Department of
Environment and Conservation (NSW)

Assessment of Garden Organics Collection Systems

May 2005

This Report was prepared for the Department of Environment and Conservation (NSW) by Nolan-ITU Pty Ltd.

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Executive Summary

Introduction

In 2003, Nolan-ITU was commissioned by the NSW Jurisdictional Recycling Group (NSW JRG) and the Publishers National Environment Bureau (PNEB) to conduct a study of the technical, financial, environmental and social costs and benefits associated with different domestic waste and kerbside recycling systems inclusive of collection and processing.

As an outcome of the consultative process undertaken for that study, the Department of Environment and Conservation (NSW) commissioned Nolan-ITU to extend the assessment to include options for garden waste management.

This report is the result of assessing garden organics management systems based on information about garden waste quantities and currently implemented systems by NSW councils. It builds upon Life Cycle Assessment (LCA) work and environmental economic valuations of organics undertaken by Nolan-ITU, RMIT and the Recycled Organics Unit (ROU) in recent years.

Garden Organics Recycling and Waste Data

The waste generation profile for this study has been derived based on the work undertaken in the *Assessment of Alternative Domestic Waste and Recycling Systems* (DEC; 2004) as well as the *Study of Local Management Costs for Garden Organics* (DEC; 2003a).

For garden organics, both high and low generation scenarios have been derived. The high generation scenario was derived from surveyed councils employing fortnightly collection of garden organics from 240 litre mobile bins (DEC; 2003a). The low generation scenario was based on the base case waste profile developed as part of DEC (2004).

Garden organics diversion increases with increasing frequency of collection and when a receptacle is provided (receptacles enable capture of grass clippings, leaves, etc). Derived quantities of garbage, garden organics, and recyclables for each of the collection systems modelled are shown in Table I. The following garden organics collection systems have been assessed:

- Fortnightly collection (with mobile bins);
- Monthly collection (tied and bundled); and
- Three times yearly collection (tied and bundled).

Garden organics *diversion* for the three collection system options were based on collated survey results from DEC (2003a).

Table I: Quantities of Collected Garbage, Garden Organics and Recyclables for Alternative Garden Organics Management Options – Metropolitan Areas (kilograms per household per year)

Stream	Metropolitan						Rural
	High GO Generation			Low GO Generation			
	Fort'ly Mobile Bins	Monthly Tied and Bundled	3 x Yearly Tied and Bundled	Fort'ly Mobile Bins	Monthly Tied and Bundled	3 x Yearly Tied and Bundled	Fort'ly Mobile Bins
Garbage	601	835	894	579	682	707	525
Garden Organics Diverted	351	117	59	154	51	26	318
Recyclables Diverted (including contamination)	237	237	237	237	237	237	195
Total	**1,189**	**1,189**	**1,189**	**970**	**970**	**970**	**1,038**

Processing/Disposal Arrangements Assessed

For each of the collection scenarios presented above, the following processing/disposal arrangements have been assessed:

Stream	Process/Disposal
Garden organics	Open windrow composting
Dry recyclable materials	Materials Recovery Facility (MRF)
Garbage	Best practice landfill; or Mechanical Biological Treatment (MBT), with production of some (low grade) compost and disposal of residues to landfill; or (alternatively) Thermal Treatment (TH) of garbage through a Waste to Energy plant employing state-of-the-art incineration technology, with disposal of residues to landfill.

For councils in NSW, the most common collection, recycling and disposal scenario is source separation of garden organics, windrow composting of garden organics, dry recycling (kerbside with MRF) and landfill of residuals. MBT and thermal processing options are currently in their infancy in NSW, and represent possible future options based on international experience for the processing of waste and recyclables.

Financial Performance

In metropolitan areas, while the costs of providing a separate garden organics collection system varies from $0 per household per year (no service) to $45 per household per year (fortnightly 240 litre mobile bin collections), when considering the *total* waste management system costs, the increase in total costs for providing garden organics collections are less than $5 per household per year (in areas of high garden organics generation) and less than $15 per household per year (in areas of low garden organics generation), assuming landfill disposal of domestic garbage.

As the cost of garbage treatment/disposal increases (through MBT and/or thermal treatment) the *net* cost of garden organics collection reduces (i.e. the (higher) *avoided* costs of garbage treatment makes garden organics management cheaper). For some collection scenarios modelled where (e.g. garbage is thermally treated), the provision of a separate garden organics collection service *reduced* overall waste management costs.

Estimated garden organics management costs modelled in this study are consistent with costs derived from a recently completed *Study of Local Government Management Costs for Garden Organics* (DEC; 2003a).

Estimated total waste management system costs are consistent with average domestic waste management charges as surveyed annually by the Department of Local Government (DLG; 2003) when accounting for ancillary costs such as administration, education and other waste management services offered (i.e. clean up collections, drop-off, street sweeping and litter).

Regional/rural garden organics management costs are typically cheaper than metropolitan systems due mainly to the lower cost of processing ($44 per tonne in metropolitan areas versus $11 per tonne in rural areas).

Environmental Performance

The environmental value of garden organics recycling is estimated to be $114 per tonne of source-separated garden organics. This value is comprised of *resource savings* as well as the full range of environmental impact categories associated with avoided product credits, including air and water pollution and global warming potential. The estimate is based on extensive data analysis using the method of life cycle assessment and environmental economic valuation. The contribution of the various aspects is listed in Table II.

In the LCA interpretation phase conducted as part of this study the estimated environmental value of $114 per tonne was found to be conservative. An expanded valuation, conducted using proxy values to account for some of the known data gaps, yielded an environmental value of garden organics recycling of $277 per tonne.

Table II: The Environmental Value of Compost ($ per tonne source-separated garden organics)

Life Cycle Aspect	Value (Eco$ per tonne source-separated garden organics)
Composting process emissions	-$ 0.64
Collection	-$ 7.61
Compost application benefits	$40.50
Compost transport	-$ 0.57
Net avoided landfill emissions	$82.53
Net Benefit	**$114.21**

On a per household basis the environmental benefits of garden organics recycling vary depending on generation levels and yield. Results for metropolitan areas are summarised in Table III.

Table III: The Environmental Value of Garden Organics Recycling (Eco$ per household per year)

Garden Organics Collection	High GO Generation	Low GO Generation
Fortnightly Mobile Bins	$40	$18
Monthly Tied and Bundled	$14	$6
3 x Yearly Tied and Bundled	$7	$3

Figure 5.5 attempts to summarise the findings by grouping the three different collection frequencies for the "high" garden organics generation scenario (i.e. the typical 'green' outer Sydney suburb).

Figure I: Scenario Comparison – Metropolitan High Generation (Eco$ per household per year)

It can be concluded that the inclusion of organics collection and composting with landfilling of garbage is a lower performing option than the use of alternative technologies without garden organics collection. However, regardless of the fate of the garbage (residual waste), it is always environmentally superior to have a separate collection of garden organics. The main reasons are:

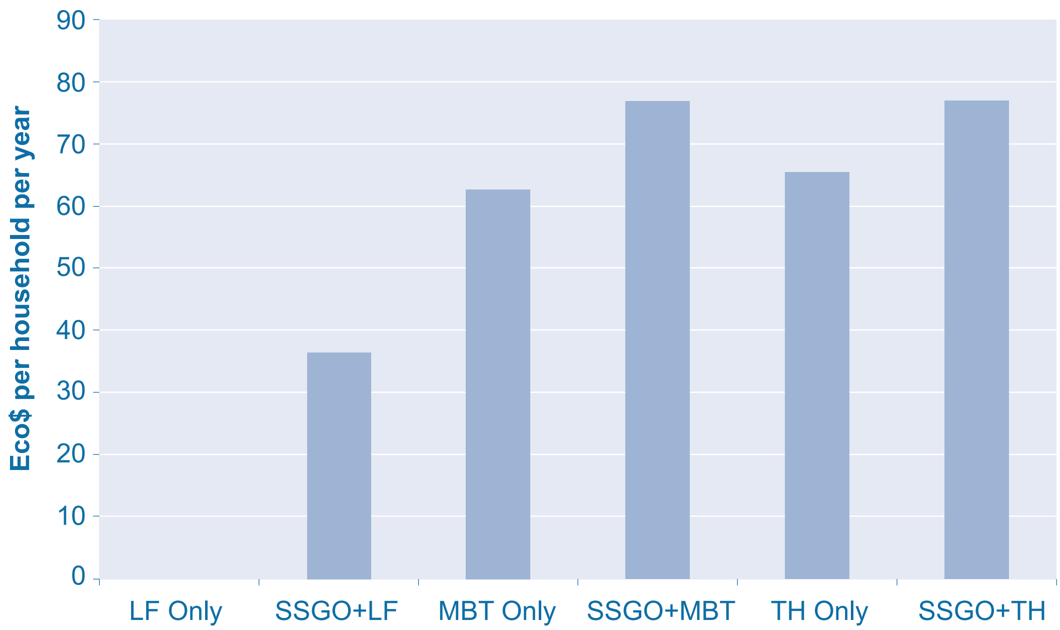
- The treatment of all organics (including food) in mixed waste processing facilities provides high benefits through reduced emissions from landfilling the stabilised materials. Recovery of some dry recyclable materials may provide additional benefits.
- Per tonne collected, the 'yield' compost from source segregated garden organics is higher than for mixed waste (a certain component will still always be part of the residues); and
- Application of mixed waste compost has been assumed to provide a range of benefits however, in accordance with the precautionary principle it has been assumed that it may not be suitable for the entire range of possible applications (i.e. food crops).

Figure II illustrates the results for the range of scenarios in a regional/rural council and compares "No Collection of Garden Organics" with a fortnightly containerised garden organics collection. Again, the system with no garden organics collection, with garbage sent to landfill, has been set at zero for ease of comparison. Due to the scarcity of available data, no differentiation has been made between High and Low GO generation. The figures used represent the average across all regional/rural councils where information is available.

For the average regional/rural council, the benefits of a separate garden organics collection system (fortnightly) amount to approximately:

- Eco$37 per household per year for a separate fortnightly containerised GO collection for the Garbage to Landfill Scenario;
- Between Eco$60 and Eco$65 per household per year if *no* garden organics collection service is provided but the garbage is sent to a treatment facility ("MBT Only" and "TH Only");
- Between Eco$75 and Eco$80 per household per year (an additional Eco$15 per household per year) for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

Figure II: Scenario Comparison – Rural Council, Fortnightly Collection (Eco$ per household per year)



Peer Review

A peer review of the environmental assessment component of this study has been conducted by Mr Tim Grant from RMIT Centre for Design. He has been consulted during the course of setting up the framework for this assessment, and undertook the peer review on completion of the draft report.

Cost Benefit Analysis

When combining the financial costs of domestic waste management scenarios with the environmental costs and benefits expressed in dollar terms, the *overall net economic cost benefits* for the introduction of a separate GO collection system (assuming garbage is sent to landfill) are as follows:

*Councils with **high** GO Generation rates:*

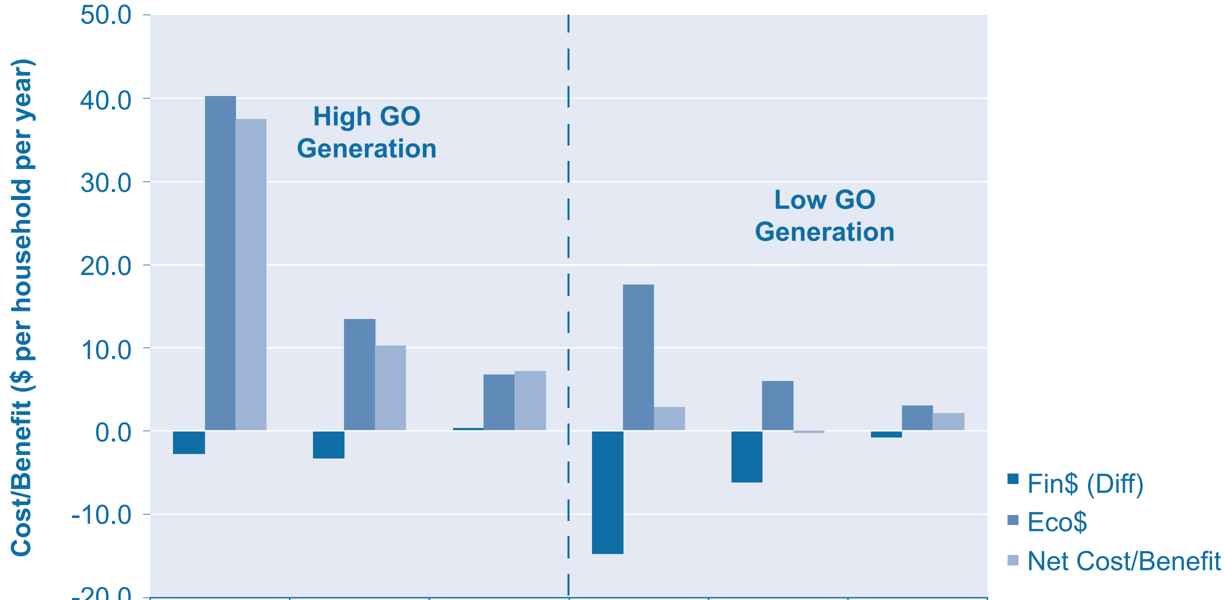
- Fortnightly collection $37.5 per household per year
- Monthly collection $10.3 per household per year
- Three yearly collection $7.1 per household per year

*Councils with **low** GO Generation rates:*

- Fortnightly collection $2.9 per household per year
- Monthly collection ($0.3) per household per year
- Three yearly collection $2.2 per household per year

Figure 7.1 illustrates the outcomes of this assessment. The additional financial cost impact is represented by the dark blue bars, environmental benefits by the blue bars, and the net cost benefit by the pale blue bars.

Figure III: Cost Benefit Results for Source Separation of Garden Organics



	Fort'ly	Monthly	3/yr	Fort'ly	Monthly	3/yr
Fin$ (Diff)	-2.7	-3.2	0.4	-14.78	-6.21	-0.82
Eco$	40.2	13.5	6.8	17.63	5.93	3.02
Net Cost/Benefit	37.5	10.3	7.1	2.85	-0.29	2.20

This CBA highlights the significance of actual garden organics quantities generated. For councils with a high GO generation rate, the introduction of a containerised GO system provides substantial net benefits. For councils with a low GO generation rate, it may not be warranted to implement a frequent containerised collection system as an infrequent (three yearly) tied and bundled service achieves similar overall benefits (which are also not substantial).

Combining garden collection services with alternatives for residual waste disposal (i.e. AWT), a combination of MBT and a fortnightly GO service provides the highest benefits. This is mainly due to the avoided landfill emissions when only stabilised material is being disposed of. For councils with a low GO generation rate, a single MBT facility without the provision of a separate GO service achieves equivalent benefits to a scenario where GO are collected separately.

For councils in regional/rural NSW, the assessment shows similar results. The three highest ranking options under the CBA for councils in SMA and also regional/rural NSW are:

1. MBT + fortnightly GO collection
2. Landfill + fortnightly GO collection
3. MBT only.

Multi-Criteria Assessment

All scenarios were assessed through both concordance and additive weighting multi-criteria analysis methodologies. Notwithstanding the complexity surrounding the application of different methodologies when assessing 42 scenarios, some clear trends become apparent. These are summarised in Table I and discussed below.

- For councils with a high GO generation rate, the introduction of a fortnightly collection of GO always ranks highest, regardless of methodology or weightings applied.
- The treatment of residual waste in a MBT facility ranks highly, mainly due to the relatively small increase in costs compared to landfill and the substantial environmental benefits achieved.
- For councils with a low generation rate, the introduction of a frequent and containerised GO collection service does not provide any significant benefits. If such councils intend to improve their 'Triple Bottom Line', it may be preferable to consider sending their garbage (including the (small) quantities of garden waste) to an MBT facility.

Table IV: Highest Ranking Options from Different Approaches (High GO generation)

Rank	Cost Benefit Analysis	Multi Criteria Assessment			
		Community Weightings [1]		Local Government Weightings [1]	
		Concordance	Additive Weighting	Concordance	Additive Weighting
1	MBT + GO Fortnightly	LF + GO Fortnightly	MBT + GO Fortnightly	LF + GO Fortnightly	LF + GO Fortnightly
2	MBT + GO Three Yearly	MBT + GO Fortnightly	LF + GO Fortnightly	LF Only	MBT + GO Fortnightly
3	MBT and GO Monthly	MBT + GO Monthly	MBT + GO Monthly	LF + GO Three Yearly	MBT + GO Three Yearly

[1] The weights that were determined through the consultative process for a previous project (*Assessment of Alternative Domestic Waste Management Systems*; DEC (2004)) have been applied to the MCA.

Recommendations

Based on the outcomes of this integrated triple bottom line assessment of garden organics management options, it is recommended that:

- Councils with a high rate of garden organics generation (175 kilograms per household per year or more) introduce a fortnightly, containerised garden organics collection and composting system as this will be a significant step towards a more sustainable resource management system.
- Councils with a low generation of garden organics (175 kilograms per household per year or less) also achieve sustainability benefits however these are much smaller than for councils with a high garden organics generation rate. It is recommended that such councils introduce a three times yearly tied and bundled collection which will provide similar overall benefits as a fortnightly containerised collection.
- All councils consider the introduction of residual waste (garbage) treatment processing to capture the substantial sustainability benefits which can be achieved MBT systems achieve higher overall economic benefits. However, there are still significant additional benefits to be achieved by also introducing a separate garden organics collection system where a council area does generate large quantities of garden organics.
- Research in the following areas continue to be supported to increase the currently limited knowledge of environmental benefits of organics recycling and composting:
  - Identification and quantification of long term benefits of recycled organics application to soils, looking at a variety of crops;
  - Inclusion and assessment of benefits of food waste separation and composting;
  - Further quantification and determination of carbon sequestration through compost application in different soils, and under different agricultural regimes;
  - Enabling further scientific work in the area of valuation of environmental costs and benefits across a larger spectrum of impact categories and pollutants; and
  - Environmental economic valuation of water for specific locations/areas within the country.
- A state-wide policy be developed addressing the treatment of residual wastes either through MBT, Hybrid Technologies or combinations of MBT and thermal treatment as well as procedures for the assessment of emerging technologies;
- The performance of new waste technologies be monitored and confirmed as they are commissioned and over the operating life.
- A decision support framework for waste technologies and waste management systems be developed and promoted for use on a case-by-case basis that is transparent, user-friendly, and rigorous.

1 Introduction

Within waste management and recycling circles there is currently significant debate over the relative merits of different systemic approaches to waste and recyclables collection and processing. This debate has several core elements, including:

- Growing range of available waste/recyclables collection and processing technology options, including Alternative Waste Treatment (AWT);
- Increasing economic competitiveness of AWT against landfill disposal;
- Ongoing concerns of many local government representatives with regard to waste management costs;
- Community expectations with regard to alternatives to landfill disposal; and
- Growing appreciation that waste management and recycling decisions need to be based on holistic evaluation of full technical, financial, environment, and social costs and benefits.

In 2003, Nolan-ITU was commissioned by the NSW Jurisdictional Recycling Group (NSW JRG) and the Publishers National Environment Bureau (PNEB) to conduct a study of the technical, financial, environmental and social costs and benefits associated with different domestic waste and kerbside recycling systems inclusive of collection and processing.

As an outcome of the consultative process undertaken for that study, the Department of Environment and Conservation (NSW) subsequently commissioned Nolan-ITU to extend the assessment to include options for garden organics management.

This report is the result of assessing a range of alternative garden organics management systems based on information about garden organics quantities and currently implemented systems by NSW councils. It builds upon Life Cycle Assessment (LCA) work and environmental economic valuations of organics undertaken by Nolan-ITU and others in recent years including the *LCA of Waste Management Options* for EcoRecycle Victoria (RMIT and Nolan-ITU; 2003), and the *LCI and LCA for Windrow Composting Systems* (ROU; 2003). Another important source of information has been the recently completed *Study on Local Government Management Costs for Garden Organics* (DEC; 2003a).

The project is designed to achieve the following objectives:

- Assist Local Government in decision making when considering the introduction of garden organics collection systems and Alternative Waste Treatment (AWT); and
- Present the findings in a form consistent with the previous study for JRG and PNEB, and also with the *Independent Assessment of Kerbside Recycling (2001)* for the National Packaging Covenant Council.

2 Systems Characterisation

2.1 Collection Systems Analysed

The garden organics (GO) collection systems analysed in this study are:

- Fortnightly garden organics collection using 240 litre mobile bins;
- Monthly tied and bundled garden organics collection; and
- Three tied and bundled collections of garden organics per year.

To estimate the financial and environmental impacts of these alternative garden organics management systems, these need to be considered in the context of the total domestic waste management service. Accordingly domestic garbage and kerbside recyclables systems have also been included in the analysis.

The assumed garbage and kerbside recyclables services has been based on the base case service analysed in the recently completed *Assessment of Alternative Domestic Waste and Recycling Systems (NSW JRG-14)* (DEC; 2004). This service comprises:

Garbage:	120 litre mobile bins collected weekly
Kerbside Recyclables:	240 litre mobile bins fortnightly collection of commingled containers and paper/cardboard

Each garden organics management scenario has been analysed assuming the above garbage and kerbside recycling systems are in place.

In addition to the assessment of the three alternative garden organics collection systems, each waste management *system* was separately assessed assuming collected garbage is disposed/processed at either a landfill, through a Mechanical Biological Treatment (MBT) facility or through a Thermal Treatment facility.

2.2 Waste Profile Derivation

2.2.1 Methodology

The waste profile for this study has been derived based on the work undertaken in the *Assessment of Alternative Domestic Waste and Recycling Systems* (DEC; 2004) as well as the *Study of Local Management Costs for Garden Organics* (DEC; 2003a).

For garden organics, both high and low generation scenarios have been derived. The high generation scenario was based on the garden organics recovery rate from the surveyed councils employing fortnightly collection of garden organics from 240 litre mobile bins (DEC; 2003a). The low generation scenario was based on the base case waste profile developed as part of DEC (2004).

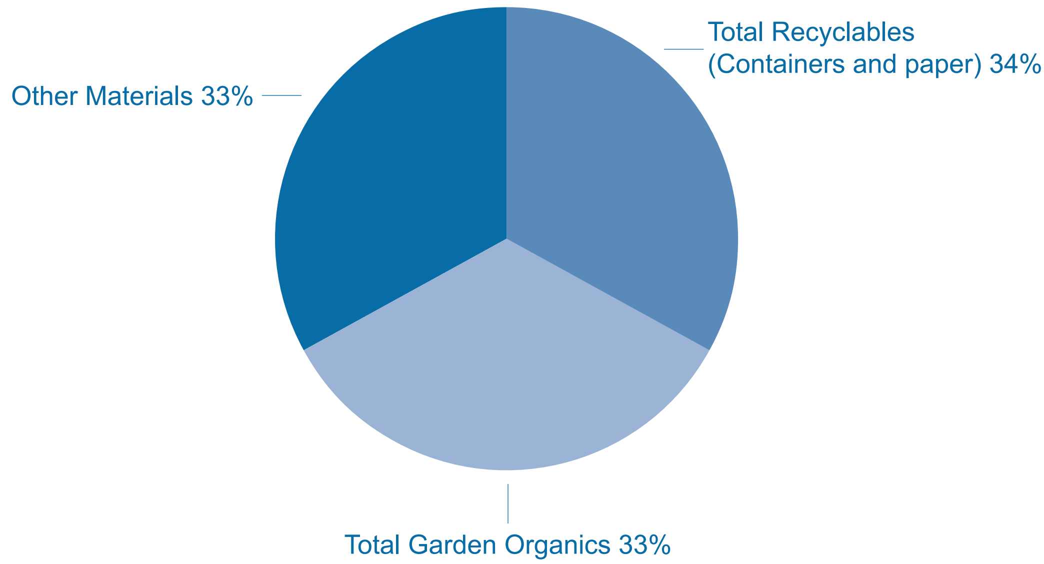
Garden organics recovery rates for the three collection system options were based on collated survey results from DEC (2003a).

2.2.2 Generation

a) Metropolitan

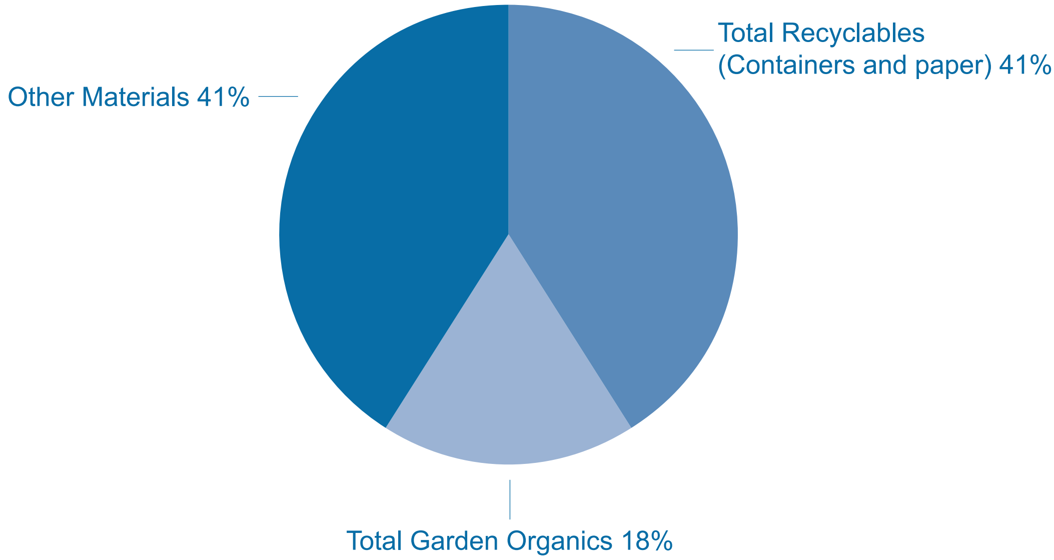
Total derived *generation* (disposed and recycled) of garden organics, recyclables and other materials for metropolitan areas are presented for both high and low garden organics generation scenarios below.

