied to farm land and pelt processing solids are disposed of to a local coal mine as part of its remediation. Although these are all examples of beneficial reuse, there may be opportunities to change practices to AD if greater overall benefit can be achieved[4].

The following sections provide a high level discussion of the potential options for beneficial reuse of organic wastes generated in the Southland region with a discussion on AD options for domestic food wastes, garden waste and dairy wastes. Consideration is also given to commercial composting options for food and garden wastes.

4.1.1 Waste Quantity Estimates

Organic waste makes up an estimated 223 tonnes per week (28.7%) of the waste from Southland Region as measured in June 2011. Table 4-1 summarises data, by each district, relating to the tonnages of organic waste collected at SRL during the period, 20-26 June 2011. There are a number of points which should be taken into consideration with regards to this data and its source[5]

- The source report is based upon waste to landfill only and, therefore, does not necessarily include all waste. For example, waste separated out by customers at Refuse Transfer Station's (RTS's) and recovered is not included. For example all District Transfer Stations have separate garden waste (greenwaste) facilities ,
    - The greenwaste in Gore is separated out and used either as a mulch on the Council's parks and gardens or composted and used as cover material on a closed landfill site.
    - Greenwaste dropped off to the Invercargill RTS is composted through a windrow system and used as closed landfill cover material.
    - The greenwaste at Southland District facilities is mulched and given away to customers.

  The diverted greenwaste annual figures are provided separately in Table 4-2.
- Domestic organic waste found in household kerbside rubbish collections are disposed to landfill, these figures are included in table 4-1. This includes kitchen (food), compostable (lawn clippings, vegetation, branches), non-compostable (bamboo, flax, palm, cabbage tree, stumps) and other material (meat processing waste, dead animals).
- The survey was conducted in winter (June 2011) when vegetative growth and gardening activity are low, therefore, figures are conservative (refer section 4.2.3 for more information relating to seasonality).

The table shows the composition of organics collected at each of Gore RTS, Invercargill RTS and Southland District RTS's, in addition, to the composition of organics delivered to SRL from each of the districts. This difference in tonnages occurs on account of the fact that the overall contributions to SRL are influenced by additional waste-streams. Specifically, Southland District's overall contribution to SRL consists of waste from transfer stations, special waste, Industrial/ Commercial/ Institutional (ICI) waste, and kerbside collections

[4] Alliance Group Southland waste data provided by Frances Wise, Environmental Manager, Alliance Group, 18th July 2011

[5] Composition of Solid Waste in Southland Region – 2011. WasteNot Consulting, July 2011.

taken to the Invercargill RTS. Invercargill's contribution includes waste from RTS, special waste and ICI waste.

ICI waste provides an additional 14 tonnes of organic waste per week to the estimates shown in Table 4-1. Of the wastes from the Southland Region disposed of at SRL the survey indicates that compostable greenwaste is 4.4% or 34T/week.

This is highlighted to demonstrate that the tonnage of waste available for beneficial reuse may be a function of the facility site selected.

Table 4-1 Estimates for key organic wastes in the Southland region (June 2011 SWAP)

	Overall waste (includes kerbside collections)	
Gore RTS[6]	Organics collected at Gore RTS	Organics delivered from Gore to SRL
	Tonnes/week	Tonnes/week
Kitchen waste	17.3	17.3
Compostable	6.6	6.6
Non-compostable g'waste	1.1	1.1
Material/other	2.3	2.3
Subtotal	27.3	27.3
Invercargill RTS[7]	Organics collected at Invercargill RTS	Organics delivered from Invercargill to SRL[8]
	Tonnes/week	Tonnes/week
Kitchen waste	108	107.3
Compostable	20	18.6
Non-compostable g'waste	5	5.3
Material/other	12	22.8
Subtotal	144	153.9
Southland RTSs[9]	Organics collected at SDC	Organics delivered from SDC to SRL
	Tonnes/week	Tonnes/week
Kitchen waste	9.6	26
Compostable	3.2	9
Non-compostable g'waste	0.4	1
Material/other	0.8	3
Subtotal	14	39

Source: Composition of Solid Waste in Southland Region July 2011. NB Figures are rounded so column totals do not always appear to add up.

[6] Composition of Solid Waste in Southland Region 2011, Appendix 8
[7] Composition of Solid Waste in Southland Region 2011, Appendix 9 and 11
[8] The overall waste stream disposed of to SRL from Invercargill is composed of: Waste Collected at Invercargill RTS, special wastes (biosolids, infrastructural cleanfill, or industrial wastes that either requires special handling or have eco-toxic properties) from Invercargill, ICI wastes from Invercargill District, less the kerbside collections from SDC disposed of at Invercargill RTS.
[9] Composition of Solid Waste in Southland Region 2011, Appendix 10 and 12

Acknowledging that not all greenwaste is sent to landfill, Table 4-2 shows the greenwaste diverted from landfill by the Councils, for the period July to June from 2006 - 2011[10]

Table 4-2 Tonnage of greenwaste diverted by Council (July 2006 to June 2011)

Council	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011
Invercargill	4,985	5,232	6,058	6,013	5,573
Gore	815	735	844	802	895
Southland	821	245	223	385	247
Total	**6,621**	**6,212**	**7,125**	**7,200**	**6,715**

Source: Southland Region Waste Assessment January 2012

Separately, broad estimates have also been made for total tonnes of manure generated from dairy farms across the region. Further estimates have been developed to assess AD options for a theoretical, average sized dairy farm that uses herd houses for wintering of stock. The focus is on dairy farming due to it being the largest scale agricultural activity within the Southland region and one that is expected to grow significantly in coming years. Increased use of herd homes, and resulting increases in the amount of manure collected, is also expected as current practices of off-farm wintering of stock are costly and logistically challenging in terms of transporting large numbers of animals to northern areas in Southland or outside the region.

Annual manure quantities from a pig quarantine facility, currently under construction, have also been estimated. This wastestream was focused upon due to proven AD facilities for piggery wastes and the potential for further quarantine facilities to be developed within Southland[11].

Table 4-3 Estimated dairy and piggery waste available for beneficial reuse

Waste type / source	Total waste generated		Waste available for beneficial reuse	
Dairy wastes – manure	5.7 Million T/yr	Assumes 12.5T/yr of manure per cow[12], and 458,306 dairy cows in the Southland region[13]	2,300 T/yr/farm (4.3 T/yr/dairy cow)	Assumes a herd size of 539, use of herd homes for 20 hours per day, 90 days pa and 15% of manure collected from milking shed. Also assumes farming practices would be amended to maximise AD production, e.g. method and frequency of manure collection.
Piggery wastes – manure		Assumes 4.5T/yr of manure per sow[14]	3,000 T/yr/farm	Assumes 700 pigs housed indoors/on concrete pads 22 hours per day. Also assumes site practices would be amended to maximise AD production, e.g. method and frequency of manure collection.

[10] Southland Region Waste Assessment, Morrison Low Consultants, November 2011.

[11] New facility to quarantine Auckland Island pigs, information provided by Steve Canny, Venture Southland, 8th July, 2011.

[12] Manure production calculated using the Intelligent Energy Europe biogas calculator, assuming a 539 dairy cow herd and weight per cow of 400kg - http://www.dairyenergy.eu/index.php?option=com_ieecalculator&calcType=12&Itemid=221

[13] Herd data based on 2009/10 NZ Dairy statistics - http://www.dairynz.co.nz/file/fileid/34190

[14] Manure production calculated using the Intelligent Energy Europe biogas calculator, assuming a 700 sow pig herd and weight per sow of 250kg - http://www.dairyenergy.eu/index.php?option=com_ieecalculator&calcType=12&Itemid=221

The volumes above are calculated on manure alone, however it is likely that manure will be mixed with other material, such as woodchip, which may be used for animal bedding. This would increase the volume substantially. For example it is known that 100 pigs produces 160 T/mth of organic waste a month, assuming 700 pigs, at 19.2T/yr, this equates to 13,440T/yr.[15] This mix however may present challenges in AD, as the woody waste takes longer to break down, as discussed below under section 4.2.2.

4.2 Beneficial Reuse Options

Whether treatment by composting or anaerobic digestion is appropriate is, at least in part, dependent upon the composition and quality of the feedstock. This section identifies the treatment/(s), appropriate for each of the primary organic feedstocks within the Southland region.

4.2.1 Domestic Food Waste

DEFRA, the UK Department for Environment, Food and Rural Affairs, states[16] that the most 'environmentally preferably treatment options for food waste are usually AD or composting' and that 'AD is generally preferably because it produces both renewable energy and a biofertiliser'.

Food wastes are considered technically appropriate for AD and composting.

4.2.2 Mixed Domestic Food and Garden Waste

Although strong advocates of wet AD treatment, DEFRA also acknowledges[7] that 'for some organic wastestreams, composting will remain the best option, such as co-collected food and garden waste, or woody garden waste that is collected on its own'.

These guidelines are provided on the basis that garden waste may not break down or contribute to the energy generation of the plant; a sentiment supported by data indicating that the biogas potential of municipal greenwaste (and particularly woodier greenwaste) is lower than that for food waste[17] and that the retention time for gas production is higher for the garden wastes than food waste[18].

That is not to say that all greenwaste is inappropriate for wet AD systems. It is acknowledged that the biogas potential of greenwaste can be increased by mixing with some alternative wastestreams but, when greens and food waste are comingled as feedstock, it can increase the processing costs and decrease production efficiency, relative to a food waste only feedstock (as shown by examples from the United Kingdom[19]).

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[15] New facility to quarantine Auckland Island pigs, information provided by Steve Canny, Venture Southland, Feb, 2012.

[16] Anaerobic Digestion Strategy and Action Plan, A commitment to increasing energy from waste through Anaerobic Digestion - http://www.defra.gov.uk/publications/files/anaerobic-digestion-strat-action-plan.pdf

[17] Energy Consumption and Savings in Indonesian Resort Hotels, Perspectives for Energy Efficiency and Renewables, Jan Sternstein, 2011. Page 98, Table 4.12. - http://books.google.co.nz/books?id=TKckT-eIbPIC&pg=SA1-PA91&lpg=SA1-PA91&dq=methane+production+from+garden+waste&source=bl&ots=1OyA6SCUtd&sig=S12jMk#v=onepage&q=methane%20production%20from%20garden%20waste&f=false

[18] Feedstocks for Anaerobic Digestion, Steffen R., Szolar O. and Braun R., 1998. Pg 17, Table 4. http://www.adnett.org/dl_feedstocks.pdf

[19] Biogas Regions, Shining Examples Report – http://www.biogas.org/doc/shining_examples/21_40.pdf

Therefore, for the treatment of food waste by AD, where food waste only feedstocks are preferable, it is recommended that food waste be collected separately at source, whereas, for composting food waste can be comingled with greenwaste.

4.2.3 Greenwaste Only

Greenwaste can technically be treated by composting or by AD. However, as highlighted in section 4.2.2, it is generally desirable to increase the biogas potential of a green AD feedstock by mixing it with another feed (although this option needs to be further evaluated on account of the potentially increased processing costs etc.). Aside of this issue, there are other complications associated with AD systems for greenwaste as follows:

Seasonality of Feedstock

A recent study[20] showed monthly tonnages of all waste from Southland Region disposed of to landfill. The study demonstrated that the overall mass of waste received was a function of the time of the year and supports the logical assumption that the quantity of greenwaste tends to vary on a seasonal basis.

Table 4-4 shows the overall organic waste, inclusive of both green and kitchen waste from kerbside collections, received from the Southland region. Comparison of the 2011 study with an earlier equivalent report[21] indicates that approximately 1.5 times as much organic waste was collected in the Southland region during a one week period in November 2007 than in the one week during June 2011(as per Table 4-4). Clearly, these figures may be influenced by the presence of the kitchen waste but a variance is apparent.

Table 4-4 Waste Received from the Southland Region in June 2011 and November 2007 (SWAP)

	Jun-11	Nov-07
	T/week	T/week
Overall organic waste		
Gore RTS	27.3	39
Invercargill City	144	226
Southland District RTS	14	17
Overall organic waste	185.4	282

Separately, the reports detail the equivalent data for putrescibles - greenwaste. These figures represent the diversion potential of the greenwaste and indicate that that approximately 4 times as much organic waste was collected in the Southland region during a one week period in November 2007 than in the one week during June 2011.

[20] Composition of Solid Waste in Southland Region – 2011. WasteNot Consulting, July 2011.
[21] Part Two – Survey of Composition of Solid Waste in Southland – 2007, WasteNot Consulting, May 2008.

Table 4-5 Putrescible – greenwaste- from the Southland Region in June 2011 and November 2007

	Jun-11	Nov-07
	T/week	T/week
Putrescibles - greenwaste		
Gore RTS	1.5	3.5
Invercargill City	8.6	36.7
Southland District RTS	0.4	3.6
Overall organic waste	10.5	43.8

Clearly, the variance may be attributed to a greater number of factors than seasonality alone (for example, community education and participation, population changes etc.) but regardless, the feedstock levels are seen to vary significantly, which means control of the feedstock (mix) can be difficult[22].

