Getting more from our recycling systems

Assessment of domestic waste and recycling systems

Final report

recycling systems

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Disclaimer

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Executive Summary

Introduction

At present, a significant debate is occurring in waste management and recycling circles with regard to 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;
- On-going 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.

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

The project is designed to achieve the following objectives:

1. The establishment of a contemporary data set on the operational performance of six waste / recyclables collection scenarios (as specified by the brief), including recovery rates, quality rates, market values, and financial costs.
2. An integrated assessment of the full technical, financial, environmental and social costs and benefits of six waste / recyclables collection scenarios;
3. An integrated assessment of each of the six collection scenarios in a mechanical-biological waste treatment situation and a thermal waste treatment situation for both metropolitan and regional situations;
4. Insights into the sustainability-based performance of different scenarios vis-à-vis specific material streams, particularly paper and cardboard;
5. Application of the NSW Department of Environment and Conservation's (DEC) Waste Technology Assessment Methodology; and
6. Stakeholder appreciation and ownership of project objectives, methodology, and outcomes.

Collection systems analysed

The six kerbside collection systems analysed in this study are summarised in Table I.

Table I: Collection system configurations assessed

Scenario	Domestic Garbage		Kerbside Recyclables		
	Receptacle	Frequency	Receptacle	Frequency	Materials Collected
Baseline	120 L MGB	Weekly	240 L MGB	Fortnightly	Commingled containers and paper/cardboard
Scenario A	240 L MGB	Weekly	-	-	-
Scenario B	120 L MGB	Weekly	120 L MGB	Fortnightly	Commingled containers
			120 L MGB	Fortnightly	Paper/cardboard
Scenario C	120 L MGB	Weekly	240 L MGB	Fortnightly	Commingled containers only (no paper/cardboard)
Scenario D	240 L MGB split	Weekly	240 L MGB split	Weekly	Commingled containers and paper/cardboard
Scenario E	120 L MGB	Weekly	Crate	Weekly	Commingled containers
			Crate	Weekly	Paper/cardboard

Each system was separately analysed assuming collected domestic garbage is processed at a Mechanical Biological Treatment (MBT) facility and at a Thermal treatment facility. For comparison purposes, an analysis was also conducted for the base case system configuration assuming collected domestic garbage is disposed to landfill. For the single bin system (Scenario A), recyclables recovery is assumed to be achieved via a front end sorting facility (recyclable materials are recovered from the incoming mixed waste stream through sorting) for collected domestic garbage prior to biological or thermal processing.

Current kerbside recycling system performance

To determine the relative performance of different kerbside collection configurations, the latest available recycling and waste generation information was collated from a number of references. Of the six domestic waste management collection scenarios considered in this study, and based on the latest available recycling and waste generation data, recyclables diversion is highest for the kerbside recycling system employing fortnightly collection of commingled containers in an MGB and fortnightly collection of paper cardboard in a separate MGB. Relatively high yields are also achieved through fully commingled recycling collections and also through crate systems (which have the lowest contamination rates). Figure I shows the average performance of kerbside recycling systems in NSW according to latest available data, with Baseline, B, D and E currently in place throughout NSW. The contamination shown is that caused by the incorrect disposal of a waste material in the recycling container by the household.

Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**

Scenario A – Single Bin **Scenario D – 1 Split Bin**

Scenario B – 3 Bin System **Scenario E – Bin & Crates**

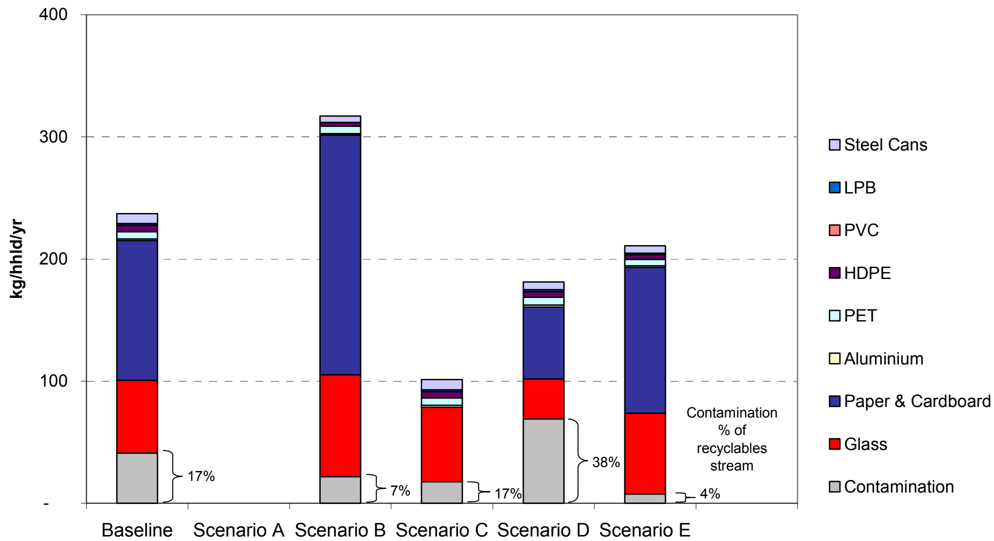


Figure I: Performance of kerbside recycling systems

Financial assessment

The estimation of the costs for collection, sorting and material delivery for the different systems was made using the *Australian Waste and Recycling Cost Model* developed by the Cooperative Research Centre for Waste Management and Pollution Control in association with EcoRecycle Victoria and Recycle 2000 to allow organisations to evaluate existing and alternative collection systems to see the effect they have on yields and costs.

A summary of the results is presented in Table II. 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 and recyclables collections as well as administration, education and other waste management services offered by Councils (e.g., garden organics collections, clean up collections, drop-off, street sweeping and litter). By comparison, the estimated *cost* of the base case service modelled in this study for kerbside garbage and recyclables is $171, which is $48 less than current average charge. The difference between the base case waste management *costs* estimated here and the waste management charge is attributable to provision of ancillary waste management services.

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 base case service modelled in this study is $119, which is $40 less than current average charge.

Table II: Summary of estimated waste collection, transport and disposal/processing costs

System Component	*Base Case – Landfill*	Base Case	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
Total system costs ($ per Household per Year)							
Metropolitan – MBT	*$171*	$178	$182	$178	$182	$179	$183
Metropolitan – Thermal	*$171*	$233	$255	$227	$247	$241	$240
Regional / Rural – MBT	*$119*	$153	$152	$163	$151	$141	$160
Regional / Rural– Thermal	*$119*	$205	$218	$207	$213	$190	$211

In metropolitan areas, the estimated cost of domestic garbage and recycling including MBT waste treatment of the garbage stream varied between $178 and $183 per household per year for the six scenarios investigated. For systems involving thermal treatment of collected domestic garbage, estimated costs varied between $227 and $255 per household per year.

In regional/rural areas, the estimated cost of domestic garbage and recycling including MBT waste treatment of the garbage stream varied between $141 and $163 per household per year for the six scenarios investigated. For systems involving thermal treatment of collected domestic garbage, estimated costs varied between $190 and $218 per household per year.

In metropolitan areas, for the base case collection system (fortnightly 240 L MGB commingled kerbside recyclables collection and weekly 120 L MGB garbage collection), the introduction of MBT and thermal treatment processes to the garbage stream increases domestic waste management costs by an estimated $7/hhld/yr and $62/hhld/yr respectively. The corresponding cost increases in rural areas, where current disposal costs are significantly lower, were estimated at $34/hhld/yr (MBT) and $86/hhld/yr (thermal).

As the cost of garbage treatment/disposal increases the *net* cost of kerbside recycling reduces, i.e. recycling becomes more cost effective. For some collection scenarios modelled where garbage is thermally treated, providing a separate recyclables collection service *reduced* overall waste management costs.

For single bin systems (Scenario A) where recyclables are recovered through front end sorting prior to waste treatment, the savings in avoided recyclables collection costs need to be measured against the increased costs of processing the mixed garbage stream. When taking into account the increased costs of processing (from front end sorting) the overall cost of the single bin system was found to be similar to the other systems modelled.

Regional / rural collection garbage and recyclables systems are typically cheaper than metropolitan systems mainly due to increased efficiencies of collection vehicles from reduced traffic congestion and lower waste generation per household.

Environmental assessment

Life cycle assessment was used to assess the environmental performance of the various systems. The methodology has been based on the growing amount of work in this area; from the *Independent Economic Assessment of Kerbside Recycling in Australia*; the Packaging Material LCAs undertaken by RMIT; and the recent LCA of Waste Management Options published by EcoRecycle Victoria. The following environmental impact categories have been considered and discussed for a range of more than 50 pollutants:

- Greenhouse gases;
- Resource depletion;
- Human toxicity;
- Eco toxicity;
- Photochemical oxidation; and,
- Air and water pollution potential.

The Environmental Economic Valuation method was used to estimate the monetary value of the environmental performance of systems. This method was developed, and internationally peer reviewed, for the National Packaging Covenant Council in the *Independent Economic Assessment of Kerbside Recycling in Australia* (Nolan-ITU, 2001). For simplicity, the results shown are for the metropolitan area only. Results for regional NSW are similar.

Performance of kerbside recycling

Figure II shows the results of the environmental economic evaluation by impact categories for all scenarios sending garbage to landfill. In other words, here the environmental benefits/impacts of the different *recycling* systems are illustrated, without the influence of the various residual waste (garbage) treatment technologies. The graph reflects the performance of the various recycling systems in accordance with their net diversion rates i.e., only those recyclable materials contribute to the benefit that are actually reprocessed (contamination and sorting losses are deducted and are modelled as waste going to landfill).

Note that Scenario A Landfill (i.e., all waste collected in one bin and going to landfill) has been set at zero to show the benefits of (kerbside) recycling over landfilling. Scenario B (separate bins for paper and containers) and the “Baseline” scenario (fully commingled recyclables) provide the highest benefits due to highest yields. Scenario E (separate crate for paper and containers) is a close third due to relatively high yields and very low contamination rates.