Total Domestic Waste Generation (Garden Organics, Recyclables and Other)
Metropolitan – High GO Generation



Total waste (garbage, garden organics and recyclables) generation = 1,189 kilograms per household per year

Total Domestic Waste Generation (Garden Organics, Recyclables and Other)
Metropolitan – Low GO Generation

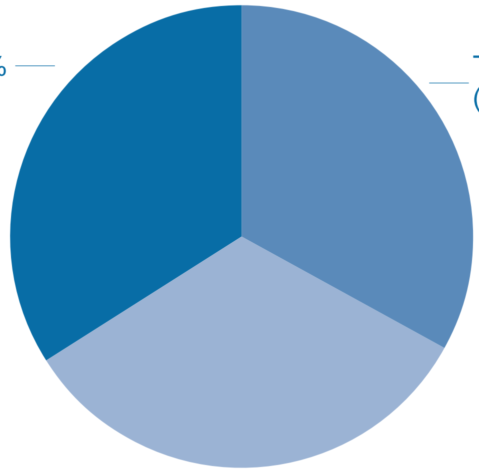


Total waste (garbage, garden organics and recyclables) generation = 970 kilograms per household per year

b) Regional/Rural

For regional/rural areas only the high garden organics generation scenario has been derived and assessed in this study. Total derived *generation* (disposed and recycled) of garden organics, recyclables and other materials for regional/rural areas are presented below.

Total Domestic Waste Generation (Garden Organics, Recyclables and Other)
Regional/Rural – High GO Generation



Total waste (garbage, garden organics and recyclables) generation = 1,038 kilograms per household per year

2.2.3 Streaming

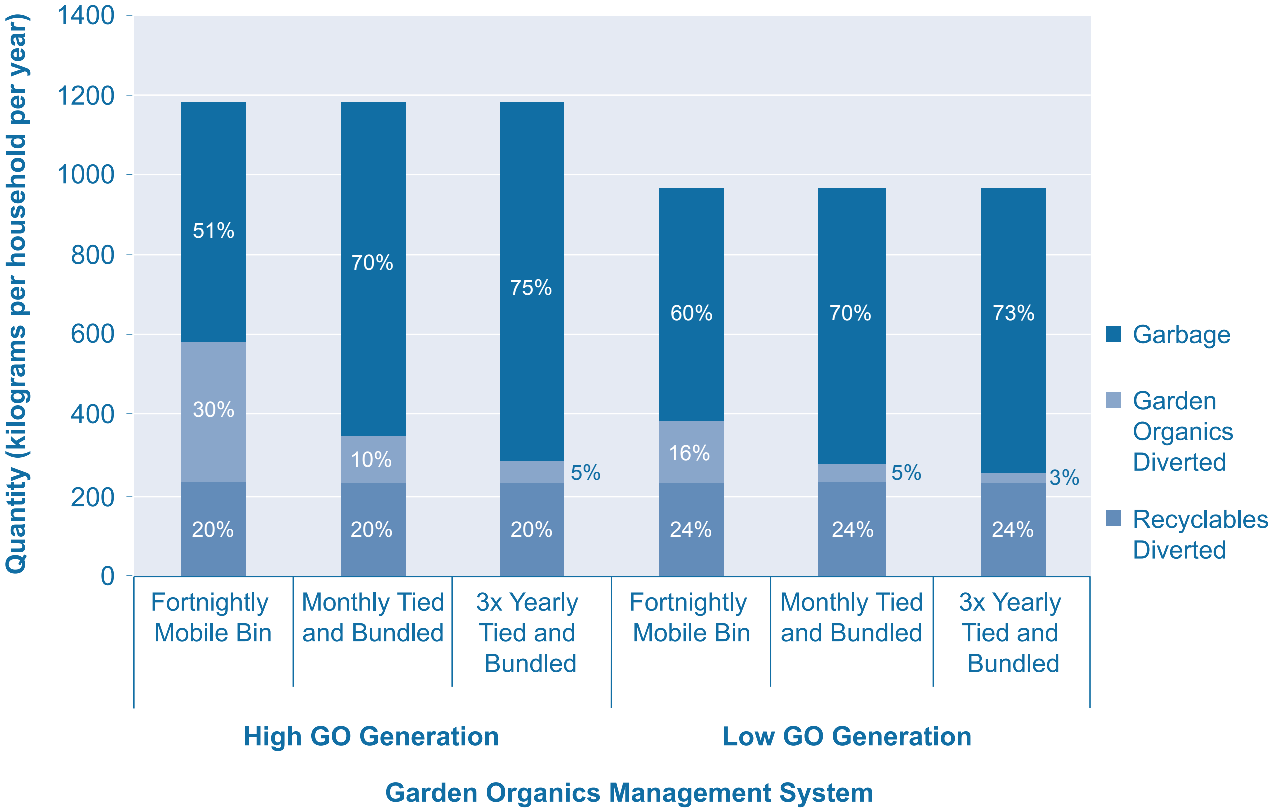
a) Metropolitan

Garden organics diversion increases with increasing frequency of collection and when a receptacle is provided (receptacles enable capture of grass clippings, leaves, etc). Derived quantities of garbage, garden organics, and recyclables for each of the collection systems modelled are shown in Table 2.1 and Figure 2.1.

Table 2.1: Quantities of Collected Garbage, Garden Organics and Recyclables for Alternative Garden Organics Management Options – Metropolitan Areas (kilograms per household per year)

Stream	High GO Generation			Low GO Generation		
	Fortnightly Mobile Bins	Monthly Tied and Bundled	3 x Yearly Tied and Bundled	Fortnightly Mobile Bins	Monthly Tied and Bundled	3 x Yearly Tied and Bundled
Garbage	601	835	894	579	682	707
Garden Organics Diverted	351	117	59	154	51	26
Recyclables Diverted (including contamination)	237	237	237	237	237	237
Total	**1,189**	**1,189**	**1,189**	**970**	**970**	**970**

Figure 2.1: Garbage, Garden Organics and Recyclables Collected per System - Metropolitan



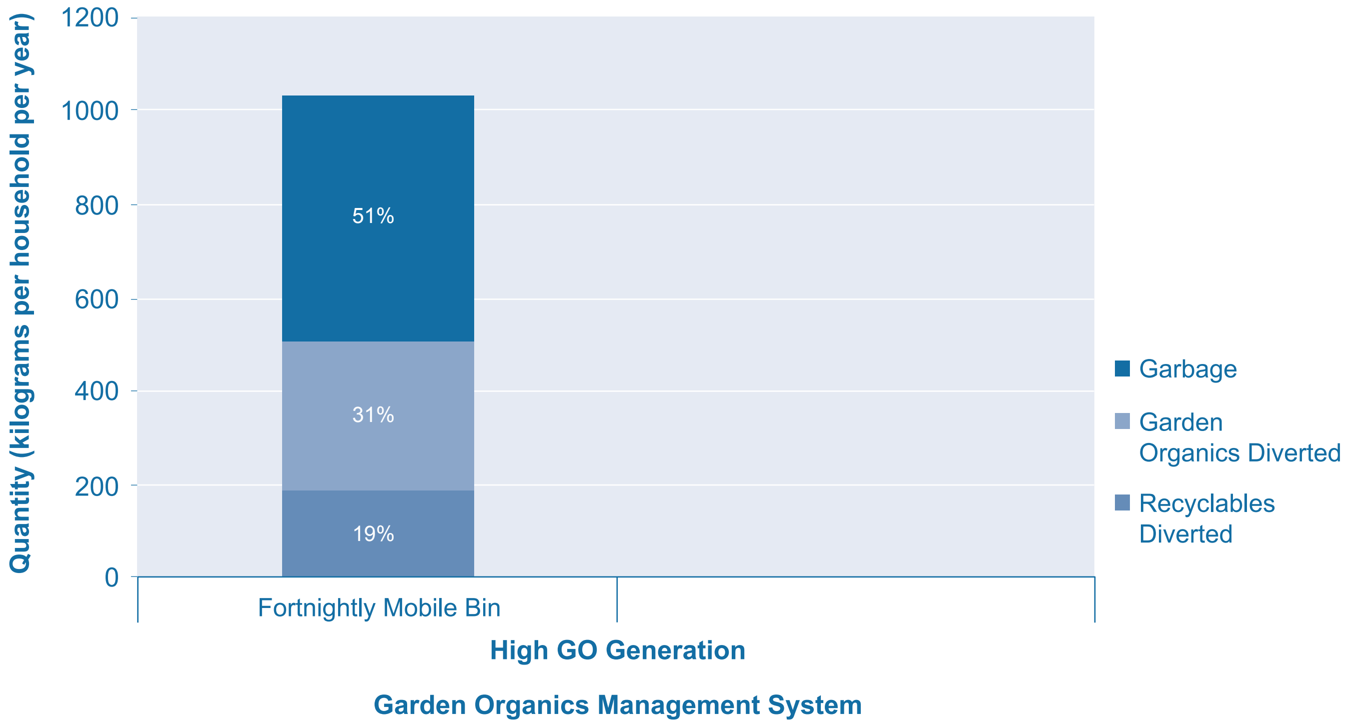
b) Regional/Rural

The assumed garden organics collection system for regional/rural areas is fortnightly mobile bin collection. Derived quantities of garbage, garden organics, and recyclables for this system are shown in Table 2.2 and Figure 2.2.

Table 2.2: Quantities of Collected Garbage, Garden Organics and Recyclables Regional/Rural Areas (kilograms per household per year)

Stream	High GO Generation
	Fortnightly Mobile Bin
Garbage	525
Garden Organics Diverted	318
Recyclables Diverted (including contamination)	195
Total	**1,038**

Figure 2.2: Garbage, Garden Organics and Recyclables Collected per System Regional/Rural



3 Financial Assessment

3.1 Modelling Approach

3.1.1 Introduction

The estimate of costs for collection, processing and material delivery for the different systems was made using the *Australian Waste and Recycling Cost Model* (WRCM) developed by the Cooperative Research Centre for Waste Management and Pollution Control in association with EcoRecycle Victoria and Recycle 2000. The model enables the user to evaluate current and alternative collection systems to see the effect on yields and costs. Amongst other information, the model calculates the following:

Cost of garbage collection and disposal: These values represent the cost of collecting and landfilling/disposing of garbage. System costs include the value of trucks, fuel, provided bins, landfilling/processing, haulage and other associated expenditure. Garbage collection and processing costs vary according to the amount of garden organics diverted from the garbage stream as well as the end disposal option employed.

Cost of garden organics recycling: This represents the cost of collecting and treating garden organics. It does not include transport of materials beyond an Organics Processing Facility, although it can include the delivery of materials to a buyer. As a rule, post-treatment transport costs are reflected in the price per tonne offered for the collected materials. The calculated cost of recycling also includes the cost of sorting and disposing of contaminants, which should be considered as part of the recycling process.

Cost of recycling: This represents the cost of collecting, sorting and/or treating kerbside recycled materials. As the recycling system is held constant for each garden organics management scenario, recycling costs do not change.

Total system cost: This value is the aggregation of the garbage, garden organics recycling and kerbside recycling costs.

3.1.2 Key Operational Parameters

To estimate costs, a range of key operational parameters was sourced to provide the input to the model. Parameters were sourced from collated industry data and discussions with industry stakeholders. They include:

- Crew size and labour costs;
- Truck capacities;
- Truck pick-up times;
- Collection area characteristics;
- Landfill disposal cost and gate fees for Alternative Waste Treatment (AWT) facilities;
- Set out rates.

These are discussed in the following sections.

a) Crew Size and Labour Costs

Crew sizes for systems collecting materials from Mobile Bins are typically either driver only or driver plus one runner. For modelling purposes crew sizes were assumed to comprise the equivalent of 1.5 persons. Tied and bundled collections of garden organics material was assumed to be collected by a three member crew – a driver and two runners.

Labour costs for drivers, including wages and other on costs (i.e. work cover, insurances, superannuation, etc) have been assumed at $23 per hour. Labour costs for runners were assumed to be $20 per hour.

b) Truck Capacities

Collection systems for both domestic garbage and garden organics are based on vehicles using nominal 18 cubic metre bodies.

c) Truck Collection Times

The truck collection time input to the model represents the time taken per lift including transport between adjacent properties. The adopted times are shown in Table 3.1.

Table 3.1: Truck Collection Run Times (seconds per lift)

Truck Type	Crew Size	Collection Run Times (seconds per lift)	Collections per day (assuming six hours collecting)
Single compaction truck (Mobile Bins collection systems)	1.5	21	1,000
Single compaction truck (tied and bundled garden organics collections)	3.0	18	1,200

For movement of collection vehicles while not collecting (i.e. between depots and collection areas, haulage to delivery points) assumed average truck speeds were 30 kilometres per hour (metropolitan collection systems) and 50 kilometres per hour (regional/rural collection systems).

d) Collection Area Characteristics

Assumed collection area characteristics in relation to traffic, housing density, and street width are presented in Table 3.2.

Table 3.2: Collection Area Characteristics

Collection Area	Traffic	Housing Density	Street Width
Metropolitan	Moderate – significant interference during collection	Standard suburb	Slight impediment due to hilly or narrow streets
Regional/rural	Medium – some interference during collection	Fairly spread	Generally wide streets – minor hindrance only

e) Landfill disposal cost and gate fees for alternative waste treatment facilities

Gate fees applicable at landfill and alternative waste treatment facilities were based where possible on gate fees charged at existing or planned facilities, with GST removed (Table 3.3)

For metropolitan collection areas, collected garbage was assumed to be delivered to a transfer station. Gate fees at transfer stations were assumed to be $17 per tonne higher than the applicable waste treatment/disposal gate fee to account for transfer station operation and bulk haulage costs. For regional/rural areas, collected garbage was assumed to be delivered directly to waste treatment/disposal facilities.

Table 3.3: Adopted Waste Treatment Facility Gate Fees (excluding GST)

Waste Treatment/ Disposal Facility	Metropolitan Collection Areas	Regional/Rural Collection Areas
Landfill	$76 per tonne	$35 per tonne
MBT	$85 per tonne	$85 per tonne
Thermal	$160 per tonne	$160 per tonne

f) Organics Processing Costs

Assumed costs for garden organics processing were based on those documented in the recently completed *Study on Local Government Management Costs for Garden Organics* (DEC; 2003a). Median gate/processing fees for surveyed metropolitan Sydney and rural NSW councils were $44 per tonne and $14 per tonne respectively. The cited reason for the low fee for rural councils is that many of these own and operate their own plant and facilities. Costs are often internalised, making it difficult to identify processing costs.

g) Set-Out Rates

Bin set out rates (% of collections that bins are set out) have been sourced from those reported in surveys based on industry evidence, and in-house data sources. For garbage collections, a bin set out rate of 95% was assumed for all cases. For the garden organics collections a bin set out rate of 80% was assumed.

3.2 Results

The following tables show the results for systems in metropolitan areas and regional/rural areas for each of the scenarios investigated. *System costs* are presented on a dollar per household per year basis separately for the garbage component, the garden organics component and the kerbside recyclables component, then as a total. The *net* cost of providing a separate garden organics collection service has been derived based on the difference between the total system cost and the system cost without a separate garden organics service (i.e. garden organics included in the garbage stream).

Also shown for each modelled scenario are the average proportion of garbage, garden organics and recyclables streams (including contamination).

It is noted that the results represent averages for the systems studied. The averages mask a wide variation in estimated system costs: within each system category, across different regions; and at the operational level, where local influences are important. The average data have been used to draw broad conclusions, but at the local level cost variations from these averages may be significant.

The average domestic waste management *charge* for Sydney metropolitan councils for 2001/2002 is $219 per household per year (DLG; 2003). This includes kerbside garbage, garden organics and recyclables collections as well as administration, education and other waste management services offered by councils (i.e. clean up collections, drop-off, street sweeping and litter). By comparison, the estimated *costs* of the metropolitan scenarios modelled in this study (assuming landfill disposal of garbage) vary between $172 and $202. The difference between the waste management *costs* estimated here and the waste management charge is attributable to provision of ancillary waste management services such as litter bins and hard waste collections.

For NSW regional/rural councils with populations in excess of 10,000, the average domestic waste management charge was $159 per household per year in 2001/2002 (DLG; 2003). The estimated cost of the regional/rural scenario modelled in this study (including fortnightly collection of garden organics and landfill disposal of garbage) is $138.

3.3 Metropolitan Areas

3.3.1 Fortnightly Mobile Bin Collection of Garden Organics

Table 3.4: Estimated Waste Management Costs
Metropolitan – Fortnightly Mobile Bin Collection of Garden Organics

System Component		High GO Generation			Low GO Generation		
		Landfill	MBT	Thermal	Landfill	MBT	Thermal
$ per Household per Year							
Garbage	Collection/Transport	$50	$50	$50	$50	$50	$50
	Disposal/Processing	$56	$61	$106	$54	$59	$103
Garden Organics	Collection/Transport	$29	$29	$29	$24	$24	$24
	Processing	$15	$15	$15	$7	$7	$7
Recyclables	Collection/Transport	$38	$38	$38	$38	$38	$38
	Processing	$13	$13	$13	$13	$13	$13
Total system cost		$202	$207	$253	$186	$191	$235
System cost without garden organics recycling[1]		$197	$206	$277	$171	$178	$233
Net cost of garden organics recycling		$5	$2	-$25	$15	$13	$2
% Garbage		51%			60%		
% Garden Organics		30%			16%		
% Recyclables (including contamination)		20%			24%		

[1] Also modelled in WRCM assuming no GO collection. This consequently increases the collection and disposal costs for garbage (which is then higher in GO).

Cost estimates for garden organics management (i.e. collection and processing) as derived from WRCM modelling were compared to those derived from the *Study on Local Government Management Costs for Garden Organics* (DEC; 2003a) as a quality check. Results (Table 3.5) indicate that good agreement is achieved between costs estimated from modelling here and those derived from the survey (for comparable garden organics recovery rates).

Table 3.5: Comparison of Garden Organics Management Costs
Metropolitan – Fortnightly Mobile Bin Collection of Garden Organics

Source	GO Service Cost ($ per household per year)	GO Recovery Rate (kilograms per household per year)
WRCM Estimate – High GO Generation	$45	350
WRCM Estimate – Low GO Generation	$31	154
Local Government Survey (Sydney Metropolitan Area)	$43	339[1]

[1] Median recovery rate for fortnightly GO collections – 16 NSW councils

A graphical representation of estimated metropolitan waste management costs, assuming fortnightly collection of garden organics using mobile bins, is presented in Figure 3.1. Aggregated costs are presented in Figure 3.2.

Figure 3.1: Waste Management Costs for Metropolitan Areas
Fortnightly Mobile Bin Collection of Garden Organics

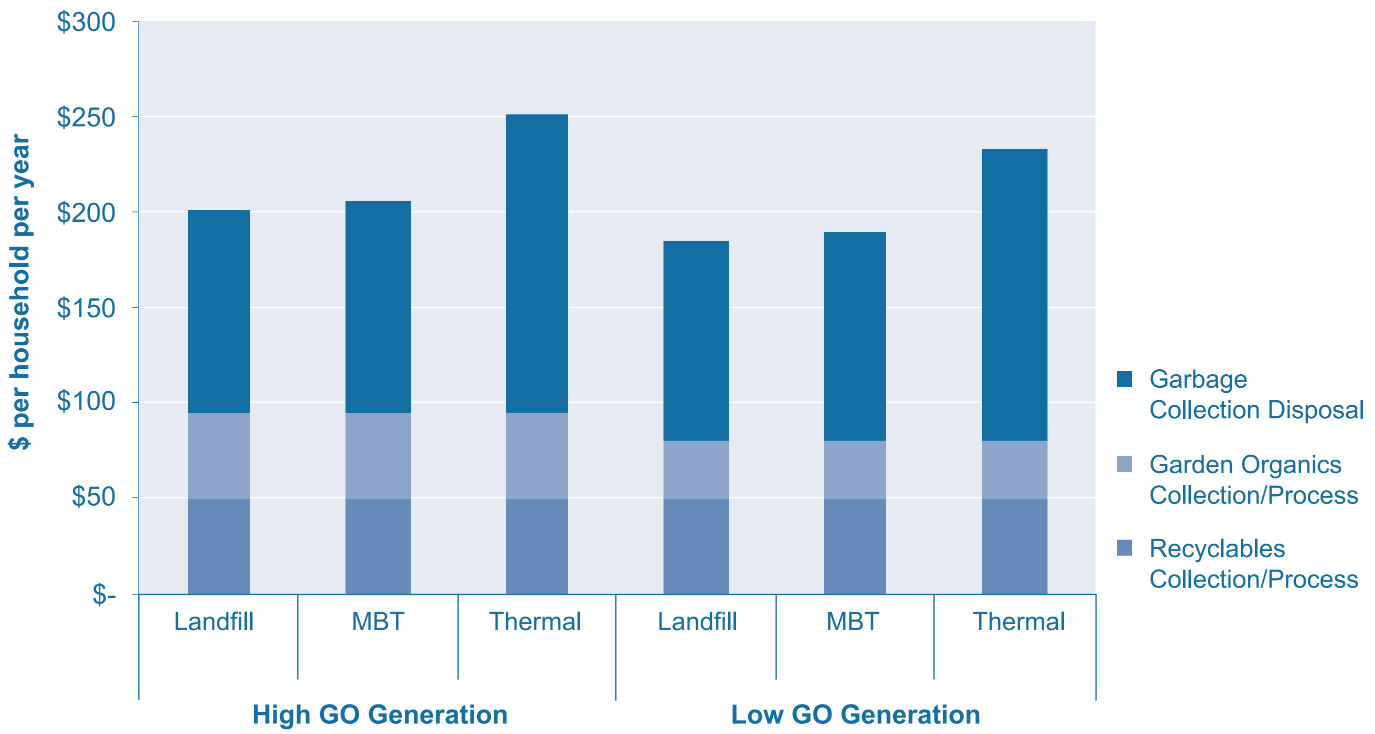
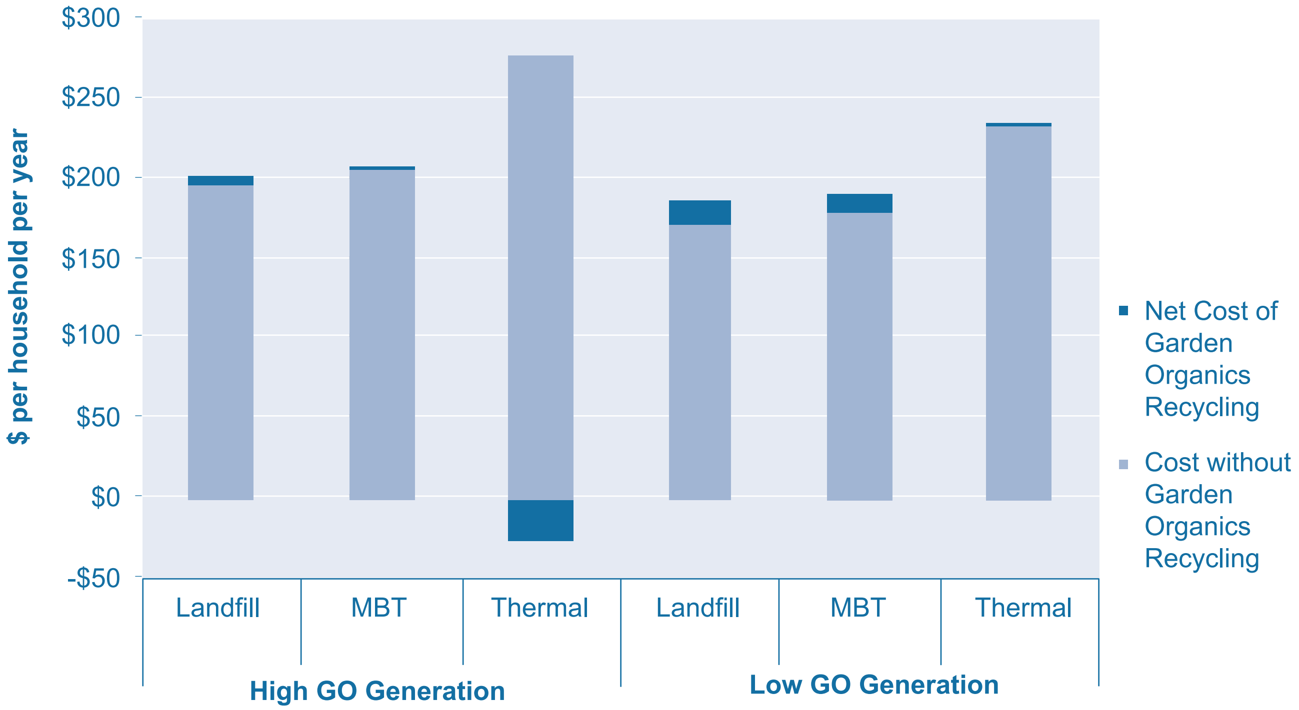


Figure 3.2: Aggregated Waste Management Costs for Metropolitan Areas
Fortnightly Mobile Bin Collection of Garden Organics



3.3.2 Monthly Tied and Bundled Collection of Garden Organics

Table 3.6: Estimated Waste Management Costs
Metropolitan – Monthly Tied and Bundled Collection of Garden Organics

System Component		High GO Generation			Low GO Generation		
		Landfill	MBT	Thermal	Landfill	MBT	Thermal
$ per Household per Year							
Garbage	Collection/Transport	$56	$56	$56	$52	$52	$52
	Disposal/Processing	$78	$85	$148	$63	$70	$121
Garden Organics	Collection/Transport	$11	$11	$11	$9	$9	$9
	Processing	$5	$5	$5	$2	$2	$2
Recyclables	Collection/Transport	$38	$38	$38	$38	$38	$38
	Processing	$13	$13	$13	$13	$13	$13
Total system cost		$200	$208	$271	$178	$184	$235
System cost without garden organics recycling		$197	$206	$277	$171	$178	$233
Net cost of garden organics recycling		$3	$2	-$7	$6	$6	$2
% Garbage		70%			70%		
% Garden Organics		10%			5%		
% Recyclables (including contamination)		20%			24%		

A comparison of cost estimates from the WRCM modelling with those derived from the Local Government survey is provided in Table 3.7. While only two survey responses were received from councils employing monthly garden organics collections, modelled costs estimates are within the range of those derived from the survey (for comparable garden organics recovery rates).