In addition, it is further assumed that the composition of greenwaste also varies with season.

Greenwaste Composition

The composition of the feedstock effects the microbial activity and, hence, the anaerobic degradation efficiency of AD systems. Typical greenwaste will consist of biodegradable organic fraction (grass and tree cuttings), combustibles (slow degrading lignocellulosic organics) and inert material, including stones and grit[23]. To improve the feedstock quality, the lignite (woody) composition should be removed (as it does not break down during digestion[24]) with other large or inert components, which can cause damage or wear to the plant and equipment.

Additionally, pre-treatment for AD systems can also involve mixing with different feedstocks and / or the addition of water. These pre-treatments can increase the operating costs relative to food waste or manure fed systems. This is not to suggest that composting systems do not require pre-treatment of the feedstock and, in fact, wet AD systems may be better suited than composting when the feedstock is heavily contaminated with particularly plastics[25].

Transportation

By its nature, greenwaste tends to be bulky and have large volume, resulting in higher transportation cost per tonne; a factor which remains unchanged regardless of the treatment selected. However, it may be more economical to have multiple, smaller treatment facilities (increased capital costs but decreased transportation costs), as opposed to, a large and central facility (reduced capital costs and increased transportation costs).

With regards to the facility, because AD systems typically have higher capital costs than composting, an economic assessment may conclude that it is beneficial to have multiple, smaller composting sites (and reduced transportation costs), as opposed to, a reduced number of AD systems (and increased transportation costs). Clearly, an economic assessment which considers these scenarios is a complicated exercise, involving multiple

[22] MfE (2005) Options for Kerbside Collections of Household Organic Waste
[23] Department of Earth & Environmental Engineering, Henry Krumb School of Mines, Shefali Verma, May 2002.
[24] http://www.defra.gov.uk/publications/files/anaerobic-digestion-strat-action-plan.pdf para 42
[25] Feasibility of Generating Green Power through Anaerobic Digestion of Garden Refuse from the Sacramento Area, RIS International Ltd. & MacViro Consultants Inc. April 2005.

contributing factors. For example, it is recognized that AD sites would generate biogas, which may potentially be converted to liquid fuel for vehicles used to transport waste , or vehicles could be converted to run on compressed gas (as is done in Redvale landfill[26]).

Summary

To summarise, composting is better able to cope with the variations in seasonal tonnages and feedstock compositions associated with greenwaste. Also composting may require less pre-treatment than AD systems. These factors both contribute to composting systems typically have lower operating costs than AD systems.

A detailed cost benefit analysis would be required to compare each of the following scenarios:

1. Separate collections of food and greenwaste for treatment by AD and composting respectively
2. Separate collections of food and greenwaste for treatment by separate AD systems
3. A comingled green and domestic food waste fed AD system

This extensive and detailed exercise would need to include, but not be limited to:

- the method of separation appropriate for the Southland region,
- the tonnage and composition of feedstocks
- the location of and type of treatment facilities
- the relative operating and capital costs of these facilities
- the quality of product required

However, the observations made above in relation to greenwaste are supportive of the increasing global trend for food waste to be collected separately to greenwaste and also for food waste to be treated by AD while greenwaste is composted[27]. Therefore, for the purpose of this report, composting is focused upon as a suitable processing option for garden waste (and commingled food and garden wastes). Anaerobic digestion is a suitable processing option for foodwaste.

4.2.4 Dairy and Piggery Wastes

Both composting and anaerobic options are considered for cow and pig manures.

4.3 Waste Treatment Processes

This section contains a description of the composting and AD processes. Available proprietary technologies for composting and AD are outlined in sections 4.3.1 to 4.3.3 respectively. It is noted that there are a wide range of proprietary systems available and those selected should be considered as examples rather than an exhaustive list of options.

[26] http://www.transpac.co.nz/BiogasLaunch.pdf
[27] http://www.biogasregions.org/doc/shining_examples/21_40.pdf

4.3.1 Composting

The composting process is suitable for both food wastes and manures, although all will require the addition of a suitable bulking agent to balance out carbon to nitrogen ratios, moisture content and mix porosity. Greenwaste is a commonly selected bulking agent, as is woodchip, often combined with (untreated) sawdust.

In-vessel composting systems are focused upon due to their ability to optimise the composting process and control odours released from putrescible wastes, such as food and manures. Both composting systems outlined below have a proven record for the composting of food wastes, manures, sludges and animal processing wastes.

Proprietary Technology - HotRot®

The HotRot composting system was developed and is manufactured in New Zealand by R^5 Solutions Limited. It is a modular, in-vessel system comprising of one or more horizontal cylinders connected by common feed and harvest systems. The largest HotRot cylinder is 18 m long with a 3.5 m diameter. HotRot modules range in processing capacity from 1-12 tonnes of waste per day, depending on the desired retention time for the processing material.

Additional information relating to the HotRot® system is contained within Appendix A.

Proprietary Technology – NaturTech®

NaturTech is an in-vessel composting system comprised of a series of airtight customised shipping containers. They are constructed from a 20 or 40 ft long boxes, with capacities of 40 m^3 and 80 m^3 respectively. For a 20-day retention time this converts to approximately 1 T/day (20 ft long box) or 2 T/day (40 ft long box). Containers are sold in increments of 4 or 5 composting units connected to a biofilter unit (biofilter also within a converted shipping container). NaturTech containers produce between 1.2 and 3.3 tonnes of compost per day per container and existing NaturTech facilities compost primary wastewater solids, dissolved air flotation (DAF) solids, food residuals, forest products, poultry feathers, chicken manure and dairy manure.

Additional information relating to the NaturTech® system is contained within Appendix A.

4.3.2 Anaerobic Digestion

Regional digester facilities processing a range of agricultural and food waste feedstocks are common in parts of Europe[28]. However, due to differences in economic boundary conditions (power costs, fuel costs, waste disposal costs) and country specific technical constraints (farming practices, environmental regulations), it is difficult to simply transpose regional digester facility costs and performance from these European examples into New Zealand.[29] The general conclusion is that New Zealand opportunities for AD are likely to be relatively small in size and limited to the wastewater treatment and farming sectors[30]. These projects would use the energy produced on-site, which improves the economics insofar as there are no transport costs/losses and the energy produced offsets energy purchased at retail cost

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[28] Al Seadi, T. (2000). Danish Centralised Biogas Plants – Plant Descriptions. Bioenergy Department, University of Southern Demark, Torben Skott, BioPress.

[29] http://www.nzpork.co.nz/LinkClick.aspx?fileticket=PcSls1PRc0k%3D&tabid=145&mid=790

[30] Cockes and Sounes (2004) Presentation to Bioenergy Association of New Zealand Biogas Workshop Christchurch,

rather than competing on the wholesale market.

AD systems suitable for digesting agricultural wastes include low rate covered ponds and higher rate tank based systems. AD tank systems may be mixed or static; continuous or batch flow. The most suitable system needs to be assessed on a case by case basis, depending on waste quantities and economics. It is expected that covered ponds would be the most economically viable for on-farm digestion. Tank systems may become viable for a multi-farm and/or multi-wastestream centralised facility, particularly if seasonality of dairy farm wastes can be offset by the supply of alternative wastestreams. High rate bio-digesters incorporating multiple filters and biofilm processes such as packed bed reactors are not suitable for digestion of manures and other slurry or semi-solid agricultural wastes as these systems are intended for liquid wastes (higher solid contents tending to clog filters).[31]

AD technology is currently employed at the Clifton Wastewater Treatment Plant in Invercargill. Further discussion on this facility and other wastewater treatment facilities are covered within section 9.

Covered Ponds

Covered ponds, or lagoons, provide the simplest form of anaerobic digestion and are well suited to handling manure in a liquid form such as flush water from sheds. Typically this would mean a solids content of less than 3 %[32] although some systems state an ability to handle solids contents of up to 5 %[33]. Ponds are sized according to effluent quantities and required retention time (typically a number of months). Covers allow the capture of emitted gases and help maintain a better environment for gas production. However, production rates are low compared to other digestion systems and are affected by seasonal temperature changes (more gas produced during warmer months). For this reason covered ponds are best suited to warm and temperate climates.

Solids may be screened out from the effluent prior to entering the pond (e.g. for use as fertiliser), however, this reduces biogas potential. Daily operating and maintenance requirements are low; however, settled solids need to be pumped out periodically. Solids pumped out from an AD pond are expected to be less odorous than those pumped out from a standard (uncovered) effluent pond.

Covered ponds may be newly constructed or created through conversion of existing effluent ponds. This technology is unlikely to be suitable for the digestion of post-consumer food wastes due to higher solids content and greater risk of physical contaminants (particularly with domestic food wastes). Pathogen risk from introducing meat products into a farm system may also be an issue, particularly if it is intended to spread AD fertiliser products onto pastoral or stock feed land.

NIWA covered anaerobic ponds

NIWA has been working with a number of farms in New Zealand to develop a simple pond based AD system specifically suited to the New Zealand environment and organic loading

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[31] Burke, D. A., 2001. *Dairy Waste Anaerobic Digestion Handbook, Options for Recovering Beneficial Products From Dairy Manure*, Olympia, Washington, USA.

[32] Schwart, R. et. al, 2005. *Methane Generation, Final Report to the State Energy Conservation Office*, Texas, United States, June, 2005.

[33] Heubeck, S. et. Al, 2007. Biogas and Manure Management Options for the New Zealand Pork Industry, NIWA presentation, October 2007 - http://www.nzpork.co.nz/LinkClick.aspx?fileticket=6XG5mVoM65A%3D&tabid=71&mid=674

conditions on a farm by farm basis. The earthen ponds are covered with a UV resistant, flexible polypropylene liner and the biogas is captured via a network of plastic piping. The NIWA system also incorporates a ring pipeline and fan to increase biogas draw-off and a rainwater collection system. Existing effluent ponds can be retrofitted with the NIWA cover system, although new AD ponds are likely to be smaller than effluent ponds and new construction costs may be similar, or less, than retrofit costs.

The NIWA system is employed at a 400 sow piggery in Lepperton, Taranaki. The pond is 60 m by 20 m by 7 m deep, with a capacity of 7,200 m^3. The cover balloons out to contain up to 1200 m^3 of gas[34]. A 48kW biogas generator converts the biogas to enough electricity to offset over half of the piggery's requirements (previously costing $6,000 to $7,000 per month). Heat energy is also captured and will ultimately be used within the piggery for under floor and boiler heating. The facility has successfully reduced odours and screened out solids are also being sold as a fertiliser product. The covered pond system was installed in 2009 and the generator in early 2010. Primarily based on reduced energy spend, the payback period is expected to be within 3 to 4 years. Although the initial take-up has been on piggeries, NIWA are confident that their systems would also provide a solution for dairy farms.[35]

4.3.3 Digesters

Details of example proprietary digesters are provided below.

BioGenCool™

The BioGenCool system is a tank digester that combines anaerobic digestion processes with milk cooling. The tank is constructed from tanalised pine and is Polyvinyl chloride lined and insulated. A prototype was developed by Ian Bywater of Natural Systems Limited and operates on a Landcorp-owned dairy farm in North Canterbury. With a capacity of 160 m^3 the system processes manure from around 900 cows, flushed from a concrete pad outside the milking shed. As well as cooling milk, energy generated from the facility provides one third of the farm's electricity requirements.[36,37]

Cigar® Anaerobic Digester

The Cigar system is an in-ground anaerobic digester developed by New Zealand company Waste Solutions. It has a larger footprint than tank based digesters and therefore is best suited to sites where land supply is not an issue. Waste Solutions put forward the Cigar system as a suitable option for the digestion of agricultural, municipal and industrial organic wastes; in liquid, semi-solid or solid forms. They also claim to have higher gas production, lower costs and lower maintenance requirements than other above-ground biogas systems. An ultra violet light stabilised plastic membrane removes corrosion risk and more than 20 Cigar facilities are currently in operation.

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[34] Taranaki Daily News, 2010. *A Silk Purse from a Sow's Ear* - http://www.stuff.co.nz/taranaki-daily-news/farming/3371639/A-silk-purse-from-a-sows-ear

[35] Personal communication with Stephan Heubeck, NIWA, 15th July 2011.

[36] EECA, 2009. *Technical Guide 6.0, Biogas on your farm*, EECA Business, New Zealand Government, August 2009/ECC1077.

[37] http://www.techlink.org.nz/Case-studies/Technological-practice/Food-and-Biological/Print-PDFs/techlink-tp-cow-power.pdf

Additional information on the technology was sought from the supplier, along with specific comment on its suitability for processing food and manure wastes of the scale applicable to the Southland situation. However, no response was received prior to preparation of this issues paper. Although expected to be a higher cost option that covered anaerobic ponds, the Cigar may warrant further investigation for larger Southland farms and/or multi-farm/multi-waste options.