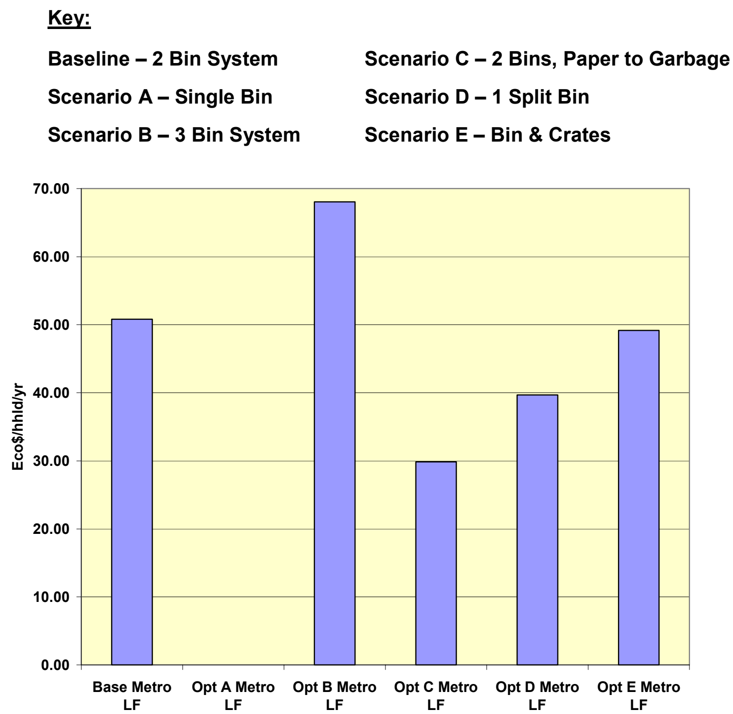


Figure II: Net environmental impacts/benefits of scenarios with different recycling schemes and garbage sent to landfill

This study confirms the key finding of the *Independent Assessment of Kerbside Recycling*: that the environmental benefits of kerbside recycling clearly outweigh the net financial costs of providing the service. The more material that is recycled the higher the environmental benefits. Systems using two MGBs for recycling, (one for paper, one for commingled containers, each collected fortnightly (or on alternate weeks) i.e., Scenario B, showed the highest recycling rates, followed by the 240L fully commingled recycling bin, followed by the two crate recycling system (lower yields but also low contamination). Split garbage/recycling bins are inferior due to low yields and high contamination.

Performance of residual waste management

Figure III illustrates the net results for these options (Note: landfilling of all waste set at zero). The figure indicates that both MBT and Thermal residual waste treatment systems provide considerable environmental benefits over landfilling. However, the recycling credit is still a highly significant variable influencing the overall environmental performance of the systems.

Treatment of residual waste prior to landfilling provides environmental gains of a similar order of magnitude to recycling. Both MBT and thermal technologies provide overall environmental benefits of a similar order. Using current environmental accounting techniques, thermal treatment provides slightly greater greenhouse gas savings than MBT and slightly lower savings in other impact categories. This is however dependent on the type of energy source assumed when calculating electricity offsets.

There are a number of new waste treatment/resource recovery technologies entering the market, which are likely to achieve better environmental performance than the generic technologies used in this assessment.

Key:

Baseline – 2 Bin System	**Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin	**Scenario D – 1 Split Bin**
Scenario B – 3 Bin System	**Scenario E – Bin & Crates**

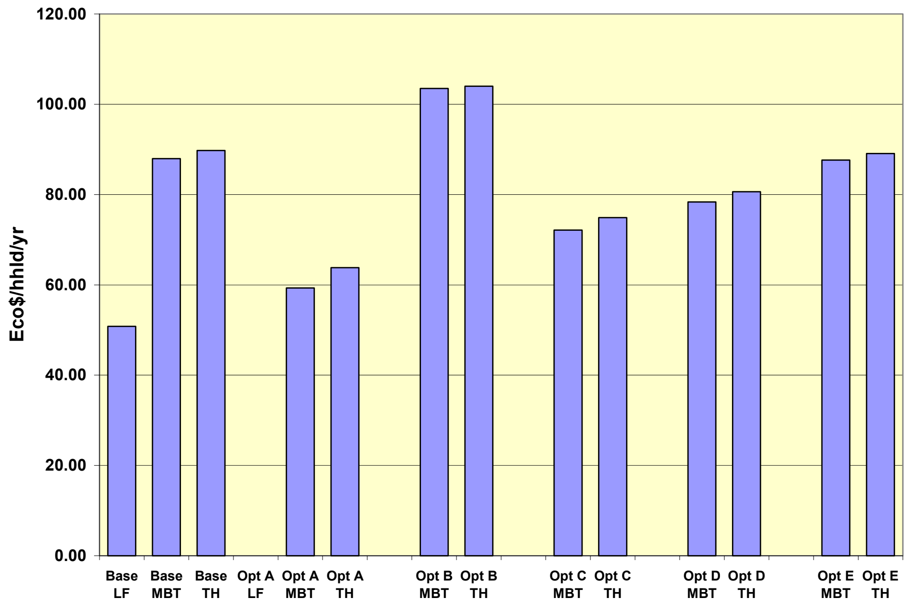


Figure III: Net environmental impacts/benefits of all scenarios

The impact of paper waste management

The environmental assessment was also extended to determine the performance of paper and cardboard in the following waste management systems:

- Paper collected as part of the garbage stream (no source separation), and sent to an MBT facility with subsequent production of (mixed waste) compost;
- Paper collected as part of the garbage stream (no source separation), and sent to an Thermal (waste-to-energy) facility;
- Paper separated at source and recycled into paper and board.

The net environmental results are presented in Figure IV. The recycling of paper to make paper provides significant environmental benefits. These are much higher than the use of paper for energy recovery. Systems that convert paper into mixed-waste derived compost provide the lowest benefits.

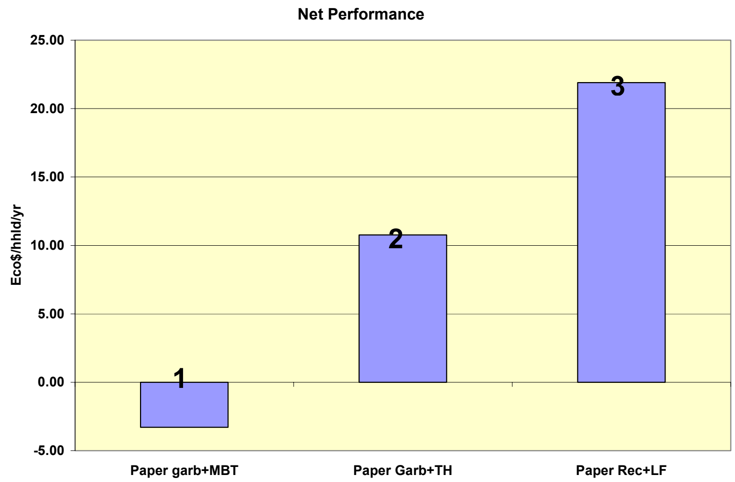


Figure IV: Net environmental performance of paper waste management

Cost-benefit analysis

Combining the financial costs of domestic waste management scenarios with the environmental costs and benefits expressed in dollar terms (Figure V), the following three scenarios show the best overall performance for the metropolitan area:

1. **Scenario B with MBT:** Collection of recyclables from two separate MGBs, one for paper/cardboard and one for containers, and the residual waste (garbage) sent to an MBT facility.
2. **Baseline with MBT:** Collection of recyclables in one MGB (commingled), and the residual waste (garbage) sent to an MBT facility.
3. **Scenario E with MBT:** Collection of recyclables from two separate crates, one for paper/cardboard and one for containers, and the residual waste (garbage) sent to an MBT facility.

Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**

Scenario A – Single Bin **Scenario D – 1 Split Bin**

Scenario B – 3 Bin System **Scenario E – Bin & Crates**

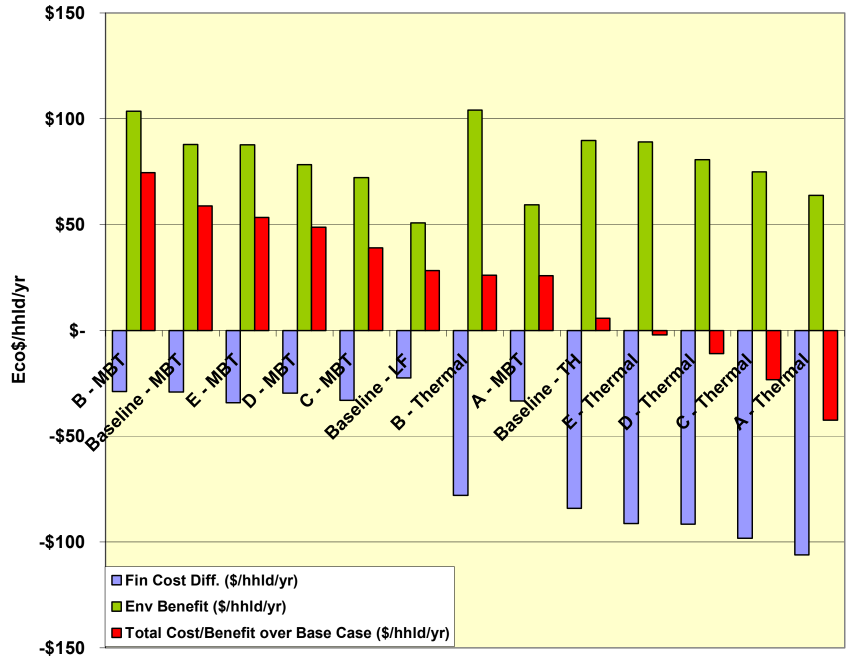


Figure V: Cost-benefit summary of metro scenarios

Consultative process and preferences

During the study the importance attributed by stakeholders to the various criteria used to evaluate the domestic waste management scenarios was elicited from two stakeholder groups: local government and the broader community.

For local government a survey was distributed to waste managers in all Councils in NSW, asking them to provide their preferences with regard to waste management and recycling service outcomes, as well as to provide some basic information about their waste management and recycling services. 115 responses were received (67% of all Councils).

For the broader community two focus group sessions were held: One group was based in metropolitan Sydney; the other group was based in Orange. The recruited focus group participants represented a cross section of “typical” metropolitan and regional communities based on occupational mix, educational levels, gender, ethnic background, and age mix.

The outcomes of the consultation found some variation between the “weightings” provided by the local government waste managers and the community focus groups, with local government placing a higher emphasis on financial and technical/operational aspects, while the community focus groups placed a higher emphasis on environmental outcomes. The variation reflects differences between the two groups in terms of: a) overall knowledge about waste management and recycling, and; b) different roles and responsibilities in the overall waste management and recycling value chain.

Multi-criteria assessment (MCA)

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 13 scenarios, are highly complex, some clear trends become apparent:

- MBT technologies for residual wastes rank higher than thermal technologies; and
- Well performing kerbside recycling systems rank generally higher than systems with lower recovery rates (i.e. single bin systems (Scenario A) are at the bottom).

The MCA outcomes are very similar to the cost-benefit analysis, apart from some minor variations that are due to the variances in social impacts associated with residential amenity (number of truck passes) and householder convenience (not considered in the cost-benefit analysis). Regardless of the approach, the following conclusions can be drawn:

- High net diversion rates for kerbside recycling are the most significant influencing factor in the overall performance of all scenarios assessed;
- These are (currently) best achieved through two recycling bins, with the 'classic' commingled bin following closely behind; and
- MBT is the preferred approach for residual wastes.

