Household Organic Waste Cost Benefit Analysis

Report to Greenfingers Garden Bags/Earthcare Environmental Limited & Envirofert Limited

Executive Summary

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Report for:

Greenfingers Garden Bags/Earthcare Environmental Limited & Envirofert Limited.

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Introduction

This report presents the outcomes of a study commissioned jointly by Greenfingers Garden Bags/Earthcare Environmental Limited and Envirofert Limited. The study concerns household organic waste management practices, and has sought to identify the most promising solutions for the management of household organic waste in New Zealand.

The work comes at a critical time for the country. The revised waste strategy has just been released. In light of evidence which shows that organic waste makes up the biggest component of household collected residual waste, most Territorial Authorities are now at least considering options for alternatives to landfill as part of their waste management and minimisation plans.[1] Decisions made today have the potential to shape the sorts of programmes, systems and facilities that will be in place for years to come. It is crucial, therefore, that these decisions are made on the basis of the best available information regarding the costs and benefits of different options.

E.1.1 Aim

The work undertaken in this study aims to:

1. Understand the context for organic waste management in New Zealand, with particular reference to the economic and environmental impacts of avoiding landfill and the beneficial use of diverted materials;
2. Provide a critical evaluation of international best practice;
3. Consider the costs and benefits of some key options for household organic waste management in New Zealand. The options considered are ones which are established internationally and that are capable of being implemented in New Zealand today utilising readily available techniques and technologies. The modelling takes a Cost Benefit Analysis (CBA) approach in which the environmental costs of different options are monetised, and combined with financial costs to produce a net cost for each option; and
4. Make recommendations, on the basis of the consideration of the options, regarding how policy and practice might best be configured to deliver the most desirable outcomes.

E.2.0 New Zealand Situation

Overall the situation in New Zealand is one where disposal to landfill is still the main option for the management of household organic waste. Organic waste has long been recognised as the major component of residual household collected waste. While the capability of collecting organic wastes, in terms of systems and processing technology,

[1] B. Middleton (2008) *Benchmark Waste Data – Where Measuring Progress Starts*, presentation to WasteMINZ Conference, Blenheim, New Zealand. See also Section 4.0 below.

has been available in New Zealand for some time, local authorities have, by and large, been slow to adopt these schemes.[2]

A review of policy highlights the fact that in the past, legislative, economic and political drivers have failed to generate a widespread shift of organic wastes away from landfill. With the introduction of the waste disposal levy, the potential for the Waste Minimisation Fund investment to kick start schemes, and the introduction of the NZETS, policy is beginning to shift the balance away from the historical disposal-dominated approach.

Perhaps almost as importantly there is a low level of knowledge and information on best practice – how to design and implement systems and the true (whole system) costs of doing so. The pathway to collection and processing of organic waste appears difficult and potentially costly, and, although this is clearly beginning to change, fully addressing household organic waste has, until now, often been consigned to the 'too hard' basket.

E.3.0 International Practice with Organic Waste Collection

Despite the understandable variation in international practice in respect of household organic waste collection and processing systems, the review highlights that there are a number of principles that emerge when considering the design of high performing systems:

1. **Incentives / encouragement for householders to use the systems.** This can take the form of user pays refuse collections, or less frequent collections of refuse. Large refuse containers, frequent refuse collections, refuse systems which are more convenient than the alternatives and the absence of charges for refuse collection can all reduce the incentive to separate out organic waste;
2. **Where collections of garden waste are offered free of charge to households, there tends to be a significant increase in the quantity of garden waste collected.** In the UK, WRAP estimated this effect to be to draw in an additional 107 kg/hh/yr of garden waste[3]. If this level of effect was applied to NZ it would mean an additional 170,000 tonnes per annum having to be collected and processed[4]. This can contribute impressively to increasing recycling rates, but it may undermine home composting, and introduce additional cost for no obvious benefit;

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[2] For example MacKenzie District's scheme has been in place since 2002

[3] WRAP (2008) *Home Composting Diversion: District Level Analysis*. Banbury, UK

[4] The level of effect in New Zealand is estimated to be higher than UK due to climate differences and larger average garden sizes. NZ data suggests there could be up to 400kg/hh/yr of additional material drawn into the system depending on the collection systems in question. For the purposes of modelling in this report we have calculated a relatively conservative figure of 150kg/hh/yr based on a 120 Litre weekly collection of food and garden waste. This is discussed further in Appendix A.4.0 and Appendix A.6.0 of the main report.