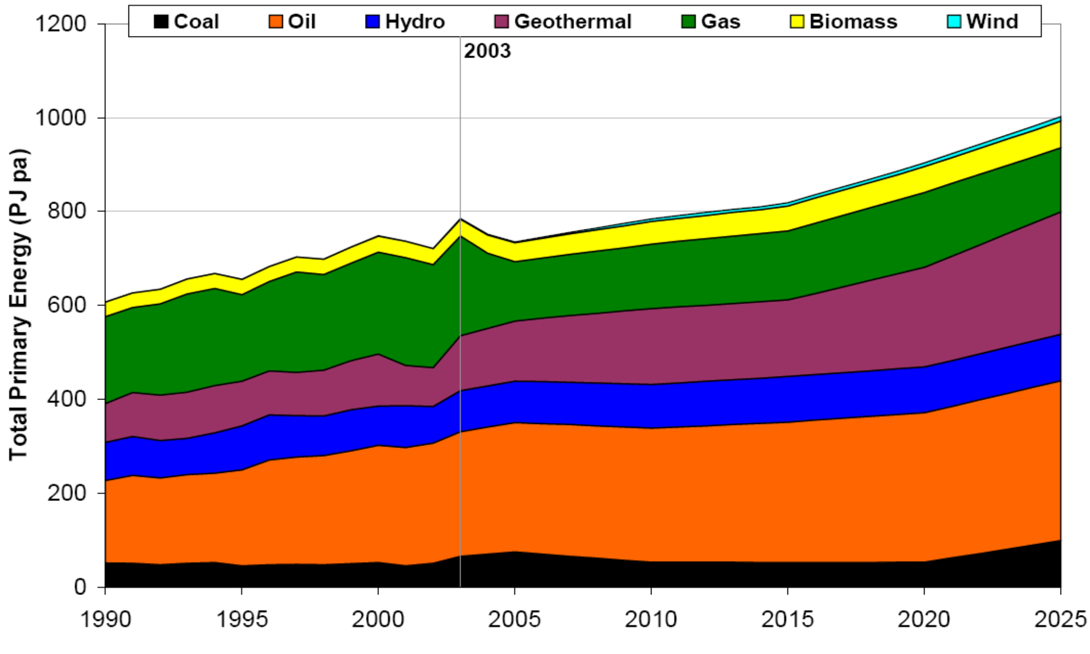
5. ECONOMICS OF ORGANIC SOLID WASTE OPTIONS

5.1 Energy composition New Zealand overview

In order to take a closer look at specific energy from waste applications and issues it is prudent to begin with a high level overview of the energy sector in New Zealand.

Figure 5-1 depicts the total primary energy generation supply for a range of generation methods. If viable waste to energy alternatives are to be developed then reference to predicted generation supply is critical, particular attention needs to be given to likely fossil fuel generated energy that could be replaced with a renewable source through waste to energy applications.

Figure 5-1 Primary generation supply 1990-2025



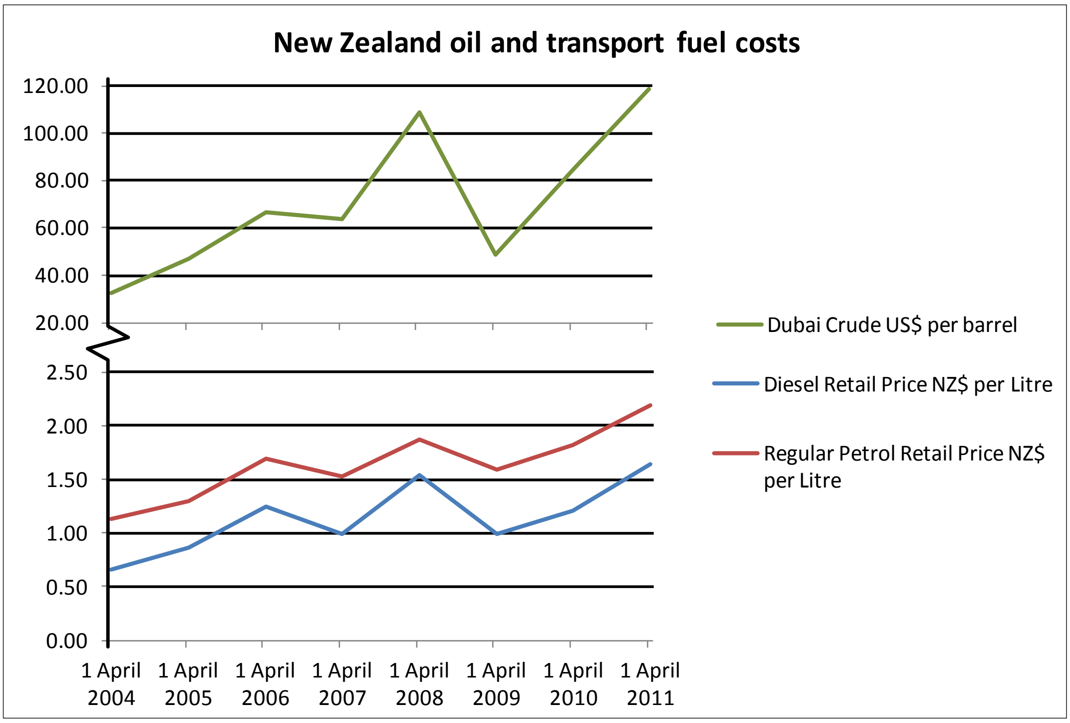
Source: Ministry for Economic Development Energy Outlook to 2025[38]

[38](http://www.med.govt.nz/templates/Page____10341.aspx?&MSHiC=65001&L=0&W=energy+prices+&Pre=%3cb%3e&Post=%3c%2fb%3e#P50_9607)

5.2 Energy prices overview

The economic viability of any energy from waste options is impacted by a range of factors, of these the price of oil and transport fuels are key considerations. The long term viability of any of the options is dependent to a degree on price predictions. As energy prices increase then the viability of other options may increase. While an in depth analysis of energy trends is outside the scope of this report it is noted that issues such as peak oil could see a steady increase in the price of oil over time. Figure 5-2 shows the price of transport fuels in New Zealand over time.

Figure 5-2 New Zealand oil and transport fuel costs



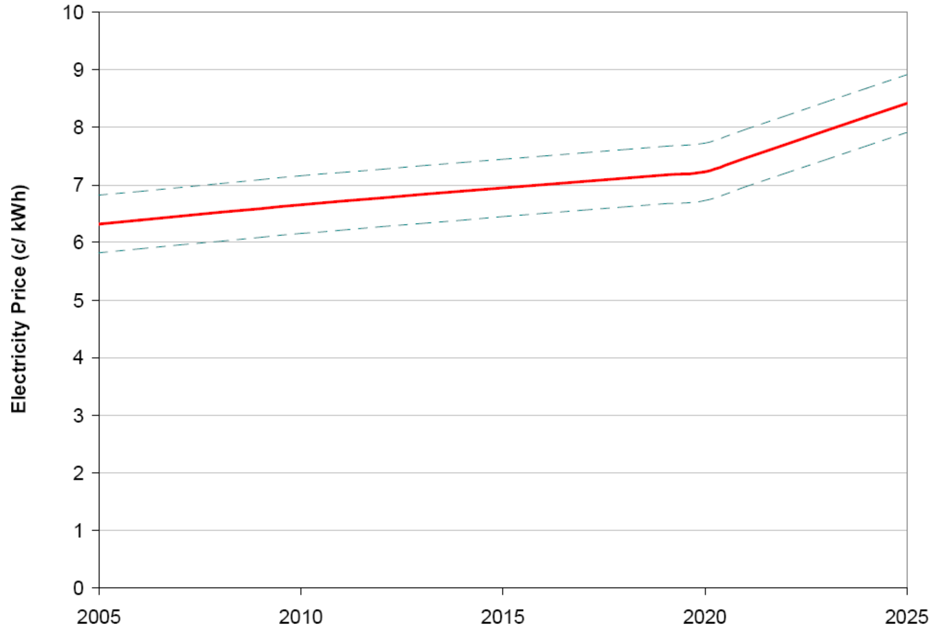
Source: Ministry for Economic Development 2011[39].

This figure illustrates that the general trend is for a gradual increase in the price of transportation fuels. This is of relevance to energy from waste options that may produce "fossil fuel equivalents" such as syngas or biodiesel type fuels. When energy prices increase so does the viability of non-fossil fuel alternatives as higher prices paid for the end product can ensure any investments in plant have a shorter payback period.

The following Figure 5-3 shows the wholesale electricity price predictions for the period up to 2025, based on a steady average growth rate of 1.4 %. It also shows some possible variations in pricing. Once again this information is crucial in considering the viability of potential options. It is, therefore, suggested that more comprehensive data is sought in the long term prior to choosing potential options.

[39](http://www.med.govt.nz/templates/MultipageDocumentTOC____39564.aspx)

Figure 5-3 Wholesale energy price fluctuations 2005-2025



Source: Ministry for Economic Development 2011[40].

It is also recommended that both current and future energy price considerations form part of the criteria used to assess viability of particular energy from waste options. In addition to becoming part of the potential criteria for judging future programmes or initiatives, energy prices will also have an effect on current waste contract prices, although this is usually dealt with as part of the contract terms and conditions.

5.3 Process Cost Estimations

It is not the intention of this section to provide detailed cost estimates for each of the processing options, in each of the potential facility locations (each with differing tonnage feedstock variations), as this is outside of the scope of work. However, the following options are acknowledged as requiring further investigation from a capital and operating expense perspective. The tonnages of feedstock are provided for each of the facilities, assuming processing is undertaken at the separate locations. Industrial/ Commercial/ Institutional (ICI) waste, particularly from Invercargill and Southland District would further increase these volumes, by an additional 10 tonnes of kitchen and compostable greenwaste per week, as shown in Table 4-1 below. The volumes of kitchen and compostable waste are likely to be conservative given they are based on a week's data from a SWAP study in June 2011, multiplied by 52 weeks, and organic waste is likely to be seasonally influenced. The Greenwaste at RTS are more accurate as they are annual figures from the refuse transfer stations (RTS).

[40] Figure 6: Wholesale Electricity Prices 2005-2025 (Reference Scenario)

1. In-vessel composting or AD processing of comingled food and garden waste

Waste Source	Kitchen Tonnes/pa[41]	Compostable Tonnes/pa[42]	Greenwaste at RTS Tonnes/pa[43]	Total (tonne/pa)
Gore District	899.6	343.2	895.0	**2,137.8**
Invercargill City	5,616.0	1,040.0	5,573.0	**12,229.0**
Southland District	499.2	166.4	247.0	**912.6**
Region from transfer stations	**7,014.8**	**1,549.6**	**6,715.0**	**15,279.4**
Industrial/ Commercial/ Institutional Waste Direct to SRL[44]	468.0	52.0	n/a	520
Regional total/pa	**7,482.8**	**1,601.6**	**6,715.0**	**15,799.4**

2. In-vessel composting of compostable greenwaste with separate AD processing for food waste

Waste Source	Compostable Greenwaste, Tonne/pa[45]	Food waste for AD, Tonne/pa
Gore District	1,238.2	899.6
Invercargill City	6,613.0	5,616.0
Southland District	413.4	499.2
Region from transfer stations	**8,264.6**	**7,014.8**
Industrial/ Commercial/ Institutional Waste Direct to SRL[46]	52.0	468.0
Regional total/pa	**8,316.6**	**7,482.8**

Also, composting and AD options for diary and piggery manures need to be assessed, taking into account the potential requirement for food and greenwaste. To assist further investigation, initial enquiries were made of suppliers who have subsequently provided indicative pricing for their composting systems. Their responses are summarised below for three example scenarios.

5.3.1 In-vessel composting

HotRot

HotRot Scenario 1: 8,000 T/yr of mixed food and garden wastes

- Two HotRot 3518 composting units, integrated feed hopper, discharge auger, biofilter and electrical and control system - indicative capital cost: $3.4M
- Labour requirements: 1 person 2 hours per day - 7 days per week

[41] Calculated the annual kitchen waste tonnage by multiplying the applicable figure (Table 4.1)by 52 weeks
[42] Calculated the annual compostable tonnage by multiplying the applicable figure (Table 4.1) by 52 weeks
[43] Using the 2010/2011 annual greenwaste figures from Table 4.2
[44] Annual ICI kitchen (9T/wk) and compostable greenwaste (1T/wk) by 52 weeks.
[45] Adding Compostable Tonnage per year and Greenwaste at RTS.
[46] Annual ICI kitchen (9T/wk) and compostable greenwaste (1T/wk) by 52 weeks.

- Power consumption - approximately 28kWh/tonne - $4.20/tonne at 15c/kWh
- Maintenance - approximately $5,000 per annum - allows for tine replacement after 6 years
- No water needed, no leachate disposal costs.

HotRot Scenario 2: 5,000 T/yr of mixed food and garden wastes, with around 2,400 T/yr of food waste collected from kerbside (Invercargill) and greenwaste added to achieve a 50:50 mix[47]:

- One HotRot 3518 composting unit, integrated feed hopper, discharge auger, biofilter and electrical and control system **or** Six HotRot 1811s, two feed hoppers (each serving three 1811s) discharge augers, biofilters and electrical and control system - Indicative capital cost: $1.9M - 2.5M
- Labour requirements: 1 person 1.5-2 hours per day – 7 days per week
- Power consumption - approximately 28kWh/tonne - $4.20/tonne at 15c/kWh
- Maintenance - approximately $3,000 per annum - allows for tine replacement after 6 years
- No water needed, no leachate disposal costs.