Recommendations

- Continue to support kerbside recycling and introduce best practice systems that lead to the highest possible net diversion of recyclables for reprocessing.
- Continue to support paper and cardboard recovery for recycling into paper products.
- Develop a policy of treating residual waste through MBT or Hybrid Technologies or combinations of MBT and thermal treatment, and procedures to assess emerging technologies;
- Monitor and confirm the performance of new waste technologies as they come on line.
- Based on feedback from Local Government representatives at a workshop during the conduct of this study, organics management be incorporated into the assessment to provide a comprehensive appraisal and decision support tool to Councils.
- Research is sponsored into the establishment of more comprehensive and compatible life cycle inventories and databases to improve the assessment of environmental performances of waste management technologies and systems, and to incorporate information on emerging systems.
- 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 rigoro

1 INTRODUCTION

1.1 Background

At present, a significant debate is occurring in waste management and recycling circles with regard to 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) and the increasing economic competitiveness of AWT against landfill disposal;
- Concerns about waste management costs by many local government representatives;
- 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.

Some local government waste management and recycling providers are increasingly considering or adopting consolidated waste and recyclables collection systems. This is partly due to the apparent cost savings of collecting and delivering mixed waste and recyclables to AWT facilities where one or more of the following processes could be employed:

- Sorting and materials recovery;
- Mechanical conditioning;
- Anaerobic digestion;
- Aerobic composting (open or in-vessel);
- Conversion to energy; and/or
- Product refining / materials recovery.

A potential shift to “single bin” type approaches has significant implications for established methods, systems and infrastructure for waste management and recycling, particularly in the case of paper and cardboard. For example, a number of AWT facilities being established in Australia process paper and cardboard for compost and/or energy products. In contrast, other facilities are capable of recovering these materials for reprocessing after "front-end" sorting. In such cases, the recovery of paper and cardboard may be increased through the "pooling" of paper and cardboard from the domestic garbage stream along with that which would traditionally have been segregated as part of kerbside recycling collections, but a major consideration is the quality of materials recovered and its suitability for recycling.

The Pulp and Paper Yearbook (2002) reports that a total of 2,028,000 tonnes of waste paper was collected in 2002 for pulp and paper reprocessing. Based on an estimated figure of 626,000 tonnes per year recovered from domestic kerbside recycling, about 1,402,000 tonnes per year or 70% of the total paper and cardboard collected for reprocessing came from commercial and industrial (C&I) sources.

Current developments in waste collection and waste treatment technology are unlikely to reduce the quantity of paper collected from C&I sources. However, the progressive roll out of AWT facilities, combined with opportunities for “single bin” collection of domestic waste and recyclables, can potentially reduce the quantity of paper that is available to recycling mills from kerbside collections. Preliminary, unpublished estimates compiled by Nolan-ITU shows that potential losses of paper and cardboard available to reprocessing facilities due to a shift towards "single bin" collection systems and AWT may be up to 450,000 t/yr nationwide.

1.2 Objectives

Nolan-ITU was commissioned by the NSW Jurisdictional Recycling Group (JRG) and the Publishers National Environment Bureau (PNEB) to conduct a study of the technical, financial, environmental and social costs and benefits of different domestic waste management and recycling systems, including collection and processing. The project was designed to achieve the following objectives:

1. The establishment of a contemporary data set on the operational performance of six waste / recyclables collection scenarios (as specified by the brief), including recovery rates, quality rates, market values, and financial costs.
2. An integrated assessment of the full technical, financial, environmental and social costs and benefits of six waste / recyclables collection scenarios;
3. An integrated assessment of each of the six collection scenarios in a mechanical-biological waste treatment situation and a thermal waste treatment situation for both metropolitan and regional situations;
4. Insights into the sustainability-based performance of different scenarios vis-à-vis specific material streams, particularly paper and cardboard;
5. Application of the NSW Department of Environment and Conservation's (DEC) Waste Technology Assessment Methodology; and
6. Stakeholder appreciation and ownership of project objectives, methodology, and outcomes.

1.3 Acknowledgments

The authors of this report gratefully acknowledge the contributions of the following persons:

- A Steering Committee comprising Steve Richards (Chair), Frank Kelett (PNEB), Tony Wilkins (PNEB), Neil Chapman and Roz Hall (Department of Environment and Conservation (NSW)), and Michael Pyne (Sutherland Shire Council) for its valuable input, ideas and contributions.
- Tim Grant and Karli Simon (RMIT) for their invaluable support in the environmental assessment of various waste management systems. Tim Grant peer reviewed the study.
- EcoRecycle Victoria, which previously commissioned RMIT and Nolan-ITU to undertake a large scale *Life Cycle Assessment of Waste Management Options for Victoria* as part of the preparation of Victoria's state-wide strategy. Without the Victorian study (which was finalised just before this project commenced), it would have been impossible to address the environmental performances of the systems under consideration in the detail, with the accuracy and within the time and budget available to prepare this report.

2 SYSTEMS CHARACTERISATION

2.1 Collection systems analysed

The six kerbside collection systems analysed in this study are summarised in Table 2.1.

Table 2.1: Collection system configurations assessed

Scenario	Domestic Garbage		Kerbside Recyclables		
	Receptacle	Frequency	Receptacle	Frequency	Materials Collected
Baseline	120 L MGB	Weekly	240 L MGB	Fortnightly	Commingled containers and paper/cardboard
Scenario A	240 L MGB	Weekly	-	-	-
Scenario B	120 L MGB	Weekly	120 L MGB	Fortnightly	Commingled containers
			120 L MGB	Fortnightly	Paper/cardboard
Scenario C	120 L MGB	Weekly	240 L MGB	Fortnightly	Commingled containers only (no paper or cardboard)
Scenario D	240 L MGB split	Weekly	240 L MGB split	Weekly	Commingled containers and paper/cardboard
Scenario E	120 L MGB	Weekly	Crate	Weekly	Commingled containers
			Crate	Weekly	Paper/cardboard

Each system was separately analysed assuming collected domestic garbage is processed at a Mechanical Biological Treatment (MBT) facility and at a Thermal treatment facility. For comparison purposes, the baseline scenario was also analysed with the assumption that the collected domestic garbage is disposed of to landfill. For the single bin system (Scenario A), it was assumed that recyclables were recovered from the collected domestic garbage via a front end sorting facility for biological or thermal processing. Assumed material recovery rates from this system are shown in Table 2.2. [1]

Table 2.2: Assumed recovery rates (Front-end sorting)

Material	Recovery rate (%)
Paper & cardboard	20
Glass	20
Aluminium	80
PET	30
HDPE	30
PVC	30

[1] Based on the information available on the very few facilities (DEHNR, 2003; Biocycle, 2003; TBU, 2003; Waste Age, 2001; Smith et al, 2000; Apotheker S, 1994-1997) that feature sorting (for materials other than metals). For the purpose of this study, the recovery rates exclude organic materials where the greatest waste reduction and recovery usually occurs. The quality of materials (e.g., paper) recovered through front end sorting may substantially restrict its use.

Steel cans	90

2.2 Waste profile derivation

2.2.1 Methodology

In deriving the profile (quantities and composition) of domestic garbage and recyclables for the various collection systems analysed during the study, the following basis was applied:

> *"If all NSW households produced the same quantity of waste with the same composition, what would be the result of different collection systems which are currently in place on a metropolitan and rural / regional basis?".*

The latest available recycling and waste generation information was used to determine the relative performance of different kerbside collection configurations. This included:

- *Aggregated NEPM data* on domestic waste management, provided by the EPA (now part of the Department of Environment and Conservation (NSW));
- 2002 survey information obtained from 26 NSW metropolitan Councils through the NSW Jurisdictional Recycling Group's *Best Practice Council Support Program*;
- Reported Council data from the NetWaste region *(Netwaste Subregional Waste Plan, 2001; Netwaste Midwestern Subregional WMP, 2003; Orange HUB Facility EIS (work in progress), 2003)*
- *Independent Economic Assessment of Kerbside Recycling in Australia* (Nolan-ITU, 2001); and
- 2001 census statistics from the Australian Bureau of Statistics (ABS).

Based on this information the relative performance of different collection systems was determined using the following steps.

Step 1 – Collection system profile

Based upon survey data, Councils were grouped according to their kerbside collection system configuration and an average waste generation rate (inclusive of garbage and recycling) was determined for each system type. A household waste compositional profile was then determined for each system type, based on the NSW metropolitan total waste profile (garbage and recycling) determined by the *Independent Economic Assessment* and *NetWaste waste generation / disposal data*. Once a total waste profile (garbage and recycling) was developed, average recyclables capture quantities were deducted to provide an indication of the *composition of the garbage* stream for the different collection configurations. As with the total waste profile, this relied upon capture information contained within the *Independent Economic Assessment* study.

Step 2 - Updating of recyclables capture quantities

Once collection system profiles were developed, recycling capture quantities were adjusted to reflect the latest Council survey information (e.g. *Best Practice Study*) and the results of the most recent publicly available garbage and recycling audits. In doing so, an up-to-date profile was developed for each collection system.

Step 3 - Normalisation of capture quantities

In order to remove the socio-economic effects on consumption and disposal patterns, total waste quantities were "normalised" based on average waste generation figures for NSW metropolitan and regional households. To determine up-to-date averages of total waste generation, garbage and recycling generation tonnages for 26 Sydney metropolitan and 19 rural / regional Councils (2002 figures) were aggregated and divided by the total number of reported household services. The average total waste generation rate (domestic garbage and kerbside recycling) was calculated to be 970 kg per household per year for metropolitan Councils and 882 kg per household per year for rural / regional Councils. Garbage and recyclables quantities were then adjusted proportionately so that each collection system profile amounted to 970 and 882 kg of total waste per household per year respectively, providing a basis for system comparison in the absence of non-system related biases.

2.2.2 Generation

Derived proportions of garbage and recyclables for each of the collection systems are shown in Figure 2.1 (Metropolitan) and Figure 2.2 (Rural/regional). Recyclables diversion is highest for Scenario B, which comprises fortnightly collection of commingled containers in an MGB and fortnightly collection of paper cardboard in a separate MGB. Examples of such systems can be found in Lane Cove and Manly local government areas.