Table 3.7: Comparison of Garden Organics Management Costs
Monthly Tied and Bundled Collection of Garden Organics

Source	GO Service Cost ($ per household per year)	GO Recovery Rate (kilograms per household per year)
WRCM Estimate – High GO Generation	$16	117.0
WRCM Estimate – Low GO Generation	$11	51.0
Local Government Survey[1] (individual council responses)	$3	18.8
	$33	150.0

[1] Only two councils with monthly collections surveyed – results for both councils shown.

A graphical representation of estimated metropolitan waste management costs assuming monthly tied and bundled collection of garden organics is presented in Figure 3.3. Aggregated costs are presented in Figure 3.4.

Figure 3.3: Waste Management Costs for Metropolitan Areas
Monthly Tied and Bundled Collection of Garden Organics

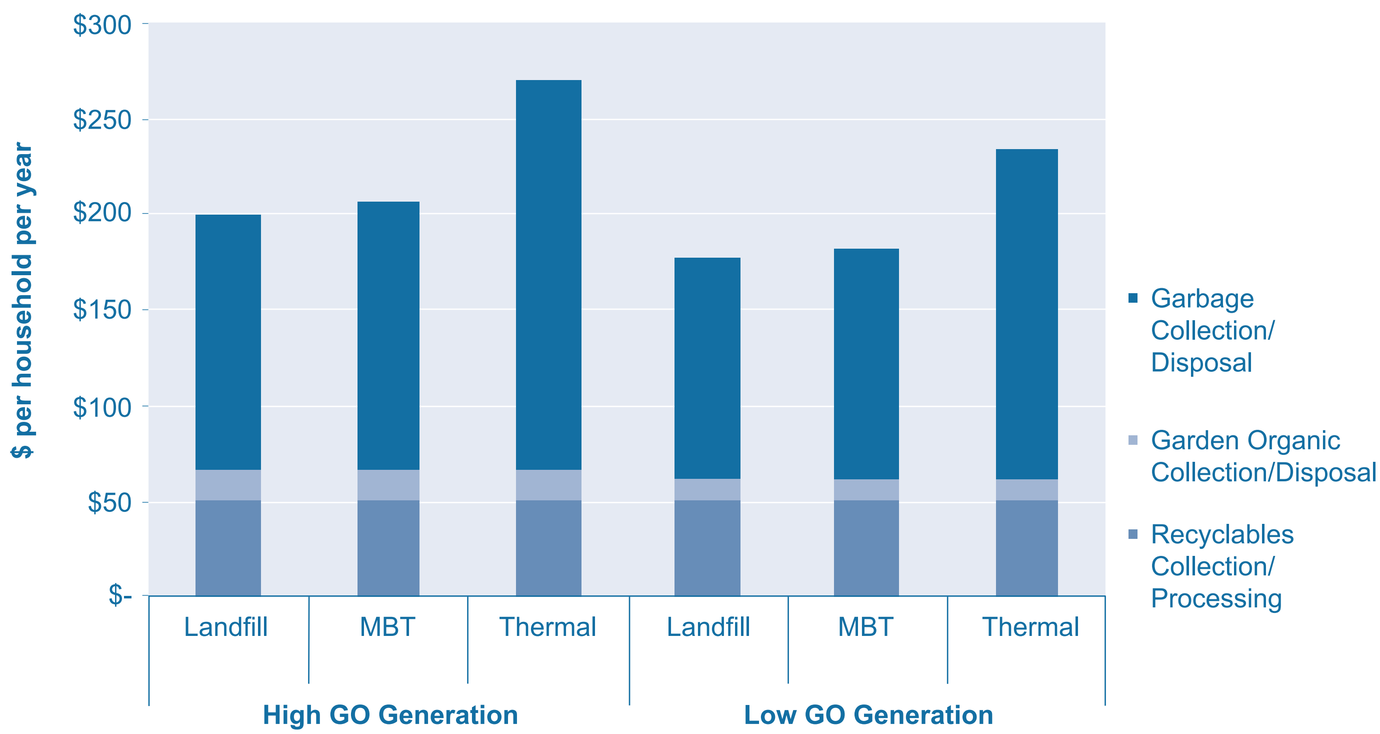
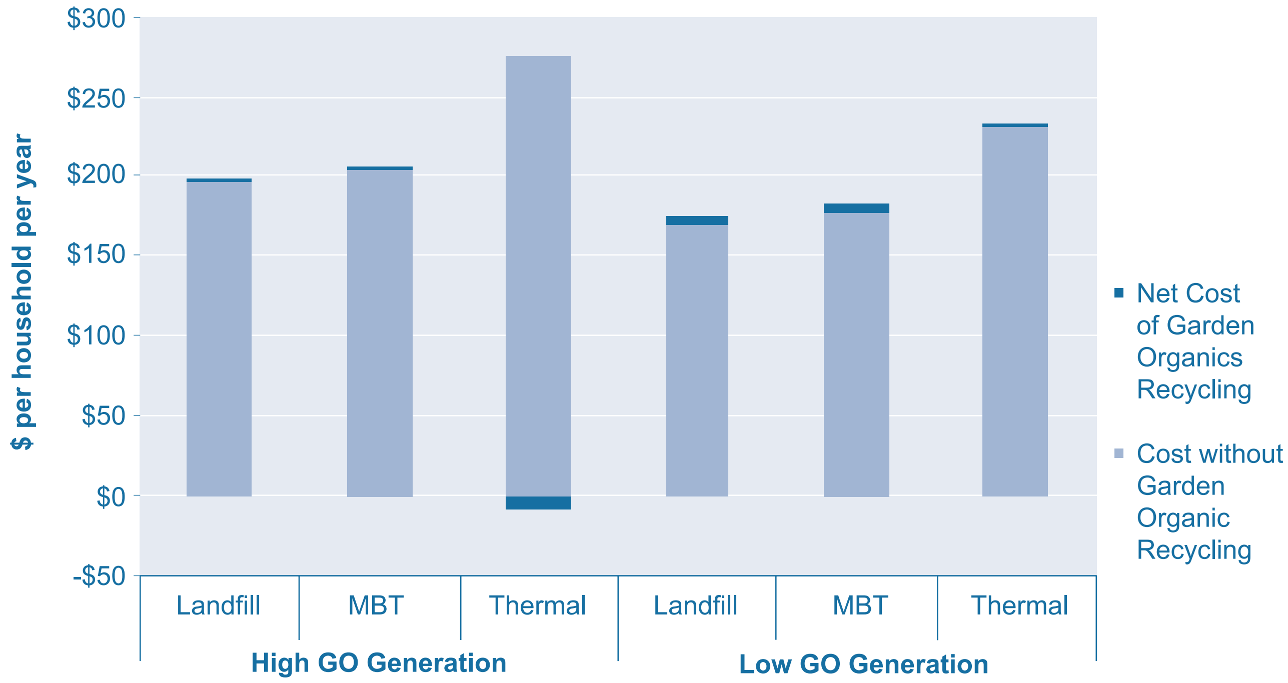


Figure 3.4: Aggregated Waste Management Costs for Metropolitan Areas
Monthly Tied and Bundled Collection of Garden Organics



3.3.3 Three x Yearly Tied and Bundled Collection of Garden Organics

Table 3.8: Estimated Waste Management Costs
Metropolitan – 3 x Yearly Tied and Bundled Collection of Garden Organics

System Component		High GO Generation			Low GO Generation		
		Landfill	MBT	Thermal	Landfill	MBT	Thermal
$ per Household per Year							
Garbage	Collection/Transport	$57	$57	$57	$52	$52	$52
	Disposal/Processing	$83	$91	$158	$66	$72	$125
Garden Organics	Collection/Transport	$3	$3	$3	$2	$2	$2
	Processing	$3	$3	$3	$1	$1	$1
Recyclables	Collection/Transport	$38	$38	$38	$38	$38	$38
	Processing	$13	$13	$13	$13	$13	$13
Total system cost		$197	$205	$272	$172	$179	$232
System cost without garden organics recycling		$197	$206	$277	$171	$178	$233
Net cost of garden organics recycling		-$0	-$1	-$5	$1	$1	-$1
% Garbage		75%			73%		
% Garden Organics		5%			3%		
% Recyclables (including contamination)		20%			24%		

A comparison of cost estimates from the WRCM modelling with those derived from the Local Government survey is provided in Table 3.9. Modelled costs estimates are within the range of those derived from the survey for comparable garden organics collection systems and recovery rates.

Table 3.9: Comparison of Garden Organics Management Costs
Infrequent Tied and Bundled Collection of Garden Organics

Source	Frequency	GO Service Cost ($ per household per year)	GO Recovery Rate (kilograms per household per year)
WRCM Estimate – High GO Generation	3 per year	$6.00	59.0
WRCM Estimate – Low GO Generation	3 per year	$4.00	26.0
Local Government Survey (individual council responses)	6 per year	$1.80	11.0
	5 per year	$1.18	9.2
	4 per year	$3.73	36.4
	4 per year	$5.63	47.1
	3 per year	$2.50	Not published

A graphical representation of estimated metropolitan waste management costs assuming 3 x yearly tied and bundled collection of garden organics is presented as Figure 3.5. Aggregated costs are presented in Figure 3.6.

Figure 3.5: Waste Management Costs for Metropolitan Areas
3 x Yearly Tied and Bundled Collection of Garden Organics

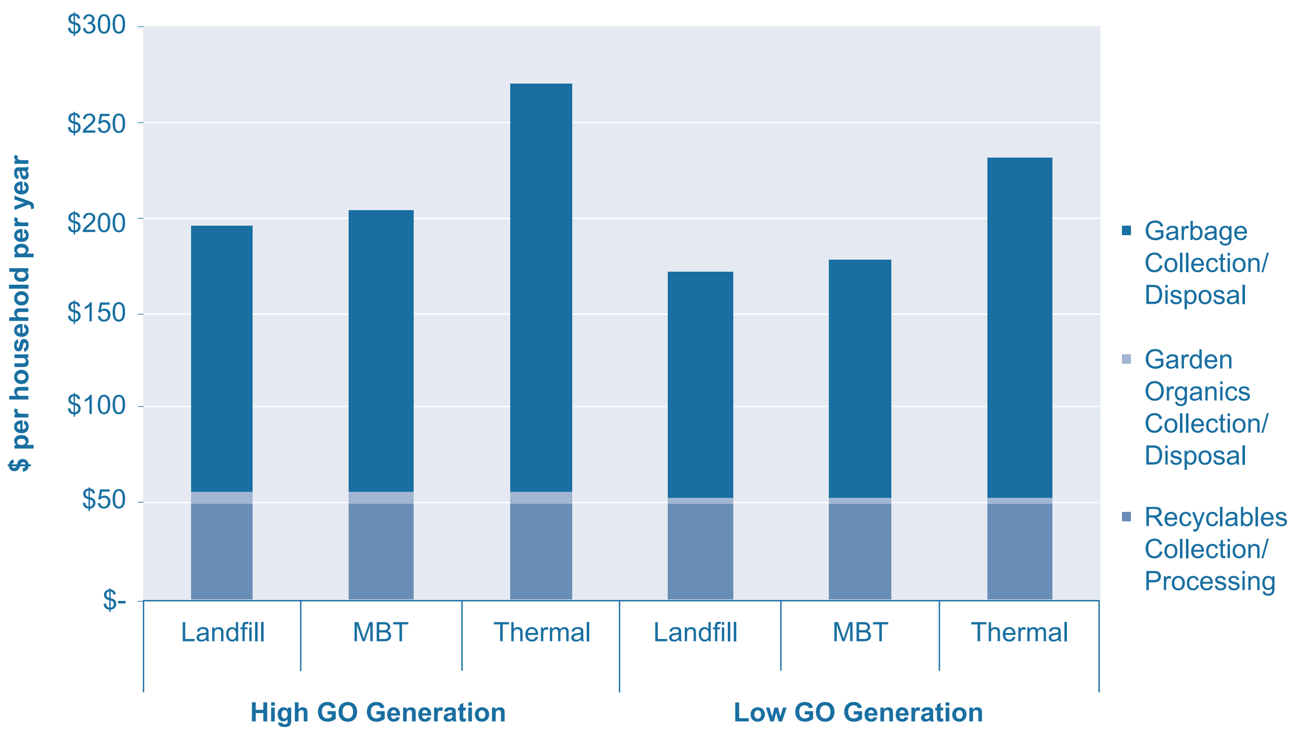
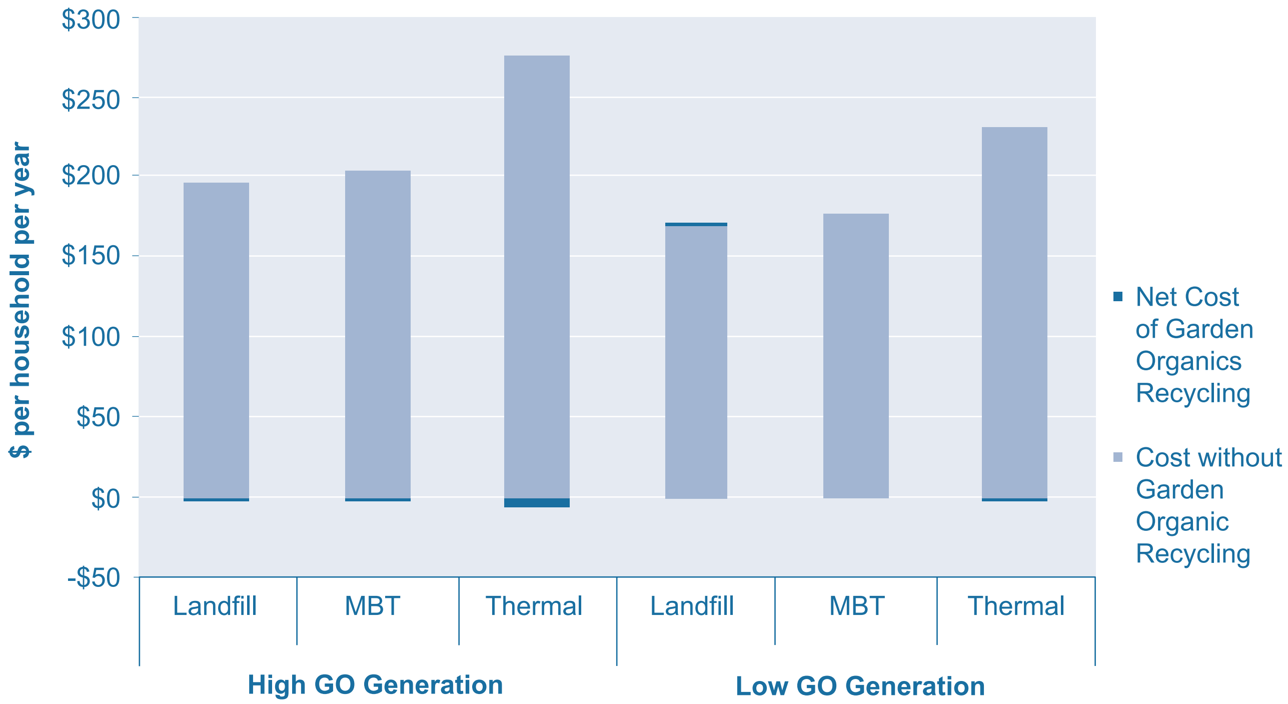


**Figure 3.6: Aggregated Waste Management Costs for Metropolitan Areas
3 x Yearly Tied and Bundled Collection of Garden Organics**



3.4 Regional/Rural

3.4.1 Fortnightly Mobile Bin Collection of Garden Organics

**Table 3.10: Estimated Waste Management Costs
Regional/Rural – Fortnightly Mobile Bin Collection of Garden Organics**

System Component		Landfill	MBT	Thermal
$ per Household per Year				
Garbage	Collection/Transport	$48	$48	$48
	Disposal/Processing	$18	$45	$84
Garden Organics	Collection/Transport	$23	$23	$23
	Processing	$4	$4	$4
Recyclables	Collection/Transport	$32	$32	$32
	Processing	$13	$13	$13
Total system cost		$138	$165	$204
System cost without garden organics recycling		$127	$169	$233
Net cost of garden organics recycling		$11	-$5	-$29
% Garbage		51%		
% Garden Organics		31%		
% Recyclables (including contamination)		19%		

A comparison of cost estimates from the WRCM modelling with those derived from the Local Government survey is provided in Table 3.11. The results indicate good agreement between costs estimated from modelling in this study and those derived from the survey.

Table 3.11: Comparison of Garden Organics Management Costs
Regional/Rural – Fortnightly Mobile Bin Collection of Garden Organics

Source	GO Service Cost ($ per household per year)	GO Recovery Rate (kilograms per household per year)
WRCM Estimate	$28	318
Local Government Survey (Rural)	$26.25	339[1]

[1] Median recovery rate for fortnightly GO collections – 16 NSW councils.

A graphical representation of estimated regional/rural waste management costs assuming fortnightly collection of garden organics using Mobile Bins is presented in Figure 3.7. Aggregated costs are presented in Figure 3.8.

Figure 3.7: Waste Management Costs for Regional/Rural Areas
Fortnightly Mobile Bin Collection of Garden Organics

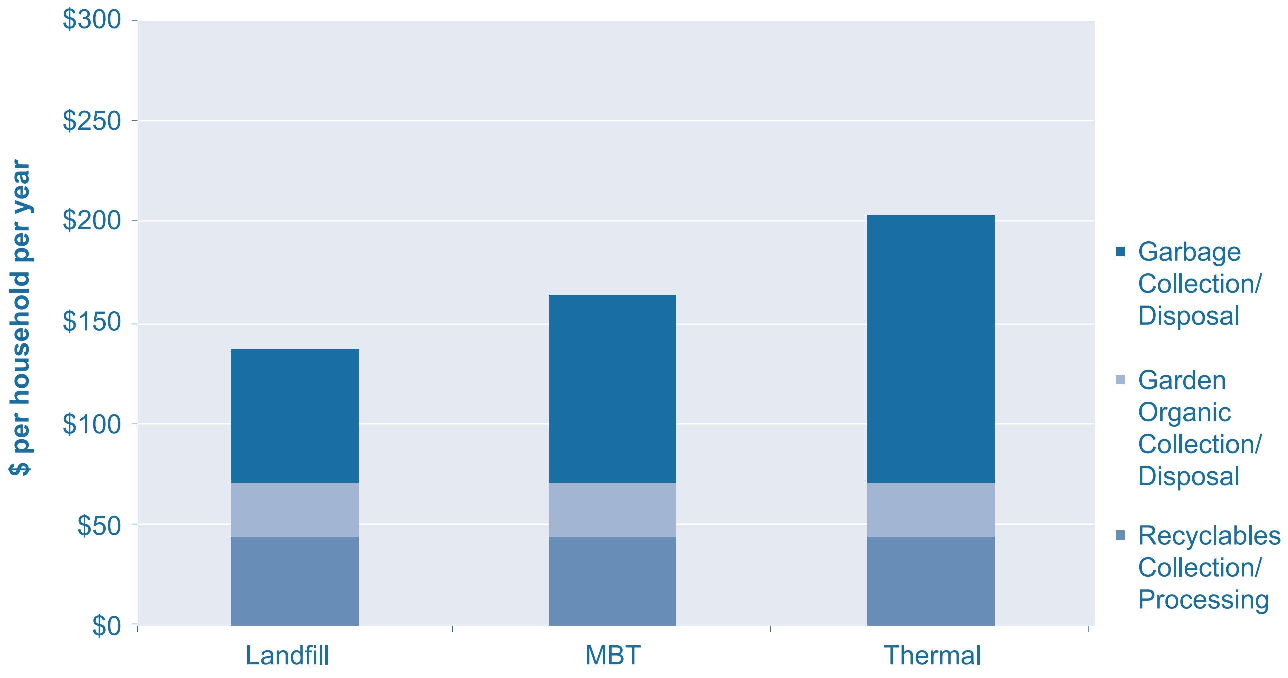
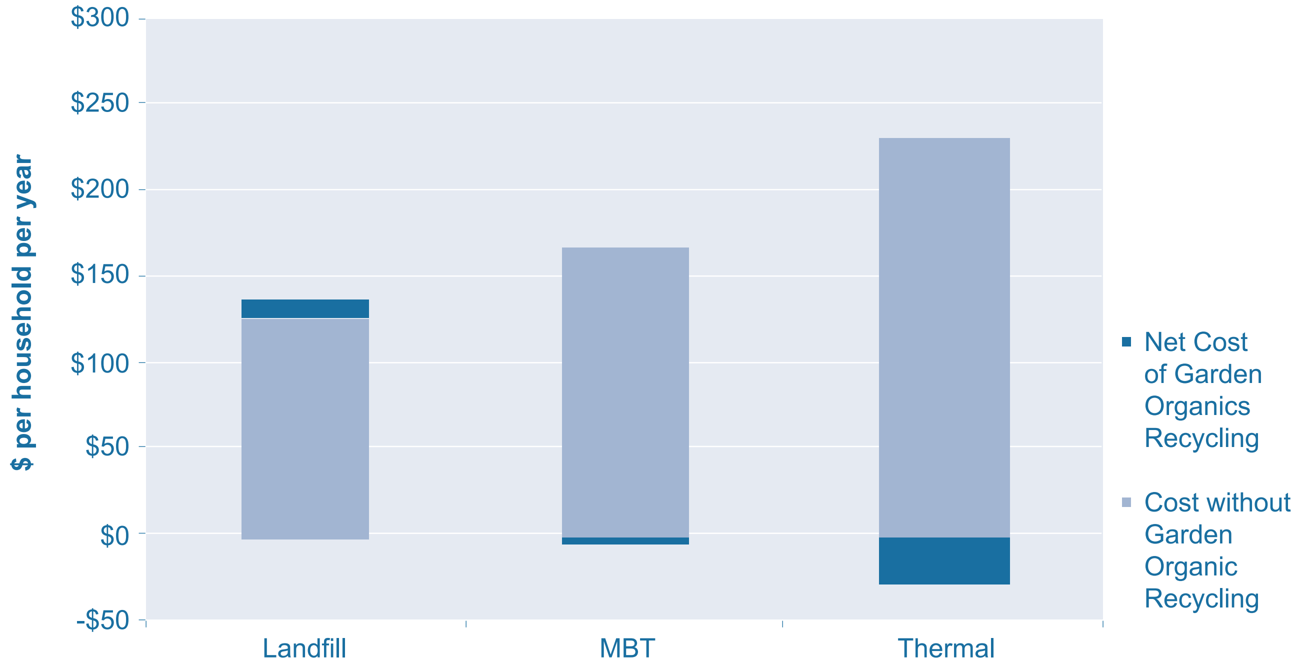


Figure 3.8: Aggregated Waste Management Costs for Regional/Rural Areas Fortnightly Mobile Bin Collection of Garden Organics



3.5 Summary

Table 3.12 presents a summary of estimated system costs for each of the systems investigated.

Table 3.12: Summary of Estimated System Costs – Metropolitan

Garden Organics Recovery Option	Garden Organics Management Cost		Total System Cost (garbage, garden organics and recyclables)		
	High GO Generation	Low GO Generation	Garbage Disposal/ Treatment	High GO Generation	Low GO Generation
None	$0	$0	Landfill	$197	$171
			MBT	$206	$178
			Thermal	$277	$233
Fortnightly Mobile Bin Collections	$45	$31	Landfill	$202	$186
			MBT	$207	$191
			Thermal	$253	$235
Monthly Tied and Bundled Collections	$16	$11	Landfill	$200	$178
			MBT	$208	$184
			Thermal	$271	$235
3 x Yearly Tied and Bundled collections	$6	$4	Landfill	$197	$172
			MBT	$205	$179
			Thermal	$272	$232

Table 3.13: Summary of Estimated System Costs – Regional/Rural

Garden Organics Recovery Option	Garden Organics Management Cost	Total System Cost (garbage, garden organics and recyclables)	
		Garbage Disposal/ Treatment	Cost
None	$0	Landfill	$127
		MBT	$169
		Thermal	$233
Fortnightly Mobile Bin Collections	$28	Landfill	$138
		MBT	$165
		Thermal	$204

In metropolitan areas, while the costs of providing a separate garden organics collection system varies from $0 per household per year (no service) to $45 per household per year (fortnightly 240 litre mobile bin collections), when considering the total waste management system costs, the increase in total costs for providing garden organics collections are less than $5 per household per year (in areas of high garden organics generation) and less than $15 per household per year (in areas of low garden organics generation), assuming landfill disposal of domestic garbage.

