Household Organic Waste Cost – Benefit Analysis – Stage 2

Report to Earthcare Environmental Limited, Envirofert Limited and Lowe Corporation

EXECUTIVE SUMMARY

July 2011

Report for:

Earthcare Environmental Limited

Envirofert Limited

Lowe Corporation

Prepared by:

Dr Dominic Hogg

Duncan Wilson

Ann Ballinger

Lisa Eve

Contact Details

Eunomia Research & Consulting Ltd
PO Box 78 313
Grey Lynn
Auckland 1245
New Zealand

Tel: +64 9 376 1909
Fax: +64 9 360 5187

Web: www.eunomia-consulting.co.nz

Disclaimer

E.1.0 Overview

E.1.1 Introduction

This study aims to distil key factors that will influence decision making on household organic waste management. The study builds on our Stage 1 report, which showed that, from a cost-benefit perspective, household food and garden waste should be:

- Diverted to beneficial use rather than be sent to landfill; and
- That the most cost effective approach is to collect food and garden waste as two separate streams.

The question of treatment for food and garden waste collected as two separate streams was more open, and it is addressed in more detail in this report.

E.1.2 Treatment

Windrow composting can be used to process garden waste on its own or food and garden waste together. In-vessel composting (IVC) is best suited to processing food and garden waste together, while anaerobic digestion (AD) can process food waste on its own but is generally not suited to processing garden waste.

The findings of the current study show the following:

- From an environmental perspective AD has the highest level of benefits followed by IVC, then open air windrow composting;
- However, in cost-benefit terms these benefits are outweighed by the relative financial costs of the processes; which are in reverse order, with open air windrow the most cost effective processing option followed by IVC then AD.

This would suggest that open air windrow composting should be the preferred approach. However, open air windrow processing will not necessarily be most cost effective in all situations. The reasons for this are as follows:

- Open air windrow operations are generally not suitable for siting close to population centres[1]. IVC and AD both have smaller footprints and greater process control, and hence are more appropriate for being sited near urban areas[2];
- This means that although windrow is cheaper, it is likely to incur greater bulking and transport costs of the raw material, as it more likely to be rurally based[3];

---

[1] Particularly if they are processing putrescible wastes like food waste, as the risk of odour issues is increased.

[2] However, it should be noted that if the output digestate is to be composted, then the AD plant will require a reasonable area of land to compost the material.

[3] Rurally based facilities may however be closer to the markets for the compost produced, which would offset some of the additional transport costs.

- Depending on the extent of these costs (which are essentially a function of distance), this may have the effect of reducing the cost advantage of open air windrow.

In instances therefore where windrow facilities are not in close enough proximity to population centres, IVC or AD may be preferred options. Key findings in relation to these technologies include the following:

- Because AD is capital intensive it requires a relatively large scale before it is likely to become economic[4];
- In system terms, some of the costs of AD can be mitigated if garden waste is able to be processed through the cheaper windrow option (while food waste is handled by the AD process). In such cases AD may be the preferred option;
- IVC will tend to come into its own when a more central location is necessary, when there is not sufficient scale for AD, and when there is no option to open windrow garden waste.

E.1.3 End Use

The study found the following in respect of end use:

- All processes, if well managed, are capable of producing valuable outputs, which may be varied according to the type of products demanded by local markets;
- In the medium to long term, there is potential for markets for compost products to be developed further and for prices paid for compost products to increase as their benefits are more widely recognised (which will in turn make organic waste collection and processing more cost effective);
- The beneficial application of end products (in the form of compost or digestate) is a critical determinant of overall system performance;
- There is a growing body of evidence to suggest that there can be substantial benefits from the application of compost in the horticulture sector, leading to higher productivity and reduced need for application of synthetic fertilisers;
- Conversely, should any of the end product end up being used in low value applications – such as landfill cover - the benefits in terms of recycling and waste minimisation are effectively lost;
- Because there is no established market in NZ for digestate (a by-product of the AD process), this means that there is, at present, a greater risk associated with this technology choice because of the need to further process this by-product at additional cost.

[4] This is potentially in the order of at least 10,000 tonnes per annum, although in the New Zealand context an optimal sized plant may need to be substantially greater to achieve an acceptable rate of return on the investment.

E.1.4 Lessons for Waste Management Service Procurement

A key observation for urban authorities is that to the extent that the choice of 'the best technology' is not an obvious one, they should not constrain options unnecessarily as they seek to procure new waste management services.