3. **User-friendly food waste collection services.** Food waste can be potentially off-putting for householders to deal with –especially if it involves cleaning of dirty bins caked with rotten food, and if services are so infrequent that the material becomes malodorous. The most effective systems therefore tend to be the ones that provide ventilated caddies with liners, which reduce odours and mess, and where food waste is collected frequently;

4. **In seeking to optimise costs, collection and treatment have to be considered as an integrated whole.** Although collection costs will be dependent on a wide range of factors, there is evidence to suggest that collecting food waste separately and using non-compacting collection vehicles to do so, can help to deliver low cost systems where food waste is collected frequently, and refuse, less so. There are a number of reasons for this:

   - **Targeted separate collection of food waste** provides the opportunity to either not collect garden waste at all (and encourage its mulching / home composting / delivery to transfer stations) or to charge for its collection. There is evidence to show that collecting garden waste for free results in additional garden waste being attracted into the municipal waste collection system. This is material that then must be paid for by the council to collect and process that was not being paid for previously. All ratepayers then subsidise those that use the service. A user pays system for garden waste can also recover any additional cost.

   - **Non-compacting collection vehicles** are low cost and can be used to collect food since food waste has a high bulk density and tends to compact itself on vehicles as it is collected;

   - **Small containers can be used** rather than wheeled bins. These are efficient in terms of the speed of pick up (bin lifts are required only at multi-occupancy properties, or where 'slave bins' are used) and tend to discourage the 'over-delivery' of waste so often seen where garden waste collections are offered free of charge;

   - **Manual collections of food waste** using translucent biobags enables easier and better quality control resulting in reduced processing costs and higher quality outputs;

   - **Separate collection of food waste** as opposed to the co-collection of food and garden waste, opens up processing options and enables processors to control inputs to their composting / digestion processes. Specifically, it allows for better usage of more capital intense facilities since it avoids the need to cater for seasonal fluctuations in garden waste yields;

   - **Reduced residual waste collection frequency** is more acceptable to households where food waste collection systems are provided on a convenient and frequent basis. This allows the frequency of residual collections to be reduced and the savings used to offset the costs of the additional collection.

5. **In environmental terms, systems that process organic material through anaerobic digestion (AD) are likely to be preferable to in-vessel, or windrow, aerobic composting processes.** This is because whilst all systems can produce a soil amendment (such as compost), AD offers the additional advantage of recovering energy (with the associated carbon benefits).[5] A system collecting food waste only can incorporate AD within the service offering at a relatively low cost, and in some countries (UK and Italy), the different costs of windrow composting, in-vessel composting and AD enable food waste collections, coupled to AD, to be cost competitive with systems collecting food and garden waste combined, with the collected waste sent for aerobic composting.[6]

E.4.0 Scenarios Modelled

In order to model impacts across systems, it is necessary, from a practical perspective, to develop a number of 'Scenarios' that represent certain likely combinations or configurations. The Scenarios chosen include co-mingled food and garden waste options, as well as source separated food and garden waste options. The Scenarios aim to highlight the factors which may influence the search for the most appropriate solution from a whole system perspective.

The Scenarios modelled in this study consist of a Baseline Scenario which broadly reflects current practice, plus three alternative Scenarios, each modelled with weekly and fortnightly collection of residual waste. This makes a total of seven Scenarios including the Baseline. The Scenarios are described in Table E. 1.[7]

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[5] It is possible to recover heat from aerobic composting systems, bit this is rarely done in practice.

[6] This is the finding for the UK where financial incentives exist for the generation of renewable energy through Renewable Obligation Credits. There are no such incentives in place in NZ at present and this is likely to adversely affect the economics of Anaerobic Digestion in NZ. The economics of this technology are explored further in this study.

[7] There are some minor variations of these basic scenarios in the case study modelling to allow for local factors and existing systems. For example, in Whakatane scenarios 2 & 3 provide for a rates funded collection of garden waste as is currently in place.