As the cost of garbage treatment/disposal increases (through MBT and/or thermal treatment) the *net* cost of garden organics collection reduces (i.e. the (higher) *avoided* costs of garbage treatment makes garden organics management cheaper). For some collection scenarios modelled (e.g. where garbage is thermally treated), the provision of a separate garden organics collection service *reduced* overall waste management costs.

Estimated garden organics management costs modelled in this study are consistent with costs derived from the recently completed *Study of Local Government Management Costs for Garden Organics* (DEC; 2003a).

Estimated total waste management system costs are consistent with average domestic waste management charges as surveyed annually by the Department of Local Government (DLG; 2003) when accounting for ancillary costs such as administration, education and other waste management services offered (i.e. clean up collections, drop-off, street sweeping and litter).

Regional/rural garden organics management costs are typically cheaper than metropolitan systems due mainly to the lower cost of processing ($44 per tonne in metropolitan areas versus $14 per tonne in rural areas).

4 Environmental Cost Benefit Assessment

4.1 Method

4.1.1 Method overview

The environmental assessment of system alternatives has been conducted within the broader framework of an economic assessment. It aims to define and value the environmental externalities (or non-financial costs) associated with source-separated garden organics collection and composting within various management strategies for municipal solid waste.

The environmental assessment has involved the application of Life Cycle Assessment (LCA) and environmental economic valuation methods consistent with the NSW Jurisdictional Recycling Group's research into alternative mixed waste and recycling systems (DEC; 2004) and the National Packaging Covenant study of kerbside recycling in Australia (Nolan-ITU and SKM Economics; 2001). Methodology details are provided in Appendix A. The analysis is also consistent with Department of Environment and Conservation (NSW) *Alternative Waste Treatment Technologies Assessment Methodology* and *Handbook* (2003b) and the findings of the *Life Cycle Inventory and Life Cycle Assessment for Windrow Composting Systems* (ROU; 2003).

The application of the environmental economic assessment within the LCA methodology framework as well as the expanded valuation is shown in Figure 4.1.

In addition to the environmental economic assessment, an expanded valuation has been conducted within the interpretation phase of LCA. This provides a final value that takes account of some known data gaps and limitations of the approach. For details refer to the following sections.

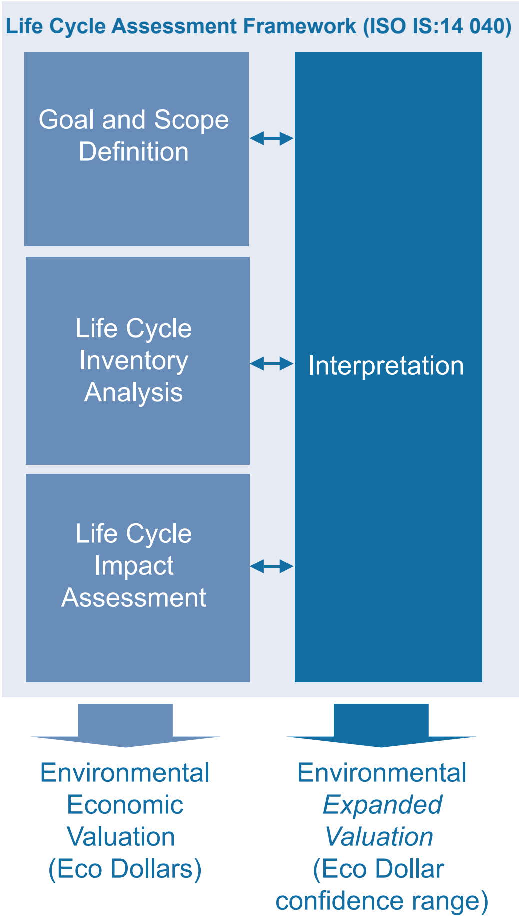


Figure 4.1: LCA method (ISO 14 040, 1998) – application within the economic assessment

As suggested by Figure 4.1, the results of the LCA are presented as an environmental economic valuation of the system under review (in Eco dollars) as well as an expanded valuation that stems from the LCA interpretive phase (also in Eco dollars) which is presented as a confidence range.

4.1.2 Objectives

The environmental assessment has sought to provide:

I. Environmental cost benefit valuation of source-separated garden organics, including collection, composting and compost application.

II. Comparative analysis of options for the management of the garbage stream (with and without source-separated garden organics collection and composting). This includes the technology options of:

- MBT (aerobic)
- Thermal treatment
- Landfill

III. Expanded cost benefit valuation of the above using proxy valuation data that reflects known data gaps and methodological limitations.

4.1.3 Data

The assessment has involved the application of a vast amount of data from local and international research and industry experience that have been built into LCA modelling systems.

The main LCA inventory data sources are:

- Eunomia Research and Consulting (2002): *Economic Analysis of Options for Managing Biodegradable Municipal Waste*, final report to the European Commission.
- Nolan-ITU (1998): *Biowaste Processing Life Cycle Assessment and Environmental Valuation (Proposed Enclosed Biowaste Processing Facility at Lucas Heights)*, for Waste Service NSW and the Southern Sydney Waste Board.
- DEC (2004): *Assessment of Alternative Domestic Waste and Recycling Systems*, for the NSW Jurisdictional Recycling Group and Publishers National Environment Bureau.
- Nolan-ITU and Access Economics (2002): *Organic Waste Economic Values Analysis*; for the Department of Industry and Trade, Environment Protection Agency.
- RMIT and Nolan-ITU (2003): *Life Cycle Assessment of Waste Management Options in Victoria*, for EcoRecycle Victoria.
- Sonesson, U (1997): *The Orware Simulation Model for Compost and Transport LCA Sub-models*, Swedish EPA.

The environmental economic values are referenced from previous published and unpublished reports (Nolan-ITU; 2001, 2002, 2003 and DEC; 2004).

Compost application benefits have been updated to reflect water use benefits from a recent report prepared for the Department of Environment and Conservation (NSW) (ROU; 2003). Data sources and updates for compost application benefits are detailed in Table 4.2.

4.1.4 Assumptions

The assumptions for the environmental assessment have been based mainly on work undertaken in previous studies as documented in Section 10: References, and Appendix A. This study has been commissioned as an 'extension' to the recently published *Assessment of Alternative Domestic Waste and Recycling Systems* (DEC; 2004), and the majority of assumptions are therefore similar. Key parameters and additional assumptions are summarised below.

a) Landfilling

The environmental impacts of landfill (and benefits through avoided landfill) have been modelled as per the LCA of Waste Management Options (RMIT and Nolan-ITU; 2003). This comprised modelling material specific and generic emissions for each component in the residual (garbage) stream. The (long known) weakness of this methodology is that the impacts of landfilling are underestimated as the total emissions to air and water calculated with this model do not include a range of trace contaminants monitored and reported in a number of international studies. An extension to account for these pollutants would also require a modification to the impact model i.e. the Nolan-ITU Environmental Economic Valuation Model which allows consolidation of environmental performance results into a single indicator expressed as a 'monetary value'.

b) Mechanical Biological Treatment (MBT)

A generic MBT facility has been assumed for the treatment of domestic waste (i.e. the contents of the garbage bin) prior to landfilling. Mass balance and emissions data have been used from both local – Nolan-ITU has undertaken a number of studies for technology providers in Australia – and international sources (refer Section 10: References, and Appendix A).

The key characteristics of the assumed MBT plant are: mechanical separation of metals, homogenisation, intensive aerobic processing (fully enclosed) over a four week period with subsequent less intensive stabilisation/maturation over an additional four weeks, screening and refining, production of stabilised residues for landfill (42% of input), production of low grade compost (19% of input), gas generation from landfilling of stabilised residues reduced by 90% compared to untreated garbage, leachate generation from landfilling of stabilised residues reduced by 85% compared to untreated garbage, and biofiltration of process air from the plant. Energy consumption was reduced from averages for aerobic MBT to account for the possibility of partial anaerobic digestion of input.

The environmental benefit of low grade compost generated by the assumed MBT technology is predominantly from avoided landfill impacts. The only assumed application benefits are from carbon sequestration in soils. The impacts of heavy metals are also taken into account based on actual concentrations analysed in MSW-derived compost.

c) Thermal Treatment

The assumed thermal treatment process is based on a state-of-the-art Waste-to-Energy plant employing incinerator technology. 30% of input (by weight) is output, with 2.5% fly ash. Depending on the waste composition, 2-4% of metals are recovered and transported for reprocessing. The fly ash is assumed to be vitrified prior to disposal. Energy recovery in the form of electricity is 300 kilowatts per tonne, including allowance for vitrification requirements. Solid process residues (slag and vitrified fly ash) are assumed to be inert in landfill. No energy recovery has been assumed from generated steam. Lime and NaOH consumption (and the respective Life Cycle Inventory (LCI) datasets) for the flue gas cleaning system has also been included into the modelling.

d) Garden Organics Collection and Composting

Collection systems have been modelled assuming average council sizes for metropolitan Sydney and for regional/rural areas.

Collected garden organics has been assumed to be processed by open windrow composting. Energy usage (and relevant emissions) during processing (shredding, turning, watering) has been documented in a number of studies, most recently in ROU (2003).

Use of compost in a range of intensive agricultural applications has been assumed. The environmental benefits of garden organics recovery, conversion to compost (open windrow composting) and compost application are described in Section 4.2.

For metropolitan options, the use of a bulking and transfer facility has been assumed with subsequent transport in a 50 cubic metre bulk haul vehicle to a composting facility. Distance of final product to market has been assumed at 20 kilometres (if 100 kilometres is assumed, the environmental benefit would reduce by Eco$2.26 per tonne).

e) Kerbside Recycling

For the purpose of this report, kerbside recycling has been held constant across all options modelled. Environmental impacts/benefits of kerbside recycling have not been included in the reported results. These are documented separately in the report on *Assessment of Alternative Domestic Waste and Recycling Systems* (DEC; 2004).

Further assumptions can be found in Section 3.1.2.

4.2 The Environmental Value of Garden Organics

The environmental assessment component of the study has sought to define and value the environmental externalities (or non-financial costs) of source-separated garden organic waste collection and composting so that they may be incorporated into an assessment of the total economic welfare of management options for organic materials.

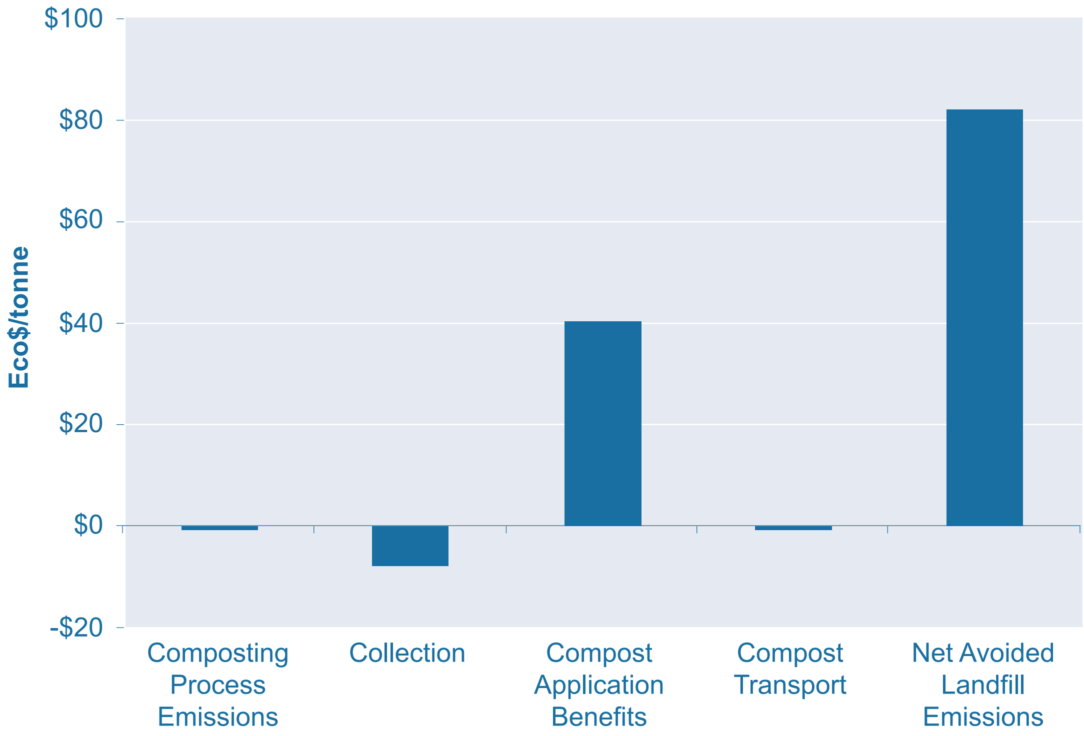
4.2.1 Valuation Overview

The environmental value of garden organics recycling is estimated to be $114 per tonne of source-separated garden organics. This value is comprised of *resource savings* as well as the full range of environmental impact categories associated with avoided product credits, including air and water pollution and global warming potential. The estimate is based on extensive data analysis using the method of life cycle assessment and environmental economic valuation. The contribution of the various aspects is listed in Table 4.1 and Figure 4.2.

Table 4.1: The Environmental Value of Compost (Eco$ per tonne source-separated garden organics)

Life Cycle Aspect	Value (Eco$ per tonne source-separated garden organics)
Composting process emissions	- $0.64
Collection	- $7.61
Compost application benefits	$40.50
Compost transport	- $0.57
Net avoided landfill emissions	$82.53
Net Benefit	**$114.21**

Figure 4.2: The Environmental Value of Compost ($ per tonne source-separated garden organics)



In the LCA interpretation phase conducted as part of this study (Section 5) the potential for bias in the interpretation was investigated. Based on this the estimated environmental value of $114 per tonne was found to be conservative. An expanded valuation, conducted using proxy values to account for some of the known data gaps, yielded an environmental value of garden organics recycling of $277 per tonne.

4.2.2 Compost application benefits – valuation overview

Much of the environmental value of garden organics composting is associated with compost application benefits. Table 4.1 indicates that, of the $114 per tonne benefit per tonne of source-separated *input*, $40.50 is associated with the benefits of compost application to soil (the remainder being avoided landfill credits). This benefit translates to $65.80 per tonne of compost end product (i.e. *output* from windrow composting) with the main benefits arising from moisture retention in soil and the fertiliser value of nutrients in compost. The environmental components of the valuation are presented in Table 4.2. Note the benefits listed in Table 4.2 relate to compost application benefits only (per tonne compost) and not the overall waste management life cycle system costs and benefits as presented in Table 4.1.

Table 4.2: Derivation of Compost Application Benefits ($ per tonne compost)

Environmental Category	Value $ per tonne compost	Data source
Water Retention	$23.70	Water valuation adapted from Hassall and Associates, *Forward* By Francis Grey (1998); Submission to IPART (Bulk Water Pricing) on behalf of World Wide Fund for Nature (WWF) – Australia, Australian Conservation Foundation (ACF), Nature Conservation Council of NSW (NCC) and Pers Comms. Warwick Smith (WWF) March 2001. (Nolan-ITU; 2001). Water calculations updated based on grapevine intensive agricultural application (ROU; 2003). This value is consistent with applied average (Nolan-ITU; 2002) of $22.70 per tonne compost see Table 4.4 and Table 4.5.
Soil Structure Improvement	$1.69	Calculated from Land and Water Resources Research Development Council, Land and Water Audit, 1993. Assumes annual cost of soil structure decline at $200 Million (Nolan-ITU; 2001).
Acidification	$2.54	Calculated (Nolan-ITU; 2002). Assumes annual cost of soil acidity $300 million.
Salinity	$2.06	Calculated (Nolan-ITU; 2002). Assumes annual cost of salinity $243 million. Hill, R. J. 1997.
Avoided phosphate depletion	$22.48	Assumes fertiliser substitution of 20 kilograms per tonne compost (Nolan-ITU; 2003).
Avoided Urea (N)	$6.64	Avoided urea production modelled (RMIT and Nolan-ITU; 2003).
Avoided KCl (K)	$0.05	Avoided pesticide savings at 2*10E-6 $ per tonne compost. Avoided pesticide production modelled (RMIT and Nolan-ITU; 2003).
Nitrous Oxide Emissions	$1.21	Calculated (RMIT and Nolan-ITU; 2003).
Increased yield	$0.89	Potential increased generation for a number of crops has been modelled (RMIT and Nolan-ITU; 2003).
Avoided Pesticide	$1.82	Avoided pesticide (RMIT and Nolan-ITU; 2003). Proxy valuation suggests this benefit is much higher.
Carbon Soil Sequestration	$2.73	Carbon Sequestration assumes 10% of degradable, available organic matter in compost is sequestered over the life of the application (RMIT and Nolan-ITU; 2003)
Total	**$65.81**	

4.2.3 Externalities not considered

In this study considerable effort has been made to derive (where not available) and apply economic values for the various benefits of garden organics-derived compost. However quantification and valuation of all benefits has not been possible. A good example of this is the medium and long term benefits of compost application on the (micro)organism communities within soils ('soil health'). Some environmental cost benefits of compost application that remain unvalued by this approach are listed in Table 4.3.

Table 4.3: Environmental Cost Benefits of Compost that remain External

External Benefits
Pollutant retention and assimilation
Soil conditioning – porosity and aeration
'Soil health'
Micronutrient supply

4.2.4 Compost Application Data

a) Water Loss Saving

The water loss saving from compost arises from the water retention capacity of organic matter added to soil. The ecological value of this amount of water is the *water loss saving* associated with compost.

The ecological value specifically refers to external or non-costed environmental benefits of water and is not a measure of yield or other economic improvements in agricultural systems. Benefits that are potential transaction costs are incorporated in the *financial* assessment component of the study.

Amount of Water Loss Saving

The water retention improvement in soils arising from the application of compost is found to be between 2% and 20% depending largely on the soil type. The average assumed for previous compost application calculations is 9.25% as presented in Table 4.4.

Table 4.4: Water loss saving

Avoided water loss saving	Low	high
Water retention improvement capacity – clay soils	2%	5%
Water retention improvement capacity – sandy soils	10%	20%
Water retention – average used by previous Nolan-ITU studies.	9.25%	

Source: Pers Comms. Dr Simon Lott (EA Systems) September, 2003 used for Australian soils and consistent with other data (Eunomia; 2002).

Water loss savings reported by the Recycled Organics Unit (2003) are consistent with the above data, as shown in Table 4.5.

Table 4.5: Updated water loss saving

Avoided water loss saving	Low	High
Increased water holding capacity of top 15 centimetre soil layer for application to cotton crops	2.4%	3%
Increased water holding capacity of top 15 centimetre soil layer for application to grapevine crops	9.82%	
Water saving applied from ROU source for grapevine crops and used by this study	9.82%	

Environmental Economic Value of Water

The true ecological value of water is variable and difficult to calculate (WWF et al; undated). The value used for this study is $600 per megalitre which is median of a widely accepted range of between $300 and $900 per megalitre[1].

While this valuation appears high, it is consistent with other published valuations that could be found. An attempt to allocate a dollar value to these costs and benefits was made in the Forward to Hassall (1998) by Francis Grey of the Australian National University. Table 4.6 is presented as an example of the work carried out.

Environmental groups, through the Nature Conservation Council of NSW, highlighted the "uncosted", benefits and costs of water use and extraction activities in NSW (Hassal; 1998) to be upwards of $400 million per year for indirect subsidies and upwards of $600 million per year for direct subsidies[2].

This is consistent with a valuation by Environment Australia (1996) that estimated the total extent of the subsidy provided to the NSW rural water industry to be $400 million per year in 1994-95 dollars[3].

Table 4.6: Selective Rough Estimates of Annual Costs of River Degradation in NSW From Hassall and Associates (1998)

Type of Degradation	NSW Cost $million per year
Damage costs caused by salinity (non-dryland)	77
Damage costs caused by eutrophication (blue green algae)	98
Damage costs of turbidity	Not available
Damage costs due to stream bank erosion	Not available
Damage costs caused by toxicants and contamination	Not available
Damage costs for acid sulphate soils	Not available
Damage costs for wetlands	88 (approximately)
Loss of fisheries	Not available
Loss of tourism	41 (estimate)
Social impact costs	Not available
Total (based on available figures)	**Assume almost 300**

[1] Pers comms Warwick Moss (August 7, 2001) World Wide Fund for Nature.

[2] Sydney Morning Herald 4/8/03, Page 1 reported Sydney's Water consumption at 630 gigalitres per year. Considered alongside agricultural consumption in NSW, this points to an ecological cost consistent with the estimated range of $300-$900 per megalitre.

[3] Based on 1992-93 Department of Water Resources Annual Report. Subsidy calculated on rural water/wastewater failing to achieve an 8% rate of return.

Water Valuation Assumptions and Final Valuation

Table 4.7 shows how a monetary value reflecting the increased water retention capacity through compost application was derived. The temporary transfer flow of water in the soil means that an equivalent amount of water is potentially no longer to be drawn from other environmental media. Note that compost application has been assumed at 5 tonne per year over a period of four years to achieve the assumed effect.

Table 4.7: Water valuation assumptions and final valuation

Water valuation – assumptions and valuation	Newly derived from ROU	Original data Value	Units
Temporary water transfer flow	8	8	megalitres per hectare
Water saving (retention at 9.82% / 9.25%)	0.79	0.74	megalitres per hectare
Environmental economic saving (Eco$ per hectare)	$474	$444	$ per hectare per year
Compost application	20	5 x 4	tonne compost per hectare per year
Water loss saving (savings attributable to compost)	$23.70	$22.20	$ per tonne compost

b) Soil structure, Acidification and Salinity

Benefits of compost application arise through improvements to soil structure and reduced soil acidity and salinity. Previous valuations (Nolan-ITU; 2002) have been used for this study.

Table 4.8: Avoided Product – resource depletion valuation

	Resource component	Amount	Unit	Data source
A	Soil structure decline	200	$million per year	Land and Water Resources Research Development Council (LWRRDCL) Land and Water Audit, 1993
B	Acidification	300	$million per year	Nolan-ITU, Waste Service LCA of Organics Processing, 1998 – adapted CSIRO, 1990
C	Salinity	243	$million per year	Hill, R. J. 1997. Environmental Accounting – Depletion and the Measurement of Sustainable Development. ANI Canberra
D	Soil structure	1.69	$ per tonne	A allocated according to assumptions listed under G
E	Acidification	2.54	$ per tonne	B allocated according to assumptions listed under G
F	Salinity	2.06	$ per tonne	C allocated according to assumptions listed under G
G	Allocation assumes total arable land is 46.1 million hectares and land available for intensive agriculture is 23.6 million hectares. Compost allocation assumed at 5 tonne per hectare per year.			

c) Nitrous Oxide Emissions

External benefits from the reduction in N_2O emissions are associated with replacing nitrogen-based fertiliser with compost. Subsequent greenhouse gas benefits arise. These benefits have not been costed separately as they are incorporated into the LCA model developed for this study and are therefore accounted for in the total greenhouse gas emissions savings.

d) Carbon Sequestration through Compost Application

In Australia, 80% of soils are estimated to have lost up to 50% of the total Soil Organic Carbon (SOC) in the top 20 centimetres of soil profile (AGO; 2000). It has also been estimated that 75% of Australian soils have less than 1% SOC in their surface horizons.

The production of compost and incorporation in topsoil has the potential to act as a significant reservoir of carbon. When combined with responsible agricultural practices it could have a positive impact on reducing the rate of global warming.

Gibson et al (2002) have conducted the most extensive research into carbon sequestration in soils through compost application in the Australian context. The study highlights the lack of long term field data on these issues. However, from the information provided, it appears reasonable to assume that around 10% of the carbon applied as recycled organics is retained in the soils over a sufficiently long period to be considered as sequestered.

The team around Eunomia (2002) reached a similar conclusion: Depending on soil properties and climatic condition, the proportion of carbon from compost application remaining in topsoils after 50 years of mineralisation is assumed to average at 13%. Another study prepared by AEA (2002) assumes an 8% sequestration.

In this context it is worth noting that the potential for soil carbon sequestration is dependent on its current soil carbon level. A degraded soil with low SOC will have a greater potential to sequester carbon than a soil that has been under optimum management for a number of years [4]. The current state of discussions of carbon sequestration in soils is hampered by the fact that it is extremely difficult to estimate national carbon accounting figures which could be sufficiently validated under the Kyodo protocol. For recycled organics available near denser populated areas and their application in better defined agricultural and soil systems, it appears easier to estimate the amount of carbon actually sequestered, with the figures indicated above being considered conservative estimates.

e) Avoided Fertiliser – Displacement of Alternative Nutrient Sources

Displacement quantity

The fertiliser value of compost is mainly due to the release of nutrients as organic matter continues to decompose. Normally, high levels of mineralised nutrients become available in semi-mature compost. Composts that are considered mature generally have lower levels of fertiliser value as the mineral nutrients and humic substances become only gradually available over a number of seasons through the further decomposition of organic matter in the field.