E.2.0 Waste Management Systems

E.2.1 Introduction

This study aims to develop a clear logic for management of household organic waste, based on maximising benefit through the value chain. Organic waste management encompasses:

- Collection;
- Bulking and transport;
- Processing; and
- End use.

When making decisions around how to manage household organic waste it is critical to take account of these elements in terms of how they perform as an integrated system. The optimum system configuration will tend to vary depending on the situation and context.

This report is a follow-on piece of work from an earlier study conducted by Eunomia[5] (the 'Stage 1 report') which undertook a cost-benefit analysis of different options for managing organic waste. The analysis took account of economic, environmental and social factors. It showed that from a cost-benefit perspective organic waste should be diverted to beneficial use rather than disposed of to landfill. The study came to a firm view that the most cost-effective approach to managing household organic wastes was as follows:

1. The separate collection of food wastes;
2. With garden wastes collected through user pays systems; and
3. With other general household refuse collection 'constrained' either through user pays systems, through reduced frequency refuse collections, or through constraining container volumes.

The question of treatment/processing options for green waste and food waste was not covered in detail in our Stage 1 report. This report addresses this, with a particular focus on treatment options in the context of the overall system.

This study provides an overview of the elements of the waste management system then develops a logic for determining the most appropriate processing option, taking account of transport, processing, and end use financial and environmental considerations.