HotRot Scenario 3: On-farm composting unit for dairy/pig manure:

Costs would need to be developed on a site by site basis, with greater information required about waste quantities and composition and dewatering. A suitable bulking agent would be required to ensure that feed mix moisture content does not exceed 60 %. However, as an indication, the smallest HotRot 1206 processes 300-400kg/day and starts at about $160,000 installed. The next size up - HotRot 1811 – provides additional capacity and costs approximately $450,000 installed.

The above pricing excludes a shredder and product screen, permits/consents, any buildings, foundations and footing (although a budget cost would be $30,000 per HotRot unit), and connection to mains power.

NaturTech

Site specific information is required for a NaturTech supply and install estimate, however, indications from the 2011 product pricelist are as follows:

- 4T/d 20ft composting system – NZ$213,000
- 16T/d 20ft composting system – NZ$640,000
- 30T/d 40ft composting system – NZ$780,000

These indicative costs include supply and installation of containers, operating and monitoring equipment and training, but exclude land and permitting costs, loading/unloading equipment (e.g. specialist trucks), site preparation and building costs. For ease of comparison, the three scenarios noted above for the HotRot system convert to processing rates of:

- 8,000 T/yr mixed food and greenwaste – 22 T/d
- 5,000 T/yr mixed food and greenwaste – 14 T/d

[47] It is assumed that sufficient quantities of greenwaste would be available from other sources (e.g. greenwaste drop-off site, separate greenwaste collection etc.), also assumed that food waste quantity remains relatively constant throughout year (i.e. no seasonal peak allowed for facility sizing)

Based on these indicative prices, the NaturTech system is potentially lower cost than the HotRot technology. However, this would need to be confirmed via a formal quotation process. NaturTech costs for on-farm composting of manure is potentially cheaper than a reactor-type AD system, although this would depend on the amount of bulking agent required to balance feedstock properties.

5.3.2 Anaerobic Digestion discussion

Site specific information would be required in order to determine likely capital and operating costs for a pond based digestion system. However, as an indication, the NIWA covered pond system at the Lepperton Piggery, treating manure from around 400 pigs, had a capital cost of around $130,000[48]. The payback period for the facility, taking into account capital and operating costs, energy cost savings and fertiliser product revenue, is reported to be within 3 years. This is confirmed by NIWA staff who have indicated a payback period of around 3 to 4 years for an on-farm AD system servicing at least 400 animals[49]. NIWA also provides the following indicative unit rates for pond construction[50]:

- Anaerobic pond (earth lined) – $8-10/m^3 excavated
- Pond liner (installed) - $15-20/m^2
- Biogas collection cover (installed) - $20-25/m^2
- Generator (CHP unit) - $1-1.50/kWh.

Pricing for higher tech digester systems such as the BioGenCool and Cigar Anaerobic Digester would also need to be developed on a site by site basis. However, indicative pricing for on-farm AD systems in the United States are in order of NZ$600 to NZ$950 per cow (US$500 to $800 per cow[51]). This includes the cost of digestion, solids processing and generation. Based on the average sized Southland dairy farm of 539 cows, this equates to an investment of around $300,000 to $500,000, substantially more than the cost for covered anaerobic ponds. These indicative capital costs should be taken with caution as costs can vary significantly with location, farm size and selected technology.

International experience suggests that while farm-scale AD systems are a viable business concept – even where operations are profitable, the return on capital may be marginal. The Andersons Centre Report[52] cautions:

- Firstly, that projects be fully costed: "Beyond the headline figure supplied to you by the biogas company you decide to work with, remember the additional costs they will not be responsible for. These might include the cost of electrical connection, roadway preparation and earthworks, or building an additional nearby silage clamp if necessary. They should be clearly costed as these can add up to substantial amounts. The feasibility study and project development costs are easily forgotten: these include planning, professional fees, expert advice, time and effort, training"

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[48] Investment by farmer Steve Lepper of around $100,000 plus a $30,000 EECA grant - http://www.stuff.co.nz/timaru-herald/news/3396939/Pig-farms-effluent-becomes-liquid-gold

[49] Personal communication with Stephan Heubeck, NIWA, 15th July 2011.

[50] NIWA Information Series No. 32 2008 - http://www.biogas.org.nz/Publications/WhosWho/biogas-pond-booklet.pdf

[51] Burke, D. A., 2001. *Dairy Waste Anaerobic Digestion Handbook, Options for Recovering Beneficial Products From Dairy Manure*, Olympia, Washington, USA.

[52] The Andersons Centre Report (2008) A Detailed Economic Assessment of Anaerobic Digestion Technology and its suitability to UK Framing systems and waste systems, Leicestershire, UK.

- Secondly, that the high capital cost of setting up an AD plant means the enterprise should be considered a long-term operation: "The longer the capital investment can remain operational, the greater the profitability of the project will be. The life of an AD plant should be in excess of 20 years to provide a reasonable return on capital".

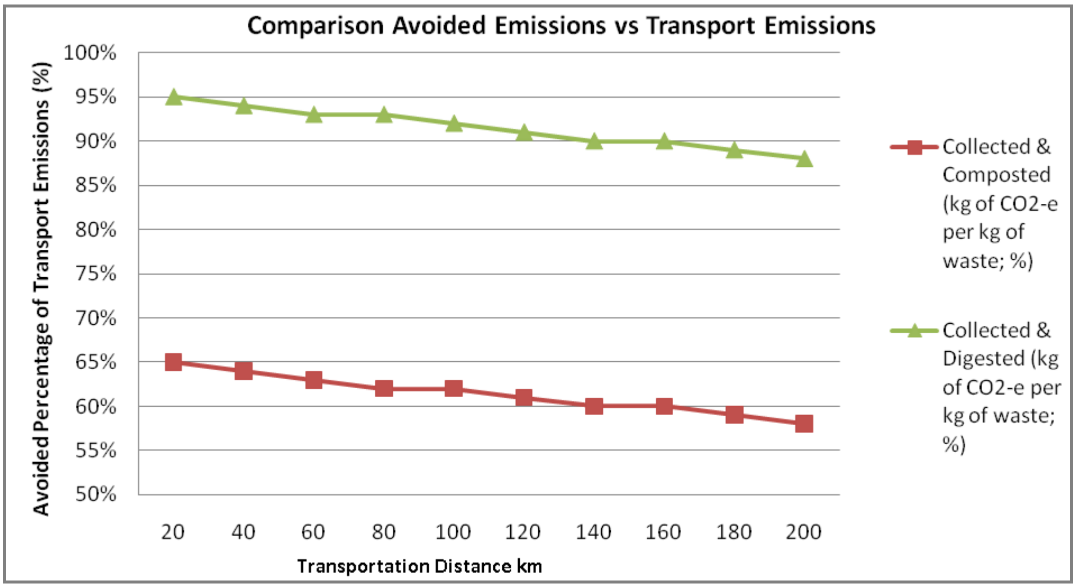
It is also noteworthy that across Europe and the US/Canada, contestable grants (in the order of 40% or sometimes up to 80% of project costs) have been essential in supporting the establishment of AD facilities; with the level of support reflecting the government commitment to achieving wider environmental objectives[53].

6. BENEFITS

6.1 Greenhouse gas emissions

A high level assessment has been prepared for greenhouse gas benefits of both composting and AD, as compared to landfill disposal and pastoral decomposition of manure, respectively as illustrated in Table 6-1 below.

Figure 6-1 Greenhouse Gas emissions comparison



Source: This assessment is based on general emission factors taken from a combination of Intergovernmental Panel on Climate Change (IPCC) literature and New Zealand specific emissions data.

Figure 6-1 demonstrates the greenhouse gas emissions avoided compared to those incurred through transporting the wastes. It clearly shows that AD performs better than composting as an alternative to avoided emissions, however, both do not avoid or recover more than the transportation emissions. It should be noted that this is under normal operating conditions using standard fuels. If the gas collected from AD waste is used and considered as an alternative fuel then the emissions would be significantly lower and would create a positive scenario for greenhouse gases. Also of note is the fact that transport emissions from waste collection may occur anyway as organic waste is collected for alternative non-energy recovery disposal.

[53] Sustainable Farming Fund Report (2009) "Waste to Wealth "

6.2 Potential revenue

There is potential for revenue from the sales of compost products or solid and liquid AD fertiliser products. However, the size and value of the market would require a more detailed assessment of the local area, potential users and local sales data for composts and synthetic fertilisers. Typically there is a lag time before compost/fertiliser revenue can be realised, with an initial period required to develop markets and potentially carry out medium term demonstrations on local farms.

The greatest potential product value is the replacement of current electricity or vehicle fuel use with biogas derived alternatives, with the offset value based on retail values (unless large energy users are able to obtain significant energy supply discounts). Potential revenue from sales of excess electricity are likely to be low due to New Zealand's low spot pricing and lack of price based incentives for renewable energy alternatives. However, there is potential for the conversion of biogas to liquid fuels to create a higher return, particularly as fuel prices continue to increase.

This option is particularly attractive for Southland due to its large land area, relatively large spread of industry, relative remoteness from supply and sale markets and current reliance on fossil fuels. However, key requirements for use of biogas based fuels are regular (i.e. daily) use of the fuel and long-term commitments for its purchase/use. Potentially there are large transport companies operating within Southland that could meet these requirements.

Alternatively, the Councils' contracted waste collection vehicles may be a feasible user of biogas based transport fuels.

6.3 Other benefits

Although this paper has focused on energy and carbon based benefits of AD of agricultural wastes there are a range of other benefits for farmers, the wider community and the environment. These include the reduction of:

- odours and associated benefits for farmers meeting resource consent conditions etc.
- pollution of waterways through increased capture of manure
- use of costly synthetic fertilisers (i.e. where replaced by digestate fertiliser)
- pathogens contained in manures (i.e. destroyed, at least in part, by AD processes)

7. ISSUES FOR CONSIDERATION

7.1 Scale

Composting technologies typically suit a wide range of waste tonnages with anticipated food, garden and manure waste tonnages for the Southland region within operational tonnage bands. According to the US Environmental Protection Agency, a general guideline for economic viability of on-farm AD is at least 500 cows or 2,000 pigs, and 90 percent of manure regularly collected. However, this is a general guideline only and smaller stock numbers and/or lower manure collection rates may still lead to a viable solution depending on individual farm factors (e.g. high energy costs due to more remote locations and/or intensive farming practices).

An example of a smaller successful operation in New Zealand is the Lepperton 400 pig operation in the Taranaki region described in section 5.3.2. For this facility NIWA recommends a herd size of 400 or more animals for cost effectiveness. With an average dairy farm size of 539 cows, Southland farms certainly appear to be of sufficient size to warrant further consideration of on-farm anaerobic digestion. This is also true for the Southland pig quarantine facility.

7.2 Waste sources and flows

Anaerobic digesters best operate on a regular and consistent flow of organic waste (feedstock). Irregular feedstock quantities can disrupt the biological processes involved, or stop them entirely. As manure collected from herd homes would presumably be maximised over winter months, or only collected during winter depending on how herd homes are utilised, variability in manure quantities is a key issue that would need to be addressed. Other organic wastes would therefore need to be sourced to offset periods of low dairy manure volumes. Further work would be required to identify waste quantities and flows from across the region with more certainty.

Pond based digestion systems are more flexible for seasonal variability in feedstocks, with the digestion ponds either able to also act as storage ponds, or to work in series with separate storage ponds. Biogas generation from the ponds is higher during warmer temperatures, therefore, would operate at a higher rate per incoming volume of manure during summer months and a lower rate per incoming volume but higher volume scenario in winter months.

Greater economies of scale could theoretically be achieved through the creation of centralised facilities for multi-farm or multi-waste stream scenarios. However, cost benefits would need to be considered against increased transport logistics and costs. Cross contamination issues would also need to be considered, particularly if fertiliser products were intended for use on pastoral or animal feed crop land.

7.3 On farm practices

"Biogas production is best suited for farms that handle large amounts of manure as a liquid, slurry or semi-solid with little or no bedding added."[54] However, excessive dilution will reduce biogas production. Optimum solids content varies with the digestion technology, however, an optimum total solids content for digestion is thought to be around 6 to 7 percent[55]. Solid manure (solids content >25%) is better suited to other treatment options such as composting rather than digestion.

Manure loses its biogas potential as it ages. Therefore, if intended for digestion, fresh manure would need to be collected at least on a weekly basis, preferably daily. Bedding material will introduce contaminants into the feedstock, therefore bedding material will need to be minimised if manure is to be digested.

Successful operation of an on-farm AD facility requires a commitment from the farmer to allocate the necessary time and financial investment required to not only establish and maintain the plant but also to up-skill and understand the various processes involved. Estimates of daily time commitments are 30 minutes to 1 hour for plant operation (depending on selected technology) plus around 15-30 minutes per day for maintenance and monitoring and additional but less frequent blocks of time for preventative maintenance. It is expected that daily commitments would be less for pond based systems.