The use of compost as a fertiliser is presented in Table 4.9. The main fertilising value of compost is for nitrogen (N), phosphorus (P) and potassium (K). Its value as an NPK fertiliser is dependant upon the quality of the materials used.

[4] Several references provided in Gibson T.S. et al (2002)

The N levels for garden organics-derived compost are presented as being around 1-2% and 1.5-3.0% for food organics derived compost. N levels for garden organics (1.5%) have been assumed for this study. It can be expected that 40% of the N will be available over five years for a single application of compost. The value of the organic N is estimated as an equivalent fertiliser to Ammonium Nitrate which is worth $384 per tonne and contains 33% N.

The P levels are estimated to be around 0.1-0.4% for garden organics derived compost and 0.2-0.6% for food organics derived compost. It can be expected that all of the P will become available over five years after a single application. The value of P is estimated as an equivalent fertiliser to Superphosphate which is worth $255 per tonne and contains 9% P.

K levels in composts were estimated to be similar to P. The value of K is estimated as an equivalent fertiliser to Potassium Sulphate which is worth $650 per tonne and contains 50% K.

Table 4.9: Fertiliser Value – Yearly benefit over five years of a single application of compost

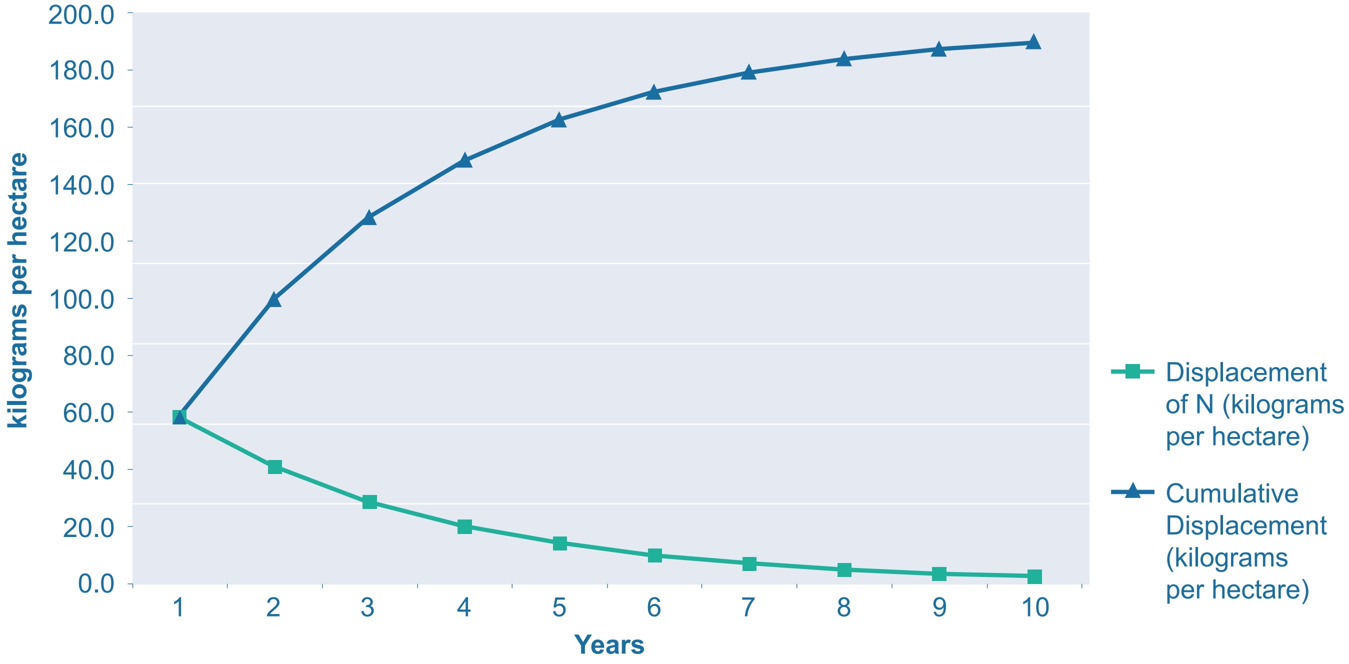
Additional benefits currently not reflected in market prices (as an approximate $ per tonne value)	1 tonne of Garden Organics Derived Compost	1 tonne of Garden and Food Organics Derived Compost
Fertiliser replacement value equivalent to:		
- Ammonium Nitrate	$0.93 – $1.86 N	$1.40 – $2.79 N
- Superphosphate	$1.13 – $2.26 P	$1.70 – $3.40 P
- Pot. Sulphate	$0.52 – $1.04 K	$0.78 – $1.56 K
The figures presented are a typical guide (Source: Nolan-ITU internal)		

Eunomia (2002) assume a mineralisation rate of 30% for all nutrients in the Southern Member States of the EU. For synthetic fertilisers, a loss rate of 23% is assumed for nitrogenous fertilisers whereas, nitrogen from compost is assumed to be 100% available over time. The results are given in Table 4.10 and graphically depicted in Figure 4.3.

Table 4.10: Evolution in N Displacement Associated with 10 tonne per hectare Dry Matter of Compost (Southern Member States) (Eunomia; 2002)

Year	Displacement of N (kilograms per hectare)	Cumulative Displacement (kilograms per hectare)
1	58.4	58.4
2	41.0	99.4
3	28.6	128.0
4	20.0	148.0
5	14.1	162.1
6	9.8	171.9
7	6.9	178.8
8	4.8	183.6
9	3.3	186.9
10	2.4	189.3

Figure 4.3: Evolution of N Displacement over time from Single ten tonne per hectare Compost Application (Eunomia; 2002)



Similarly, the Eunomia team (2002) reports P_2O_5 and K_2O displacement estimates which are given in Table 4.11 and Table 4.12.

Table 4.11: P_2O_5 Displacement associated with ten tonne dry matter of compost applied to Farmland, Southern Member States (Eunomia; 2002)

Year	Displacement of P_2O_5 (kilograms per hectare)	Cumulative Displacement (kilograms per hectare)
1	15.0	15.0
2	10.5	25.5
3	7.4	32.9
4	5.1	38.0
5	3.6	41.6
6	2.5	44.1
7	1.8	45.9
8	1.2	47.1
9	0.9	48.0
10	0.6	48.6

Table 4.12: K_2O Displacement associated with ten tonne dry matter of compost applied to Farmland, Southern Member States (Eunomia; 2002)

Year	Displacement of K_2O (kilograms per hectare)	Cumulative Displacement (kilograms per hectare)
1	36.0	36.0
2	25.2	61.2
3	17.6	78.8
4	12.3	91.2
5	8.6	99.8
6	6.1	105.9
7	4.2	110.1
8	3.0	113.1
9	2.1	115.2
10	1.5	166.6

Based on this data, the following assumptions have been made in order to derive avoided product credits for the impact category of resource depletion savings.

Table 4.13: Avoided Product – resource depletion valuation

	Resource component	Amount	Unit	Data source
A	Fertiliser	0.02	kilograms per kilograms compost	Calculated (ERV Victoria; 2003)
B	Phosphate Rock	8.8	kilograms per kilograms fertiliser	Sima Pro Data used by Waste Plan Victoria, 2003
C	Phosphate Rock	0.176	kilograms per kilograms compost	derived A x B
D	Phosphate Rock Valuation @ Limestone	91.52	$ per tonne	Limestone value (Nolan-ITU; 2001)
E	Avoided Phosphate valuation	16.1075	$ per tonne compost	derived D x C

f) Avoided Pesticide and Disease Suppression

Compost is known to be disease suppressive. Disease control in compost has been attributed to four main mechanisms. These are:

- Successful competition for nutrients by beneficial micro-organisms;
- Antibiotic production by beneficial micro-organisms;
- Successful predation against pathogens by beneficial micro-organisms; and
- Activation of disease resistant genes in plants by composts.

Disease suppressive attributes of composts are found to be more prevalent in hardwood bark, or garden organics, than in food organics composts.

External Costs of Pesticides

A number of attempts have been made to estimate in money terms the environmental costs of pesticides.

Studies show that through compost application the amount of pesticides used can be reduced by up to 50%. In many instances however, this was achieved through a combination of compost application with a more sustainable farm and crop management system. Therefore, a reduction of 20% has been assumed as a conservative estimate, and in accordance with the EC study by Eunomia (2002).

The pesticide inventory data available to this study contains very generic process information with no specific data on emissions or raw materials; or application overspray and fate. The main data available is on energy use. As it is beyond the scope of this study to further research and quantify these benefits, an improved valuation is used in the proxy valuation. The modelled valuation changes under the proxy valuation to $22.82 per tonne of compost.

5 *Life Cycle Assessment Results*

In this section, the results of the environmental economic valuation are presented and discussed. Assumptions on quantities of garden organics recovered are presented in Section 2.2.

5.1 Scenarios Assessed

The main options compared are as follows:

LF Only	Garbage to Landfill (no Garden Organics Collection)
SSGO+LF	Garbage to Landfill plus Garden Organics Collection (Source-separated Garden Organics – SSGO)
MBT Only	Garbage to Mechanical Biological Treatment (MBT) (no Garden Organics collection)
SSGO+MBT	Garbage to Mechanical Biological Treatment (MBT) plus Garden Organics Collection
TH Only	Garbage to Thermal Waste Treatment (no Garden Organics collection)
SSGO+TH	Garbage to Thermal Waste Treatment plus Garden Organics collection

As in the financial assessment, a number of different garden organics collection systems were analysed. These are:

- Fortnightly garden organics collection using 240 litre mobile bins:
  - Metropolitan, high garden organics generation;
  - Metropolitan, low garden organics generation;
- Monthly tied and bundled garden organics collection:
  - Metropolitan, high garden organics generation;
  - Metropolitan, low garden organics generation;
- Three tied and bundled collections of garden organics per year
  - Metropolitan, high garden organics generation;
  - Metropolitan, low garden organics generation; and
- A regional/rural scenario with fortnightly collection using 240 litre mobile bins.

The total number of scenarios assessed is 42.

5.2 Contribution of Impacts to Single Indicator

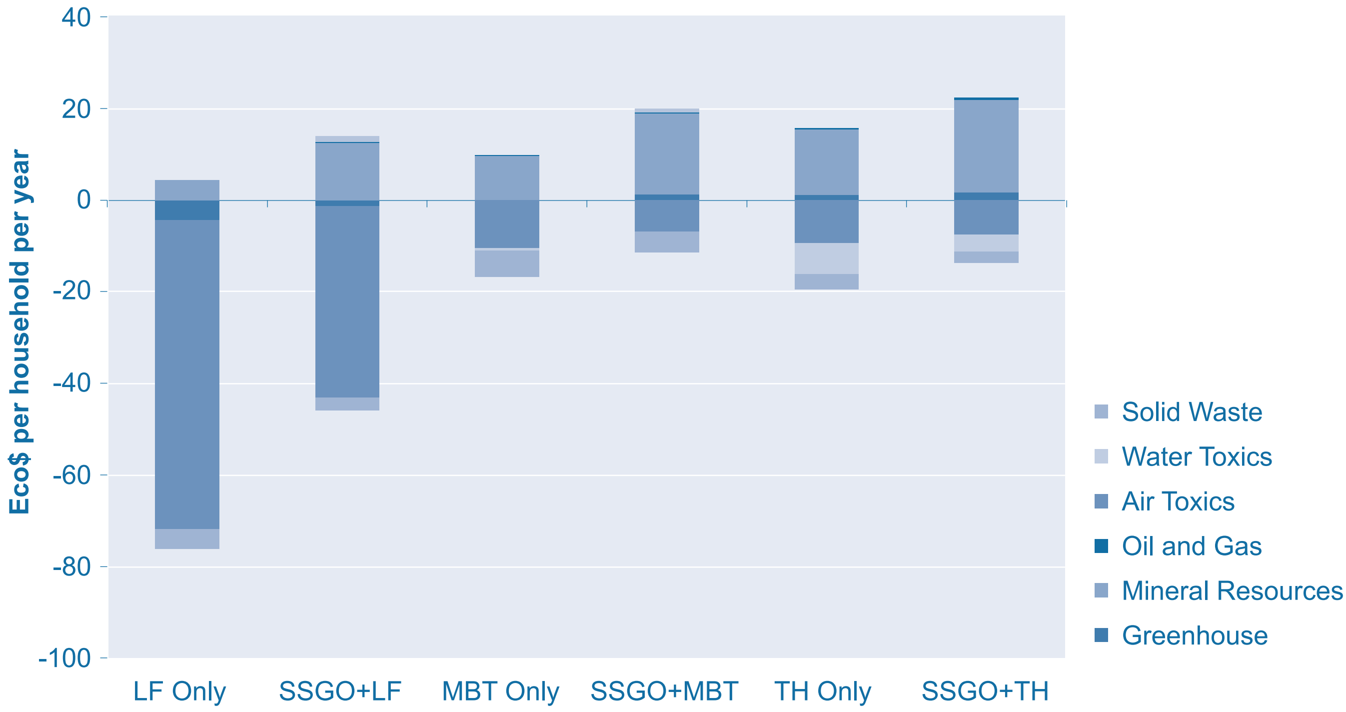
As described in the previous section, the environmental economic valuation derives a single indicator (in this case, an "Eco$" value) from a number of environmental impact categories. The single indicator ('eco-dollar') is provided to assist the wider economic considerations forming the basis for the development of the Triple Bottom Line Assessment which is the primary goal of this study. It can be a useful tool but should not be seen as the final expression of the LCA as it is not ISO 14042 compliant to aggregate the results in this way.

The relative contributions of the categories within the environmental-economic damage valuation model are comparable with the normalisation values calculated for EcoRecycle Victoria (RMIT and Nolan-ITU; 2003), although care must be taken in comparing these two different impact models.

Figure 5.1 illustrates the contributions of the various impact categories to for each of the main scenarios (for the system: Metropolitan, High Garden Organics Generation, Fortnightly Collection). A comparison of the options showing aggregate figures is provided in the following section.

Air toxics and mineral reserves are the dominant environmental impact categories. Treatment options generally have a high air pollution cost but offer benefits in terms of resource saving, arising largely from the avoided product credit associated with process residual, such as electricity offsets from cogeneration and compost application benefits.

Figure 5.1: Eco-Cost/Benefit Breakdown of Different Options (Metropolitan Fortnightly Collection)



5.3 The Scenarios

The scenarios assessed are depicted as follows: The six main alternatives (Landfill, MBT, Thermal, each with and without source-separated Garden Organics (SSGO) system) are always listed on the category axis (x-axis). The three different levels of collection services (fortnightly, monthly and three x yearly) and the "High" and "Low" garden organics generation scenarios (representing different Sydney metropolitan councils i.e. typical outer suburbs vs. typical inner suburbs with higher proportion of multi-unit dwellings, smaller backyards etc.) are depicted in separate figures.

Assumptions regarding garden organics generation and recovery rates as described in Section 2.2.3 (which reflect the results of the recently completed Local Government Survey (DEC; 2003)).

5.3.1 Metropolitan – Fortnightly Containerised Collection

Figure 5.2 illustrates the results for the range of scenarios in the metropolitan council and compares "No Collection of Garden Organics" with a fortnightly containerised garden organics collection.
No garden organics collection, with garbage sent to landfill, has been set at zero for ease of comparison.

a) High GO Generation

For the high garden organics scenarios, the benefits amount to approximately:

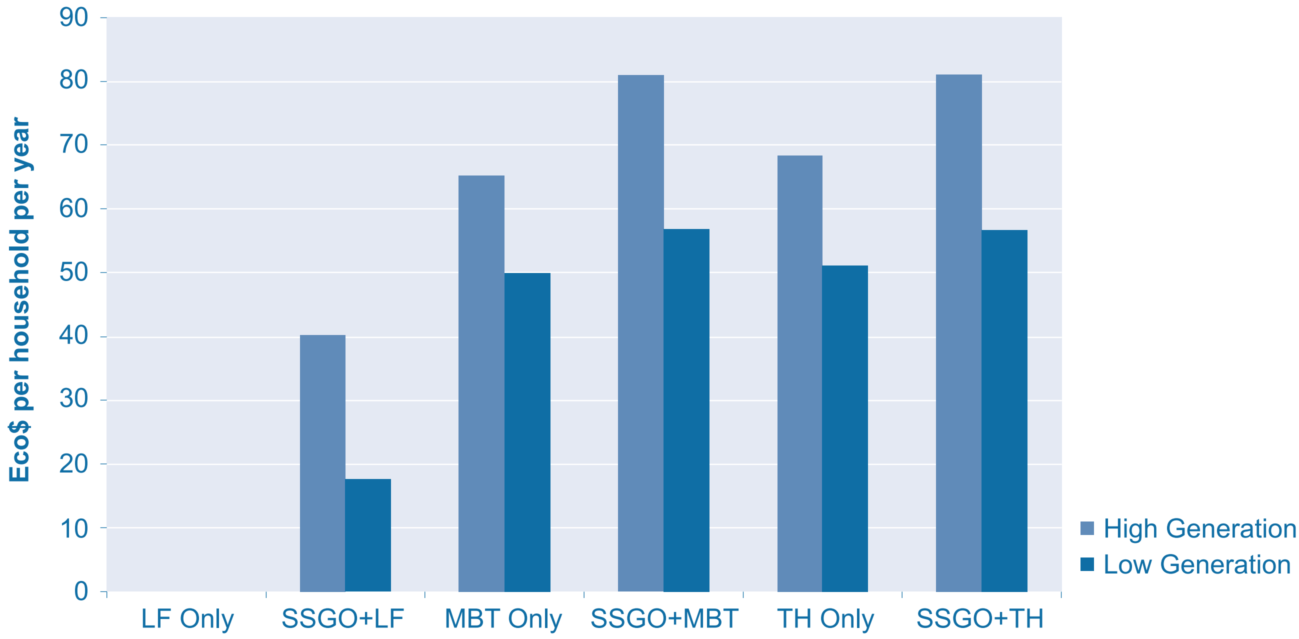
- Eco$40 per household per year for a separate fortnightly containerised GO collection for the Garbage to Landfill Scenario;
- Between Eco$65 and Eco$70 per household per year if no garden organics collection service is provided but the garbage is sent to a treatment facility ("MBT Only" and "TH Only");
- Up to Eco$12 per household per year for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

b) Low GO Generation

For the low garden organics scenarios, the benefits amount to approximately:

- Eco$18 per household per year for a separate fortnightly containerised GO collection for the Garbage to Landfill Scenario;
- Around Eco$50 per household per year if no garden organics collection service is provided but the garbage is sent to a treatment facility ("MBT Only" and "TH Only");
- Up to Eco$8 per household per year for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

Figure 5.2: Scenario Comparison – Metropolitan Fortnightly Collection (Eco$ per household per year)



5.3.2 Metropolitan – Monthly Tied and Bundled Collection

Figure 5.3 illustrates the results for the range of scenarios in the metropolitan council and compares "No Collection of Garden Organics" with a monthly tied and bundled garden organics collection.

a) High GO Generation

For the high garden organics scenarios, the benefits amount to approximately:

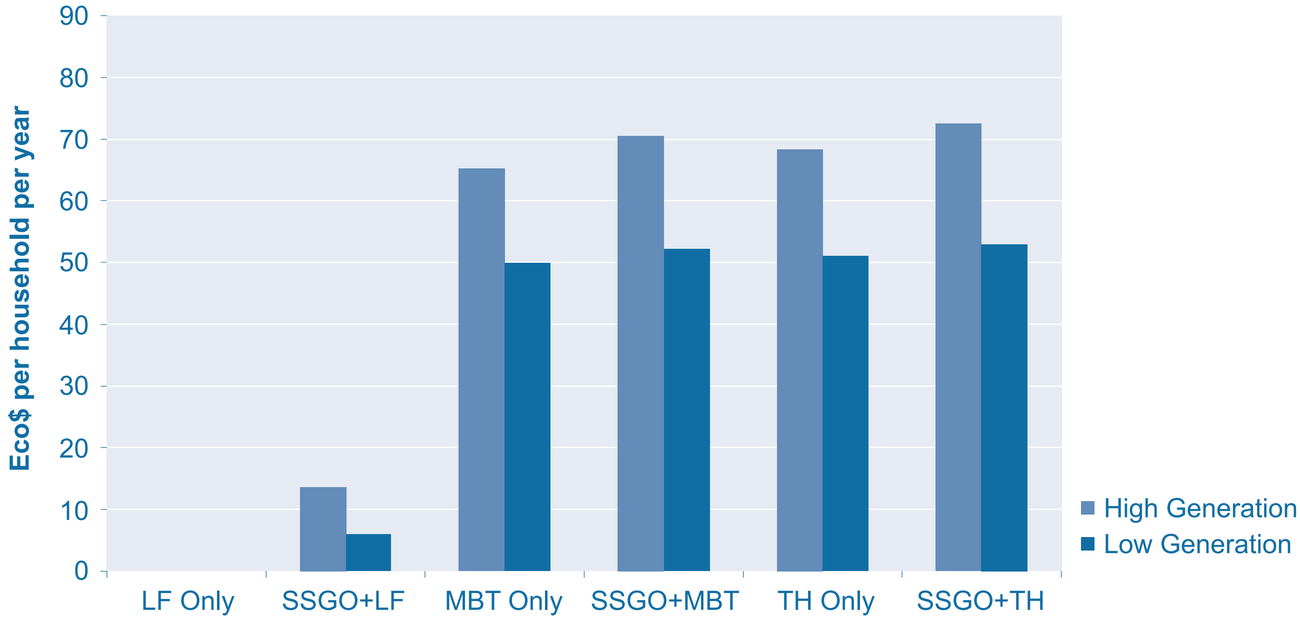
- Eco$14 per household per year for a separate monthly tied and bundled GO collection for the Garbage to Landfill Scenario;
- Between Eco$65 and Eco$70 per household per year if no garden organics collection service is provided but the garbage is sent to a treatment facility ("MBT Only" and "TH Only");
- Up to an additional Eco$6 per household per year for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

b) Low GO Generation

For the low garden organics scenarios, the benefits amount to approximately:

- Eco$6 per household per year for a monthly GO collection for the Garbage to Landfill Scenario;
- Around Eco$50 per household per year if no garden organics collection service is provided but the garbage is sent to a treatment facility ("MBT Only" and "TH Only");
- Up to an additional Eco$3 per household per year for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

Figure 5.3: Scenario Comparison – Metropolitan Monthly Collection (Eco$ per household per year)



5.3.3 Metropolitan – Three Yearly Collection

Figure 5.4 illustrates the results for the range of scenarios in the metropolitan council and compares "No Collection of Garden Organics" with a three x yearly (tied and bundled) garden organics collection.

Due to the relatively low yields, the environmental benefits of a separate collection are relatively low ($7 and $3 per household per year if the garbage goes to landfill).

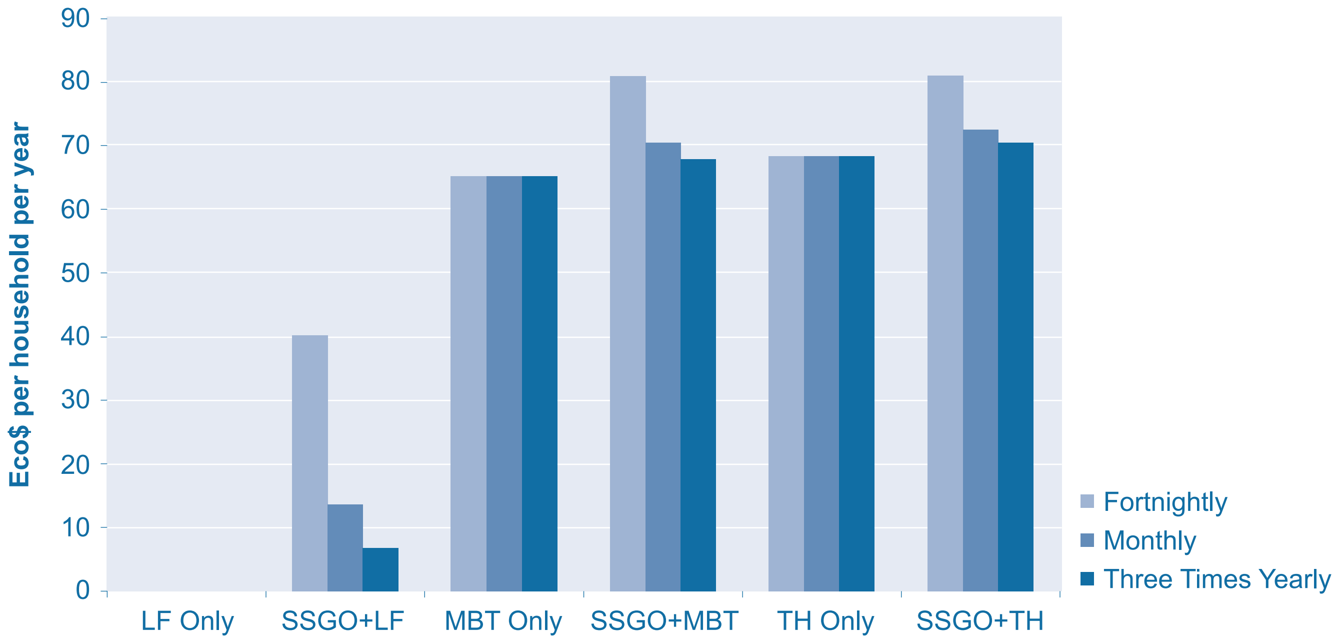
The benefits of residual waste treatment (MBT and TH) are similar to the above scenarios however there is almost no discernible difference between the provision of a separate garden organics service and no provision if such residual waste treatment systems are implemented.