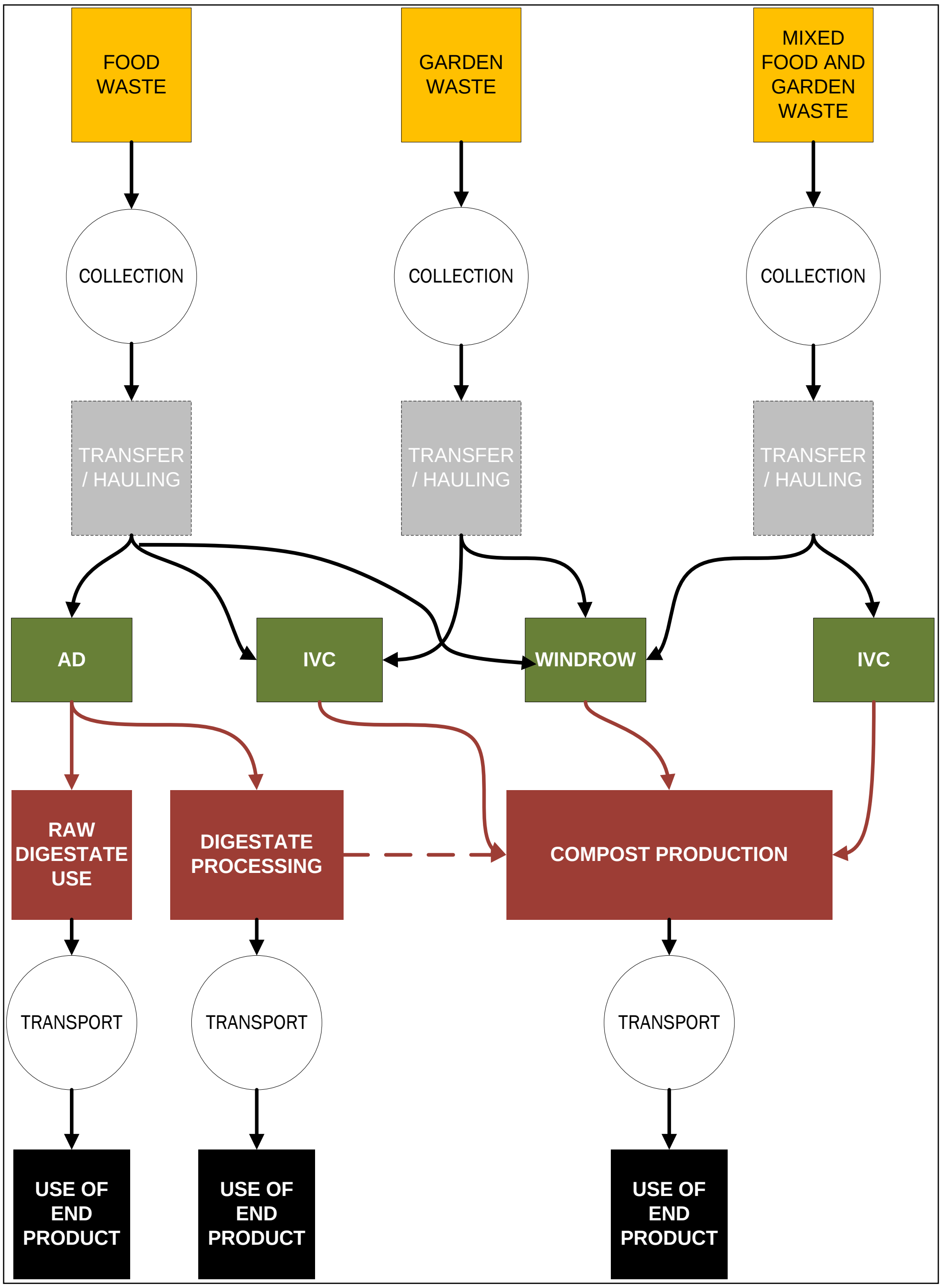
---

[5] Eunomia (2010) *Household Organic Waste Cost Benefit Analysis*, Report to Greenfingers Garden Bags/Earthcare Ltd and Envirofert Ltd, 5th November 2010.

E.2.2 Overview of the Organic Waste Management Process

Figure E-1 provides a basic graphical representation of the organic waste management process. The key characteristics of each of these elements is briefly explained in the subsequent sections.

Figure E- 1: Representation of Organic Waste Collection and Treatment System



E.3.0 Collection

The table below outlines the key characteristics of collecting different waste streams.

Table E- 1: Summary of Collection Characteristics

Food	Garden	Residual Waste Streams
Collecting food on its own is generally most cost effective: - Food only collections enable better control of contamination - Food waste collection needs to be frequent and convenient	Garden waste collected without charge results in large amounts of additional material requiring collection / processing and consequently significant increased cost for councils. Conversely, charging constrains additional material.	Residual waste streams can be collected less frequently if food waste is collected separately thereby reducing costs Constraining residual waste through charging, reduced frequency of collection and/or volume constraints increases participation in food waste collections and reduces garden waste in the residual

Detailed cost modelling was undertaken as part of our earlier Stage 1 report. The modelling looked at financial as well as monetised environmental costs. The environmental costs associated with transport are very small in comparison to the total financial costs, with the range varying between $0.26-0.34 per household depending on the type of collection system implemented. Set out below in the table is a summary of the financial and environmental costs of collection per household:

Table E- 2: Financial and Environmental Costs of Collection

Collection service	Scenario 1A (food and garden mixed)	Scenario 2A (food and garden separate)	Scenario 1B (food and garden mixed)	Scenario 2B (food and garden separate)
	Fortnightly Residual Collection		Weekly Residual Collection	
Organic waste collection	$48	$40	$48	$40
Residual Household Waste	$28	$26	$42	$42
Total financial cost	**$76**	**$66**	**$90**	**$82**
Environmental costs	**$0.31**	**$0.26**	**$0.34**	**$0.33**

The data shows that the most cost effective collection system will be one where food is collected frequently, garden waste is collected with a user pays system, and refuse is collected fortnightly and / or with a user pays charge or some volumetric constraint.

In such a system, garden and food waste quantities are likely to each be in the order of 100kg per household per year, giving a ratio of around 1:1.

The above type of system will also assist in ensuring the material delivered for processing is in a form that best optimises subsequent processing options (i.e. it is important that food waste and green waste is separated to enable processing systems to be managed in the most efficient manner).

E.4.0 Processing and Transport

E.4.1 Processing Options

The treatment systems are broadly of two types:

1. **Composting systems**[6], where the degradation of the organic waste occurs in the presence of air (aerobic systems). Composting systems operate in the open air (Open Air Windrow systems or OAW) or may be enclosed (in vessel, or IVC systems). The in-vessel systems take various different forms, including housed windrow systems, tunnel based systems, rotating drum systems and vertical silo-type systems;
2. **Anaerobic digestion (AD) systems**, where the degradation process happens in the absence of air. AD systems can be vertical or horizontal in layout, and may be classified according to whether they are a 'wet' or 'dry' process and thermophilic (high temperature) or mesophilic (lower temperature) process.