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[54] US EPA, 2004. *AgStar Handbook, A Manual for Developing Biogas Systems at Commercial Farms in the United States*

[55] Burke, D. A., 2001. *Dairy Waste Anaerobic Digestion Handbook, Options for Recovering Beneficial Products From Dairy Manure*, Olympia, Washington, USA.

7.4 Product use

Biogas and/or heat produced from the AD facility will firstly need to be utilised to run the plant itself. The form and amount of energy required for this purpose will depend upon the technology selected. Excess biogas can then be converted to electricity for onsite use, or can be directly used to power other onsite equipment such as gas-operated chillers for milk refrigeration. Heat generated from the AD process can also be captured and used within specialised shed heating systems. Conversion of excess biogas to electricity for sale back to the grid is expected to be less beneficial, with electricity likely to only achieve wholesale rates and incurring additional costs for both electricity generation and supply to the grid.

Diesel is a large component of the energy use profile for dairy farms, therefore the potential to convert biogas to liquid fuel may be of interest. However, benefits from this would need to be assessed against costs for the additional conversion processes required. Solid and liquid by-products from the AD process also have value as fertilisers. There is potential for these fertiliser products to either be used on-farm or sold to other farms within the local area. There may be regulatory requirements that need to be met in order to use or sell digestion products, particularly for the sale of electricity or biodiesels.

8. ORGANIC WASTES CONCLUSIONS

Table 8-1 provides a summary of the findings of this assessment and comparison of processing options available for key organic wastes generated in the Southland region.

Table 8-1 Summary of Composting and AD Systems - Suitability for Southland Organic Wastes

Option	Advantages	Disadvantages	Comments
In-vessel composting	• can process food waste, greenwaste and manures • compatible with either commingled food and garden waste kerbside collection or food waste only collection • produces compost product that improves soil structure and has added nutrient value from food wastes and/or manure • requires semi-solid / solid feedstocks, therefore not suited to manure flush systems • modular systems allow for flexibility to manage seasonal variability • high level of control and process monitoring • operating footprint varies with system, however, in-vessel processing typically reduces land area requirements compared to windrow composting and potentially also to covered AD ponds • enclosed process minimises effects of seasonal temperature changes • composting process generates heat therefore less affected by lower temperatures than AD • reduces greenhouse gas emissions compared to landfill disposal	• no energy production • requires semi-solid / solid feedstocks, therefore not suited to manure flush systems • requires addition of greenwaste or other bulking agent – increasing facility size and potentially limiting putrescible waste fraction depending on how much greenwaste is available • higher capital cost than covered AD ponds, although potentially lower cost than higher tech digester systems • reduction in greenhouse gas emissions less than for anaerobic digestion options	• large range of composting systems available, including both NZ and overseas options • agitated systems such as HotRot provide additional mixing, aeration and a continuous processing method • static, batch processing systems such as NaturTech provide an option with lower maintenance requirements and energy use

Option	Advantages	Disadvantages	Comments
AD – covered pond	• well suited to liquid manures • creates energy and fertiliser products (solid and liquid) • energy can be used in heat form and/or converted to electricity or liquid fuels • lower capital cost • lower operating cost/time • can be designed for storage and digestion capacity • greater ability to manage seasonal variability in manure/effluent flows (e.g. from use of herd homes in winter only or increased use over winter) • more similar to standard farming practices, e.g. modification of effluent ponds rather than completely new technology and compatibility with flush manure collection systems • can be designed to retrofit existing effluent ponds (although new pond design is preferable) • significantly reduces greenhouse gas emissions compared to land spreading of wastes with no biogas removal (although ponds may remove less biogas than reactor AD options)	• low rate energy production • lower total energy potential than higher tech digester systems • less controlled than higher tech digester systems • liquid manure feedstock increases capacity requirements (compared to semi-solid, solid waste systems) • greater space requirements (unless using existing effluent ponds) • gas production varies with seasonal temperature, reducing during cold months and increasing in warmer weather • not well suited to digestion of post-consumer food wastes • not suitable for processing of greenwaste	• An example of NZ based technology is the covered pond system developed by NIWA. There are existing NZ systems for piggery wastes, with dairy farm systems yet to be developed. NIWA would be interested in developing a dairy prototype in Southland if there is local interest.

Option	Advantages	Disadvantages	Comments
AD – digester	• depending on specific plant design, can process liquid, semi-solid and solid manures (although greater water content increases capacity requirements) • high rate energy production • creates energy and fertiliser products (solid and liquid) • energy can be used in heat form and/or converted to electricity or liquid fuels • highly controlled / monitored process • lower space requirements than covered ponds and potentially also less than for composting options • enclosed nature and external heating (if employed) reduces impacts of seasonal temperature variations on gas production • significantly reduces greenhouse gas emissions compared to land spreading of wastes with no biogas removal	• reduced ability to manage seasonal variability in manure/effluent flows (e.g. from use of herd homes in winter only or increased use over winter) • higher capital and operating costs than covered ponds and, potentially also higher than composting options • although can process greenwaste, this is unlikely to be economically viable (due to low density and gas potential)	• There are a wide range of digester options available, including tanks and in-ground reactor options. To increase biogas generation digesters may employ mixing and/or heating, and may operate on either a batch on continuous flow system. However, more mechanical parts typically increase costs and operating requirements. Digesters are commonly used overseas to process manures, with some NZ examples available. Although some international examples are available, they are less commonly used to process domestic food and garden wastes.

9. OPPORTUNITIES TO UTILISE THE CLIFTON WASTE WATER TREATMENT PLANT

While considering the potential treatment of organic waste, it was noted that the Clifton Wastewater Treatment Plant in Invercargill already undertakes AD as part of its waste treatment process. As part of this Waste to Energy report, it was requested that consideration be given to the opportunity to combine commercial liquid waste streams into the Clifton Plant. Without a detailed analysis of the configuration and capacity of the Clifton Plant as well as laboratory analysis of the potential commercial waste streams, it is not possible to provide a definitive response to this question. The following information is therefore indicative only.

9.1 Current Anaerobic Digestion Processing - Opportunities

During the waste water treatment process at the Clifton Wastewater Treatment Plant, sludge that has already been through a number of treatment stages is fed into anaerobic digesters. The AD treatment of waste water at the Clifton plant currently produces biogas and 5 tonnes biosolids a day. The process is contained within a digester tank and floating lids are used to help maintain the temperature, keep air out, and collect the biogas. The resultant biosolids are applied to land while a proportion of the biogas is used to heat the digester, and the excess is flared.

The Councils are potentially interested in increasing the biogas production for co-generation, or to be bottled for use in vehicles. Co-generation units simultaneously produce electricity and heat. This would allow the wastewater treatment plant to generate electricity, which could be used to offset the electricity currently purchased or alternatively the excess electricity could be put back into the grid.

There appears to be limited opportunities to increase the volume of domestic sludge processed at the plant due to the fact that Southland and Gore Districts rely primarily on oxidation ponds for sewage treatment. When the oxidation ponds are periodically desludged the resulting product is very stable and no longer suitable for AD. However there may be opportunities to explore the production of increased volumes of biogas from digestion of additional commercial waste sources, or domestic organic waste streams. Depending on the particular properties of the waste, liquid commercial wastes may be introduced into the treatment plant at the anaerobic digestion stage. An upgrade to enable digestion of a wider range of wastes has been undertaken successfully at a number of wastewater treatment facilities around New Zealand. One example is Palmerston North City Council's Totara Rd Wastewater Plant. The Totara Rd upgrade has enabled the plant to achieve much greater efficiencies and allowed it to digest piggery manure, whey waste, grease trap waste, and selected food industry flotation in addition to wastewater sludge. The total cost of upgrading this facility cost $3 million dollars but it is believed that the upgrade will pay for itself within 8 years[56].

[56] http://www.biogas.org.nz/Publications/WhosWho/LG-June-2010-p21-22-LR.pdf

9.2 Additional Waste Stream Potential

Both the South Pacific Meats and Dairy Trust factories are relatively close to the Clifton Wastewater Treatment Plant and it had been suggested that these may provide potential liquid waste sources. While attempts have been made to contact environmental managers / key personnel from both these sites, at the time of this report no feedback was received. Research through the Southland Regional Council revealed that neither of these sites has a consent to discharge to land. Both sites have tradewaste discharge consents, so waste will already be fed into the Clifton stream.

Extensive information was received from the Alliance meat works. Their major plant is in Mataura, which is a distance of over 50 kilometres from the Clifton plant. This site is likely to be expanded in future and Alliance are very keen to explore alternative waste solutions. However the significant cost of transport would need to be factored into any feasibly study. Likewise the Fonterra Edendale Plant is 50 kilometers from Clifton and may be a source of suitable waste. Fonterra is actively investigating AD at some of its other sites around the country. It should be noted that sludges from this feedstock may have a higher residual value if kept separate from municipal wastewater, which may have negative cultural connotations around re-use.

In addition, L&M Energy is looking at coal seam gas in Ohai. Should it go ahead, the coal seam methane produced from mining could possibly support co-generation activities. Utilising domestic organic wastes to boost biogas production levels at Clifton may also present an opportunity, particularly if transport costs associated with getting the feedstock are avoided. For example, by encouraging the use of insinkerators.

9.3 Potential Biogas Production

Dr Jurgen Theile from CPG Ltd was asked to estimate the amount of biogas that could be created from incorporation of the Mataura Alliance Meat works site. Dr Theile is an international expert on the microbiology and biotechnology of industrial pollution control and provided advice to the Palmerston North City Council (PNCC) around their wastewater plant upgrade.

Based on a number of meat works DAF solids digestion studies Dr Theile has done in the past, CPG estimate the following "annual biogas potential" for a co-digestion of these materials in a municipal digester plant:

	Waste Materials considered				Biogas Production Estimate		
Material	**Wet weight (t/annum)**	**Dry weight (t/annum)**	**Volatile solids content (estimate, % of dry)**	**Volatile solids reduction in digester (estimate, % of VS)**	**Annual** (m^3 per annum, 60% CH4 assumed)	**Daily** Based on 180 days season length **Biogas production (m^3/d)**	**Daily** Based on 250 days season length **Biogas production (m^3/d)**
Meat plant, DAF solids Alliance	17000	1530	90%	60%	743580	4131	2974
Dairy trust	*No records for discharge to land made available so assumption that material is possibly already discharged to sewer*						
Sheep yard solids, beef paunch	1600	320	80%	40%	92160	512	369
VS: volatile solids	*Relative Uncertainty of all estimates +/- 25%*				*Uncertainty of all estimates +/- 25%*		

The processing season may vary, therefore two estimates of likely daily additional biogas production from anaerobic digestion have been provided.

To confirm the underlying assumption of the estimates would require lab analysis and testing of samples. In addition assumptions around the configuration of the plant would need to be confirmed. It has been assumed that the Clifton digester plant is comparable in concept to the PNCC digester plant and the daily biogas production potential above is capable to support a reasonably sized and successful cogeneration project.

Payback for the digester operation components of the upgrades could be as rapid as 2-3 years (depends on local conditions, subject to confirmation of digester local facilities and capability by site visit). This is based on the in-depth CPG experience when planning and executing the very successful PNCC Totara Road codigestion plant upgrade to digest DAF solids to biogas (Thiele 2009, Thiele 2010 Water NZ Conference papers, see proceedings).

Payback for cogeneration genset operation would depend on a number of local factors that cannot be assessed until a detailed feasibility study has been commissioned, which should include transportation costs. It may also be worthwhile considering more local organic material sources as part of this feasibility study. For example organic waste from kitchens and compostables in Invercargill could deliver 128T/pwk, 6656T/pa – which would also be less seasonal than the meat works.

9.4 Scion Thermal Oxidation Process

Another option worthy of consideration for the treatment of biosolids is the Scion Thermal Oxidation Process. A pilot plant utilising this technology has just opened in Rotorua. The pilot plant uses thermal deconstruction to "cook" the biosolids (sewage sludge) and break them down into re-useable chemicals and a range of other by-products. These can be used for fertilisers or in the production of bioplastics and biofuels. In Rotorua, biosolids are currently going to landfill, which creates an additional impetus for this kind of technology. In Southland, however, it is estimated that there are some decades of available land for application of biosolids.

10. WOOD WASTE

A significant proportion (12%[57]) of the waste to landfill in the region is wood waste; approximately 96 tonnes of timber a week enter the landfill[58] over a year this amounts to almost 5,000 tonnes. Unpainted and untreated timber accounts for 19%, fabricated timber 17% and multi-material/other 64%.[59]

10.1 Combustion

Energy from waste originating from wood can take a number of forms such as simple low tech combustion opportunities to sort and sell the non-treated element as firewood at a nominal fee to divert it from landfill. This could become standard practice at transfer stations. However there may be a cost to segregate the waste which may not be recoverable if only a small charge was applicable. This would not provide a solution for the treated wood waste which appears to be a major component (up to 81%) of the problem. Wood waste could also

[57] Southland Waste Assessment (2011), Morrison Low

[58] WasteNot Consulting Solid Waste Analysis 2011

[59] Composition of Solid Waste in Southland region 2011, Waste Not Consulting.

be utilised in simple combustion operations, for example using wood waste in cement kilns as an alternative source of fuel. However the implications for emissions from treated timber would need further investigation. A straightforward combustions exercise would be considered a low response disposal operation under the waste hierarchy unless further energy recovery was part of the process.