Table E. 1 Scenarios Modelled

	Food Waste Collection	Garden Waste Collection	Residual Collection[8]	Organic Waste Treatment
Scenario 1a	Weekly with garden	Weekly with food	Fortnightly	In-vessel composting
Scenario 1b	Weekly with garden	Weekly with food	Weekly user pays	In-vessel composting
Scenario 2a	Weekly separate	Opt in user pays	Fortnightly	In-vessel composting
Scenario 2b	Weekly separate	Opt in user pays	Weekly user pays	In-vessel composting
Scenario 3a	Weekly separate	Opt in user pays	Fortnightly	Anaerobic Digestion
Scenario 3b	Weekly separate	Opt in user pays	Weekly user pays	Anaerobic Digestion

To make the work relevant at a national level, we modelled, as a central case, all seven Scenarios at the 'all NZ' level. In addition to this, we have modelled two other cases:

- a large urban centre, represented by Auckland; and
- a small district, represented by Whakatane.

The same seven Scenarios were modelled in the case study areas (though with locally relevant data, particularly in respect of the Baseline Scenarios). The intention is to explore how the findings may apply at a local level where different Baseline systems are in place.

E.5.0 Results

The modelling takes a Cost Benefit Analysis (CBA) approach in which the environmental costs of different options are monetised, and combined with financial costs to produce a net cost for each option.

E.5.1 Net Costs and Benefits

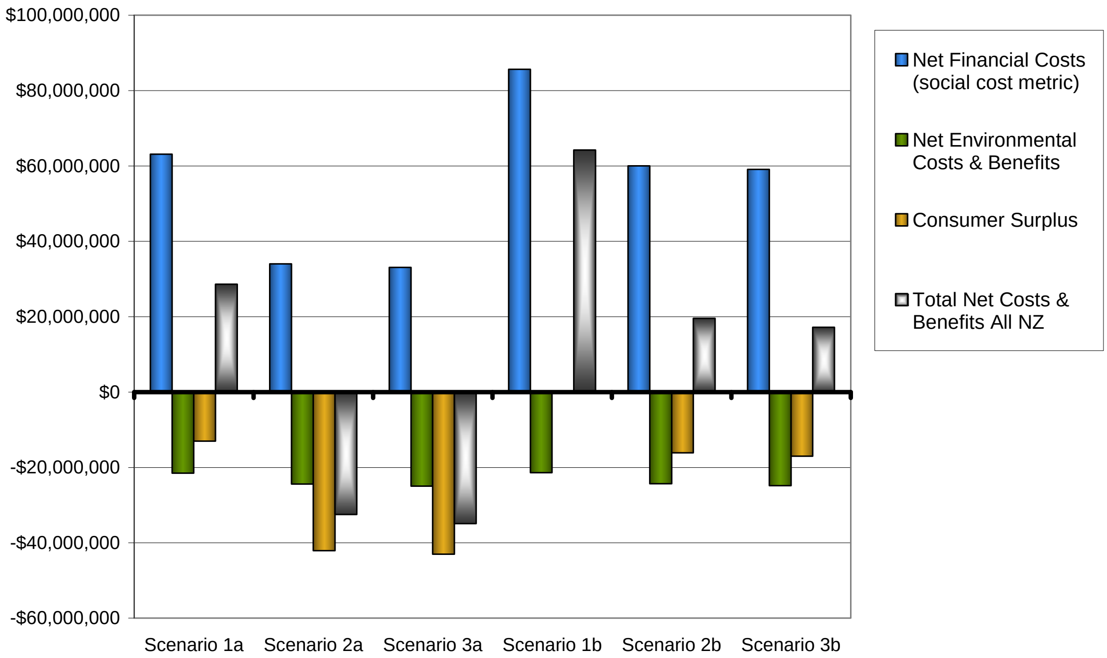
The charts below show the net outcomes of the modelling taking account of financial costs, monetised environmental benefits and social benefits (as represented by the estimated consumer surplus[9]). It should be noted that the results for each of the

[8] In all scenarios all residual waste is assumed to be sent to landfill.

[9] Consumer surplus is a measure derived from householders 'willingness to pay' – in other words how much are householders willing to pay for the service to be delivered to them. As long as households are not paying this amount, or spending time which they value to be in excess of this amount, this is, in effect, considered to be an additional social benefit of the service.

Scenarios are shown relative to the Baseline Scenarios (or business as usual situations). In other words what is reported is the change from the current situation. In terms of the Figures, a positive value indicates that the system imposes additional costs relative to the current situation, whilst a negative value represents a saving, or a benefit.