Figure 5.4: Scenario Comparison – Metropolitan Three Times Yearly Collection (Eco$ per household per year)

5.3.4 Metropolitan Setting – Summary

Figure 5.5 attempts to summarise the findings by grouping the three different collection frequencies for the "High" garden organics generation scenario (i.e. the typical 'green' outer Sydney suburb).

Figure 5.5: Scenario Comparison – Metropolitan High Generation (Eco$ per household per year)



It can be concluded that the inclusion of organics collection and composting with landfilling of garbage is a lower performing option than the use of alternative technologies without garden organics collection. However, regardless of the fate of the garbage (residual waste), it is always environmentally superior to have a separate collection of garden organics. The main reasons are:

- The treatment of all organics (including food) in mixed waste processing facilities provides high benefits through reduced emissions from landfilling the stabilised materials. Recovery of some dry recyclable materials may provide additional benefits;
- Per tonne collected, the 'yield' compost from source segregated garden organics is higher than for mixed waste (a certain component will still always be part of the residues);
- Application of mixed waste compost has been assumed to provide a range of benefits however, in accordance with the precautionary principle it has been assumed that it may not be suitable for the entire range of possible applications (i.e. food crops); and
- The results show that the environmental benefits of reduced transport requirements of monthly (where a similar result occurs) and three times yearly collection are insignificant as compared to the disadvantages of decreased availability of garden organics.

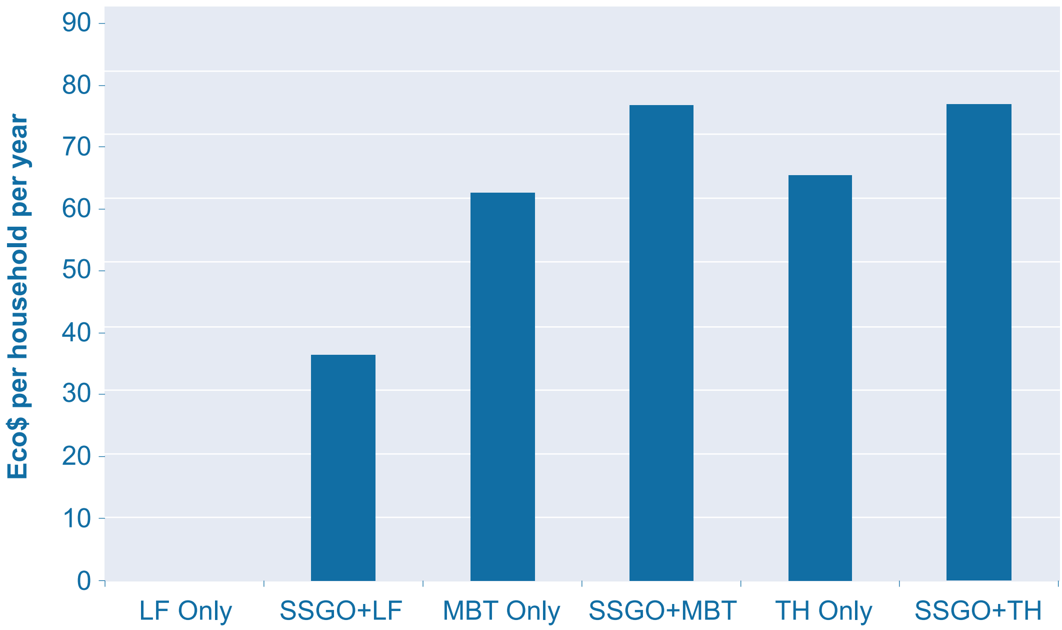
5.3.5 Regional/Rural Councils

Figure 5.6 illustrates the results for the range of scenarios in a regional/rural council and compares "No Collection of Garden Organics" with a fortnightly containerised garden organics collection. Again, the system with no garden organics collection, with garbage sent to landfill, has been set at zero for ease of comparison. Due to the scarcity of available data, no differentiation has been made between High and Low GO generation. The figures used represent the average across all regional/rural councils where information is available.

For this average regional/rural council, the benefits of a separate garden organics collection system (fortnightly) amount to approximately:

- $37 per household per year for a separate fortnightly containerised GO collection for the Garbage to Landfill Scenario;
- Between $60 and $65 per household per year if no garden organics collection service is provided but the garbage is sent to a treatment facility ("MBT Only" and "TH Only");
- Up to an additional $15 per household per year for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

Figure 5.6: Scenario Comparison – Rural Council, Fortnightly Collection (Eco$ per household per year)



5.4 LCA Interpretation and Expanded Valuation

The international standards for life cycle assessment require that the final results of an LCA be interpreted so that any potential bias in the findings can be identified and recorded alongside the final results. For this study, an attempt has been made to identify any potential cause of bias in the results. Such bias is likely to arise from data gaps, differences in data quality or from limitations in the method due to the scope of the study. In order to understand the impact of any bias on the findings, a qualitative valuation has been made of the *probable* cost benefit that might be expected if the main causes of bias were removed.

Specifically, the potential for bias in this study includes:

- Gaps and inconsistent quality in inventory data;
- Limitations in the impact assessment method;
- Absence of social valuation weights; and
- Compost benefits uncosted.

5.4.1 Source of Bias in Results

a) Gaps and Inconsistent Quality in Inventory Data

Typically it was found that the data quality for well-established processes, such as electricity generation and transport, is higher than for processes that have been less studied, such as waste treatment. This has resulted, for example, in high benefits for electricity generation credits, while, in contrast, the impacts of the waste process that generates them are not fully accounted for. Significant and known data gaps include:

- Incineration emissions associated with the disposal of residues; and
- Landfill emissions of contaminants including dioxins and furans from flaring and biogas cogeneration, and emissions of trace organic contaminants.

b) Limitations in the Impact Assessment Method

The valuation method used for this study was developed specifically and solely for the purpose of assessing the cost benefits of kerbside recycling (Nolan-ITU; 2001). This valuation method does not comprehensively cover all pollutants within the inventory data of this study and hence many of the cost benefits are not incorporated in the final assessment. As it is beyond the scope of this study to further develop the economic valuation method, an attempt has been made to understand which inventories have been most affected by this and to assign proxy values to unvalued pollutants. The proxy values have been derived based on similarities in the chemical properties of pollutants however the categorisation is broad and the final expanded valuation is intended to serve *only as an indication of a more probable valuation* of impacts.

Valuations for Landfill, MBT and incineration have been conducted using the same method. Based on this analysis, landfill air and water pollutants are the least comprehensively covered by the economic valuation method and are hence the only air and water data sets modified by the expanded valuation.

c) Social Weights

Triple bottom line analysis continues to advance in the way in which social preferences are incorporated into the final assessment. However, social preference variations that occur at intermediate steps in the assessment are difficult to incorporate. For example, the allocation of a social weight on local versus remote air pollutant release would be expected to change the final results through an increase in the *impact of process emissions from incineration* while reducing the *benefits associated with electricity offsets from coal fired power generation* (particularly in NSW where these emissions occur in less densely populated regions). The net result would be a reduction of the overall benefit associated with incineration. Other excluded preference might include differences between air and water pollutant impacts such as carcinogens versus acid precursors.

d) Compost Benefits Uncosted

In addition to limitations in the economic valuation method, impact assessment results are thought to inadequately capture the benefits of compost application to soil. While an effort is made to apply existing economic environmental values to assess the cost benefit of composted organics, the benefits are difficult to quantify and no data could be found on the potential economic value of some categories including:

- Pollutant retention and assimilation capacity by compost enhanced soils
- Soil conditioning properties – porosity and aeration
- Micronutrient supply.

5.4.2 Derivation of Proxy Values

a) Overview

Table 5.1: Summary of proxy valuations

Data Gap	Proxy Value Derivation For inclusion in model ($ per tonne)	Method
Disease suppression – Avoided pesticide	$22.82 per tonne compost	Avoided pesticide valuation from adaptation to valuation for Avoided Pesticide (Eunomia; 2002)
Incineration emissions to air and water and the valuation of these impacts.	Fly ash control cost valuation = + $2,000 per tonne fly ash LCIA method changed to record fly ash	Data gaps exist particularly with regard to disposal of process residuals. Mass balance calculations suggest that the disposal of process residuals, notably fly ash, is potentially the most polluting unit process within the system boundary. This is not valued nor are the life cycle emissions to air and water quantified. The “control cost” valuation is used based on world best practice regulation. Bottom ash is not costed.
Landfill emissions – comprehensive valuation of air and water pollution impacts.	LCIA method changed to include proxy values Net air pollutant value = + 70 $ per tonne Net water pollutant value = + 95 $ per tonne	The valuation method does not comprehensively cover all pollutants within the inventory for landfill and hence many of these are not included in the final assessment. As it is beyond the scope of this study to further develop the economic valuation method, an attempt is made to assign existing values to unvalued pollutants based on chemical similarities. Significant inventory data gaps are also known to exist for landfill such as emissions of dioxins from biogas cogeneration and flaring. These remain to be included for more complete valuation.

b) Avoided Pesticide and Disease Suppression

In order to improve on the value which results from modelling using existing data and methods for this study a proxy value is applied to estimate avoided pesticide and disease suppression benefits. The modelled valuation of compost changes under the proxy valuation from less than $1 in the ‘base case’ valuation (when only known production impacts of pesticides is modelled) to $22.82 per tonne of compost in the expanded valuation.

Table 5.2: Avoided Pesticide Externality

Item	Value	Unit	Data source
Pesticide application	1.2 – 16.3	kilograms A.I. per hectare	Eunomia (2002)
Average assumed (active ingredient)	8.75	kilograms A.I. per hectare	Calculated
Average assumed (active ingredient)	0.875	kilograms A.I. per tonne compost	Calculated
Externality valuation	12.8 – 19.2	Euro per kilograms A.I.	Eunomia (2002)
Average assumed (active ingredient)	16	Euro per kilograms A. I.	Calculated
Average assumed (active ingredient)	26	$ per kilograms A.I.	Calculated
Average per tonne of compost	22.82	$ per tonne compost	Calculated
Average per tonne of SS garden organics	14.83	$ per tonne SS GO	Calculated

Euro conversion at A$1.63. Assumed compost application at 10t DM per hectare.

c) Incineration emissions from residuals

Data gaps exist particularly with regard to disposal of process residuals. The tight regulation of air and water emissions from municipal solid waste incinerators has delivered considerable site environmental performance improvements over the past decade. However mass balance calculations throughout the life cycle of thermal treatment technologies (Hellweg S.; 2003) reveals that the most polluting unit processes of thermal technologies arise from the disposal of process residuals, notably fly ash. Investigation is underway in many countries to better understand the medium and long term behaviour of pollutants from landfill of fly ash and bottom ash.

Due to the scope of this study, a proxy environmental economic valuation for fly ash disposal is used. While the economic valuation method has typically used “damage cost” valuation, a “control cost” valuation is used in this instance. Based on world best practice regulation, the expected control cost of the land disposal of fly ash is $2,000 per tonne. Bottom ash is not costed.

d) Landfill Air and Water Pollutants – Proxy valuations

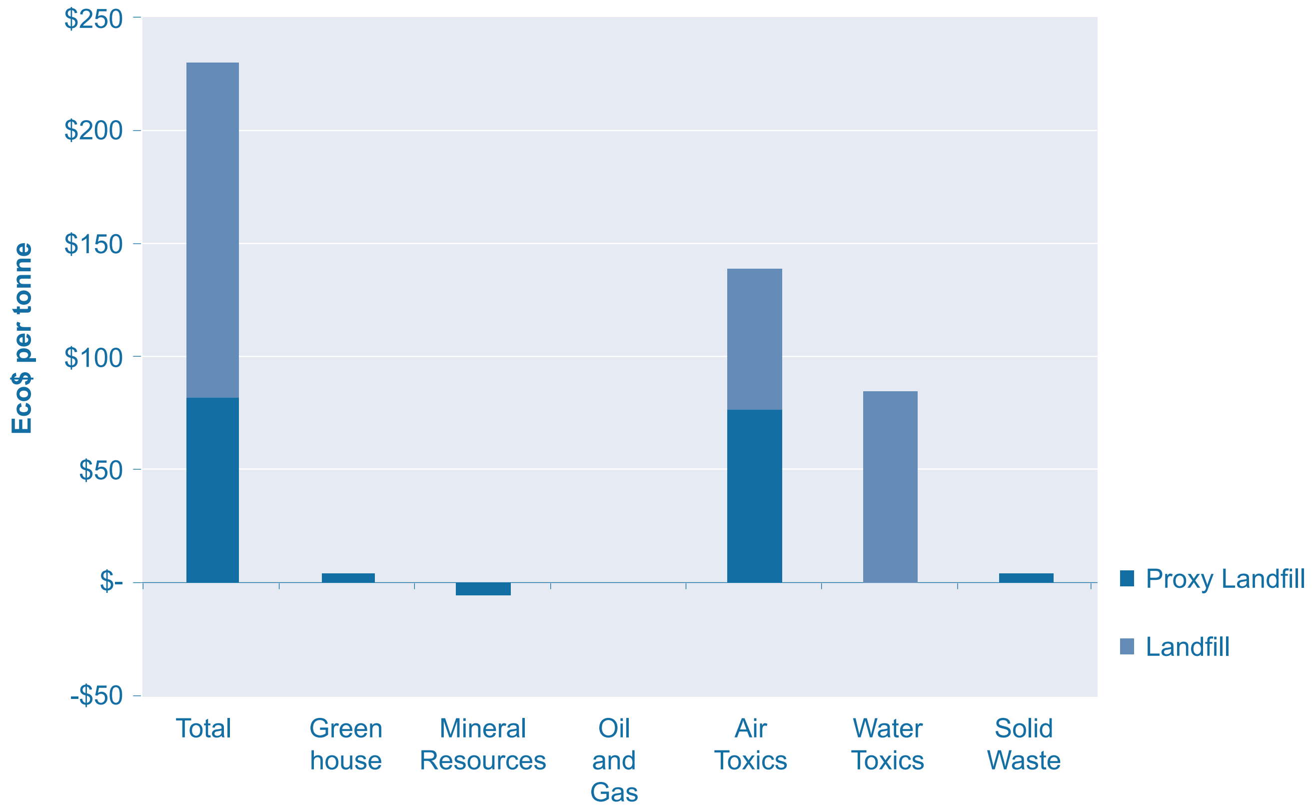
As indicated in Section 5.4.1b), in this expanded valuation proxy values have been assigned to unvalued pollutants in inventories that have been most affected by containing significant pollutant loads/benefits. These proxy values have been derived based on similarities in the chemical properties of pollutants (i.e. similar to equivalence values) however the categorisation is broad and the final expanded valuation is intended to serve *only as an indication of a more probable valuation* of impacts.

5.4.3 Impact of Expanded Valuation

a) Landfill

The inclusion of proxy values changes the results and has consequences for the management of garden organics. Importantly, the external (environmental) cost of landfill increases from about $83 per tonne to $230 per tonne. As landfill is avoided when garden organics are processed, this results in a greater credit for composting of garden organics. The difference between the original and the expanded valuation using proxy values is shown in Figure 5.7.

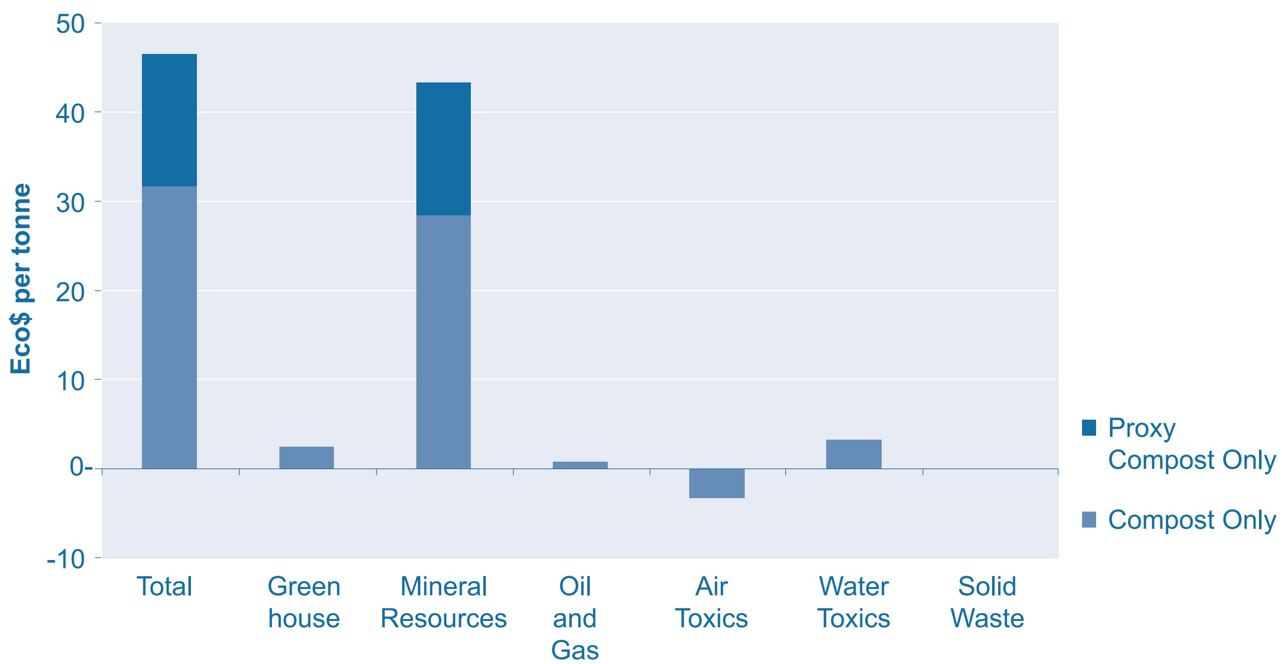
Figure 5.7: Landfill Valuation (Eco$ per tonne) Standard Eco Valuation versus Expanded Valuation



b) Composting

In addition, the benefit of composting is increased by the inclusion of a higher compost application benefit arising from the valuation of avoided pesticide.

Figure 5.8: Compost Valuation (Eco$ per tonne) Standard Eco Valuation versus Expanded Valuation



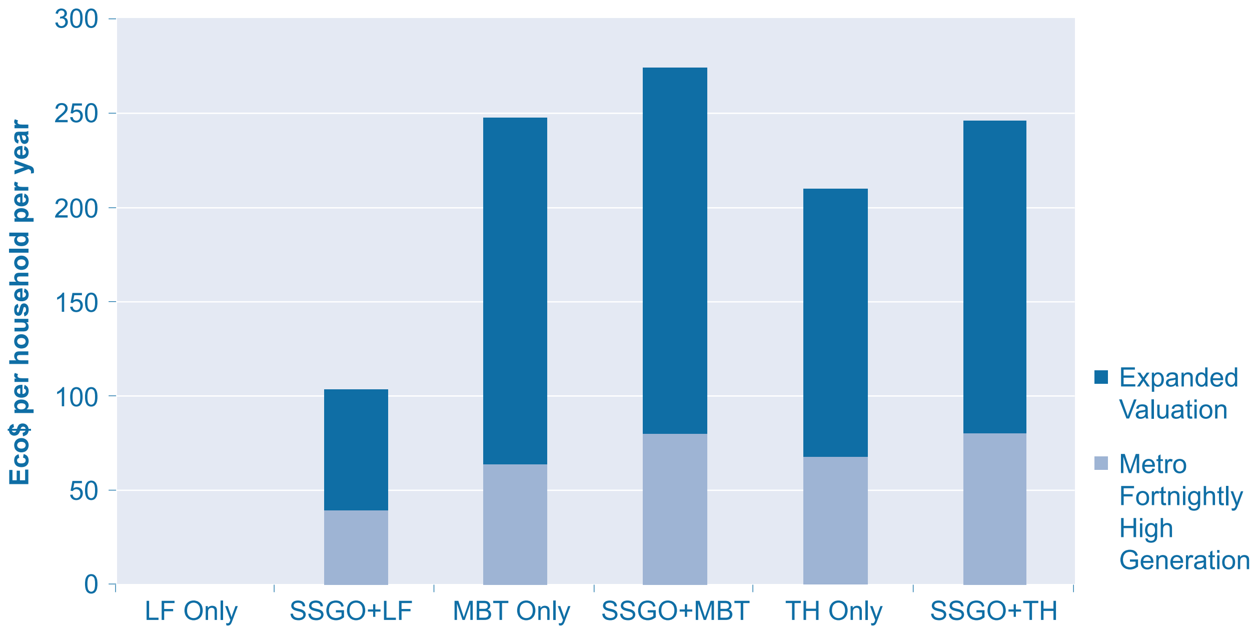
Note: The above values are net, i.e. impacts from collection, processing and transport (total of $8.82) have been deducted

c) Scenario comparisons

For the comparison between scenarios, the net effect of the expanded valuation on the results is an improvement in the overall benefit of composting garden organics and a shift in the trend line that sees the MBT improve relatively over incineration and landfill.

The environmental benefits of garden organics separation (with residual waste going to landfill) increase from Eco$40.5 per household per year to over Eco$100 per household per year. The benefits of residual waste treatment also increase significantly, from around Eco$70 to Eco$200-$250 per household per year. Note that the inclusion of proxy values has changed the overall rating of treatment scenarios such that source-separated garden organics collection and composting with MBT treatment of the residual garbage stream provides the greatest net benefit with a value of approximately Eco$280 per household per year.

**Figure 5.9: Scenario Comparison (Eco$ per household per year)
Standard Eco Valuation versus Proxy Valuation**



6 Social Impacts Identification

6.1 Approach

In terms of identification of potential social impacts from garden organics collection and treatment systems, the project team reapplied the approach taken in the recently completed *Assessment of Alternative Domestic Waste and Recycling Systems* (NSW JRG-14) (DEC; 2004). This was to ensure consistency. Additionally, it was appropriate to further maintain consistency with past analyses, including the social impact categories in DEC's *Alternative Waste Treatment Technologies Assessment methodology and Handbook* (2003b) and the NSW Government's *Alternative Waste Management Technologies and Practices Inquiry Report* (2000).

As with the *NSW JRG-14* project, the project team applied a "limited boundaries" approach to social impacts, e.g. **those most directly associated with the introduction and conduct of a garden organics collection and treatment system onto the base case waste management system**. As a result, aspects such as macro-economic costs or benefits have not been included. Nor does the social impact assessment include or encompass any social valuation of environment impact categories, e.g. a given community's views and values about different environmental aspects such as water pollution versus air pollution.

Again as with the *NSW JRG-14* project, the project team largely utilised a standard set of social impact categories commonly used when conducting social impact assessment as suggested by the widely recognised Guidelines and Principles for Social Impact Assessment developed by US Government agencies (1994). This standard set was modified to reflect local circumstances and feedback as identified in an extensive and highly representative survey of local government, as well as consultative sessions, undertaken for the *NSW JRG-14* project.

In this regard, the relationship between the *community relations* social impact category and the *individual/family impacts* category should be discussed. There have certainly been situations in NSW where a community has negatively perceived a certain system or its proponents. In developing an impact assessment, it would be unrealistic to ignore this reality and therefore there needs to be a perceptions-based category of analysis (i.e. individual and family impacts). However, a system or its proponents should not be unnecessarily or unfairly affected by perceptions-based approaches. Therefore, an additional category of community relations has been included, whereby a system or its proponents are given the opportunity to show good will and have their overall assessment adjusted accordingly.

The overall list of social impact categories considered is below.

Individual and Family Impacts, e.g. degree of potential ***public perception*** of risk to health, safety and/or amenity from a waste system; concerns about displacement/relocation potential of waste system; potential to affect public trust in political and social institutions.
Residential Amenity, e.g. degree of ***physically measurable*** noise, odour, and dust from system and related traffic movements.
Householder Convenience, e.g. potential for system to be convenient and accessible to householders including bin types and collection frequencies.
Employment, e.g. job creation.
Occupational Health and Safety
Labour Relations
Community Relations, e.g. inherent potential of the system to be used to foster community relations and social cohesion such as leveraging desirable community behaviours.

It is noted that not all of the impacts presented can be applied in a generic assessment of systems. For example, impacts/benefits arising in terms of employment, natural and cultural heritage, labour relations, and community relations are largely specific to individual circumstances. However, it was deemed important to describe all potential impacts for the future reference of waste management decision-makers in "real life" situations.

6.2 Impact Assessment Framework

For each social impact category, a series of performance indicators was developed and applied. Care was taken to ensure wherever possible that the performance indicators had a factual basis rather than a value judgement. The system of evaluation/assessment is outlined below.

Also, it should be highlighted that many social impacts associated with waste management are location-specific and dependent on a wide range of factors, including awareness levels, past historical experiences, nature of community institutions and socio-demographic profile. Some aspects are also linked to the reputation and/or performance of specific proponents. Moreover, public perception is not static and can vary at different stages of the development process.

a) Individual and Family Impacts

Category explanation: Degree of potential ***public perception*** of risk to health, safety and/or amenity from a waste system; concerns about displacement/relocation potential of waste system; potential to affect public trust in political and social institutions.