10.2 Wood waste gasification

Wood waste gasification is the partial combustion of wood waste without the presence of oxygen resulting in a synthetic gas called *Syngas. Syngas* is made up of combustible gases including methane and hydrogen. The resulting gas can be burnt to provide heat and heat conversion into energy, or it can be compressed and stored to be used as a fuel source. It should be noted that other wastes can be subject to gasification such as plastics however they are not considered further as recycling and re-use are higher up the waste hierarchy and considered as better alternatives.

The amount of energy that can be obtained from wood waste depends on a number of variable factors, such as type of wood, condition of the wood waste and the process by which the energy is released and ultimately recovered. Each tonne of dry wood waste (which is equivalent to approximately 2 green tonnes of wood waste) can generate between 0.9 and 1.3 MWh of electricity[60]. Alternatively, to produce 1 MWh of electricity it takes between 0.75 and 1.1 dry tonnes of wood waste.[61] On this basis assuming that the Southland region can access the wood waste currently disposed of to the SRL and that this waste is suitable for wood waste gasification (at a rate of 1MWh per tonne) then land filling this wood represents a lost opportunity to generate 4,732MWh. Assuming an approximate retail value of $0.15 per Kwh this could be worth as much as $709,800. In addition the avoided disposal costs of $60.00 per tonne represent an additional amount of $283,020. This rough calculation is based on estimates and represents the wood waste to landfill with effective source separation at transfer stations. Greater amounts could be available as this calculation has not taken into account wood waste already diverted or from wastestreams that are not disposed of to the SRL such as forestry residues or woody biomass. For further information on these refer to the Wood Energy Demand Assessment[62].

Wood waste gasification plants are already in operation in other parts of the world including Australia. In order to fully assess the suitability for the Southland region further investigations would have to be undertaken into the costs of a gasification plant and suitability of wastes and associated infrastructure to separate wood waste. Both EECA and the Waste Minimisation Fund could be the source of further funding options to investigate feasibility further.

[60] http://www.nafi.com.au/bioenergy_factsheets/WWFS10.pdf (report 4) Converting wood waste into renewable
energy – a summary of biomass energy conversion
technologies.
[61] Cowie (2005) Greenhouse gas balance of bioenergy systems based on integrated plantation forestry in northeast New South Wales, Bioenergy Australia Conference (Melbourne).
[62]Wood Energy Demand Assessment (2011) by EIS Energy available on www.southlandnz.com

11. INCINERATION WITH ENERGY RECOVERY

There are currently no waste to energy incineration plants in New Zealand. Yet they are common place in other OECD countries such as the UK, Japan and USA, all of whom have a significant number of waste to energy plants that burn domestic municipal waste. Traditionally there has been significant resistance to any incineration plants, and this combined with Resource Management Act processes and considerations may be one explanation for their absence in New Zealand.

While waste to energy is arguably a tier 4 waste hierarchy option (i.e. recovery of the energy from wastes) would be situated above landfill disposal of the waste in terms of the waste hierarchy, it can be very expensive to implement. Waste to energy can also have impacts on recycling and other diversion initiatives as a guaranteed feedstock to any incineration plant is needed to safeguard investment. This can run counter to the aims and intent of the WMA. For this reason energy from waste via burning a variety of wastes has not been investigated further.

12. LANDFILL GAS COMBUSTION

As putrescible waste to landfill in the Southland region is around 223 tonnes per week this would generate a significant amount of methane, which if collected using a gas reticulation system, could be collected and combusted to obtain energy. It is apparent within local government and the wider waste management industry that there is a myriad of opinions, often stated as fact, that are used as justification for inclusion or exclusion of organic and putrescible wastes from landfill to obtain gas for combustion. The Waste Minimisation Act 2008 (WMA) gives councils the responsibility for promoting effective and efficient waste management within their district.[63] Furthermore, they are required to undertake a waste assessment and produce a Waste Management and Minimisation Plan (WMMP). In doing so they must “give regard” to the New Zealand Waste Strategy[64] as the WMA specifically directs councils to have regard to the NZWS or any government policy that replaces the NZWS. The NZWS 2010 centres around two key goals:

- Reducing the harmful effects of waste
- Improving efficiency in resource use.

Opinion on the inclusion of organic wastes in landfills to obtain gas is divided, however, this presents an opportunity to consider the scientific arguments and facts surrounding diversion of organic wastes in terms of improving efficiency in resource use and reducing the harmful effects of waste. In order to collect landfill gas for the purposes of energy generation, systems must be put in place at the landfill. Facilities may collect 75% of generated methane once a cell is covered and collection equipment is functioning, outside of this period when interim daily cover is applied 30% of methane can be lost.[65] There are claims that the actual figure for overall capture of methane from landfills in the UK is a mere 40% over the life of the landfill, these figures are based on UK Department of Trade and Industry landfill gas

[63] *Waste Minimisation Act 2008 part 4 ss 42*

[64] *Waste Minimisation Act 2008 part 4 ss 44 (c)*

[65] Methane Production in Landfill, Humer-Huber et al 2008 Sage publications.

development figures.[66] When methane production drops below recoverable levels for energy generation gas reticulation equipment is turned off. There may still be a significant loss of methane to the atmosphere. Essentially, using these figures, the largest proportion (up to 60%) of methane could be lost to the atmosphere as errant emissions throughout the life of the landfill, compared to the proportion which is collected, again justifying further diversion of organics from landfill to ensure methane generation does not occur.[67]

A significant number of landfill sites do utilise landfill gas to generate energy and this is clearly preferable in the absence of any other solutions for organic waste, however, taken into the context of the WMA under which councils operate then options further up the waste hierarchy have to be considered first. Issues for the Southland region as far as landfill gas goes are that the owners and operators of the SRL would have to install and operate the systems. This would not necessarily result in any financial gain to the Councils, but their future landfill prices may not be as high due to the impacts of the ETS as the landfill's ETS obligations would be lower than they are predicted to be under a model where gas is not collected or utilised for energy recovery.

If energy recovery is the primary aim of disposal of organics then purpose built AD plants offer significant gains and improvements in energy capture over landfill gas collection and combustion. However, the technology and infrastructure for landfill gas collection may be a cheaper alternative particularly as the ETS will incentivise the private owner to do this anyway. Other considerations of this option is that the SRL is expanding as it is an active materials extraction operation so landfill space is not in short supply so obtaining energy from waste via the landfill as a bioreactor could be a viable alternative even though it would not be as efficient as other alternative energy from waste options for organic wastes. AB Lime Ltd would also be in a position to use the gas on site as part of the lime works process.

During the research for this report, communication has taken place with the SRL operator AB Lime regarding possible waste to energy options. The SRL management advised that existing landfill operations were marginal and any proposal to divert further waste from SRL would further extrapolate that situation. It is noted that the council currently enjoys a tonnage neutral contract with SRL, meaning that the price per tonne disposed of does not change if the total tonnage disposed of alters. The tonnage neutral contract, while advantageous to the council has been detrimental to the business case for SRL and places a higher risk on the landfill when waste minimisation initiatives are implemented.

The authors have been advised that a third party entity has approached SRL with an energy recovery proposal, to capture methane for electricity production, and SRL have also investigated this investment themselves. There is some uncertainty surrounding what volume of methane production is considered viable for investment in electricity generation by either SRL or a third party. As this is a commercial decision by SRL owners, it is difficult to develop specific recommendations around such investments. No data has been offered to evaluate landfill gas volumes and until a fully year of ETS reporting data is available to councils it will be difficult to assess.

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66 ETSU/DTI (1996). Landfill Gas – Development Guidelines. ETSU/DTI.cited in FOE Greenhouse gases and waste management options

67 In 2008 emissions from the waste sector contributed 2.2 per cent of total New Zealand emissions. Emissions from the waste sector are projected to total 8.2 million tonnes of carbon dioxide equivalent gas (million tonnes) during the first Kyoto commitment period 2008-2012.[67]

13. SUMMARY AND RECOMMENDATIONS

From these initial investigations it appears that there are a number of opportunities in relation to waste to energy available to the Councils to explore further. The close working arrangements between the Councils and Venture Southland provide a strong foundation to combine waste management expertise and wider economic development opportunities, which are two of the cornerstones in developing a successful initiative. However, the security of a wastestream and the market value(s) of energy and/or end products are also critical factors.

A number of energy from waste options appear to be viable in terms of technology, suitability for Southland wastestreams and available expertise within New Zealand or Australia. However, the biggest barrier appears to be transport costs. Due to the largely rural nature of the Southland region the majority of waste to energy applications are challenged by high transport costs. The relatively modest landfill price that the Councils currently enjoy as part of their long term contract with AB Lime Ltd will also make it challenging in the short term future as disposal to landfill still remains the most cost effective option. However, with the imminent introduction of ETS charges, this will change as ETS liabilities on the landfill owner are passed on to the Councils.

13.1 Anaerobic Digestion

Any opportunities that divert organic wastes will have the largest impact on diversion rates for the Southland region. The main opportunity appears to be a small food waste only collection in urban areas such as Invercargill City. Exploration into the economic viability of extending this into rural areas needs to be undertaken. This assessment should give consideration to efficient operating methodologies (for example, multiple processing sites) and maximised feedstocks (i.e. rural areas that have a kerbside collection could be considered), as with increasing landfill costs due to ETS, it may become a viable alternative.

The development of anaerobic digestion (AD) using agricultural waste is a proven technology in New Zealand and overseas, for example in the UK the National Farmers Union has estimated that by 2020 over 1000 farm waste AD plants will be operational[68]. Historically, New Zealand's low energy prices and high transport costs have made it unviable for centralised AD for farm waste. However centralised AD may become more viable as energy prices rise. It is recommended that further investigation is undertaken into low technology AD covered pool options on farms thereby eliminating transport costs.

13.2 Waste Water Treatment

The potential to upgrade the digester at the Clifton Wastewater Treatment Plant is perhaps the most promising prospect identified. In order for this opportunity to be further explored, a specialist such as Dr Jurgen Theile from CPG New Zealand Ltd will need to be engaged. Such a specialist will assess the current configuration of the plant, the necessary capital and process upgrades, plus the chemical composition of proposed additional wastes.

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[68] http://www.waste-management-world.com/index/display/article-display/4203595670/articles/waste-management-world/waste-to-energy/2011/08/What_s_Stopping_AD_Supplying_1__of_UK_s_Power_.html?cmpid=EnlWMW_WTEAugust42011

The possible liquid waste sources that have been identified will all need to be transported a reasonable distance. Again the need for transportation will affect the ultimate feasibility of the project. However usage of commercial wastes for energy generation has environmental benefits beyond application to land. Increasingly, achieving environmental outcomes is an ethical and financial necessity for industry. Indeed the industries identified are all are in the early stages of investigating their own waste to energy projects. Significant private-public synergies could be developed through advancing this project further.

13.3 Wood waste gasification

Although any gasification plant is expensive the volume of timber waste currently disposed of to the landfill could provide further opportunities, particularly if it was sorted at source and segregation at transfer stations. Additional volumes of woody biomass or forestry waste would further add to this opportunity.

13.4 Landfill gas extraction and energy capture

Purely from an energy extraction perspective comparing energy used to energy gained, with no changes to operational practices, means that landfill gas may provide the best option. It appears to be the easiest option to implement as there is no requirement on the Councils to do anything different in terms of waste collection. Any additional costs of plant etc would be borne by the landfill operator and any benefits to the Councils would be minimal other than the possibility of ETS savings being passed on to customers. In terms of waste minimisation placing organic wastes in landfill would represent a lost opportunity to divert a significant (29%[69]) element of the waste stream and gain a beneficial product. In terms of efficiency of energy production AD would be more efficient, however using landfill gas to obtain energy does not require any separate collections. Opportunities need to be explored with the SRL operator due to ETS requirements and the Councils need to fully establish the impact of any ETS liabilities and expected on-costs to the Councils.

13.5 Discontinued research

It is not recommended that further research is conducted into either incineration or combustion options other than that for wood waste due to the requirements of the WMA on the Councils. There is a fledgling industry looking at biodiesel, thermal cracking and other chemical conversion of waste plastics into fuels however it is not recommended that unproven, new technologies are pursued at this stage for the Southland region due to risk, cost, the waste hierarchy considerations and WMA requirements.

13.6 Prioritisation and further action

While it is the Councils that will make the final decision, based on the waste hierarchy, waste management operational considerations, proven technology and potential for energy capture combined with useful end products, it is recommended that the Councils give further consideration in list order to:

- anaerobic digestion opportunities
- landfill gas collection with energy capture
- further exploration of wood waste opportunities

[69] Southland Waste Assessment (2011), Morrison Low

In addition further consideration should be given to composting organic waste. Although composting does not have a captured energy component it would still be preferable to landfilling organic waste from a WMA perspective.