An advantage of AD is that it offers energy generation. Composting processes, such as open-air windrow (OAW) or in-vessel composting (IVC), offer the advantage of lower capital and operational costs, and, in the New Zealand situation, have the advantage that compost is widely recognised as a valuable soil amendment and carbon source for gardens and horticulture.

E.4.2 Processing Costs

Table E-3 below presents indicative financial costs for processing organic waste.

The table shows a range of values for each type of process which reflects the impact of the different variables that will influence the cost such as the proprietary technology used, how the process is managed, the value of the output etc.

It should be noted that the revenues shown in Table E-3 are based on current values of process outputs. However, the market for compost products is still developing (e.g. application on dairy farms) and some of the benefits from compost use (such as some of those noted in section 3.2 and Appendix A.3.0 of the main report may not yet be recognised by the market. In addition, because there is insufficient data a number

[6] Including vermicomposting which uses worms to treat feedstock

of potential benefits are unable to be quantified in the modelling. There may therefore be additional value from compost which is not accounted for in the analysis.

Both the environmental and financial costs of the processes will be influenced by the nature of the products from the process. It should be noted that it is possible to produce a quality end product from all the technology options examined above (although the benefits of digestate from AD are untested in New Zealand, and this therefore represents a risk associated with choosing this type of technology).

Table E- 3: Indicative Financial Costs for Processing Organic Waste

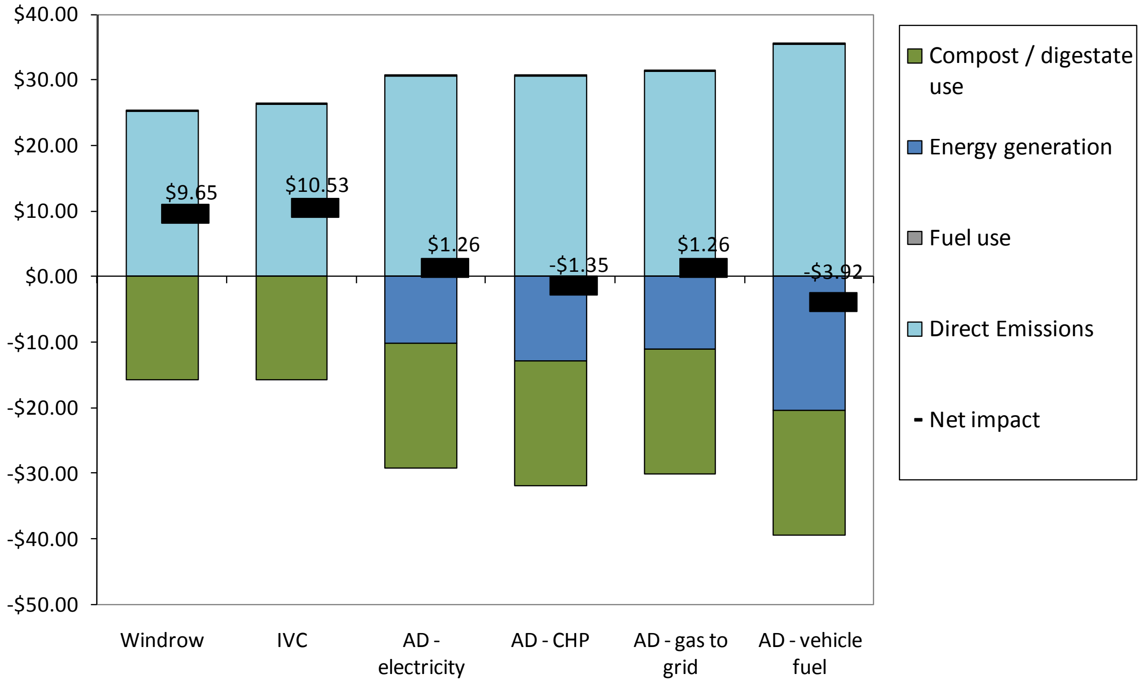
Baseline System	Total investment cost	Unit costs ($ per tonne of waste treated)				Other Cost-related Issues
		Annualised investment cost	Operating cost (excl revenues)	Revenues	TOTAL	
Open Air Windrow						
OAW Low (10kt)	$1.9m	$26	$21	$15	**$32**	Poor collection systems will incur costs to dispose of rejects Revenues from compost are dependent upon marketing effort Terms of land acquisition may be important Extent of odour control equipment required / used will affect costs
OAW High (10kt)	$2.3m	$32	$25	$0	**$57**	
In-vessel Composting						
IVC Low (10kt)	$3.5m	$48	$36	$15	**$69**	Poor collection systems will incur costs to dispose of rejects Revenues from compost are dependent upon marketing effort Extent of odour control equipment required / used will affect costs
IVC High (10kt)	$4.6m	$64	$42	$0	**$107**	
Anaerobic Digestion						
AD Low (10kt)	$6.7m	$94	$57	$25	**$126**	Poor collection systems will incur costs to dispose of rejects and will increase maintenance costs if not adequately addressed Costs of digestate management will depend upon a range of factors Costs of, and revenues from, gas utilisation depends upon the technology
AD High (10kt)	$8.8m	$123	$76	$20	**$179**	
AD Low (30kt)	$16.4m	$76	$46	$25	**$97**	
AD High (30kt)	$22.1m	$102	$59	$20	**$141**	