Figure E. 1 Annual Net Social Costs and Benefits All NZ (50% methane capture)



NB: Positive values on the chart represent costs, negative values represent benefits

The modelling shows that:

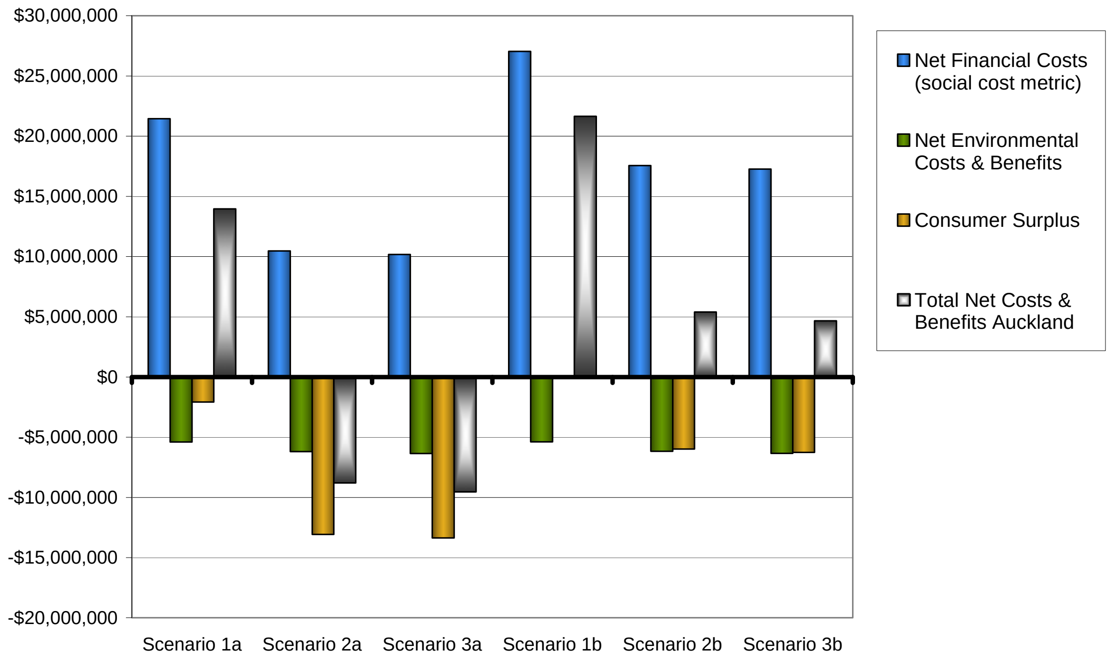
1. Relative to the Baseline there is a strong net benefit in Scenarios 2a and 3a. In these Scenarios, food waste is collected separately from garden waste (which is collected on a user pays basis), and against a background of fortnightly residual waste collection. In Scenario 2a the material is combined with garden waste for composting and in Scenario 3a it is anaerobically digested. The outcomes for 2a and 3a are almost identical in terms of the net benefit;
2. By comparison Scenario 1a incurs higher financial costs, it delivers lower environmental benefits and a lower consumer surplus than Scenarios 2a and 3a. Part of the explanation of the higher costs relates to the need to process the green waste that is collected in IVC systems. The net effect is that, even though refuse is collected fortnightly, there is a net cost to society associated with this system. This highlights the major difference between systems which co-collect food and garden waste, and those which collect food waste separately from garden waste;
3. Where the same separate food waste collection systems are operated against the background of weekly user pays residual waste collection (Scenarios 2b and 3b), the financial costs relative to the Baseline are much higher. The effect of this is to

reduce the consumer surplus, and whilst the environmental benefits remain significant, the additional costs are greater than the total benefits offered by the system. This highlights the fact that not only are the costs lower where residual waste collection frequencies are reduced, but the change may be decisive in the overall assessment of costs and benefits. Frequent food waste collections have an important role to play in making this approach more acceptable to residents because of the need to remove the putrescible food waste fraction from refuse,

4. As with the 'a' Scenarios, Scenario 1b is far more costly to society as a whole;

The results for Auckland are shown in Figure E. 2. We have modelled the Auckland case using a higher rate of landfill gas capture than for NZ as a whole.[10] The results are similar in nature to those for all NZ, and similar comments apply (although the environmental benefits are reduced as a result of the higher landfill gas capture assumed). This reflects the similarity in the Baseline systems being modelled.