Social Impact Assessment Criterion: Individual and Family Impacts

Description	Score
No evidence of community perception of risk to health, safety and/or amenity; negligible consequences.	5
Some evidence of community perception of risk to health, safety and/or amenity, including sporadic representations from groups and individuals; low consequences.	4
Moderate evidence of community perception of risk to health, safety and/or amenity, including regular representations from groups and individuals; moderate consequences.	3
Significant evidence of community perception of risk to health, safety, and/or amenity, including regular representations from groups and/or individuals and development of local activism/ opposition; high consequences.	2
Highly significant evidence of community perception of risk to health safety and amenity, including numerous representations from groups and individuals, media reports, local activism, and community-initiated meetings; extensive consequences.	1

b) Residential Amenity

Category explanation: Degree of physically measurable residential amenity impacts from system including noise, odour, dust, visual/aesthetic aspects, and traffic-related impacts. For this case, it is plainly the number of trucks passing through a street per week.

Social Impact Assessment Criterion: Residential Amenity

Description	Score
No or limited discernible impact; negligible consequences.	5
Low number of total impacts; impacts can be mitigated and/or managed; low consequences.	4
Medium number of total impacts; impacts can be mitigated and/or managed; moderate consequences.	3
Medium number of total impacts; impacts difficult to mitigate and/or manage; high consequences.	2
High number of total impacts; impacts difficult to mitigate and/or manage; extensive consequences.	1

c) Householder Convenience

Category explanation: Potential for system to be convenient and accessible to householders including bin types and collection frequencies.

Social Impact Assessment Criterion: Householder Convenience

Description	Score
Weekly service; all bins highly mobile and easily handled by vast majority of community members	5
Fortnightly service; all bins highly mobile and easily handled by vast majority of community members	4
Weekly service; some bins highly mobile and easily handled by vast majority of community members	3
Fortnightly or less frequent service; some bins highly mobile and easily handled by vast majority of community members	2
Weekly, fortnightly or other service schedule; no mobile or easily handled bins (e.g. non-wheelie bin for garbage, crates or no receptacle for garden organics/recyclables)	1

d) Employment

Category explanation: Implications for both direct and indirect jobs in both short and longer terms; impacts on type of other commercial activity near waste treatment technology facility.

Note: This category has not been applied in this study which deals with generic systems (as opposed to individual technologies/proponents).

Social Impact Assessment Criterion: Employment

Description	Score
Potential to create long-term, local employment opportunities (over 50 in total).	5
Potential to create long-term, local employment opportunities (over 25 in total).	4
Potential to create some long-term employment opportunities and short term local employment opportunity in development phase of treatment component.	3
Neutral employment opportunities; potential to create short term local employment opportunities in development phase of treatment component.	2
Potential to reduce local employment opportunity.	1

e) Occupational Health and Safety (OH&S)

Category explanation: System track record/reputation in OH&S and degree to which OH&S issues have been historically addressed in system design and operating procedures; compliance with legislative provisions.

Social Impact Assessment Criterion: Occupational Health and Safety

Description	Score
System has exemplary track record in OH&S, including external recognition/accreditation of design and/or management elements.	5
System has evidence of exceeding compliance with applicable OH&S provisions in terms of either design and/or management elements.	4
System has evidence of compliance with all applicable OH&S provisions.	3
System has questionable track record on OH&S issues.	2
System has negative track-record in OH&S, including numerous claims.	1

f) Labour Relations

Category explanation: Proponent's track record/reputation in labour relations and degree to which labour relations issues have been historically addressed in management and operational procedures; compliance with legislative provisions.

Note: This category has not been applied in this study which deals with generic systems (as opposed to individual technologies/proponents).

Social Impact Assessment Criterion: Labour Relations

Description	Score
System has exemplary track-record in labour relations, including external recognition of practices.	5
System has evidence of exceeding compliance with applicable labour relations provisions.	4
System has evidence of compliance to all applicable labour relations provisions.	3
System has questionable track record in labour relations.	2
System has negative track record in labour relations, including extensive workplace stoppages and industrial disputes.	1

g) Community Relations

Category explanation: Capacity of proponent to positively engage with community and compliment broader environmental education strategies.

Note: This category has not been applied in this study which deals with generic systems (as opposed to individual technologies/proponents).

Social Impact Assessment Criterion: Community Relations

Description	Score
Very strong potential to foster community relations and social cohesion, e.g. very strong synergy with broader environmental education messages.	5
Strong potential to foster community relations and social cohesion, e.g. very strong synergy with broader environmental education messages.	4
Some potential to foster community relations and social cohesion, e.g. some synergy with broader environmental education messages.	3
Below average potential to foster community relations and social cohesion, e.g. some synergy with broader environmental education messages.	2
Difficult to foster community relations and social cohesion, e.g. weak synergy with broader environmental education messages.	1

6.3 Social Impact Assessment Results

The outcomes from the scoring of the social impacts of each scenario are listed below. Only those criteria that can be assessed at a generic level have been included in the assessment. For the other criteria, assessment can only be made when comparing specific technologies, proponents and/or local circumstances. The criteria not specifically applied in this study (or the *NSW JRG-14* project) include community relations, labour relations and employment as these can only be determined for a specific project. They have been described above to inform of the range requiring consideration in "real life" projects.

Table 6.1: Social Assessment Scores

Social Impact Category	No Garden Organics Collection	Fortnightly Mobile Bin collection	Monthly Tied and Bundled	3 x Yearly Tied and Bundled	MBT [1]	TH [1]
Individual and Family Impacts	4	5	4	4	3	1
Residential Amenity	5	4	3	3	3	3
Householder Convenience	4	3.5	1	0.5	3	3
OH&S	4.5	4	1.5	2	3	3

5… Best; 1…. Worst

[1] Scores unchanged from Nolan-ITU (2003) [5]

The main differences between the scenarios modelled are discussed below:

a) Individual and Family Impacts

The introduction of a garden organics collection service will increase the perception that the local community is provided with an additional opportunity to make a direct contribution to improving the environment.

However, this needs to be balanced against the perceived impacts associated with increased "garbage" collections, i.e. concerns about debris, visual amenity, and other aspects associated with the presentation of waste materials at kerbside, particularly for non-containerised collections.

b) Residential Amenity

The non-introduction of a garden organics service has no additional social impact on a local community and therefore scores highly. When comparing the containerised scenario to the non-containerised scenarios, it should be borne in mind that studies by EcoRecycle Victoria, the Beverage Industry Environment Council and other organisations have confirmed the community's preference for containerised waste management systems. For example, containerised systems minimise potential odour, dust, and debris aspects. However, the containerised scenario modelled here is also of a greater frequency and therefore entails greater truck movements. The more frequent containerised scenario for garden organics collection scores somewhat higher than the less frequent, non-containerised scenarios for garden organics collection.

[5] Note: Nolan-ITU (2003) assessed different recycling systems, AWT systems and combinations but not garden organics.

c) Householder Convenience

The non-garden organics collection scenario scores highest as it provides users with a weekly access to a containerised, waste management service. The introduction of an additional step of source segregation necessarily involves time and effort and therefore scores somewhat lower. Non-containerised systems, particularly those requiring householders to appropriately size, bundle, and tie garden organics have low levels of convenience. Moreover, they presume a particular level of agility and good health on the part of householders in order to participate.

d) Occupational Health and Safety (OH&S)

While there may be some very marginal OH&S gains associated with the diversion of garden organics from waste bins, the non-introduction of a garden organics collection service represents negligible additional impacts and therefore scores highly. The introduction of any additional bins/lifts into a waste management system necessarily increases the probability of OH&S liability and therefore the containerised garden organics collection scenario (involving three overall bins) scores slightly lower. In terms of the non-containerised scenarios, it is fair to say that their OH&S track record is questionable, e.g. particular care would need to be taken in both the preparation of material for presentation and its collection. Therefore, even considering less frequency and hence less probability of injuries, these systems score lower.

e) General

From the standpoint of social impacts, as would be expected, a scenario involving no additional service scores most highly. Beyond that, containerised systems perform better in terms of social impact than non-containerised systems, particularly where householder convenience and OH&S are concerned. This is true notwithstanding frequency of collection.

It should be noted that it is difficult within the social impact assessment to calculate the potential social **benefits** associated with the introduction of a garden organics services. For example, as can be deduced from the recent *Who Cares About the Environment?* research work undertaken by the DEC, some community members undoubtedly place a value on the opportunity to contribute to environmental outcomes, such as the opportunity to source segregate their garden organics. This in turn may contribute to the development of community cohesion and social capital. However, many of these aspects are quite intangible and the valuation/scoring techniques that are available to consider them are not seen as appropriately robust at this point in time. It is difficult, for example, to reasonably cost the value that an individual may put on access to an additional environmental behaviour opportunity versus the value he/she puts on the additional time and effort needed to participate in that behaviour. This would be worthwhile research for the future.

7 Cost Benefit Analysis

This section presents the outcomes of a cost-benefit analysis of scenarios from the perspective of financial and environmental costs (expressed in dollar terms). Social costs have not been determined in dollar terms and hence have not been included here because, as indicated in Section 6, there is insufficient literature and research conducted in Australia that would allow a robust monetary valuation of social factors.

7.1 Source Separation of Garden Organics

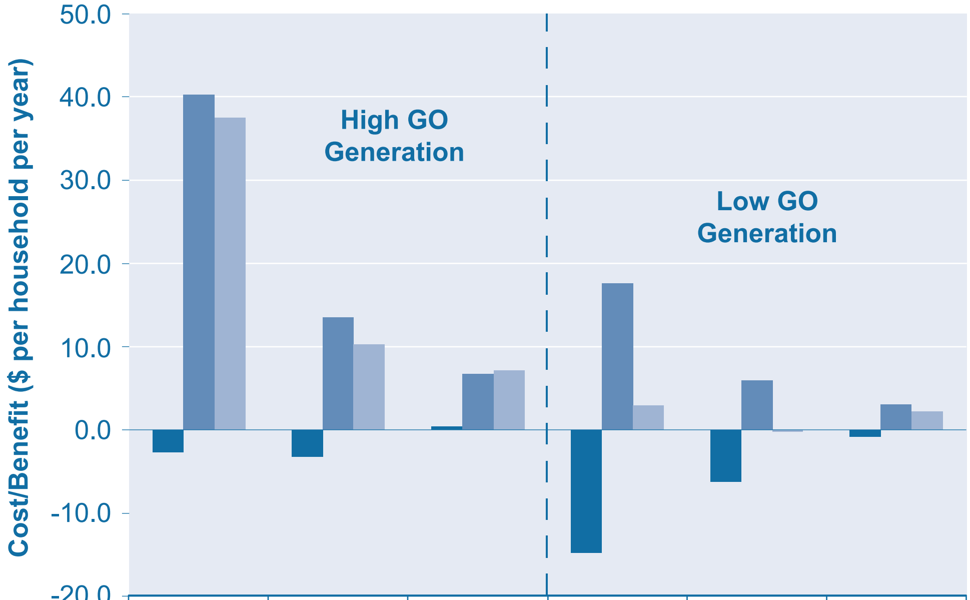
This section discusses the results of the cost benefit analysis for the various garden organics separation scenarios assuming residual waste (garbage) is sent to landfill. It therefore looks at the three different collection systems (fortnightly with container, monthly and three yearly tied and bundled) for the two different situations of either high or low garden organics generation.

Results are shown in Figure 7.1 which presents the financial cost difference of each scenario compared to the base case system with no separate garden organics collection (refer Section 2.1 for description of base case), the environmental benefits over the base case, and the resulting net cost or benefit.

For councils with **high generation** of GO, the net financial costs of GO collection and composting systems are relatively low due to the high avoided garbage collection and disposal costs (refer Section 3). The net overall benefits are by far the highest with a fortnightly GO collection system, followed by the monthly collection which is only marginally cheaper but achieves much lower environmental benefits due to significantly reduced yields. Last comes the three yearly GO collection which basically comes for free (on a net cost basis) but also provides the lowest environmental benefits (due to lowest overall yields).

For councils with a **low generation** of GO, the net financial costs of GO collection and composting systems are higher due to the relatively low avoided garbage collection and disposal costs. The environmental benefits are also substantially reduced due to the relatively low yields. The resulting overall benefits for a fortnightly collection are still higher than with the two other systems but only marginally. Due to the low costs, a three yearly GO collection achieves an almost similar net cost benefit to the fortnightly collection.

Figure 7.1: Cost Benefit Results for Source Separation of Garden Organics



	Fort'ly	Monthly	3/yr	Fort'ly	Monthly	3/yr
Fin$ (Diff)	-2.7	-3.2	0.4	-14.78	-6.21	-0.82
Eco$	40.2	13.5	6.8	17.63	5.93	3.02
Net Cost/Benefit	37.5	10.3	7.1	2.85	-0.29	2.20

7.2 Garden Organics Management in an Integrated System

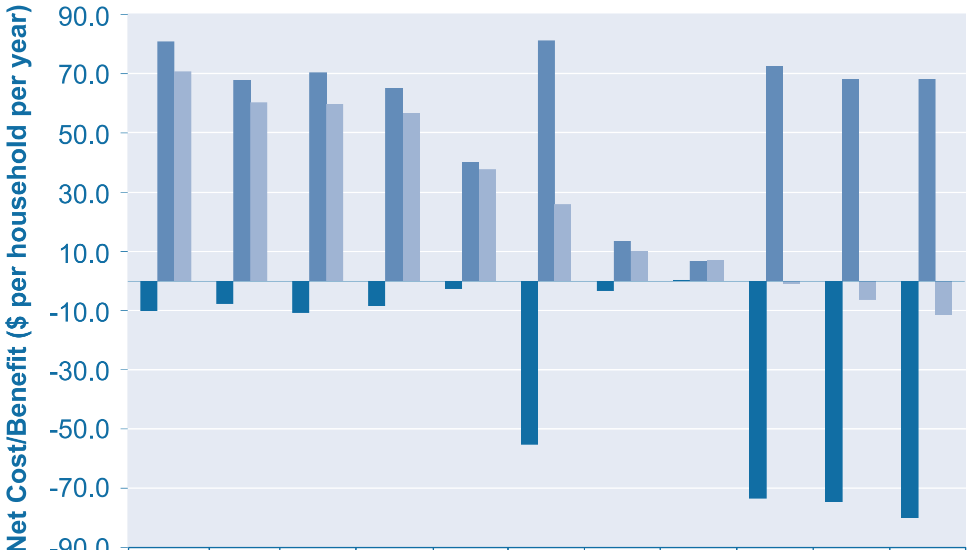
How do GO collection (and composting) schemes rate in an integrated waste management context? In this section, the costs and benefits of GO collection systems are compared to systems that provide alternative waste treatment (AWT) for residual wastes. The assessment also includes relative costs and benefits of systems that combine GO recovery with AWT.

7.2.1 Metropolitan Area, High Garden Organics Generation

Figure 7.2 illustrates the costs, benefits and overall results of the three GO systems in combination with the three (generic) residual waste treatment systems i.e. landfill, MBT and Thermal treatment. In the figure, results are presented from left to right in order from the highest performing scenario to lowest performing. MBT scenarios achieve the highest overall cost benefits, followed by the fortnightly GO collection with residual waste sent to landfill.

Source separation of GO (with fortnightly containerised collection) always achieves the best result regardless of the type of residual waste treatment. However, AWT (residual waste treatment prior to landfilling with no GO recovery) can provide higher environmental benefits than a GO segregation on its own with disposal of garbage to landfill. In combination with the financial costs, MBT only ranks higher than a GO scheme with landfilling of garbage, which ranks higher than a Thermal AWT only system (due to high financial costs).

Figure 7.2: Cost Benefit Results for Metro "High"



	MBT + GO Fortnight	MBT + GO Three	MBT + GO Monthly	MBT Only	LF + GO Fort-nightly	TH + GO Fort-nightly	LF + GO Monthly	LF + GO Three Yearly	TH + GO Monthly	TH + GO Three Yearly	TH Only
Fin$ (Diff)	-10.2	-7.7	-10.8	-8.6	-2.7	-55.3	-3.2	0.4	-73.4	-74.7	-80.0
Eco$	81.0	67.9	70.5	65.3	40.2	81.1	13.5	6.8	72.6	68.4	68.4
Net Cost/Benefit	70.7	60.3	59.8	56.7	37.5	25.7	10.3	7.1	-0.8	-6.3	-11.6

7.2.2 Metropolitan Area, High Garden Organics Generation

Figure 7.3 shows the results for councils with a low GO generation. The results are relatively similar to those from the "high generation" scenarios presented above however, the overall cost benefits of the highest ranking options are around $20 per household per year lower, and the GO recovery scenarios with garbage to landfill are around $35 per household per year lower. In other words this analysis suggests that, in councils with low quantities of garden organics generated, public funds may be more efficiently spent on residual waste treatment than on a separate GO collection scheme.

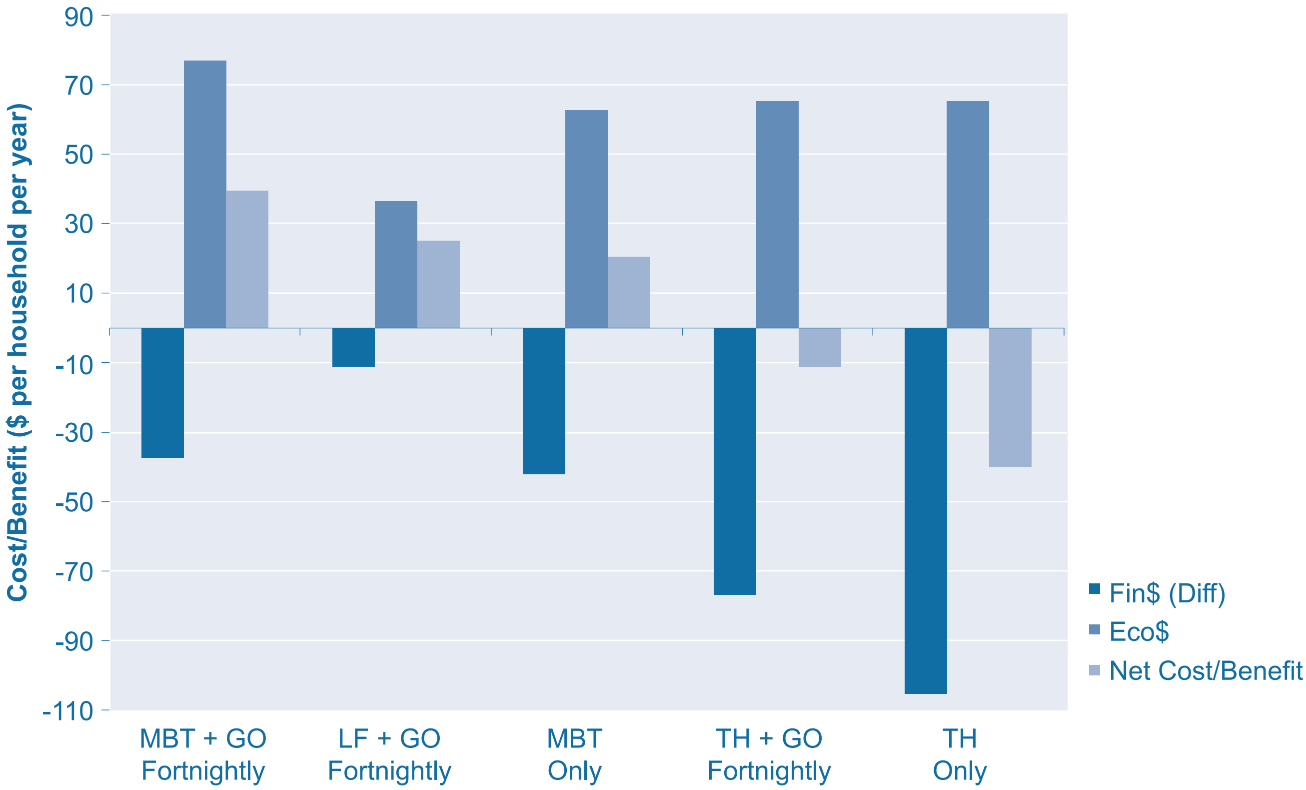
Figure 7.3: Cost Benefit Results for Metro "Low"

	MBT + GO Fortnight	MBT + GO Three	MBT + GO Monthly	MBT Only	LF + GO Fort-nightly	TH + GO Fort-nightly	LF + GO Monthly	LF + GO Three Yearly	TH + GO Monthly	TH + GO Three Yearly	TH Only
Fin$ (Diff)	-7.18	-6.60	-12.35	-19.99	-14.78	-0.82	-6.21	-63.44	-60.24	-61.57	-63.49
Eco$	51.08	49.94	52.22	56.78	17.63	3.02	5.93	56.71	52.08	51.16	51.16
Net Cost/Benefit	43.90	43.34	39.87	36.79	2.85	2.20	-0.29	-6.73	-8.16	-10.42	-12.33

7.2.3 Regional/Rural Councils

As discussed elsewhere in this report, rural councils were considered to have a high generation of garden organics. Figure 7.4 depicts the results of the cost benefit analysis for councils in a regional/rural setting. Although the general trend is not dissimilar to that for metropolitan councils, the separate collection and composting of GO appears even more efficient than in metropolitan areas. The reason for this is the significant difference in landfill disposal costs and lower GO processing costs. As landfill disposal is much cheaper in regional NSW, the marginal cost of moving to an AWT facility is much more significant. In an overall cost benefit appraisal it is therefore not surprising that GO recovery systems in combination with landfill ranked higher than MBT or Thermal residual waste treatment alone (i.e. without separate GO recovery).

Figure 7.4: Cost Benefit Results for Regional/Rural Councils



8 Multi-Criteria Assessment

Waste management planning and decision-making typically involves assessing a wide range of alternatives and numerous evaluation criteria. When public authorities seek a waste management solution there may be dozens of combinations of sites, collection systems and treatment technologies to choose from and a number of criteria by which to compare alternatives. When confronted with such an array of alternatives and criteria, it becomes difficult to sort, analyse, prioritise and make choices without the assistance of a tool or technique. To complicate matters, decisions on waste management issues often involve different stakeholder groups, the public, political considerations and are often controversial.

The project team selected Multi-Criteria Assessment (MCA) as its basis for conducting the final integrated assessment of the selected scenarios. MCA techniques have a strong reputation as a decision-making support tool in the environmental management arena.

MCA techniques have the advantage that they can be used to assess alternatives using criteria that have different units (e.g. $, tonne, kilometre, etc). This is a significant advantage over traditional decision aiding methods, for example cost-benefit analysis, where all criteria need to be converted to a single unit (e.g. dollars). Some MCA techniques also have the capacity to analyse both quantitative evaluation criteria as well as qualitative evaluation criteria (e.g. yes/no, pluses and minuses, ordinal ranking).

For this project this was particularly relevant as, on the one hand, economic valuation of the financial and environmental performance of the different scenarios was determined in dollar terms while, on the other hand, an ordinal based scoring system was used to assess the technical and social performance of the different scenarios.

8.1 Methodological Background

There are numerous multi criteria assessment techniques available, each of these varying on their suitability depending on the type of data that needs to be assessed (quantitative or qualitative or both) and the outputs generated.

For the purpose of this report, and in accordance with the technique developed for the *Alternative Waste Treatment Technologies Handbook and Assessment Tool* (DEC; 2003b), two alternative multi criteria assessment techniques are used: Additive Weighting and Concordance Analysis. The application and basis for these techniques are discussed below.

Additive Weighting is one of the simplest multi criteria assessment techniques. It involves four principal steps as follows:

Step 1: Derive an effects matrix that scores each alternative against each criterion;

Step 2: Standardise the scores in the effects matrix to a value between 0 and 1 (standardised matrix);

Step 3: Multiply the standardised scores by the criteria weights (weighted matrix);

Step 4: Sum the weighted criteria to obtain an overall score for the alternative.

It should be noted there is one significant shortfall of additive weighting techniques namely, it is not suitable where ordinally scaled data (i.e. ranks, good-bad, etc.) is used, in particular where the ordinally scaled data provides no indication of the relative numerical difference between alternatives.

Using **Concordance Analysis**, each alternative is compared against each other alternative on a pair-wise basis. Concordance analysis has the advantage that comparison of alternatives can be made where the set of criteria includes examples of each of the data scales listed above.

For each pair of alternatives (e.g. fortnightly mobile bin collection versus monthly tied and bundled) the score for each criterion for Alternative 1 is compared against the corresponding score for each criterion for Alternative 2.

Criteria weights are assigned to the alternative that outperforms the other. Concordance indices are then calculated which represent the sum of the weights of the criteria for which the alternative scores better than the other. Finally the indices are divided by the sum of all the weights.

Care must be taken when applying concordance analysis. An alternative may be superior to another in all criteria except one (e.g. cost). Concordance assessment does not provide any indication as to how badly the alternative performs for that criterion however, and the poor performance against that criterion may override other considerations. Methods for addressing this can include specifying acceptable ranges that alternatives have to fall within under various criteria, e.g. cost ranges, adherence to relevant environmental emission standards, etc.

The weights that were determined through the consultative process for the NSW JRG-14 project (Nolan-ITU; 2003) have been applied to the MCA. For subcriteria not applicable to this study (e.g. “labour relations”), the weightings of the remaining subcriteria have been adjusted so their total equals the weighting of the main criterion (e.g. “social”). Adjusted weights are presented in Table 8.1.