Notes:
1. Annualised investment costs consider the total investment cost over the lifetime of the facility (here taken to be 15 years). We have used a weighted average cost of capital of 12% to estimate the annualised unitary payment
2. Revenues from compost sales are expressed per tonne of waste input. Values derived from compost sales vary significantly depending upon the nature of the product and the level of demand in the local market. They are usually expressed per tonne of compost sold, with values varying from $0 to $70 per tonne. Some higher value outputs are derived from processes where lengthy maturation periods apply (which results in a reduction in the quantity of output), so that when expressed in terms of 'per tonne of waste', the values appear far lower.
3. Digestate revenues assume zero benefits from digestate sales, a conservative assumption. These revenues will vary depending upon the use to which biogas is put, but here, we assume the use of biogas for electricity generation only.

E.4.3 Environmental Costs and Benefits

Environmental benefits have been monetised through the application of cost-benefit techniques[7]. Figure E-2 below shows the environmental impacts of the various processing options. The conclusion is that AD processing systems offer better environmental performance when compared to IVC and Open Air Windrow.

Figure E- 2: Environmental Impacts of Processing Food Waste (Including Product Use)



Note: data below the x axis represents an environmental benefit while data above the line shows an environmental cost

E.4.4 Combined Financial and Environmental Costs

Table E-4 shows the financial costs of options in the current NZ context alongside their environmental costs (including benefits associated with energy generation and compost use). For ease of presentation, the financial costs in the table are based on the mid-point values from Table E-3 above.

[7] Refer: Eunomia (2010) *Household Organic Waste Cost Benefit Analysis*, Report to Greenfingers Garden Bags/Earthcare Ltd and Envirofert Ltd, 5th November 2010.

Table E- 4: Combined Financial and Environmental Costs for Processing Organic Waste

System		Financial cost, $ per tonne[1]	Environmental costs, $ per tonne[2]	Net costs, $ per tonne
Composting	Windrow – garden	$40	$14.82	$54.82
	Windrow – food	$50	$24.08	$74.08
	IVC – garden	$88	$4.63	$92.63
	IVC – food	$88	$10.34	$98.34
AD	10kt Food - Onsite generation of electricity	$152	$1.22	$153.22
	30kt Food - Onsite generation of electricity	$119	$1.22	$120.22

Notes

[1]. The figures for treating food and garden waste at OAW facilities are different reflecting, we believe, current market conditions. It would not be unusual to see the costs of treating food waste and garden waste at IVC facilities to diverge in a more mature market. This reflects the fact that OAW and IVC gate fees are typically calculated through reference to a 'mix' of material. The fees for each of these streams when treated separately will tend to result in lower fees for less problematic garden waste, which is more generally treated at OAW at low cost, and higher fees for more problematic food waste.

[2]. Environmental costs for AD are for food waste only

The Table confirms there is variation in both the financial and environmental costs across the options. The variation in the net costs (the sum of the financial and environmental costs) is, however, dominated by the variation in financial costs.

The costs of treating garden waste needs to be considered alongside those of treating food waste, as food waste cannot be composted by itself in either windrow or IVC systems (i.e. such systems require some greenwaste to produce an optimal compost).

The whole system costs of using AD to treat food waste may therefore be close to those associated with using IVC to treat food waste, as in the case of AD the garden waste generated within the system can be treated using the typically much cheaper windrow process. However, even where impacts are considered on a "whole waste system" basis, open windrow remains the cheapest option. In essence, the low costs of open air windrow (and IVC) treatments suggest that there is likely to be merit in their use over AD where such facilities are available locally.