Figure E. 2 Annual Net Social Costs and Benefits Auckland (70% methane capture)



NB: Positive values on the chart represent costs, negative values represent benefits

The case of Whakatane is slightly different (see Figure E. 3):

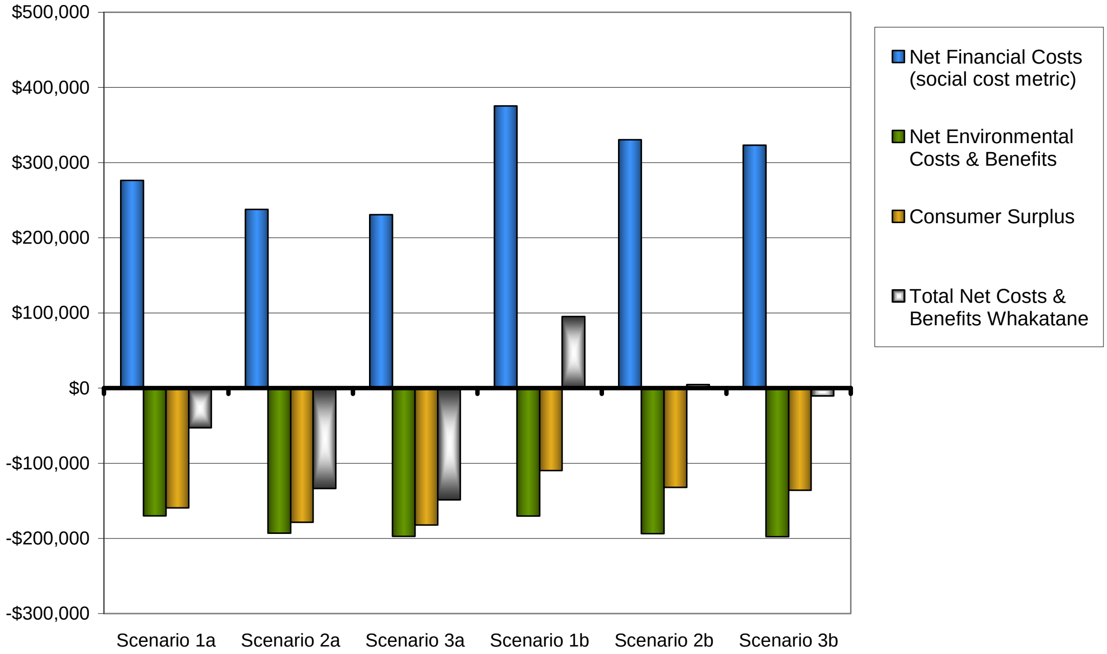
1. Whakatane District currently provides a rates-funded garden waste collection and so the costs of collecting and processing this material are already accounted for in the baseline. The pre-existing garden waste collection in Whakatane has the

[10] The issue of landfill gas capture is discussed at some length in Appendix A.16.0

effect, therefore, of making the net financial costs of the Scenario 1 variants similar to those of Scenarios 2 and 3;

2. Since there is already a garden waste collection system in place, it may be argued that the willingness to pay for food waste collection is less than that which would be normally associated with organic waste collection. We have, therefore, modelled a reduced level of consumer surplus in this case;
3. The performance of the Scenario 1 variants relative to Scenarios 2 and 3 is more favourable than in the All NZ or Auckland cases. Nevertheless, the separate food waste collection Scenarios still show more favourable results, and demonstrate somewhat similar trends to the Auckland and 'All NZ' cases, with significant net benefits in Scenarios 2a and 3a. The case for altering the system is marginal in the case where refuse collection remains on a weekly basis.

Figure E. 3 Annual Net Social Costs and Benefits Whakatane (50% methane capture)



NB: Positive values on the chart represent costs, negative values represent benefits

E.5.2 Sensitivity Analysis

As with all modelling exercises the outcomes are sensitive to a range of variables. Our approach has been to choose values which, as far as we are able to determine, provide a realistic representation of New Zealand's situation. There does however remain some level of uncertainty concerning individual modelling parameters, and considerable debate within the scientific community continues. More detailed discussion regarding the most sensitive parameters is contained within the Appendices.

In order to deal with these issues we have conducted a number of sensitivity analyses to show how the results might vary if values other than those used for the central case were chosen. Furthermore, we have investigated the sensitivity of results to simultaneous variation in key variables using Monte Carlo analysis. This enables us to give some indication of the level of confidence we may hold in the results, and the likelihood of certain outcomes being achieved, although it needs to be stated that the outcomes depend heavily on the shape of the probability distribution of values for the variables being investigated.