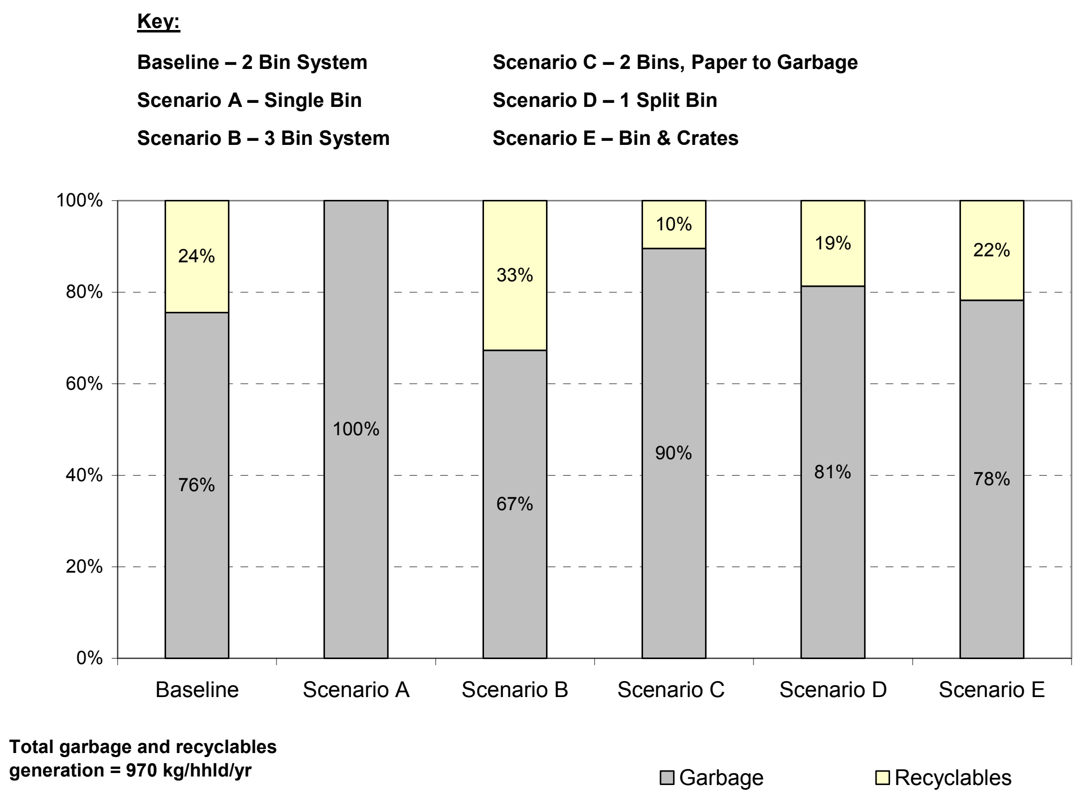


Figure 2.1: Garbage and recyclables collected per system – Metropolitan

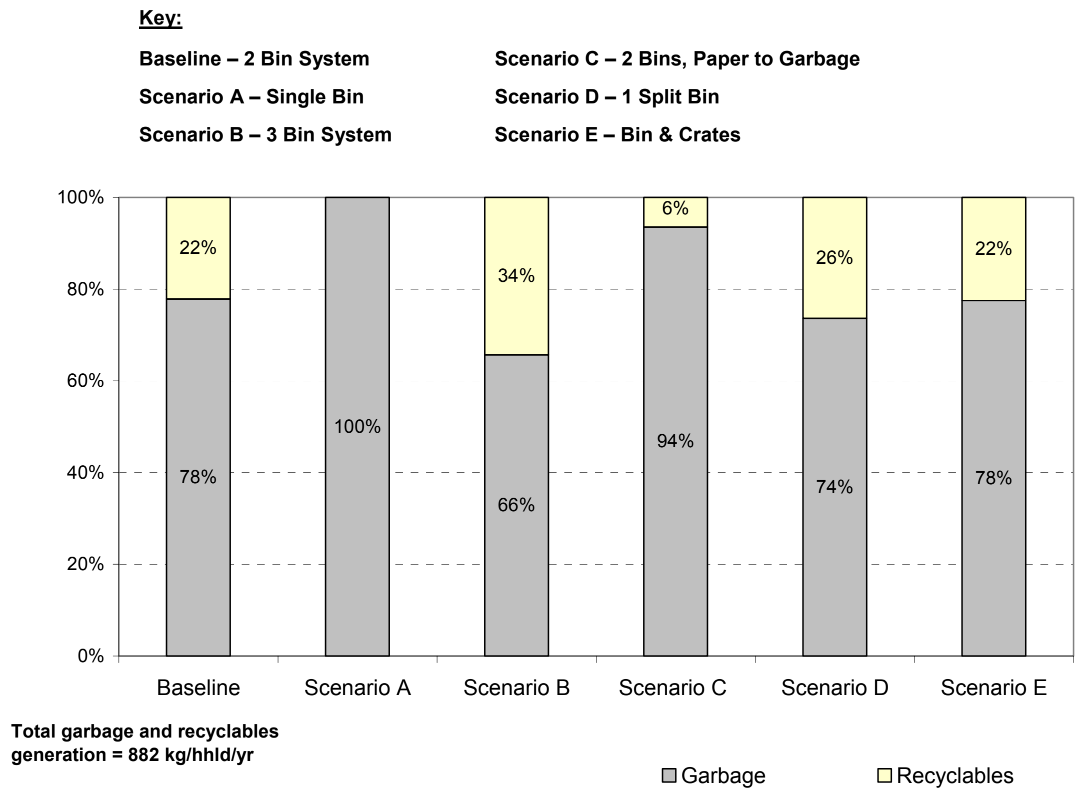
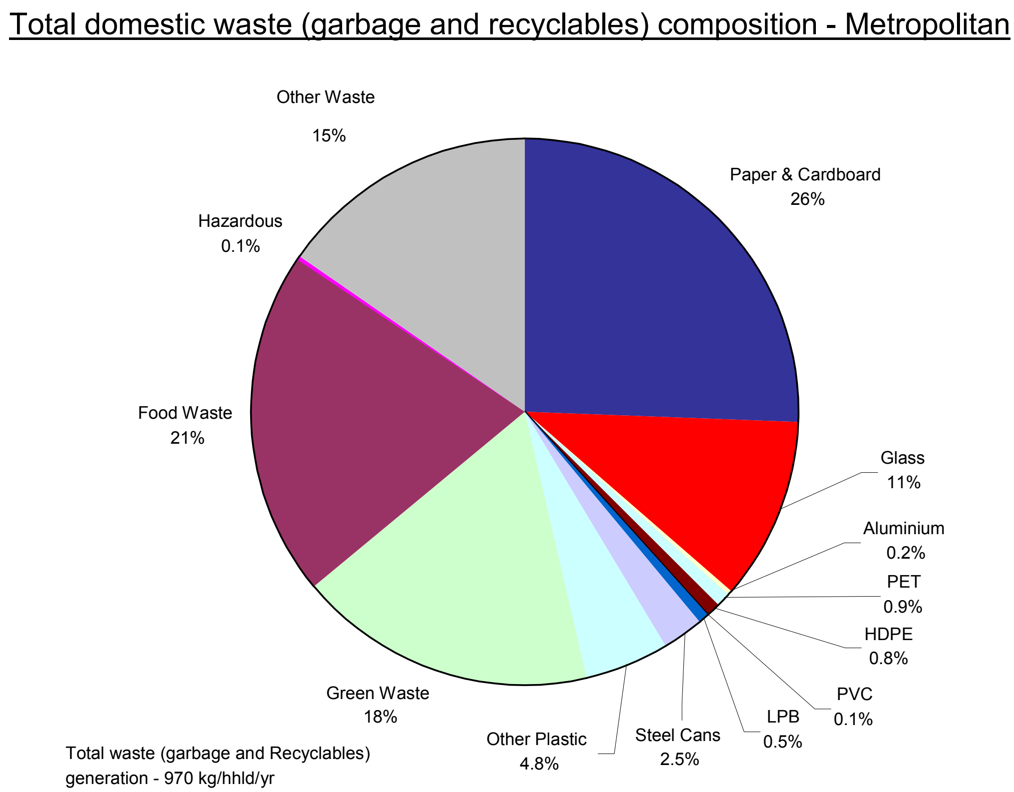


Figure 2.2: Garbage and recyclables collected per system – Rural/regional

2.2.3 Composition

This section presents the total waste (garbage and recyclables) composition for metropolitan and regional/rural areas for each collection system. Also shown are the proportions of recyclables in the garbage stream and contamination rates (caused by incorrect household disposal of waste in recycling containers) of materials in the kerbside recyclables stream.

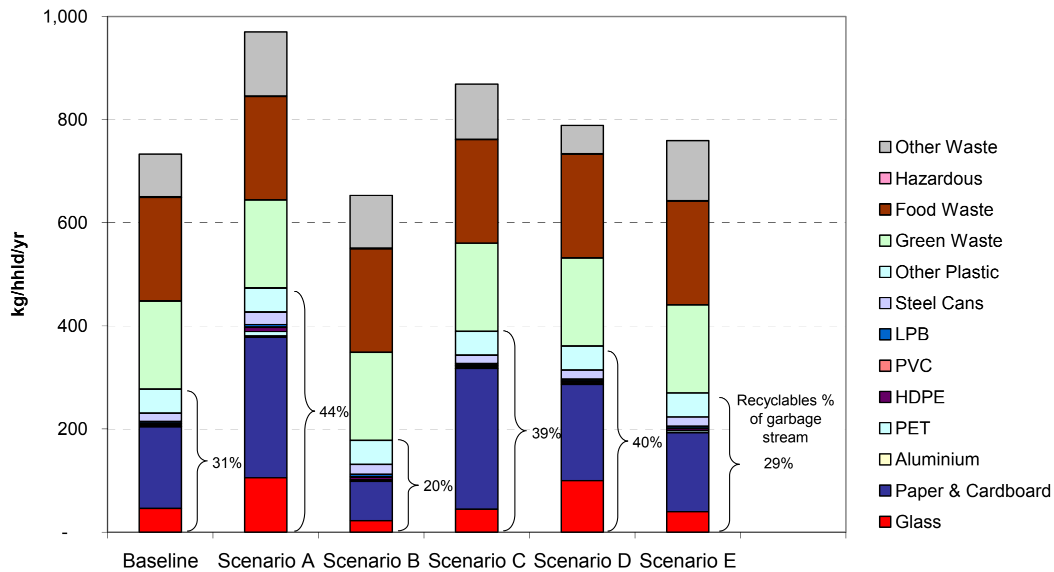
a) Metropolitan



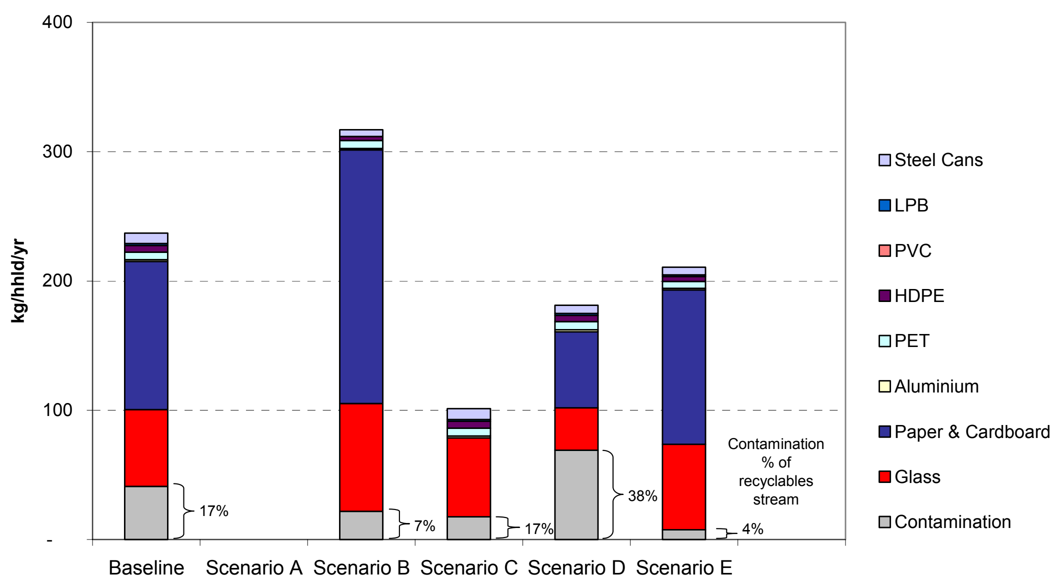
Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin **Scenario D – 1 Split Bin**
Scenario B – 3 Bin System **Scenario E – Bin & Crates**