These conclusions have to be placed into context, however. There are a range of factors that may determine the optimal combination of collection and treatment of waste. These include:

1. The way the waste is collected (does this allow for optimisation of the choice of treatment, something which will be most readily possible where materials are collected separately);
2. The availability of suitable open air sites for processing the material; and
3. The haulage distances involved in moving materials from the location where waste is collected to where it must be treated.

E.4.5 The Benefits of Compost to NZ Horticulture

The study has, to the extent possible, accounted for the benefits of compost use, although it is noted that there are likely to be some benefits that are not able to be adequately quantified at this stage. It is worthwhile noting here some of the potential benefits that increased use of compost products could bring. There is a growing body of evidence that adding compost to the soil increases plant growth and production. For example, field trials undertaken in New Zealand[8] showed that the addition of compost:

- Increased onion yields by 23% over the control plot;
- Increased both the size and number of onions grown;
- Increased carrot yields by 15% over the control plot;
- Resulted in a steady improvement in soil conditions;
- Stabilised soil pH and increased Ca, Mg, P, Cu and Zn; and
- Led to significant increases in lettuce yields measured in gm/plant when 30% compost is mixed with soil

Similarly, research by Compost Australia has also presented evidence that compost:

- Can provide fertiliser savings of one half to two thirds of the cost of applying compost[9];
- Can save 10 – 20% of irrigation costs[10]; and
- A cost-benefit analysis on capsicums showed a return of $2.08 for every $1.00 invested in compost[11]

While it should be noted that the benefits noted above vary on a case by case basis according to crop type, soils, application rates, existing management practices etc., it is reasonable to assume that across the sector there will be a level of net benefit. Given the NZ horticulture industry generated revenues of approximately $3.0bn in 2007[12], this would suggest that even a 1% increase in yield (through the addition of compost) in this sector alone would result in a benefit to the New Zealand horticulture market of approx $30 million per annum.

[8] http://www.envirofert.co.nz/technical-library/research-and-development/

[9] Compost Australia (2011) *Cost Benefit Trial of Using Compost in Vegetable Growing*. Available from www.compostforsoils.com.au

[10] Compost Australia (2011) *Compost and Commercial Vegetable Production*. Available from www.compostforsoils.com.au

[11] Compost Australia (2011) *Cost Benefit Trial of Using Compost in Vegetable Growing*. Available from www.compostforsoils.com.au

[12] Source: Department of Statistics, New Zealand

E.4.6 Processing Option Summary and Conclusions

Table E-5 Below summarises the key characteristics of each of the processing options

Table E- 5: Key Characteristics of Processing Options

	Windrow	IVC	AD
Input material	Garden or Food and Garden	Food and Garden	Food only[13]
Cost	Lowest cost per tonne for processing	Mid-level cost for processing	Highest cost per tonne for processing
Environmental performance	Lowest level of environmental performance	Mid-level environmental performance	Highest level of environmental performance
Site considerations	Requires large land area Least control over process Suitable for rural locations	Moderate spatial footprint Good level of process control More suitable for urban locations	Moderate spatial footprint Good level of process control Suitable for urban locations Requires access to power grid /proximity to vehicle fleet In the current NZ market it is likely to require access to an appropriate sized site for processing/ maturation of digestate into compost
Bulking and Haulage implications	As located outside of population centres will tend to incur greater bulking and haulage costs	Likely to have reduced haulage costs if located nearer to population centres	Likely to have reduced haulage costs if located near population centres

There are differences in environmental performance between the technologies – with AD performing best and OAW having the lowest level of environmental performance of the three types of processes. However, when environmental performance is monetised, the differences in environmental performance between the technologies are not great enough to make up for the differences in financial performance. At a broad level the

[13] 'Dry' AD processes may require up to 50% garden waste

determination of which process is likely to be preferred therefore comes down to a balance between the cost of the processing and the cost of transport and bulking. In general, windrow, the least expensive option, will be located more rurally and incur higher transport costs, while IVC and AD are more expensive, but if located centrally will incur lower transport costs.

E.5.0 Outputs and End Use

Table E-6 Below summarises the key outputs and considerations from each of the processing options.