13.7 Evaluation Criteria

The range of waste to energy options is diverse and new additions are being added on a regular basis as technology develops. It is recommended that a range of evaluation criteria is further developed for the purposes of future decision making by the Councils. While it is not possible to judge all criteria for possible future options we recommend that the following criteria form part of the core decision making considerations:

- diversion of waste from landfill
- viable use of energy from waste products or outputs
- consistency / source of waste material
- maturity of technology
- logistical challenges / transportation/collection and distribution issues including amount of embedded energy vs. transportation energy to collect/distribute products i.e. energy used versus energy returned (energy balance)
- cost of investment vs. payback time (linked to both fuel prices and avoided waste disposal and ETS costs and product prices)

14. FURTHER ASSISTANCE

A range of opportunities exist to obtain further assistance to develop waste to energy opportunities. For the purposes of this report these have been split into two key areas, waste and energy. The type of assistance may vary from funding assistance to advice and information only. A range of resources and useful websites has been included for future reference.

14.1 Waste

A range of organisations offer advice and guidance regarding waste minimisation and in particular waste to energy these include:

Waste Advice

- Ministry for Environment (MfE)
- WasteMINZ
- WRAP: http://www.wrap.org.uk/ website with guidance on a range of technologies including Anaerobic Digestion
- Zero Waste Trust Website: http://www.zerowaste.co.nz/index.sm

Waste Funding

- Waste Minimisation Fund (MfE)
- Community Environment Fund (CEF) Ministry for the Environment

- Councils' share of allocated national Waste Levy funding

14.2 Energy

A range of organisations offer advice and guidance regarding energy including:

Energy Advice

- Ministry for Environment (MfE)
- Energy Efficiency and Conservation Authority (EECA)
- Wood energy section on EECA business site including case studies
- Bioenergy Association of New Zealand http www.bioenergy.org.nz

Energy Funding

- Waste Minimisation Fund (MfE) (possible waste to energy applications)
- Community Environment Fund (CEF) Ministry for the Environment
- Councils share of allocated national Waste Levy funding
- Energy Efficiency and Conservation Authority (EECA)
  - Biodiesel Grants Scheme
  - Energy audit grants
  - Design audit grants
  - Technology implementation grants
  - Crown loans for energy efficiency projects in the public sector.

MorrisonLow

APPENDIX A

Composting Technology

Proprietary Technology - HotRot®

The HotRot composting system was developed and is manufactured in New Zealand by R^5 Solutions Limited. It is a modular, in-vessel system comprising of one or more horizontal cylinders connected by common feed and harvest systems. The largest HotRot cylinder is 18 m long with a 3.5 m diameter. HotRot modules range in processing capacity from 1-12 tonnes of waste per day, depending on the desired retention time for the processing material.

The HotRot system is a continuous system whereby raw feedstock is loaded into the cylinder as processed material is passively harvested at the outfeed end, creating sufficient space to contain the day's feedstock quantity. Once the putrescible wastes and bulking agent are mixed the waste materials are transferred from a blending hopper to a feed conveyor, via a moving floor configuration. HotRot units are slightly inclined towards the infeed end to ensure that processed and partially processed material will not become recontaminated with leachate or aerosols arising from the fresh wastes. This is an important feature for feedstocks with pathogen risks such as manures.

The material is transferred along the cylinder by the moving central shaft, which has a series of tines attached and moves at a speed set via the control system (calculated based on anticipated waste volumes and the desired residence time within the cylinder). The turning action of the HotRot cylinder shaft not only aerates the material but also controls the retention time (by net forward rotation). Although some mixing also occurs within the cylinder it is important that the waste inputs are well blended to optimise the process and to create a uniform product. To ensure even wear on mechanical components material should be loaded as evenly as possible onto the feed conveyor.

The recommended moisture content of wastes is 50 to 60 percent, with a bulking agent (typically greenwaste and/or woodchip/sawdust) required to offset high moisture contents typical of putrescible wastes (such as food wastes and manures). R^5 Solutions Limited state that ratio of food wastes to bulking agent can be as little as 1 to 1 by volume, so long as moisture content is no more than 60 percent. R^5 Solutions Limited also recommends that the bulking agent be shredded or chipped to a maximum particle size of 50 mm.

The HotRot system has been designed for a bulk loading of a hopper with the blended feedstock, and feeding via an automated conveyor feed system over a set period (typically 8 hours but up to 24 hours). The feeding operation is designed to be able to be completely automated with optional remote access control and a series of alarms should a blockage occur. The units also contain sensors and control systems that adjust fan speeds. This helps maintain optimum aeration levels and extracts odours for treatment through a biofilter.

R^5 Solutions Limited recommends a 14-day retention time within the cylinder to process a blend of food and greenwastes. This would need to be followed by windrow or static pile curing for a further 8 weeks or so to ensure that the product is mature and not phytotoxic. If the bulking agent is reduced in size to 50mm, as recommended for the

HotRot system, less vigorous screening will be required than for composting systems that require larger sized particles for passive aeration.

The HotRot composting systems incorporates online monitoring and logging of product temperature profiles measured using a series of temperature probes (measuring temperatures within the cylinder as well as exhaust gas and ambient temperatures). There are also a number of access hatches along the length of each cylinder to allow sampling of the material during processing.

HotRot units have a minimum design life of 15 years. The areas expected to have the highest maintenance requirements are the feed and harvest systems and tines on the central rotating shaft.

Proprietary Technology – NaturTech®

NaturTech is an in-vessel composting system comprised of a series of airtight customised shipping containers. They are constructed from a 20 or 40 ft long boxes, with capacities of 40 m^3 and 80 m^3 respectively. For a 20-day retention time this converts to approximately 1 T/day (20 ft long box) or 2 T/day (40 ft long box). Containers are sold in increments of 4 or 5 composting units connected to a biofilter unit (biofilter also within a converted shipping container). NaturTech containers produce between 1.2 and 3.3 tonnes of compost per day per container and existing NaturTech facilities compost primary wastewater solids, DAF (dissolved air flotation) solids, food residuals, forest products, poultry feathers, chicken manure and dairy manure.

Containers are linked with automated monitoring equipment and piping for aeration, odour control, and leachate collection. They have a corrosion resistant liner and removable perforated floor through which aeration takes place. They are able to be transported around the site (by specialised truck) and can be top or front loaded, or tipped for unloading to windrows, reloading into curing containers, or further agitation. Variations include walking floors and a revised container design that allows material to be processed 'in-transit'. The system requires a controlled batch mixer or a continuous flow mixer with a high degree of process control to provide uniform 'recipe' management. The process requires a controlled blend of raw materials to achieve porosity, moisture, volatile solids and carbon to nitrogen ratio specifications established in the operating plan. 10-15 percent is required to be wood chips (or similar) to ensure porosity and even air flow through the composting mass.

Following mixing, conveyors or front end loaders transfer the material into the open topped containers for composting. Composting units are then sealed and connected to the aeration system. The aeration system uses differential pressure sensing and controlled valves to allow air to flow into the base of the unit through a plastic aerated floor and odorous gases to be extracted from the top of the unit, keeping the mixture aerated. Exhaust air is directed to the perforated drain tile at the base of the biofilter and made to filter through a medium of 50 percent wood chips and 50 percent finished compost. Leachate is removed via a system of pipes and can be drained into a holding tank for beneficial reuse or disposal into a sanitary sewer system.

After 7-10 days the units are unloaded for re-mixing and additional moisture is added to keep the process going. Where multiple bins are at the same stage material can be combined to free up processing capacity. Once the retention time has been completed tipping trailers can be used to transport material to curing containers, windrows or static piles. Each container harvests between 1.2 and 3.3 tonnes of compost per day depending on retention time and the size of container used.

It is expected that the in-vessel composting phase will last for 14 to 20 days. Additional curing in aerobic containers for 1 to 3 months will result in a product that can be screened and sold in bulk or blended with other materials for potting mix and topsoil. Windrows and static piles are alternative curing options to the aerobic containers, reducing cost but increasing curing time and land requirements. Due to the individual nature of bins and the batch process method any contaminated material would affect only one bin and the contaminating material (identified through lower temperatures) would be able to be removed. This is an advantage over continuous composting systems.

The most likely aspects requiring replacement and maintenance are the replaceable liners protecting the side walls. The systems expected to experience most faults will likely be the electronic and monitoring systems which will require more regular update and upgrade. Training is provided when the NaturTech system is bought as well as operation manuals. As a patented system, any technical support relating to the system will need to be sought from the supplier. Although the supplier is based in the United States containers are constructed in China and vehicle unloading systems in Australia.

MorrisonLow

APPENDIX B

Technology Overview

Anaerobic Digestion

Anaerobic digestion (AD) is a biological process in which biodegradable organic matters are decomposed by bacteria creating solid and gaseous byproducts. The biogas byproduct consists of methane (CH_4), carbon dioxide (CO_2), and other trace amount of gases.

The beginning of the process takes places inside of the digester, which is basically a tank sealed to prevent gaseous oxygen from entering. An anaerobic digester in concept is very similar to the human digestive system. There are two kinds of bacteria that are required for anaerobic digesters to function properly. The first type, fermenting bacteria, feed off organic materials and release organic acids. From these organic acids the second type of bacteria called methanogenic are produced. The methanogenic bacteria also feed on the organic matter and create methane as a by product. From a biochemical perspective anaerobic digestion is a very complicated process which requires optimisation of a number of factors (e.g. temperature, pH, input rate, heterogeneity of feedstock etc) in order to produce biogas quantities anywhere near the theoretical maximum.

A potential third step is the production of energy from the gas, and further processing of the solids residue to produce a soil amendment (usually via composting).

Anaerobic digestion has traditionally been used for the processing of sewage solids, animal manures and low solids content organic industrial wastes. However, it is now also being applied to process other putrescible solid wastes such as domestic food wastes. The heterogeneous nature of domestic food wastes can make them more difficult to digest than relatively homogeneous wastewater biosolids.

AD can be categorised as either ‘wet’ or ‘dry’ depending on the moisture content that the process requires. Wet AD processes material in a high moisture form, achieved either through the moisture content of the organic wastes or through the addition of water. Dry AD requires a much lower moisture content for processing and therefore may include further dewatering pre-treatment processes and the addition of a bulking agent such as greenwaste. For dry AD processing, greenwaste may be combined with food waste at a similar ratio to that employed for composting (i.e. around 1:1 by weight), although dry AD systems can be designed to allow food waste ratios to be increased from 50 to 70 percent.

The common method of collecting the biogas from the digester is with a floating lid. This device is a weighted pontoon that floats on the liquid surface of a collection/storage basin. The most abundant gas in the gaseous byproduct is methane, but the biogas also includes trace amounts of carbon dioxide, nitrogen, hydrogen, oxygen and hydrogen sulfide. The methane component of the biogas may be used as a fuel to create electricity, vehicle fuel or to generate heat in a boiler. The biogas needs treatment (or scrubbing) before it can be used to create energy. Hydrogen sulfide, one of the trace gases present in biogas is a very toxic and odorous gas. Also, volatile siloxanes must be removed from the biogas if it is to be used in any combustion process. This is due to the fact that during the combustion process volatile siloxanes will leave deposits of silicon dioxide on the machine parts leading to a decrease in machine performance.

There are several options for transporting the biogas to its final destination. Due to the fact that it is very hard to liquefy methane it is most commonly stored and transported as a gas. Small to medium size enterprises find it impractical to store the gas in large quantities due to the limited compressibility of the gas and the potential for explosion. Therefore it is often burnt on site to produce meet localised energy requirements.

Generally speaking, anaerobic digestion necessitates more complex and expensive technology than composting, although is a less expensive waste treatment option than other large scale options such as incineration. The value of the renewable energy source may also be higher than that of a compost product, potentially offsetting some capital and/or operating costs.

Anaerobic digestion costs will vary significantly depending on the scale of the facility, level of automation required and properties of incoming wastes. However, as an example of digestion processing costs, the Dufferin Organics Processing Facility in Toronto has reported operating costs of around NZ$200/T. This is made up of around $160/T paid to the operator and an additional $40/T for the disposal of liquid and solid wastes.[70].

Advanced Thermal Treatments

There are a large number of proprietary technologies for thermal treatment of waste streams. Many of these technologies claim to be unique processes. However, while they may have unique characteristics, they are generally variations or combinations of principal technologies. Below is an analysis of the principal technologies

Autoclave

Autoclaving (or Mechanical Heat Treatment) is a commercially proven sterilization technology utilized in the sterilization of quarantine wastes. There are two key variations which use either steam or direct heat to treat waste. As a result, the energy requirement to heat the waste is fundamental for autoclaving technologies, but varies according to the exact approach undertaken.

Waste is most commonly loaded into an autoclave vessel (typically a rotating drum) which is sealed and the waste heated, using steam, to 150°C for one hour under pressure. This causes plastics to soften and flatten, paper, food waste and other fibrous material to break down into a fibrous mass, and glass bottles and metal objects to be cleaned and labels removed. The waste is then separated for recyclable materials and to remove any contaminants leaving a sterilized ‘celluosic biomass’.