E.5.3 AD Biogas Use

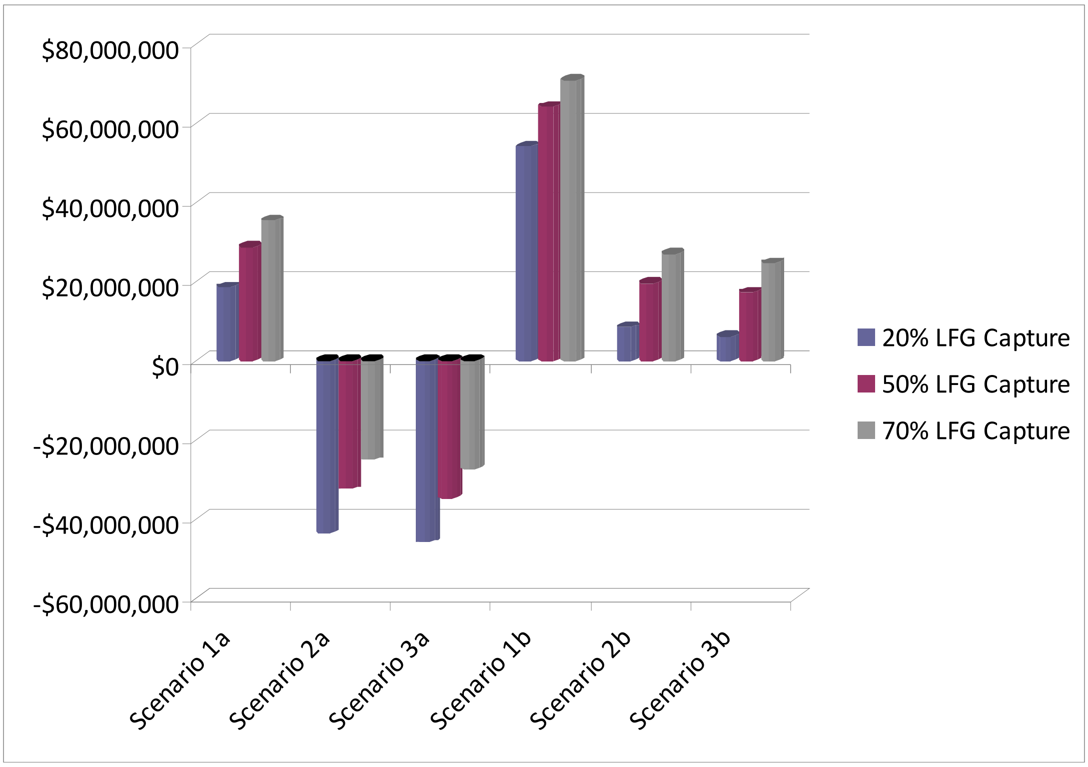
The first issue investigated was the use that to which biogas generated by AD is put. The central case, where it is used for vehicle fuel, was varied to one where the biogas was used to generate electricity. The results, however, change very little from one case to the other suggesting that there would be no imperative to legislate between one use and the other.

E.5.4 Landfill Gas Capture

The following chart shows the net cost/benefit for different levels of landfill gas capture (20%, the IPCC default, 50% and 70% - see Appendix A.16.0 for a discussion). As can be seen from Figure E. 4, the landfill gas capture rate has a marked impact on the level of cost or benefit. However it is notable that in the 'all NZ' case this level of variation is not sufficient to shift any of the Scenarios from a situation where a benefit becomes a cost, or vice versa.

More importantly, even with a high lifetime gas capture, the performance of Scenarios 2a and 3a remains beneficial to society. The performance of these Scenarios is notably superior to that of Scenario 1a.

Figure E. 4 NZ Annual Net Costs and Benefits at Different Landfill Gas Capture rates



NB: Positive values on the chart represent costs, negative values represent benefits

E.5.5 Multivariate (Monte Carlo) Sensitivity Analysis

Monte Carlo analysis provides a means through which to assess the net effect of a range of parameters about whose value there is some uncertainty. The parameters that are least well known or have the greatest potential for variation were considered to be:

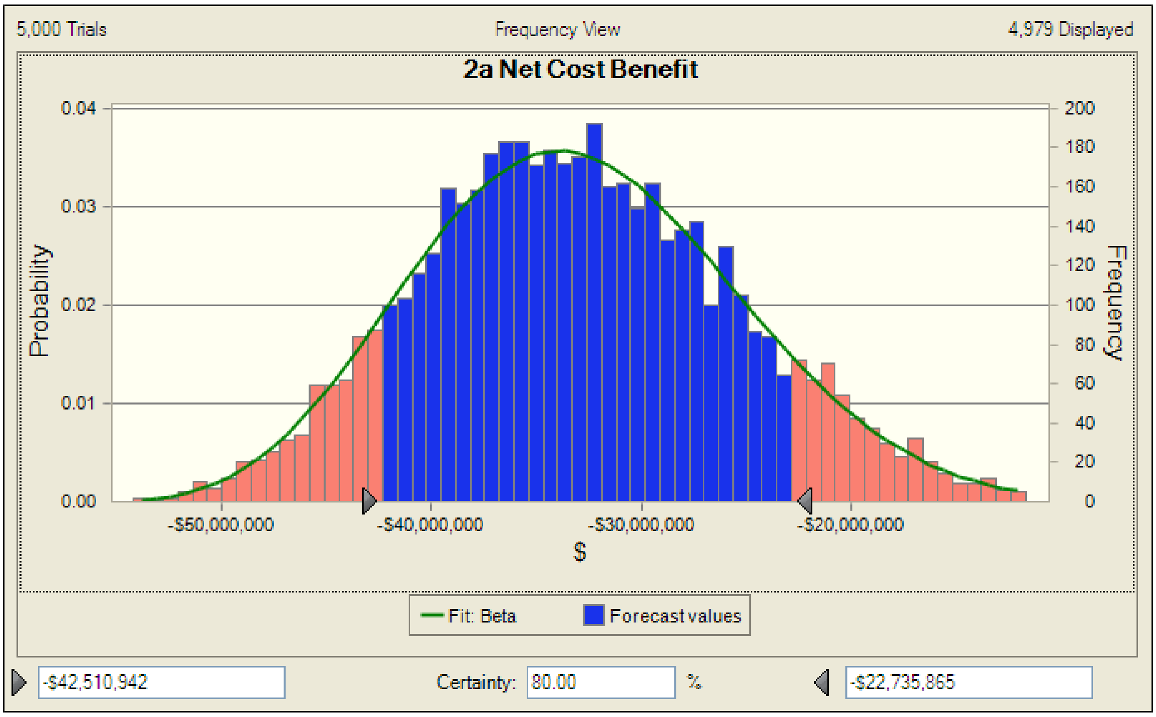
- The landfill gas capture rate;
- The costs of treatments (landfill, digestion, windrow composting, IVC);
- The costs of collection (relative to the Baseline Scenario); and
- The level of consumer surplus.

Discrete probability distributions with what we consider to be high levels of variation are applied to these individual parameters and the modelling simulation is run a large number of times until trends can be determined (a total of 5,000 times in this case). An example for Scenario 2a is shown in Figure E. 5. This highlights the probability distribution of costs imposed upon society by this Scenario under the assumptions made.

Figure E. 5 also projects that there is an 80% likelihood that the net costs to society for Scenario 2a will fall within the range -$23m to -$43m (these negative costs represent benefits to society).

Likewise for Scenario 3a, there is an 80% probability that the costs will be between -$25m and -$45m. Indeed, the full analysis suggests that the two most promising Scenarios, 2a and 3a, show a near 100% probability of delivering a net benefit to society under the assumptions made.

Figure E. 5 Monte Carlo Sensitivity Results for All NZ Scenario 2a Net Costs and Benefits



The analysis also reveals which of the parameters modelled are the 'sensitive' ones. The effective contribution to the variance observed is due most significantly to the landfill gas capture rate modelled. This accounts for around 54% of the variance observed. The potential variation in collection costs is the next most sensitive factor and accounts for around 36% of the variance. The landfill gate fee contributes a further 11% to the variance, and the three organic treatment gate fees each contribute 0.1% or under.

This tells us that the most crucial 'sensitive' factor in the analysis is the landfill gas capture rate. Even where the values for this and the other parameters are unfavourable to separate collection systems, the indication is that Scenarios 2a and 2b will consistently lead to net benefits for society.

E.6.0 Conclusions and Recommendations

E.6.1 Implications for Local Authorities

There are a number of key implications of this work for local authorities:

1. Relative to landfilling of the material, collecting food on its own and food and garden waste together deliver a similar level of environmental benefit, with food waste only collections showing a marginally greater benefit;
2. Collecting food waste on its own (with user pays garden waste) is invariably less expensive than collecting food and garden waste together. This is because when food and garden are collected together extra garden material is drawn into the system which must then be processed through an IVC process (for which the costs are higher than for windrow systems);
3. When processing food waste there is little environmental or financial difference between IVC and AD;
4. There are marked financial savings to be gained when residual waste is collected fortnightly. This is likely to be made more acceptable to residents when food waste is collected regularly. These savings can offset much of the additional cost of collecting food waste.