Table E- 6: Processing Option Outputs

	Windrow	IVC	AD
Outputs	Compost. Product maturity and quality will vary	Compost. Output from IVC process requires further maturation before use	Biogas – can be converted to electricity, used as vehicle fuel or injected into gas grid Digestate – can be used directly on land or dewatered, with the liquid fraction used as a soil amendment and the solid fraction added to a compost process[14]
Value of output per tonne input[15]	$0-$15	$0-$15	Energy: $20-$25 Digestate: $0
Markets	Specific operators have well established markets. Potential to grow markets further as benefits of compost become more recognised	Specific operators have well established markets. Potential to grow markets further as benefits of compost become more recognised	Ready market for electricity Vehicle fuel market undeveloped Digestate market undeveloped

[14] The lack of an established market in NZ means the output is most likely to be processed further into a compost product

[15] Assumed to be accounted for in financial costs

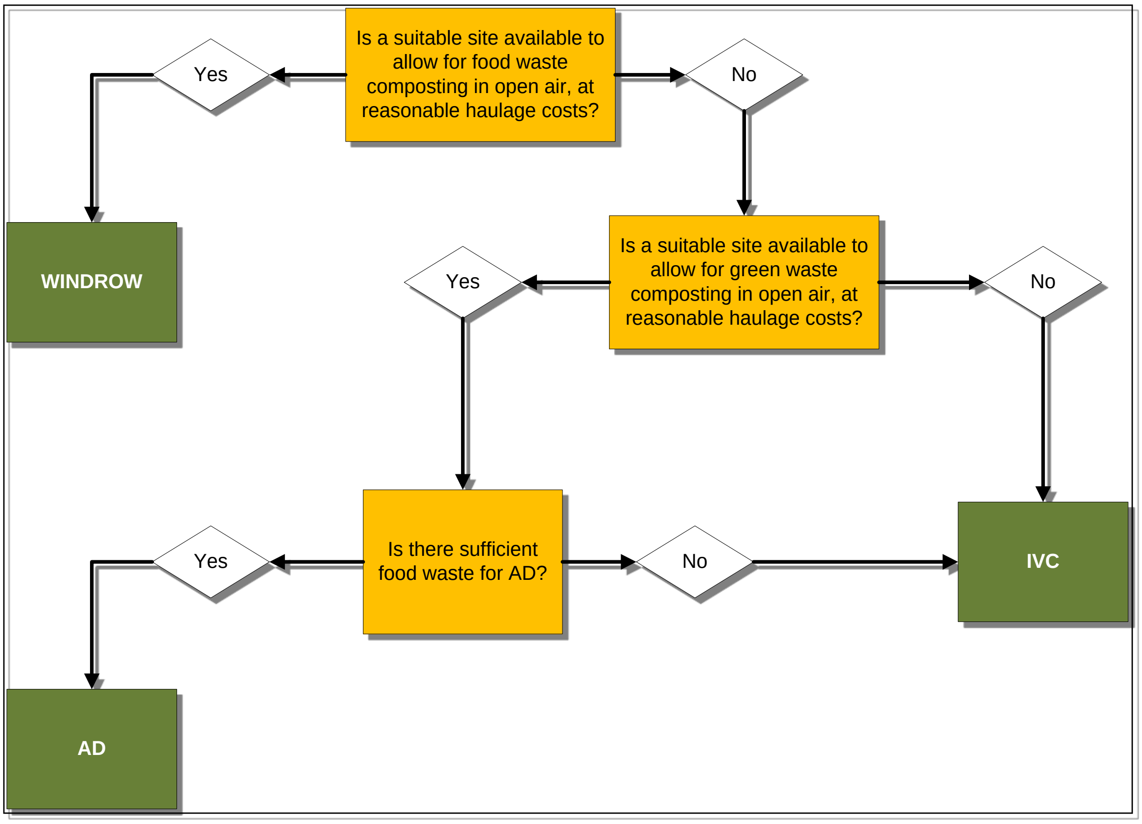
Markets for outputs from Windrow and IVC composting processes are relatively well established, and have potential to grow further. Markets for outputs from AD are, however less certain, which represents a risk for the selection of AD in the New Zealand context. Electricity has a ready (but competitive) market, but other outputs (and in particular digestate) are relatively unknown in New Zealand, and would require market development or further processing. It should be noted though that it is possible to produce a quality end product from all the technology options examined above but in the case of digestate from AD further processing costs will be incurred.