Domestic garbage composition - Metropolitan



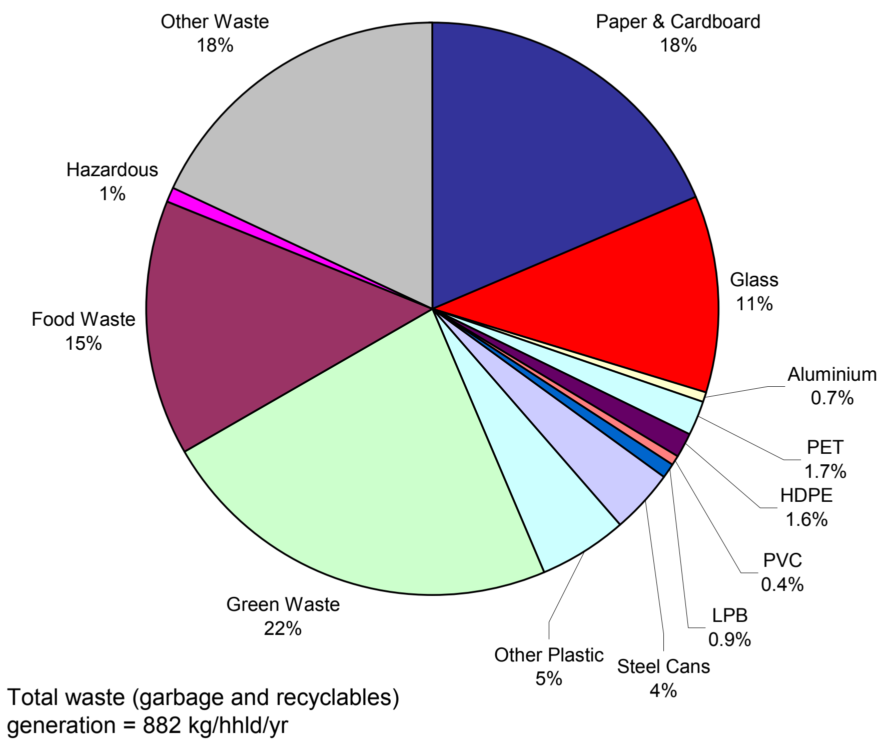
Domestic recyclables composition - Metropolitan



Note: The *diversion rate* can be calculated by comparing the amount of recyclables collected separately (kerbside recycling) with the sum of recyclables from the recycling and the garbage stream.

b) Regional / rural

Total domestic waste (garbage and recyclables) composition – Regional/rural

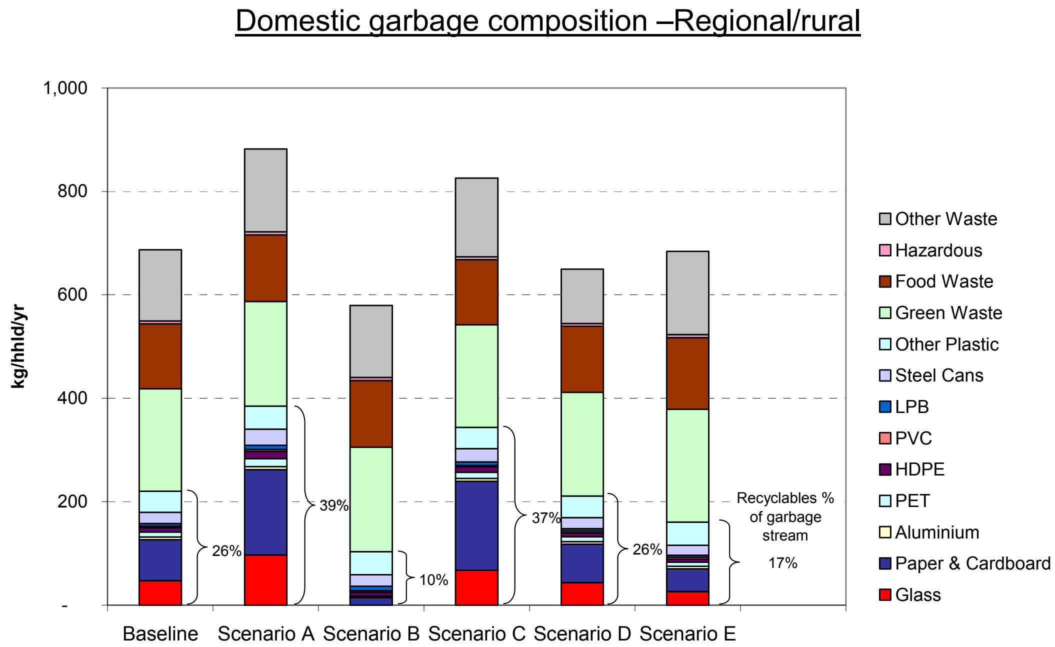


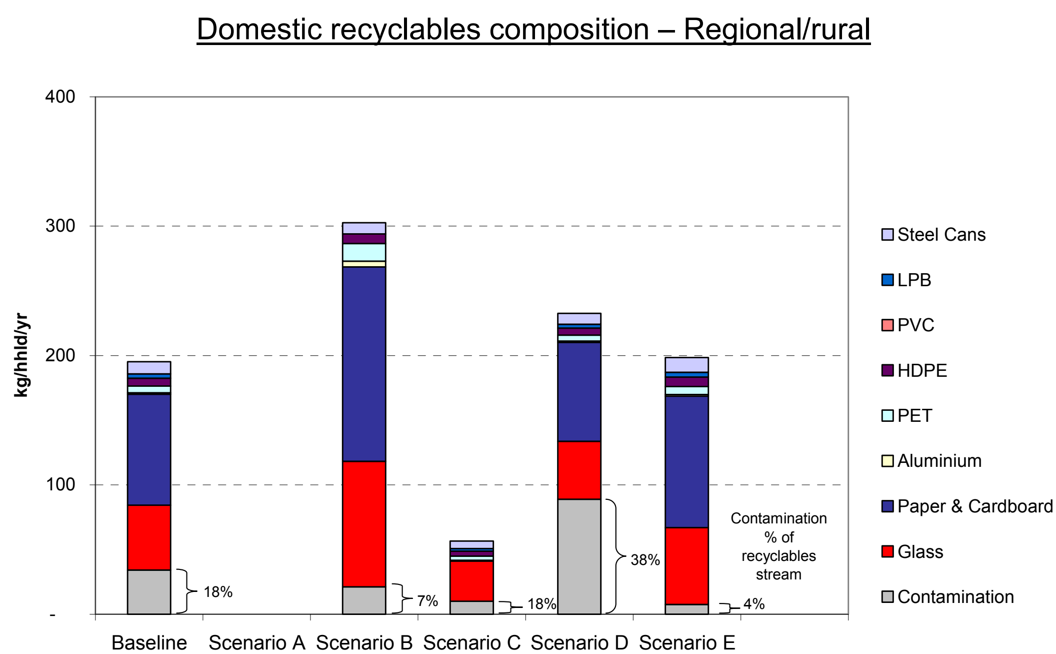
Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**

Scenario A – Single Bin **Scenario D – 1 Split Bin**

Scenario B – 3 Bin System **Scenario E – Bin & Crates**





Note: The *diversion rate* can be calculated by comparing the amount of recyclables collected separately (kerbside recycling) with the sum of recyclables from the recycling and the garbage stream.

3 FINANCIAL ASSESSMENT

3.1 Modelling approach

3.1.1 Introduction

The estimation of the costs for collection, sorting and material delivery for the different systems was made using the *Australian Waste and Recycling Cost Model* developed by the Cooperative Research Centre for Waste Management and Pollution Control in association with EcoRecycle Victoria and Recycle 2000. The aim is to enable organisations to evaluate existing and alternative collection systems to see the effect they have on yields and costs. The model calculates the following:

- ***Cost of garbage collection and disposal:*** This is the cost of collecting and landfilling/disposing of garbage. It includes the value of trucks, fuel, bins, landfilling, haulage and other associated expenditure.
- ***Cost of recycling:*** This is the cost of collecting; sorting and/or treating recycled materials. It does not include the transportation of materials beyond a Material Recovery Facility (MRF), although it can include the delivery of sorted materials to a beneficiation plant or some other buyer. As a rule, post-MRF transport costs are reflected in the price per tonne offered for the recovered 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.
- ***Total cost of garbage and recycling services:*** This is the sum of the recycling and garbage disposal costs.

3.1.2 Key operational parameters

A range of key operational parameters was sourced to provide 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 facilities; MRF sorting costs; and set out rates. These are discussed below.

a) Crew size and labour costs

Crew sizes to collect materials from Mobile Garbage Bins are generally driver only or driver plus one runner. For modelling purposes crew sizes were assumed to comprise the equivalent of 1.5 persons. For Scenario E (two crates collected weekly), both recycling crates were assumed to be collected at the same time with materials placed in a dual compartment collection vehicle employing a driver and two runners. Labour costs for drivers, including wages and other costs (e.g., work cover, insurance, and superannuation) have been assumed at $23/hr. Labour costs for runners were assumed to be $20/hr.

b) Truck capacities

Collection systems for both domestic garbage and recyclables are based on vehicles using nominal 18 m^3 bodies for single stream collections and 22 m^3 for dual stream collections (e.g., split bin systems).

c) Truck collection times

The truck collection time input to the model represents the time taken per bin 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 6 hrs collecting)
Single compaction truck	1.5	21	1 000
Split Compaction Truck (crate system)	3	18	1 200
Split compaction trucks (split bin systems)	1.5	25	900

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 km/hr (metropolitan collection systems) and 50 km/hr (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/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. For the single bin system (Scenario A) an additional $25/tonne was applied to the facility gate fee to account for the front-end sorting component of the facility.

Table 3.3: Adopted waste treatment facility gate fees (excluding GST)

Waste treatment/disposal facility	Metropolitan collection areas	Regional/rural collection Areas
Landfill	$76/t	$35/t
MBT	$85/t	$85/t
Thermal	$160/t	$160/t

f) Material Recovery Facility (MRF) sorting costs

MRF sorting costs depend on the scale of the facility, and are material specific. In general, MRF sorting costs range from $80 to $140/tonne depending on MRF size and configuration. To derive a MRF gate fee, material commodity prices are subtracted from sorting costs. For the purpose of this study, the MRF gate fees were assumed to be $45/tonne for fully commingled recyclables (containers plus paper and cardboard); $65/tonne for commingled containers only; and $15/tonne for paper and cardboard only.