E.6.2 Central Government Policy Implications

The study suggests that collection of food and garden waste separate from each other is likely to offer the best outcome in New Zealand situations. The reality in NZ at present however is that (at the time of writing the report), there are no local authorities with dedicated 'food waste only' collections, and the only authorities collecting food waste do so through co-mingled food and garden collections.

This question then arises as to how matters could be changed to deliver better outcomes. The research has suggested there are two key issues in the current policy environment:

a) The cost of landfill does not yet reflect the true environmental costs of disposal. Since the financial rationale for separate collection of *any* materials (whether dry recyclables or organics) is substantially driven by the avoided cost of disposal, it would seem that the low level of the waste levy currently fails to incentivise improved management of organics wastes; and

b) The market for waste-derived soil improvers / fertilisers is immature. In particular, there is a low level of awareness of potential benefits from use in agricultural and horticultural markets, whilst compost production would benefit from attempts to achieve more consistent quality.

There are a range of potential policy instruments that can be applied to address these issues. Three policies, if used in combination, would, we believe, be sufficient to generate the necessary impetus for change.

1. Waste Disposal Levy
   The waste disposal levy is an instrument that provides the opportunity to internalise externalities and provide incentives for development of separate collection systems and associated treatment infrastructure. The current rate of the levy is set at $10 per tonne, but there is scope for this to be increased. Even with a landfill gas capture rate over the site's lifetime of 70%, the external costs of

landfilling food waste are only marginally lower than $100 per tonne. Under the Waste Management Act 2008, the Minister is required to review the effectiveness of the levy within two years of its introduction and at least every three years after that. It is understood the first review of the levy is currently underway. We propose the following evolution in levy rates, designed to give sufficient time for local authorities and industry to adapt to the changing levy rates, and to develop the necessary infrastructure to improve management of organic (and other) wastes:

- 2012 $NZ 20 per tonne
- 2013 $NZ 30 per tonne
- 2014 $NZ 50 per tonne
- 2015 $NZ 70 per tonne
- 2016 $NZ 90 per tonne

At this level, the NZ levy would be comparable with some of the 'moderate level' landfill levies in Europe.

2. Research, Market Development & Quality Standards
The work in this study hints at significant potential environmental and economic benefit for the country through the wider use of compost and compost type products. If this benefit is to be realised further work will be required on a number of fronts.

Countries which have successfully developed compost markets have generally complemented statutory and quasi-statutory standards, which protect human health and the environment, with quality assurance schemes, which seek to develop product standards, and emphasise the positive attributes of compost. The development and wider adoption of the NZ standard NZ4554 would clearly be a useful step in the right direction.

Further discussion regarding composting standards is given in Appendix A.14.2.

3. Household Residual Waste Targets
Household residual waste targets would serve to incentivise the separation and recovery of household organic wastes (as well as recyclables). The targets could be set by central Government and applied to all Territorial Authorities. Per capita residual waste targets are recommended as they are a relatively easy measure to establish and compare across localities and, because they are able to take account of waste prevention (such as food waste prevention and home composting), they are a more flexible and reliable type of target than, for example, recycling/composting rate targets. If targets are applied to the local authority, then as long as the targets were backed by sanctions, local authorities might be expected to be more pro-active in using the means available to them to meet these targets. Indeed, they might seek to become more involved in service provision, or failing that, doing what they can to enhance service quality.

Currently each New Zealander is responsible for approximately 250kg per year of household waste sent to landfill. A set of targets similar to the following are suggested for residual household waste:

- Less than 200kg per inhabitant by 2015;
- Less than 175kg per inhabitant by 2020;
- Less than 150kg per inhabitant by 2025.

These three policy measures seem likely to generate significant improvement in the management of organic (and other) wastes within New Zealand. Our aim in proposing these policies has been to have regard to the need for policy to be efficient, and to generate the incentives for delivery of positive outcomes, as well as giving clarity to Territorial Authorities as to how they should orient their future waste strategies. It is our view that they would set New Zealand's waste management on a more sustainable path in the years ahead.