Because the heat in the autoclave changes the physical characteristics of the waste, both recovery rates and the quality of recyclable materials are higher than for Mechanical Biological Treatment (MBT) technologies. This allows a greater tonnage of cleaner material to be available for processing into higher value applications. The potential for feedstock recycling (i.e. turning bottles back into bottles) typically delivers

[70] Kelleher, M. (Aug 2007). “ANAEROBIC DIGESTION OUTLOOK FOR MSW STREAMS”, BioCycle August 2007, Vol. 48, No. 8, p. 51.

much greater greenhouse gas benefits than secondary applications for dense plastics, such as PET and HDPE. Plastic film however, forms into solid 'balls' that trap putrescible contamination meaning they cannot be recycled into similar products. As a result, if not sent to landfill, autoclaved plastics films could be either manufactured into lower value applications such as 'plaswood' or sent for manufacturing of synthetic diesel.

The autoclave process allows recycling of some of the inputs and produces a fuel either with consistent characteristics or with a very high biomass content, which comprises the putrescible, cellulose and lignin elements of the waste stream. Despite this however, autoclaving municipal solid waste (MSW) can still result in significant tonnages of biodegradable material being sent to landfill, due to the mechanical separation of an oversize, reject fraction, which removes both non-biodegradable waste and biodegradable materials. Autoclaving does not reduce the biodegradability of the waste to any great effect. After exiting the core plant, this reject stream could undergo a brief maturation phase, which would also allow for moisture loss prior to landfill.

There are very few facilities operating commercially anywhere in the world for the treatment of MSW, with North America being the main centre of this technology[71]. No facilities are known of that process source separated organic wastes using autoclave based technology. Suppliers primarily focus on treatment of mixed municipal solid waste because it cleans and sterilises the material for closed loop recycling and it can produce a consistent output for ease of handling and subsequent processing.

Suitability for treatment of organic waste

Autoclave based processes do not appear to currently be used to exclusively treat source separated municipal food waste. It appears that there would be little value in doing so since the aim of the process is to produce a high biomass fuel from a mixed waste stream. Since segregated organics are assumed 100 percent biomass, no such processing can be deemed necessary. While such treatment is technically feasible, further processing steps would still be needed for either energy recovery (thermal or biological) or for the production of a soil conditioner. As such, this type of treatment is unlikely to demonstrate any significant advantages over more established and self-contained processes such as Anaerobic Digestion. The exception may be for more difficult organic wastes. Autoclaving can be used to sterilise particular wastes such as high risk animal by-products to reduce pathogen and virus risks prior to subsequent disposal.

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[71] There is one operational plant in the UK, a Sterecycle plant in Yorkshire that can process 100,000 tonnes per annum of MSW. In the last year however a number of such plants have been planned or had contracts awarded in the UK including: an Enpure plant in Derwenthaugh Ecoparc, in Newcastle, which will process 320,000 tonnes of solid waste, VT Group has plans for 3 plants in Glasgow processing 100 – 150,000 tonnes per annum, and a plant operated by Cleanaway, in Rainham, East London which will process up to 160,000 tonnes per annum.

Gasification and Pyrolysis

Gasification and pyrolysis are advanced thermal treatment processes which, because they take place in an atmosphere which is relatively starved of oxygen, do not lead to complete combustion of waste as happens in the case of incineration. The key difference between the two is that pyrolysis is the thermal degradation of a substance in the absence of oxygen, whereas gasification involves the provision of a limited amount of oxygen to allow sufficient combustion to occur to maintain the operating temperature. The gases produced by pyrolysis and gasification processes, once cleaned, have significant fuel value; alternatively the gas, tar and char can be used for synthesis of chemicals. Some processes effectively combine pyrolysis and gasification phases in the treatment of waste. There are a growing number of processes available, which may well be suited to treating refuse derived fuel, though their records in treating mixed municipal waste are varied.

Gasification

Gasification is a relatively new technology in its application to the treatment or disposal of waste.[72] Gasification treats waste in the presence of limited oxygen, preventing combustion, and temperatures typically above 750ºC. The main product is a syngas, which contains carbon monoxide, carbon dioxide, hydrogen, methane and longer chain hydrocarbons, water vapour, tar and other pollutants. The Calorific Value (CV) of this syngas will depend upon the composition of the input waste, temperature, residence time and configuration of the gasifier, as well as the subsequent gas refining stages. The other output produced by gasification is a solid, non-combustible 'char' of which there are limited applications, such as, aggregate substitute.

Syngas from gasification is potentially more efficient than direct combustion of the original solid fuel because it can be combusted through more efficient technology (gas engines or potentially gas turbines), used to produce methanol (which can be used as a vehicle fuel substitute), or even be refined for use in fuel cells. In addition, on a tonne-for tonne basis, gasification can be expected to produce a lower volume of exhaust gas than conventional combustion and, assuming the gas may be scrubbed to a similar standard, results in lower emissions overall. Accordingly however, a higher concentration of the corrosive elements such as chloride, mercury and potassium can be expected in the ash.

Gasification of fossil fuels is widely used on industrial scales to generate electricity where the efficiency advantages of large gas turbines (typically around 40 percent) are used to good effect. For homogenous wood wastes there are a number of worldwide examples of gasifiers using gas engines (mid efficiency), but most all gasifiers operating on waste feedstocks use a lower efficiency boiler/steam turbines approach.[73] However, almost any type of organic material can be used as the raw material for gasification, such as wood or plastic waste.

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[72] System has been used in the thermal conversion of wood for many decades.

[73] A number of Thermoselect plants in Japan operate waste gasifiers coupled to gas engines, but this may only be possible due to lower environmental standards than elsewhere. The Thermoselect plant previously operating in Karlsruhe Germany, ceased to operate in 2004 for an unpublicised range of technical and commercial reasons.

Gasification has received significant recent attention in the municipal waste market as a potential alternative to incineration, but with only one demonstration facility operating in the UK on MSW or MSW-derived feedstocks.[74] There are a handful of facilities operating at commercial scale within the EU, along with many high-temperature facilities in Japan. In many cases, gasification technologies are planned to treat refuse-derived fuels (RDF)[75] from MBT or autoclave facilities, as is the case for the facility planned for the East London Waste Authority.

Performance data and the operational track record of this technology are considered less reliable than that for incineration.

Suitability for treatment of organic waste

Gasification technology providers state an input specification for the fuel; typically 12-16MJ/kg lower heating value and 10-15 percent moisture content. Wet food waste has a moisture content of approximately 70 percent and lower heating value of 5MJ/kg. Although theoretically possible to dry food waste to meet the input specification (such as by autoclave), the energy involved is likely to be highly prohibitive, and issues associated with odour likely to become problematic. No gasification plants have been identified operating in the world on segregated organic waste.[76]

Assuming a supplier, the chemical energy in food waste could generate approximately 400 kWh per tonne using a gas engine, or 290 kWh per tonne using a steam cycle boiler. This compares favourably with Anaerobic Digestion which will only release approximately 50 percent of chemical energy in organic waste based on a 14 day cycle in a digester (though higher residence times would release more) and which, when the biogas is combusted through a gas engine[77] at 37 percent efficiency, would yield 250 kWh per tonne. This figure is close to the energy that may be generated through a steam cycle gasification facility.

The chemical characteristics of food and greenwaste are also less suitable for thermal treatment compared to wood fuels or fuels manufactured from mixed waste. Other things being equal, the lower carbon content of organic waste will reduce the potential syngas yield, and the higher nitrogen content will be likely to lead to increased oxides of nitrogen created from the fuel. High standards in the market on fuels would add risk to this option.

The cost of thermal treatment technologies, compared with biological technologies like anaerobic digestion are typically between one half and one third more expensive.

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[74] The Energos facility on the Isle of Wight.

[75] Also often known as solid-recovered fuels (SRF)

[76] A planning application has been made for an advanced thermal conversion technology for waste from the food processing industry in the UK (EnCycle in Immingham, Lincolnshire) but relies on packaging wastes being combined with the waste food in the fuel preparation stage, as well as shredded plastic being added in the thermal stage.

Pyrolysis

Pyrolysis technologies are considered in the same camp as gasification. Pyrolysis is endothermic, requiring an external heat source to maintain operational temperature. Typically, temperatures of between 300ºC to 850ºC are used during pyrolysis of materials such as MSW. Again, the products of pyrolysis are a solid residue and a syngas, though more of the chemical energy will remain in the solid phase. This solid residue (sometimes described as a char) is a combination of non-combustible materials and carbon. The syngas may be used in the same manner as that from gasification, though it will contain a higher content of oils, waxes and tars. The syngas typically has a net calorific value (NCV) of between 10 and 20 MJ/Nm^3 (higher than that from gasification due to a lower content of carbon dioxide and the avoidance of dilution from nitrogen in the air used in air blown gasifiers). If required, the condensable fraction can be collected by cooling the syngas, potentially for use as a liquid fuel.

The char produced from a pyrolysis process contains significant amounts of carbon. This is a hazardous waste but could be used as coal replacement in certain combustion applications or as a gasifier feedstock. It may alternatively be further processed for production of particular chemicals (such as carbon black, used widely for printing). Only if the carbon content is fully reduced (typically through gasification or combustion) can the final residue be recycled as a secondary aggregate.

Suitability for treatment of organic waste

Pyrolysis is not a stand alone piece of technology; it requires fuel preparation to match the moisture and physical characteristics to specified standards, further thermal stages are needed and significant post treatment processing needs to occur (gas clean up etc). The suitability of this technology is much the same as the assessment given above for gasification. The conclusion has to remain that it may not be the most suitable approach to processing organic waste when other more proven, simple and low cost options exist.

Plasma Technologies

Plasma waste destruction concepts have been around for a number of years, primarily focused upon treatment of hazardous and clinical wastes. Integrating plasma technologies into systems for energy recovery, however, is a particularly recent development. Direct plasma treatment of solid wastes requires large amounts of energy and thus dual systems combining gasification for the solid waste, and refining of the syngas in a subsequent plasma chamber are now being marketed. These systems are referred to as Plasma Gasification or Plasma Pyrolysis.

In such systems, extreme temperatures (between 6,000º and 10,000º Celsius) are created by a plasma arc between a graphite electrode and the anode base of the chamber. This both promotes thermal cracking of the condensable tars present in the syngas and alters its composition, whilst converting remaining combustible carbon in the char to syngas and reducing the ash to a hard vitrified slag. Although tars will be destroyed in the plasma furnace and do not require condensing out, the syngas will still contain metals and trace gas impurities which require a gas clean-up system.

Plasma gasification technology suppliers are tending to promote oxygen blown gasifiers. If coupled with a H_2 fuel cell, the greater amount of hydrogen produced by such systems means that more energy can be generated than if using a more 'conventional' air-blown gasifier.[78] In contrast, when coupled with a gas engine for power generation, a 'conventional' gasifier is likely to deliver a better net energy balance due to its lower energy use. It should be noted, however, that at least one plasma technology supplier is currently marketing a process for mixed waste which employs a gas engine for electricity production as well as recovering waste heat into steam turbines for co-generation of electricity.

Suitability for treatment of organic waste

Global market penetration for this technology use in mixed wastes remains particularly low, although it may be a more understandable technology to apply to particularly hazardous wastes (e.g. nuclear waste) where particular benefit can be gained through the vitrification achieved. For any municipal waste however, the benefits (a higher hydrogen content syngas[79]) is unlikely to be justified against cost. For segregated organic waste it is an even more unlikely competitor to the traditional biological processes (such as composting or digestion).

Reverse Polymerisation

'Reverse polymerization' is a patented technology developed by a Canadian company, Environmental Waste International (EWI). It is a microwave-based technology that works by applying the microwaves in a nitrogen atmosphere directly to any organic material that contains a hydrocarbon base. The microwave energy is able to excite the molecular bonds to the point they break apart. The process essentially takes a complex hydrocarbon molecule and breaks it down to simpler forms.

The process involves four main steps: oxygen purging via nitrogen flush, microwave reduction, environmental control, and discharge material handling. Microwave energy is absorbed by the organic material, causing rotation of inter-molecular bonds, leading to the generation and emission of narrow band infrared energy. The narrow band infrared energy is re-absorbed by surrounding material, increasing the amount of energy in the bonds until the bonds break. The breaking of the bonds results in the conversion of complex organic compounds into simpler compounds of lower molecular weight without undergoing oxidation.

The process has been principally applied to the processing of used tires. EWI claims that the process reduces the tyres to oil (55 percent), carbon black (35 percent) and the steel from the reinforcing (10 percent). EWI have also developed a microwave based process for dehydration and sterilisation of food wastes that has been used for navel shipboard applications.

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[78] It should be noted, however, that 'conventional' gasifiers may also be oxygen blown without a plasma stage.
[79] Although any increase in net calorific value is not certain.

Suitability for treatment of organic waste

While the technology suppliers claim the process can be applied to any organic material and have investigated a variety of applications there is no track record in respect of using the technology to treat food wastes, greenwastes or MSW. It should also be noted that as of late 2008 the technology has been confined to demonstration plants and there were no commercial facilities operating using the technology.