The composition and recovery rate of recyclables varies according to collection system type, particularly with regard to contamination rates (refer Section 2.2). To account for this, cost penalties were applied to collection systems with high contamination rates in the form of increased MRF gate fees (Table 3.4). For regional/rural Councils an additional $10/tonne has been assumed to apply to account for transport of materials to reprocessors/markets.

Table 3.4: Adopted MRF gate fees

Contamination (%) of recyclables stream (weight basis)	Cost penalty	MRF gate fee (commingled recyclables)	MRF gate fee (commingled containers only)	MRF gate fee (paper and cardboard only)
0% - 8%	$0/t	$45/t	$65/t	-$30/t
8% to 15%				$-15/t
15% to 25%	$10/t	$55/t	$75/t	$-5/t
> 25%	$20/t	$65/t	$85/t	$5/t

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. In general, the greater the collection frequency, the lower the set out rate. For garbage collections, a bin set out rate of 95 % was assumed for all cases. For the kerbside recyclables collections a bin set out rate of 80% was assumed.

3.2 Results

Table 3.5 and Table 3.6 below show the results for systems in metropolitan and regional/rural areas respectively. The average proportion of garbage and recyclables streams (including contamination) are also shown. Base case landfill results have also been included in each table for comparison purposes. The results represent averages, which mask wide variations 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. *System costs* are first presented on a $/hhld per year basis separately for the garbage component and kerbside recyclables component and then as a total.

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 and recyclables collections as well as administration, education and other waste management services offered by Councils (e.g., garden organics collections, clean up collections, drop-off, street sweeping and litter). By comparison, the estimated *cost* of the base case service modelled in this study for kerbside garbage and recyclables is $171, which is $48 less than current average charge. The difference between the base case waste management *costs* estimated here and the waste management charge is attributable to provision of ancillary waste management services. 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 base case service modelled in this study is $119, which is $40 less than current average charge.

Table 3.5: Estimated waste management costs (Metropolitan MBT)

System Component	*Base Case – Landfill*	Base Case	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
$ per Household per Year							
Garbage Disposal/Processing	*$68*	$75	$123	$67	$89	$80	$77
Recyclables Collection/Transport	*$38*	$38	$-	$58	$30	$29	$51
Recyclables Processing	*$13*	$13	$-	$2	$8	$12	$2
Total System Cost	*$171*	$178	$182	$178	$182	$179	$183
Cost if only Weekly Garbage Service Offered	*$149*	$158	$182	$158	$158	$158	$158
Net Cost of Recycling	*$22*	$20	$-	$20	$24	$20	$25
% Garbage	*76%*	76%	100%	67%	90%	81%	78%
% Recyclables (incl contamination)	*24%*	24%	0%	33%	10%	19%	22%

A graphical representation of metropolitan waste management costs incorporating MBT treatment/disposal of waste is presented as Figure 3.1. Aggregated garbage and recycling costs are presented in Figure 3.2, which also shows sensitivity ranges in waste management costs for assumed high ($100/tonne) and low ($75/tonne) MBT facility gate fees.

Key:

Baseline – 2 Bin System	**Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin	**Scenario D – 1 Split Bin**
Scenario B – 3 Bin System	**Scenario E – Bin & Crates**

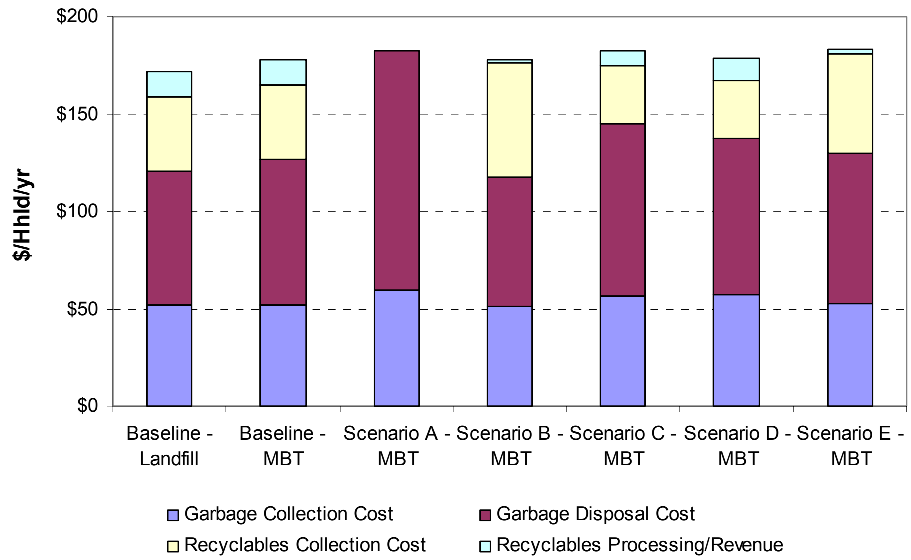


Figure 3.1: Detailed waste management costs for metropolitan MBT

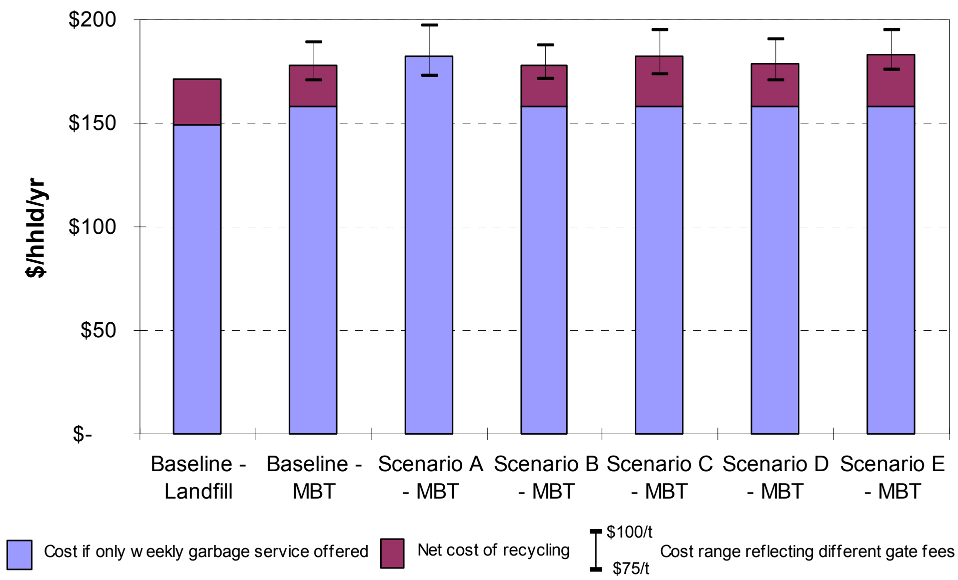


Figure 3.2: Aggregated waste management costs for metropolitan MBT

Table 3.6: Estimated waste management costs (metropolitan Thermal)

System Component	*Base Case – Landfill*	Base Case	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
$ per Household per Year							
Garbage Collection/Transport	*$52*	$52	$59	$51	$56	$59	$52
Garbage Disposal/Processing	*$68*	$130	$196	$116	$154	$140	$134
Recyclables Collection/Transport	*$38*	$38	$0	$58	$30	$30	$51
Recyclables Processing	*$13*	$13	$-	$2	$8	$12	$2
Total System Cost	*$171*	$233	$255	$227	$247	$241	$240
Cost if only Weekly Garbage Service Offered	*$149*	$231	$255	$231	$231	$231	$231
Net Cost - Recycling	*$22*	$2	$-	$-4	$16	$10	$9
% Garbage	*76%*	76%	100%	67%	90%	81%	78%
% Recyclables (incl contamination)	*24%*	24%	0%	33%	10%	19%	22%

A graphical representation of metropolitan waste management costs incorporating thermal treatment/disposal of waste is presented as Figure 3.3. Aggregated garbage and recycling costs are presented in Figure 3.4, which also shows sensitivity ranges in waste management costs for assumed high ($190/tonne) and low ($140/tonne) thermal treatment facility gate fees.

<u>Key:</u>

Baseline – 2 Bin System	**Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin	**Scenario D – 1 Split Bin**
Scenario B – 3 Bin System	**Scenario E – Bin & Crates**

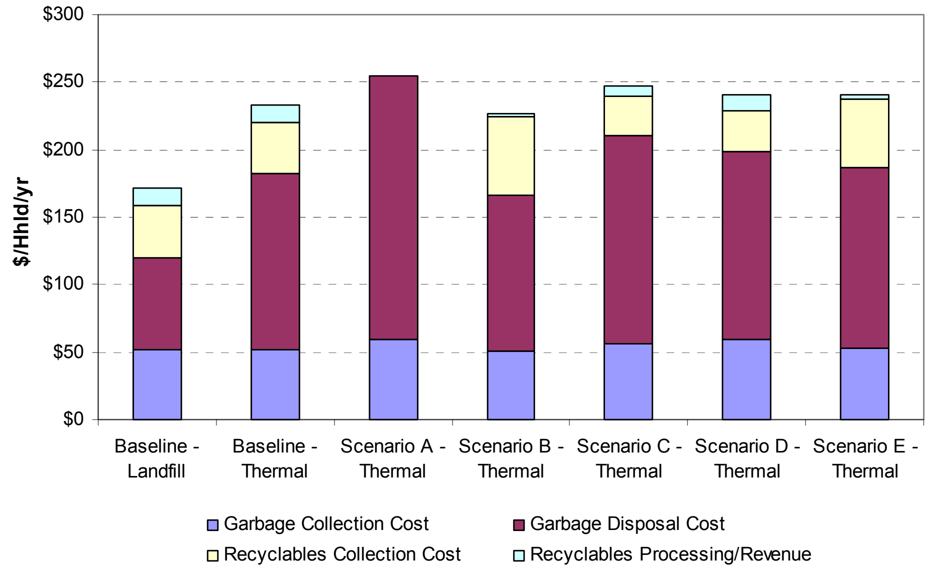


Figure 3.3: Detailed waste management costs for metropolitan Thermal

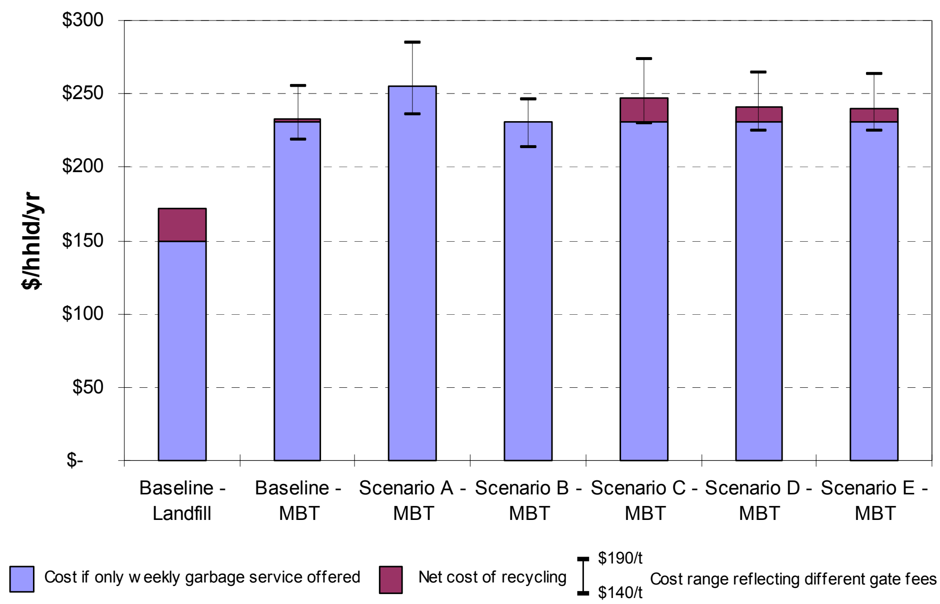


Figure 3.4: Aggregated waste management costs for metropolitan Thermal

Table 3.7: Estimated waste management costs (Regional/rural MBT)