Table 8.1: Weights for Criteria Used

Main Criteria	Subcriteria	Adopted Weight	
		Community	Local Government
Financial	System Cost	18.1%	31.8%
Environmental	Greenhouse Gases	8.0%	4.0%
	Air Pollution	11.3%	6.0%
	Water Pollution	12.3%	7.2%
	Resource Conservation	10.9%	8.1%
Technical	Flexibility in Feedstock Quality	2.7%	3.7%
	Modularity of System	3.0%	3.1%
	Process Control	1.7%	2.1%
	Efficiency in Waste Reduction	4.0%	6.1%
	Operational Reliability	3.0%	6.3%
	Alignment with State Government Policy	1.2%	3.5%
Social	Individual and Family Impacts	9.7%	3.6%
	Residential Amenity	5.1%	5.1%
	Householder Convenience	7.0%	5.5%
	OH&S	1.9%	3.8%
	Total	**100.0%**	**100.0%**

Due to the limited amount of data from regional areas with the associated uncertainty, the MCA has not been performed for regional settings. It is recommended to consider the options performance as per Cost-Benefit Analysis (refer Section 7), and to perform an MCA only based on the situation in a specific council (or group of councils) area.

8.2 'Technical' Scores

In the consultative part of the *NSW JRG 14* project, weightings were also elicited for technical parameters. Some of these parameters such as maturity of technology/reference facilities and staff requirements have not been built into the MCA as these are specific to individual technologies and can therefore only be considered in a tendering process and not in a study assessing generic technology categories. For the remaining parameters, scores have been assigned to the options assessed. These are provided in Table 8.2. A brief explanation is given below.

Table 8.2: Technical Scores

Criterion	Base LF	MBT Only	Base TH	LF + GO	MBT+ GO	TH + GO
Flexibility in Feedstock	5	3	3	5	3	3
Modularity	1	3	2	1	3	2
Process Control	1	3	4	1	3	4
Efficiency in Waste Reduction	1	3	5	3	4	5
Operational Reliability	5	3	3	5	3	3
Alignment with Government Policy	1	3	3	4	4	4

5…. Best; 1…. Worst

Differences in the technical scores occur mainly between different residual waste treatment systems because collection and composting of GO is a standard technique which does not increase or reduce the technical performance of the overall system. Only in the criterion "Alignment with Government Policy", separate GO systems have been given a higher score as source separation is seen as preferable under the NSW *Waste Avoidance and Resource Recovery Strategy* (Resource NSW; 2003).

Flexibility in Feedstock: In general, MBT and thermal technologies can accept a similar range of input material. Therefore all options are given an equal score except for landfill which can accept a wider range of materials.

Modularity: MBT facilities are more modular – can be established for smaller throughputs (>20,000 tonne per year) – than thermal facilities (>80,000 tonne per year). Landfills are the least 'modular'.

Process Control: Thermal facilities have higher levels of process control than MBT facilities. Landfills have lowest level ('process control' over decades).

Efficiency in waste reduction: Thermal facilities produce less residues than MBT. Landfills do not reduce waste. Option B has highest level of material recovery, Option D lowest (insignificant for thermal scenarios).

Operational reliability: Landfills cannot 'completely fail' at an operational level. It is possible that some fail to provide the necessary environmental safeguards however there is a very low risk of a major breakdown which would prevent waste disposal. For waste processing facilities, this risk is higher. MBT and Thermal score equally, with Options A (single bin, mixed waste sorting prior to further processing) showing a lower score because operational reliability remains to be proven. Option D ranks lowest due to difficulties with contamination in MRFs.

Alignment with Government policy: Landfill is ranked lower, whilst MBT and Thermal score equally as State Government policy has not expressed a preference for either technology on this issue. As indicated above, separate GO schemes have been assigned a higher score due to the Government's preference for source separation.

8.3 Results

8.3.1 Community Preferences

Table 8.3 shows the rankings of all options assessed for both the concordance and the additive weighting analyses when the average weightings of the community are applied. The inherent differences between the two methodologies lead to rankings that are not identical however, clear trends become apparent:

- A fortnightly collection of garden organics is the preferable option;
- This can occur either in combination with an MBT facility or a landfill for residual waste (garbage); and
- Collections with low frequency and/or in combination with thermal residual waste treatment rank generally lower.

Table 8.3: Scenario Rankings using Community Weightings

Rank	Concordance	Additive Weighting
1	LF + GO Fortnightly	MBT + GO Fortnightly
2	MBT + GO Fortnightly	LF + GO Fortnightly
3	MBT + GO Monthly	MBT + GO Monthly
4	LF Only	MBT + GO Three Yearly
5	MBT + GO Three Yearly	MBT Only
6	TH + GO Fortnightly	LF Only
7	TH + GO Monthly	TH + GO Fortnightly
8	MBT Only	LF + GO Monthly
9	LF + GO Monthly	LF + GO Three Yearly
10	TH + GO Three Yearly	TH + GO Monthly
11	LF + GO Three Yearly	TH + GO Three Yearly
12	TH Only	TH Only

8.3.2 Local Government Preferences

Table 8.4 shows the rankings when the weightings of the NSW councils participating in the survey undertaken for the *NSW JRG-14* project are applied. Landfill for residual waste in combination with fortnightly collection of garden organics is the highest ranking system. The greater emphasis by Local Government on financial performance pushed the "Landfill Only" scenario in the concordance analysis (where the absolute difference between costs is irrelevant) to second place whereas, for the additive weighting, MBT options with separate GO collections are ranked second and third.

Table 8.4: Local Government Options Ranking

Rank	Concordance	Additive Weighting
1	LF + GO Fortnightly	LF + GO Fortnightly
2	LF Only	MBT + GO Fortnightly
3	LF + GO Three Yearly	MBT + GO Three Yearly
4	MBT + GO Fortnightly	MBT + GO Monthly
5	LF + GO Monthly	LF Only
6	MBT + GO Three Yearly	MBT Only
7	MBT + GO Monthly	LF + GO Monthly
8	MBT Only	LF + GO Three Yearly
9	TH + GO Fortnightly	TH + GO Fortnightly
10	TH + GO Monthly	TH + GO Monthly
11	TH + GO Three Yearly	TH + GO Three Yearly
12	TH Only	TH Only

9 Conclusions and Recommendations

Garden Organics Recycling and Waste Data

Typical garden organics diversion rates for three alternative collection scenarios have been estimated for representative metropolitan and rural NSW councils based on collation and assessment of recent studies and survey work. Results are summarised in Table 9.1.

Table 9.1: Quantities of Collected Garbage, Garden Organics and Recyclables for Alternative Garden Organics Management Options (kilograms per household per year)

Stream	Metropolitan						Rural
	High GO Generation			Low GO Generation			
	Fort'ly MGB	Monthly Tied and Bundled	3 x Yearly Tied and Bundled	Fort'ly MGB	Monthly Tied and Bundled	3 x Yearly Tied and Bundled	Fort'ly MGB
Garbage	601	835	894	579	682	707	525
Garden Organics Diverted	351	117	59	154	51	26	318
Recyclables Diverted (including contamination)	237	237	237	237	237	237	195
Total	1,189	1,189	1,189	970	970	970	1,038

Garden organics diversion increases with increasing frequency of collection and when a receptacle is provided (receptacles enable capture of grass clippings, leaves, etc).

Financial Performance

In metropolitan areas, while the costs of providing a separate garden organics collection system varies from $0 per household per year (no service) to $45 per household per year (fortnightly 240 litre mobile bin collections), when considering the *total* waste management system costs, the increase in total costs for providing garden organics collections are less than $5 per household per year (in areas of high garden organics generation) and less than $15 per household per year (in areas of low garden organics generation), assuming landfill disposal of domestic garbage.

As the cost of garbage treatment/disposal increases (through MBT and/or thermal treatment) the *net* cost of garden organics collection reduces (i.e. the (higher) *avoided* costs of garbage treatment makes garden organics management cheaper). For some collection scenarios modelled (e.g. where garbage is thermally treated), the provision of a separate garden organics collection service *reduced* overall waste management costs.

Estimated garden organics management costs modelled in this study are consistent with costs derived from the recently completed *Study of Local Government Management Costs for Garden Organics* (DEC; 2003a).

Estimated total waste management system costs are consistent with average domestic waste management charges as surveyed annually by the Department of Local Government (2003) when accounting for ancillary costs such as administration, education and other waste management services offered (i.e. clean up collections, drop-off, street sweeping and litter).

Regional/rural garden organics management costs are typically cheaper than metropolitan systems due mainly to the lower cost of processing ($44 per tonne in metropolitan areas versus $14 per tonne in rural areas).

Environmental Performance

The environmental value of garden organics recycling is estimated to be Eco$114 per tonne of source-separated garden organics. This value is comprised of *resource savings* as well as the full range of environmental impact categories associated with avoided product credits, including air and water pollution and global warming potential. The estimate is based on extensive data analysis using the method of life cycle assessment and environmental economic valuation. The contribution of the various aspects is listed in Table 9.2.

The estimated environmental value of $114 per tonne is conservative. An expanded valuation, conducted to account for some of the known data gaps, yielded an environmental value of garden organics recycling of $277 per tonne.

Table 9.2: The Environmental Value of Compost ($ per tonne source-separated garden organics)

Life Cycle Aspect	Value (Eco$ per tonne source-separated garden organics)
Composting process emissions	- $0.64
Collection	- $7.61
Compost application benefits	$40.50
Compost transport	- $0.57
Net avoided landfill emissions	$82.53
Net Benefit	**$114.21**

Table 9.3 summarises the environmental benefits of the systems assessed as a single indicator i.e. after the environmental economic valuation, expressed in “Eco$”.

For the metropolitan high garden organics scenarios, environmental benefits amount to approximately:

- Eco$40 per household per year for a separate fortnightly containerised GO collection for the Garbage to Landfill Scenario;
- Eco$14 per household per year for a monthly GO collection, and Eco$7 for a three yearly collection for the Garbage to Landfill Scenario;
- Between Eco$65 and Eco$70 per household per year if no garden organics collection service is provided but the garbage is sent to an alternative waste treatment facility (“MBT Only” and “TH Only”);
- Up to Eco$16 per household per year for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

For the metropolitan low garden organics scenarios, the benefits amount to approximately:

- Eco$18 per household per year for a separate fortnightly containerised GO collection for the Garbage to Landfill Scenario;
- Eco$6 per household per year for a monthly GO collection, and Eco$3 for a three yearly collection for the Garbage to Landfill Scenario;
- Eco$50 per household per year if no garden organics collection service is provided but the garbage is sent to a treatment facility ("MBT Only" and "TH Only");
- Up to Eco$7 per household per year for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

For the regional/rural scenarios, the benefits amount to approximately:

- Eco$37 per household per year for a separate fortnightly containerised GO collection for the Garbage to Landfill Scenario;
- Between Eco$62 and Eco$66 per household per year if no garden organics collection service is provided but the garbage is sent to a treatment facility ("MBT Only" and "TH Only");
- Up to Eco$16 per household per year for the introduction of a garden organics collection service for the Garbage to MBT or TH Scenarios.

Table 9.3: Summary of Environmental Benefits of Systems (Eco$ per household per year)

Collection System	High GO Generation			Low GO Generation		
	LF	MBT	TH	LF	MBT	TH
Metropolitan						
No collection	$0	$65	$68	$0	$50	$51
Fortnightly	**$40**	$81	$81	$18	$57	$57
Monthly	**$14**	$71	$73	$6	$52	$52
Three yearly	**$7**	$68	$70	$3	$51	$52
Regional/Rural						
No collection	$0	$62	$66			
Fortnightly	**$37**	$78	$78			

Sensitivity and Expanded Valuation

For this study, an attempt has been made to identify any potential cause of bias in the results. Such bias is likely to arise from data gaps, differences in data quality or from limitations in the method due to the scope of the study.In order to understand the impact of any bias on the findings, a qualitative valuation has been made of the *probable* cost benefit that might be expected if the main causes of bias were removed.

The results of this expanded valuation show substantially higher benefits for garden organics recycling compared to the base assessment: Eco$277 per tonne of garden organics collected instead of Eco$114 per tonne, or approximately Eco$110 per household per year instead of Eco$40 per household per year.

Peer Review

A peer review of the environmental assessment component of this study has been has conducted by Mr Tim Grant from RMIT Centre for Design. He has been consulted during the course of setting up the framework for this assessment, and undertook the peer review on completion of the draft report.

Cost Benefit Analysis

When combining the financial costs of domestic waste management scenarios with the environmental costs and benefits expressed in dollar terms, the *overall net economic cost benefits* for the introduction of a separate GO collection system (assuming garbage is sent to landfill) are as follows:

*Councils with **high** GO Generation rates:*

- Fortnightly collection $37.5 per household per year
- Monthly collection $10.3 per household per year
- Three yearly collection $7.1 per household per year

*Councils with **low** GO Generation rates:*

- Fortnightly collection $2.9 per household per year
- Monthly collection ($0.3) per household per year
- Three yearly collection $2.2 per household per year

This CBA highlights the significance of actual garden organics quantities generated. For councils with a high GO generation rate, the introduction of a containerised GO system provides substantial net benefits. For councils with a low GO generation rate, it may not be warranted to implement a frequent containerised collection system as an infrequent (three yearly) tied and bundled service achieves similar overall benefits (which are also not substantial).

When combining garden organics collection services with alternatives for residual waste disposal (i.e. AWT), a combination of MBT and a fortnightly GO service provides the highest benefits. This is mainly due to the avoided landfill emissions when only stabilised material is being disposed of. For councils with a low GO generation rate, a single MBT facility without the provision of a separate GO service achieves equivalent benefits to a scenario where GO are collected separately.

For councils in regional/rural NSW, the assessment shows similar results. The three highest ranking options under the CBA are:

1. MBT + fortnightly GO collection
2. Landfill + fortnightly GO collection
3. MBT only.

The cost benefit assessment has used the 'base' figures from the environmental assessment. Using the figures of the expanded valuation obviously increases the overall benefits substantially however, the proportions between residual waste treatment and garden organics recycling remain roughly the same.

Multi-Criteria Assessment

All scenarios were assessed through both concordance and additive weighting multi criteria analysis methodologies. Although the issues surrounding the application of different methodologies, particularly when assessing 42 scenarios, are highly complex, some clear trends become apparent. These are summarised in Table 9.4 and discussed below.

- For councils with a high GO generation rate, the introduction of a fortnightly collection of GO always ranks highest, regardless of methodology or weightings applied.
- The treatment of residual waste in a MBT facility ranks highly, mainly due to the relatively small increase in costs and the substantial environmental benefits achieved.
- For councils with a low GO generation rate, the introduction of a frequent and containerised GO collection service does not provide significant benefits. If such councils intend to improve their 'Triple Bottom Line', they may wish to consider sending their garbage (including the (small) quantities of garden organics) to an MBT facility.

Table 9.4: Highest Ranking Options from Different Approaches (High GO generation)

Rank	Cost Benefit Analysis	Multi Criteria Assessment			
		Community Weightings		Local Government Weightings	
		Concordance	Additive Weighting	Concordance	Additive Weighting
1	MBT + **GO Fortnightly**	LF + **GO Fortnightly**	MBT + **GO Fortnightly**	LF + **GO Fortnightly**	LF + **GO Fortnightly**
2	MBT + GO Three Yearly	MBT + GO Fortnightly	LF + GO Fortnightly	LF Only	MBT + GO Fortnightly
3	MBT and GO Monthly	MBT + GO Monthly	MBT + GO Monthly	LF + GO Three Yearly	MBT + GO Three Yearly

Recommendations

Based on the outcomes of this integrated triple bottom line assessment of garden organics management options, it is recommended that:

- Councils with a high rate of garden organics generation (175 kilograms per household per year or more) introduce a fortnightly, containerised garden organics collection and composting system as this will be a significant step towards a more sustainable resource management system.
- Councils with a low generation of garden organics (175 kilograms per household per year or less) also achieve sustainability benefits however, these are much smaller than for councils with a high garden organics generation rate. It is recommended that such councils introduce a three times yearly tied and bundled collection which will provide similar overall benefits as a fortnightly containerised collection.
- All councils consider the introduction of residual waste (garbage) treatment processing to capture the substantial sustainability benefits which can be achieved MBT systems achieve higher overall economic benefits. However, there are still significant additional benefits to be achieved by also introducing a separate garden organics collection system where a council area does generate large quantities of garden organics.
- Research in the following areas continue to be supported to increase the currently limited knowledge of environmental benefits of organics recycling and composting:
  - Identification and quantification of long term benefits of recycled organics application to soils, looking at a variety of crops;
  - Inclusion and assessment of benefits of food waste separation and composting;
  - Further quantification and determination of carbon sequestration through compost application in different soils, and under different agricultural regimes;
  - Enabling further scientific work in the area of valuation of environmental costs and benefits across a larger spectrum of impact categories and pollutants; and
  - Environmental economic valuation of water for specific locations/areas within the country.
- A State-wide policy be developed addressing the treatment of residual wastes either through MBT, Hybrid Technologies or combinations of MBT and thermal treatment as well as procedures for the assessment of emerging technologies.
- The performance of new waste technologies be monitored and confirmed as they are commissioned and over the operating life.
- A decision support framework for waste technologies and waste management systems be developed and promoted for use on a case-by-case basis that is transparent, user-friendly, and rigorous.

10 References

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Nolan-ITU and Access Economics (2002): *Organic Waste Economic Values Analysis*; for the Department of Industry and Trade, Environment Protection Agency.

Nolan-ITU and SKM Economics (2001), *Independent Assessment of Kerbside Recycling in Australia*, Final Report, Volume 1, prepared for National Packaging Covenant Council, January 2001.

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Resource NSW (2003): *NSW Waste Avoidance and Resource Recovery Strategy*.

RMIT and Nolan-ITU (2003), *Life Cycle Assessment of Waste Management Options in Victoria*, for EcoRecycle Victoria.

US Government (1994), *Interorganizational Committee – US Department of Commerce, National Oceanic and Atmospheric Administration, and National Marine Fisheries Service – Guidelines and Principles for Social Impact Assessment*, May 1994.

World Wide Fund for Nature (WWF) – Australia, Australian Conservation Foundation (ACF), Nature Conservation Council of NSW (NCC), Inland Rivers Network (undated), Joint submission to the Independent Pricing and Regulatory Tribunal (Bulk Water Pricing: 2001/02 – 2003/04).

Appendix A: Details of Environmental Assessment Methodology

Methodology Overview

The environmental assessment sought to identify and **value** the environmental impacts of organic waste recovery and open windrow composting to enable an integrated assessment of management options for municipal waste. The assessment required application and modelling of existing Life Cycle Assessment (LCA) data, based on a detailed understanding of waste management systems in Australia. Consideration was given to the entire waste collection system and to the avoided product systems associated with technology residues.

The environmental assessment has included goal and scope definition, development and application of life cycle assessment data and environmental economic valuation of impacts.

Goal and Scope of the Life Cycle Assessment

a) Goal

The goal of this LCA is to provide a transparent environmental assessment of source-separated garden organics collection and composting, within the context of treatment for municipal solid waste. The analysis is to give regard to practical collection options and average conditions within metropolitan New South Wales.

b) Functional Unit

The functional unit for the study is defined as the management of typical MSW per household per year. The scenarios considered include source-separated garden organics collection followed by open windrow composting. For practical purposes, the scenarios are analysed per household. For broader consideration, the data is examined on a per tonne basis.

c) System boundaries for the study

The system boundary for the study begins at the point of waste generation (i.e. the doorstep of the household). It includes transport impacts, sorting, processing through the selected waste management technology options and then processing or disposal of any residual material. All process energy, including energy of extraction is included.

Application of LCA Data

Life Cycle Inventory data was acquired from a range of data sources. This data was reviewed and benchmarked for anomalies and the most suitable data sets were applied to the waste and recycling system. The commercial LCA software tool, SimaPro was used to apply LCA data to the systems studied.

Impact Assessment and Environmental Economic Valuation.

Once the inventory data was modelled for each of the systems under study, it was aggregated into more meaningful indicators by classification of inventory loads into the environmental impact groups and then assigned economic values. Existing environmental economic values were used from:

- Nolan-ITU and SKM Economics (2001), *Independent Assessment of Kerbside Recycling in Australia*, for National Packaging Covenant Council.
- Nolan-ITU and Access Economics (2002), *Organic Waste Economic Values Analysis; for Department of Industry and Trade*, Environment Protection Agency.
- DEC (2004), *Assessment of Alternative Domestic Waste and Recycling Systems*, NSW Jurisdictional Recycling Group and Publishers National Environment Bureau.

Pollutant loads within impact categories have been assigned monetary values based on environmental economic values within published government reports and the use of LCA equivalence factors. Equivalence factors are used as part of life cycle impact assessment to assign impacts based on the relationship between inventory loads within an impact category.

Environmental economic valuation is increasingly used for decision support throughout the world. The quantification of externalities using a rigorous Life Cycle approach has the support of peak bodies including the Directorate General for Research, of the European Commission. The group has spent a decade applying the same approach in valuing the externalities of energy use through the European Reseat Network as part of the ExternE project.

The Member of the European Commission, responsible for Research states, in regard to this work, has stated that:

> **"The assessment of externalities answers a social demand and this European research should help to lay down the basis for improved energy and transport policies."**
>
> *Philippe Busquin, External Costs (2003) Forward, European Commission EUR20198*

Environmental economic valuation however remains a controversial methodology in some scientific communities. Reasons cited for this include the perception of certainty that a final valuation implies and monetisation of some non tangible impacts[6].

[6] International Expert Group for Life Cycle Assessment and Solid Waste Management (meeting No 5 May 2001) London.

Data Sources

Table A.1 lists the main data sources for the environmental assessment.

Table A.1: LCA Inventory Data Sources

System	Data Sources
Garden organics collection and processing	• RMIT and Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria. • Eunomia Research and Consulting (2002) Economic Analysis of Options for Managing Biodegradable Municipal Waste, European Commission. • Nolan-ITU and Access Economics (2002) Organic Waste Economic Values Analysis; Department of Industry and Trade, Environment Protection Agency. • Nolan-ITU, 1998. Biowaste Processing Life Cycle Assessment and Environmental Valuation (Proposed Enclosed Biowaste Processing Facility at Lucas Heights) Waste Service NSW and the Southern Sydney Waste Board.
Materials Recycling	• DEC (2004): Assessment Of Alternative Domestic Waste and Recycling Systems, NSW Jurisdictional Recycling Group and Publishers National Environment Bureau. • RMIT and Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria. • Nolan-ITU and SKM Economics (2001): Independent Assessment of Kerbside Recycling in Australia. • Eco Recycle Victoria (2001): Stage 1 and 2 Report for Life Cycle Assessment for Paper and Packaging Waste Management Scenarios in Victoria. Melbourne. For Eco Recycle Victoria. • CRC WMPC (1998): Life Cycle Inventories for Transport, Energy and Commodity Materials.
Collection	• DEC (2004): Assessment Of Alternative Domestic Waste and Recycling Systems, NSW Jurisdictional Recycling Group and Publishers National Environment Bureau. • Nolan-ITU and SKM Economics (2001): Independent Assessment of Kerbside Recycling in Australia. • CRC WMPC (1998). Life Cycle Inventories for Transport, Energy and Commodity Materials. • Eco Recycle Victoria (2001) Stage 2 Report for Life Cycle Assessment for Paper and Packaging Waste Management Scenarios in Victoria. Melbourne.
Transport	• Eco Recycle Victoria (2001) Stage 2 Report for Life Cycle Assessment for Paper and Packaging Waste Management Scenarios in Victoria. Melbourne. • Australian Greenhouse Office, Greenhouse Inventory Update.

Landfill	• RMIT and Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria. • Nolan-ITU (2002) Decision Support System for the Assessment of Integrated Resource Recovery System, Western Australian Municipal Association. • NSW EPA (2003) Alternative Waste Treatment Technologies Assessment Methodology and Handbook.
MBT – aerobic	• RMIT and Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria. • Nolan-ITU (2002) Decision Support System for the Assessment of Integrated Resource Recovery System, Western Australian Municipal Association. • RMIT and Nolan-ITU (2003): Life Cycle Assessment of Waste and Resource Recovery Options (including energy from waste). • Published industry data.
MBT – anaerobic	• Nolan-ITU (2002) Decision Support System for the Assessment of Integrated Resource Recovery System, Western Australian Municipal Association. • RMIT and Nolan-ITU (2003): Life Cycle Assessment of Waste and Resource Recovery Options (including energy from waste). • Eriksson, O., Björklund, A. (2002) Municipal Solid Waste Model.
Thermal technologies	• RMIT and Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria. • Nolan-ITU (2002) Decision Support System for the Assessment of Integrated Resource Recovery System, Western Australian Municipal Association. • RMIT and Nolan-ITU (2003): Life Cycle Assessment of Waste and Resource Recovery Options (including energy from waste). • Finnveden et al. (2002) Energy from waste. • SimaPro Inventory Data.
Paper	• Finnveden et al. (2002): Energy from waste. • Published industry data. • Grant et al (2001): Stage 1 and 2 Report for Life Cycle Assessment for Paper and Packaging Waste Management Scenarios in Victoria. Melbourne. For Eco Recycle Victoria.

Peer Review

A peer review of the environmental assessment component of this study has been has conducted by Mr Tim Grant from RMIT Centre for Design. He has been consulted during the course of setting up the framework for this assessment, and undertook the peer review on completion of the draft report.