E.6.0 Decision Tree for Organic Waste Processing

A basic decision-tree is summarised in Figure E-3. The decision tree suggests the following:

- If an open windrow facility with capacity to treat food mixed with greenwaste is available within a reasonable distance, then our analysis shows that it makes economic sense to utilise this processing system. The environmental benefits of AD and IVC are not currently justified by the additional costs.
- In the event that an appropriate / proximate site is *not* available to process the food using windrow, then either IVC or AD could be considered as possible options.
    - If a local facility is available for treating garden waste in open windrows, then the option of AD becomes more realistic since the AD process can deal with food waste while the garden waste is treated through the much lower cost option of open windrow. It should be noted that there is likely to be a minimum economically operating scale for AD of at least 10,000 tonnes capacity (this would be equal to the quantity of food waste from municipalities of around 100,000 households).
    - If there is not a local facility available to treat garden waste in open windrow or there is not sufficient food waste available to achieve economic scale for AD, then IVC is likely to be the preferred option.

Figure E- 3: Decision Making Process for Food Waste Treatment



E.7.0 Conclusions

The analysis undertaken in this study has aimed to distil the key factors that will influence decision making regarding the most appropriate approach to organic waste management. The starting point for the analysis was the work undertaken in our Stage 1 report, which showed that from a cost-benefit perspective food and garden waste should be:

- diverted to beneficial use rather than be sent to landfill; and
- that the most cost effective approach is to collect food and garden waste as two separate streams.

The question of treatment was more open and it is addressed in more detail in this report.

From an environmental perspective AD has the highest level of benefits followed by IVC then windrow composting. However, these benefits are outweighed by the relative financial costs of the processes, which are in reverse order with open air windrow the most cost effective processing option followed by IVC then AD.

This would suggest that windrow composting should be the preferred approach. However, open windrow processing will not necessarily be most cost effective in all situations, particularly given that such operations are generally not suitable for siting close to population centres. IVC and AD both have smaller footprints and greater process control, and hence are more appropriate for being sited near urban areas[16].

This means that although windrow is cheaper, it is likely to incur greater bulking and transport costs of the raw material, as it more likely to be rural based[17]. Depending on the extent of these costs (which are essentially a function of distance), this may have the effect of reducing its cost advantage. In instances therefore where windrow facilities are not in close enough proximity to population centres, IVC or AD may be preferred options.

Because AD is capital intensive it requires a relatively large scale before it is likely to become economic (this is potentially in the order of at least 10,000 tonnes per annum, although in the New Zealand context an optimal sized plant may need to be substantially greater to achieve an acceptable rate of return on the investment). In system terms, some of the costs of AD can be mitigated if garden waste is able to be processed through the cheaper windrow option (while food waste is handled by the AD process). In such cases AD may be the preferred option.

IVC will tend to come into its own when a more central location is necessary, when there is not sufficient scale for AD, and when there is no option to open windrow garden waste.

In terms of end use, all processes, if well managed, are capable of producing valuable outputs, which may be varied according to the type of products demanded by local markets. In the medium to long term, there is potential for markets for compost products to be developed further and for prices paid for compost products to increase as their benefits are more widely recognised (which will in turn make organic waste collection and processing more cost effective).

It is worth highlighting that the beneficial application of end products (in the form of compost or digestate) is a critical determinant of overall system performance. There is a growing body of evidence to suggest that there can be substantial benefits from the application of compost in the horticulture sector, leading to higher productivity and reduced need for application of synthetic fertilisers. Conversely, should any of the end product end up being used in low value applications – such as landfill cover - the benefits of recycling and waste minimisation are effectively lost. Because there is no established market for digestate in NZ, there is at least a short term risk for this technology choice.

A key observation for urban authorities is that to the extent that the choice of 'the best technology' is not an obvious one, they should not constrain options unnecessarily as they seek to procure new waste management services. Local authorities facing such choices should therefore look to the various service providers and encourage their competitive bids for the various solutions. Local authorities should ensure that their procedures for evaluation are well-designed and account for the different aspects of the solution which affect overall performance. This pragmatic approach will ensure that ratepayers' money is well spent.

---

[16] However, it should be noted that, if the output digestate is to be composted, then the AD plant will require a reasonable area of land to compost the material.

[17] Rural based facilities may however be closer to the markets for the compost produced, which would offset some of the additional transport costs.

Organic Waste Options Research

EXECUTIVE SUMMARY