System Component	*Base Case – Landfill*	Base Case	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
$ per Household per Year							
Garbage Collection/Transport	*$51*	$51	$55	$49	$52	$39	$51
Garbage Disposal/Processing	*$24*	$58	$97	$49	$70	$55	$58
Recyclables Collection/Transport	*$32*	$32	$-	$56	$23	$29	$46
Recyclables Processing	*$13*	$13	$-	$8	$5	$17	$5
Total System Cost	*$119*	$153	$152	$163	$151	$141	$160
Cost if only Weekly Garbage Service Offered	*$85*	$130	$152	$130	$130	$130	$130
Net Cost of Recycling	*$33*	$24	$-	$33	$21	$11	$30
% Garbage	*78%*	78%	100%	66%	94%	74%	78%
% Recyclables (incl contamination)	*22%*	22%	0%	34%	6%	26%	22%

A graphical representation of detailed regional / rural waste management costs incorporating MBT treatment / disposal of waste is presented as Figure 3.5. Aggregated garbage and recycling costs are presented in Figure 3.6.

Key:

Baseline – 2 Bin System	**Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin	**Scenario D – 1 Split Bin**
Scenario B – 3 Bin System	**Scenario E – Bin & Crates**

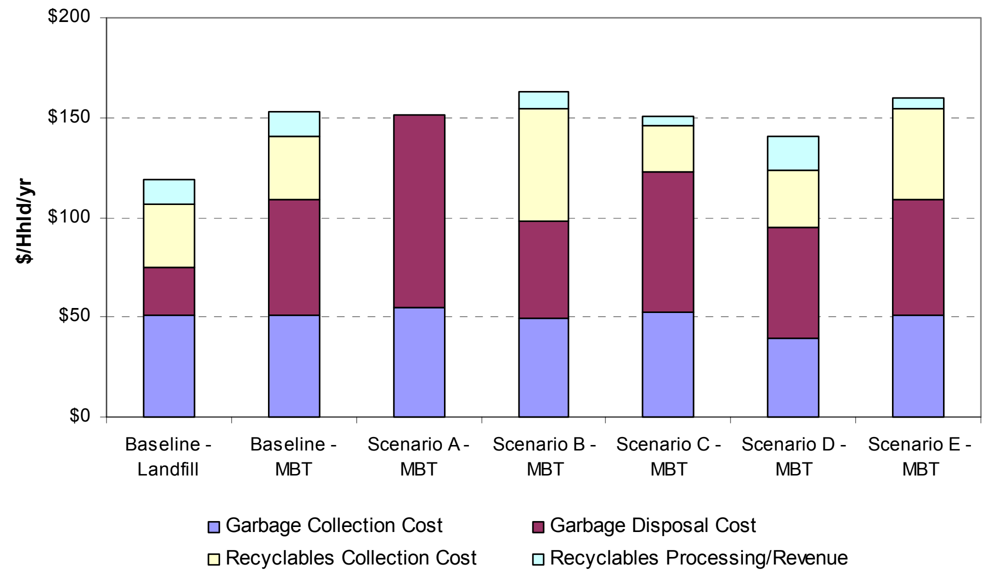


Figure 3.5: Detailed waste management costs for regional/rural MBT

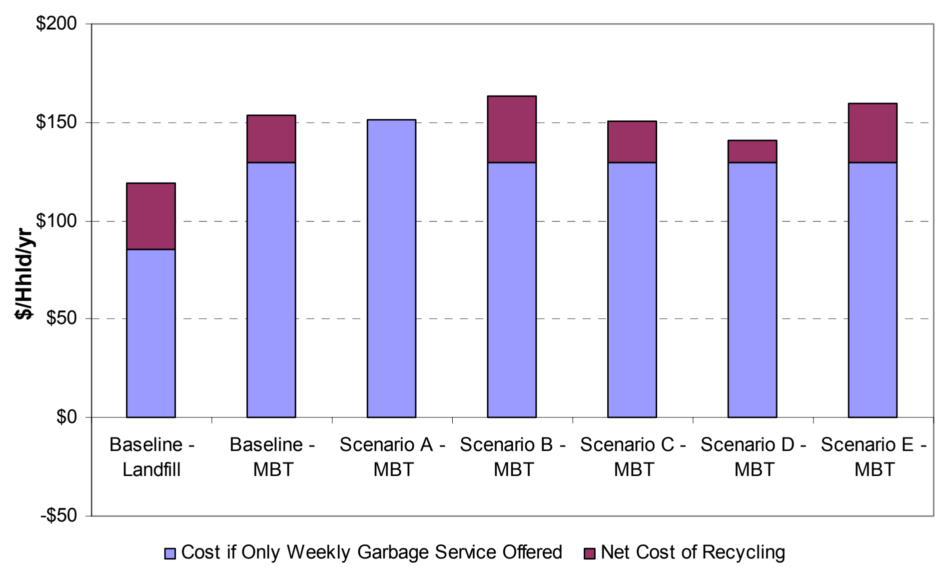


Figure 3.6: Aggregated waste management costs for regional/rural MBT

Table 3.8: Estimated waste management costs (regional/rural Thermal)

System Component	*Base Case – Landfill*	Base Case	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
$ per Household per Year							
Garbage Collection/Transport	*$51*	$51	$55	$49	$52	$39	$51
Garbage Disposal/Processing	*$24*	$110	$163	$93	$132	$104	$109
Recyclables Collection/Transport	*$32*	$32	$0	$56	$23	$29	$46
Recyclables Processing	*$13*	$13	$-	$8	$5	$17	$5
Total System Cost	*$119*	$205	$218	$207	$213	$190	$211
Cost if only Weekly Garbage Service Offered	*$85*	$196	$218	$196	$196	$196	$196
Net Cost of Recycling	*$33*	$9	$-	$11	$17	-$6	$15
% Garbage	*78%*	78%	100%	66%	94%	74%	78%
% Recyclables (incl contamination)	*22%*	22%	0%	34%	6%	26%	22%

A graphical representation of detailed regional / rural waste management costs incorporating thermal treatment / disposal of waste is presented as Figure 3.7. Aggregated garbage and recycling costs are presented in Figure 3.8.

Key:

Baseline – 2 Bin System	**Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin	**Scenario D – 1 Split Bin**
Scenario B – 3 Bin System	**Scenario E – Bin & Crates**

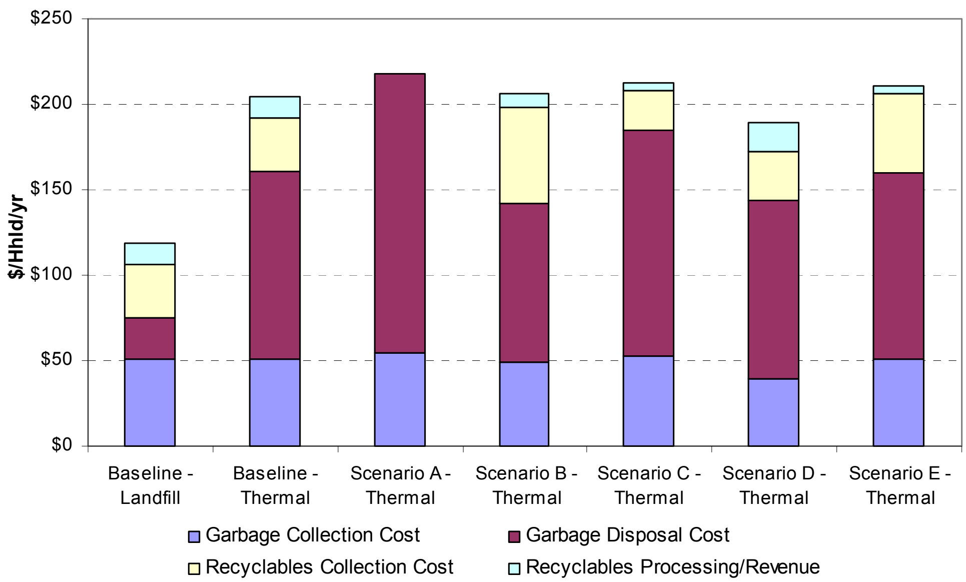


Figure 3.7: Detailed waste management costs for regional/rural MBT

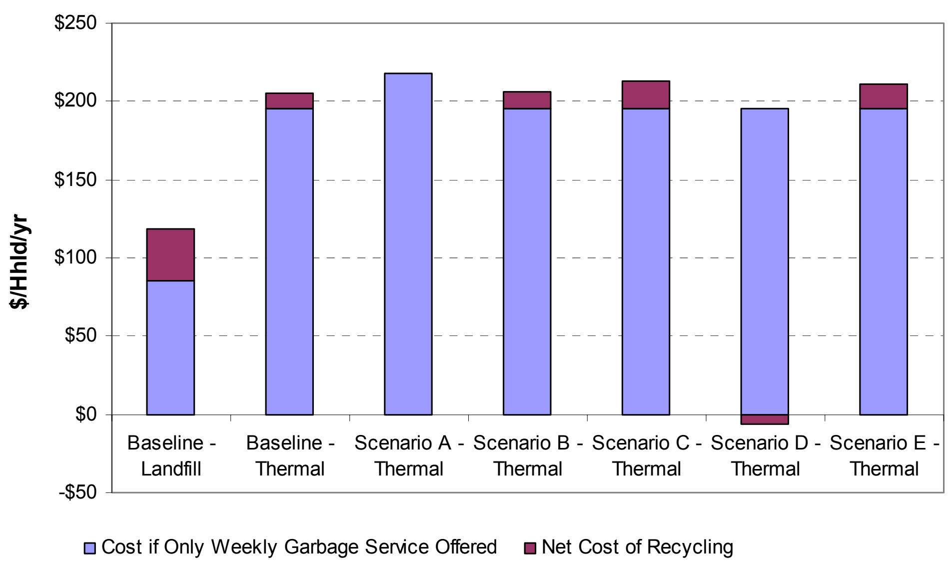


Figure 3.8: Aggregated waste management costs for regional/rural Thermal

3.3 Summary

Table 3.9 presents a summary of estimated system costs for each system.

Table 3.9: Summary of estimated waste collection, transport and disposal/processing costs – Metropolitan and regional/rural

System Component	*Base Case – Landfill*	Base Case	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
Total System costs ($ per Household per Year)							
Metropolitan – MBT	*$171*	$178	$182	$178	$182	$179	$183
Metropolitan – Thermal	*$171*	$233	$255	$227	$247	$241	$240
Regional / Rural – MBT	*$119*	$153	$152	$163	$151	$141	$160
Regional / Rural– Thermal	*$119*	$205	$218	$207	$213	$190	$211

In metropolitan areas, the estimated annual cost of domestic garbage and recycling including MBT waste treatment of the garbage stream varied between $178 and $183 per household per year. For systems involving thermal treatment of collected domestic garbage, estimated annual costs varied between $227 and $255 per household per year.

In regional/rural areas, the estimated annual cost of domestic garbage and recycling including MBT waste treatment of the garbage stream varied between $141 and $163 per household per year. For systems involving thermal treatment of collected domestic garbage, estimated annual costs varied between $190 and $218 per household per year.

In metropolitan areas, for the base case collection system (fortnightly 240 L MGB commingled kerbside recyclables collection and weekly 120 L MGB garbage collection), the introduction of MBT and thermal treatment processes to the garbage stream increases domestic waste management costs by an estimated $7/hhld/yr and $62/hhld/yr respectively. The corresponding cost increases in rural areas, where existing disposal costs are significantly lower, were estimated at $34/hhld/yr (MBT) and $86/hhld/yr (thermal).

As the cost of garbage treatment/disposal increases the *net* cost of kerbside recycling reduces (i.e., the (higher) *avoided* costs of garbage treatment make kerbside recycling cheaper). For some collection scenarios modelled, where garbage is thermally treated, the provision of a separate recyclables collection service *reduced* overall waste management costs.

For single bin systems (Scenario A), where recyclables are recovered through front end sorting prior to waste treatment, the savings in avoided recyclables collection costs need to be measured against the increased costs of processing the mixed garbage stream. It is also noted that the quality of materials (e.g. paper) recovered through front end sorting may substantially restrict its use.

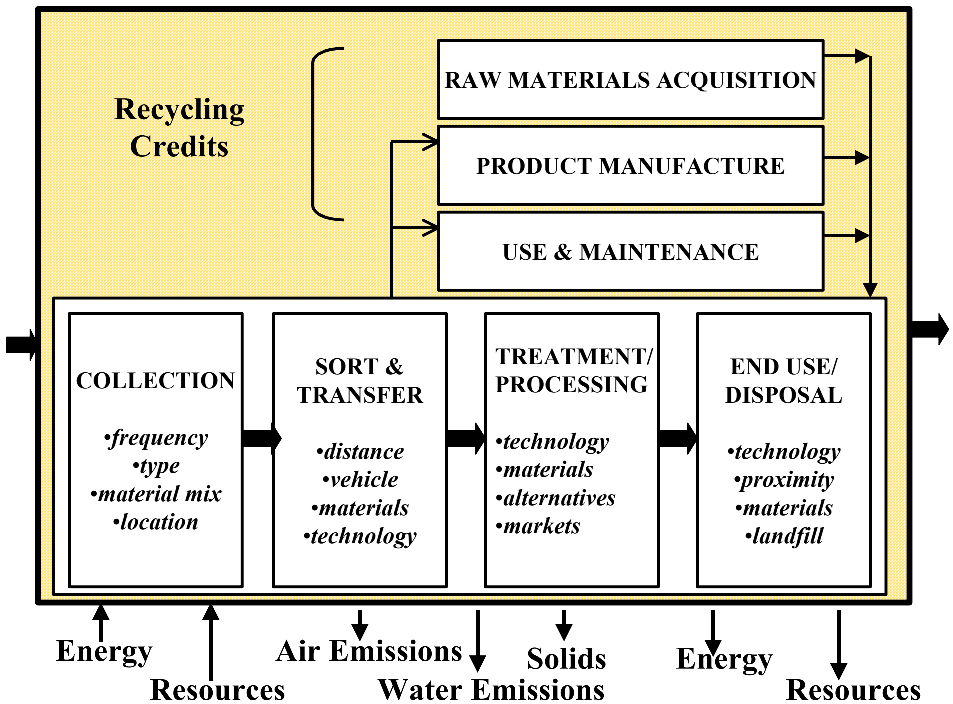
Regional / rural collection garbage and recyclables systems are typically cheaper than metropolitan systems due to increased efficiencies of collection vehicles from reduced traffic congestion and lower waste generation per household.

4 ENVIRONMENTAL ASSESSMENT

4.1 Life cycle assessment

Life cycle assessment (LCA) is the process of evaluating the potential effects that a product, process or service has on the environment over the entire period of its life cycle. Figure 4.1 illustrates the life cycle system concept of natural resources; energy coming into the system and product and emissions leaving the system.

Figure 4.1 Life cycle system concept



The International Standards Organisation (ISO) has defined LCA as “a technique for assessing the environmental aspects and potential impacts associated with a product by:

- Compiling an inventory of relevant inputs and outputs of a product system;
- Evaluating the potential environmental impacts associated with those inputs and outputs; and
- Interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study” (AS/NZS; 1998).”

4.1.1 LCA framework

The technical framework for life cycle assessment consists of four interrelated components. Based on the current ISO terminology, the four components are ‘goal and scope definition’, ‘functional unit’, ‘system boundaries’, project methodology.

a) Goal and scope definition

The goal of this LCA is to provide a transparent environmental evaluation of different waste management system configurations for metropolitan and regional / rural NSW. The study findings are to be consistent with previous LCA and waste management studies, primarily the *Independent Assessment of Kerbside Recycling in Australia* (Nolan-ITU, 2001).

b) Functional unit

The functional unit for the study is defined as the management of a typical household waste stream per year in metropolitan and regional / rural NSW. The function under examination is waste management. The system configurations which have been considered are detailed in Section 2.1. For the purposes of this exercise, the total waste generation for both metropolitan and regional / rural household has been normalised to remove demographic effects upon waste generation. To enable comparative analysis each system has been characterised both in terms of composition and materials capture. The basis of system characterisation is the latest available materials compositional data for both metropolitan and regional / rural waste management systems.

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, and processing or disposing of any residual material. While a detailed study of rigid recyclable material has not been undertaken, any flow-on effect from the choice of waste management technology (including avoided product credits) is assessed in the LCA.

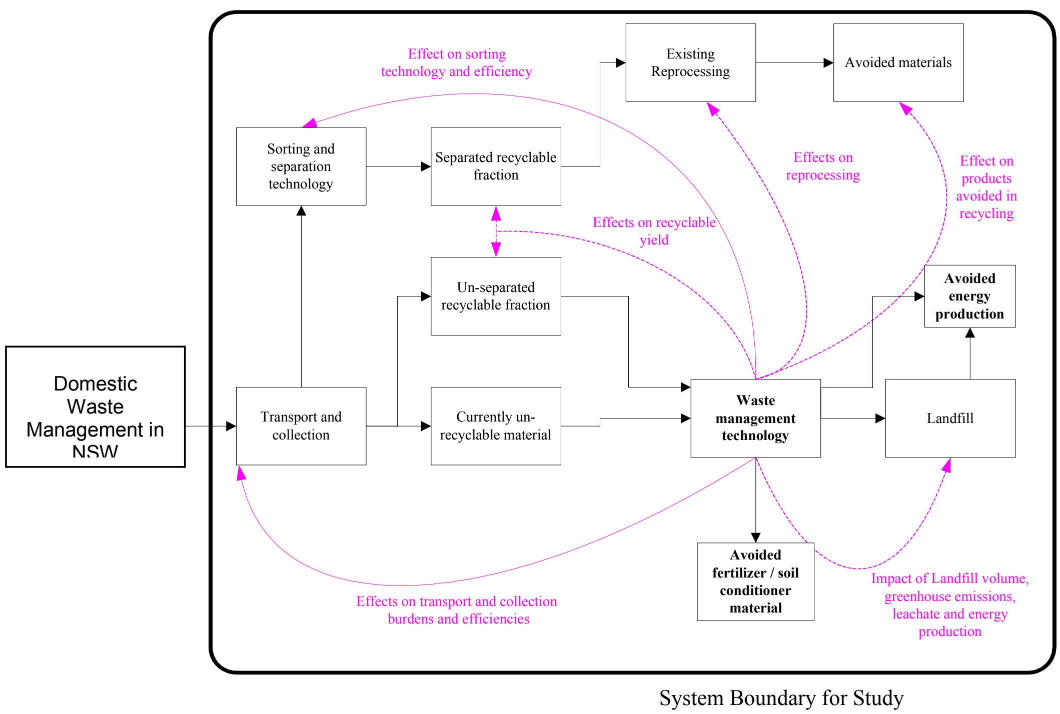


Figure 4.2 System boundary for LCA Study – showing interrelationship between waste technologies and other system elements (adapted from Grant *et al*, 2003)

d) Project methodology

The focus of the study is limited to Municipal Solid Waste (MSW) from domestic sources. The evaluation of product/production/treatment systems, which deal with bulky, low value material (such as domestic waste) normally requires consideration of site-specific factors such as proposed specific technology, scale and sensitivity of local environments. Because of this, it is difficult to generalise about the performance of individual technologies in the absence of a local context. This project has relied upon the development of typical domestic waste capture profiles for each of the various kerbside systems to examine the performance of two treatment / disposal technology categories, namely generic Mechanical Biological Treatment (MBT) and generic thermal technologies.

Figure 4.3 below illustrates the principal structure of the LCA process tree for all waste management options. The example indicates the types of process stages considered in the management of recycling and waste materials (only a small number of actual process stages shown), with the process flows being shown by the upper value in each unit process box. In this instance, the lower left hand value (and the scale bar on the right hand side of the box) represents the environmental performance expressed as a single indicator (using the Nolan-ITU Environmental Economic Valuation Model) with the connecting lines indicating (environmental) benefits (green) and costs (red).

The approach used for the study was based on the modelling of Life Cycle Inventory Data using the Sima Pro LCA software package, followed by application of two different impact assessment methods in order to interpret this data. The main method used is the Eco Dollar Model developed for the National Packaging Covenant study into recycling, the *Independent Assessment of Kerbside Recycling in Australia.* The *Eco Indicator* method, which is widely used in Europe, has also been applied for comparison purposes.

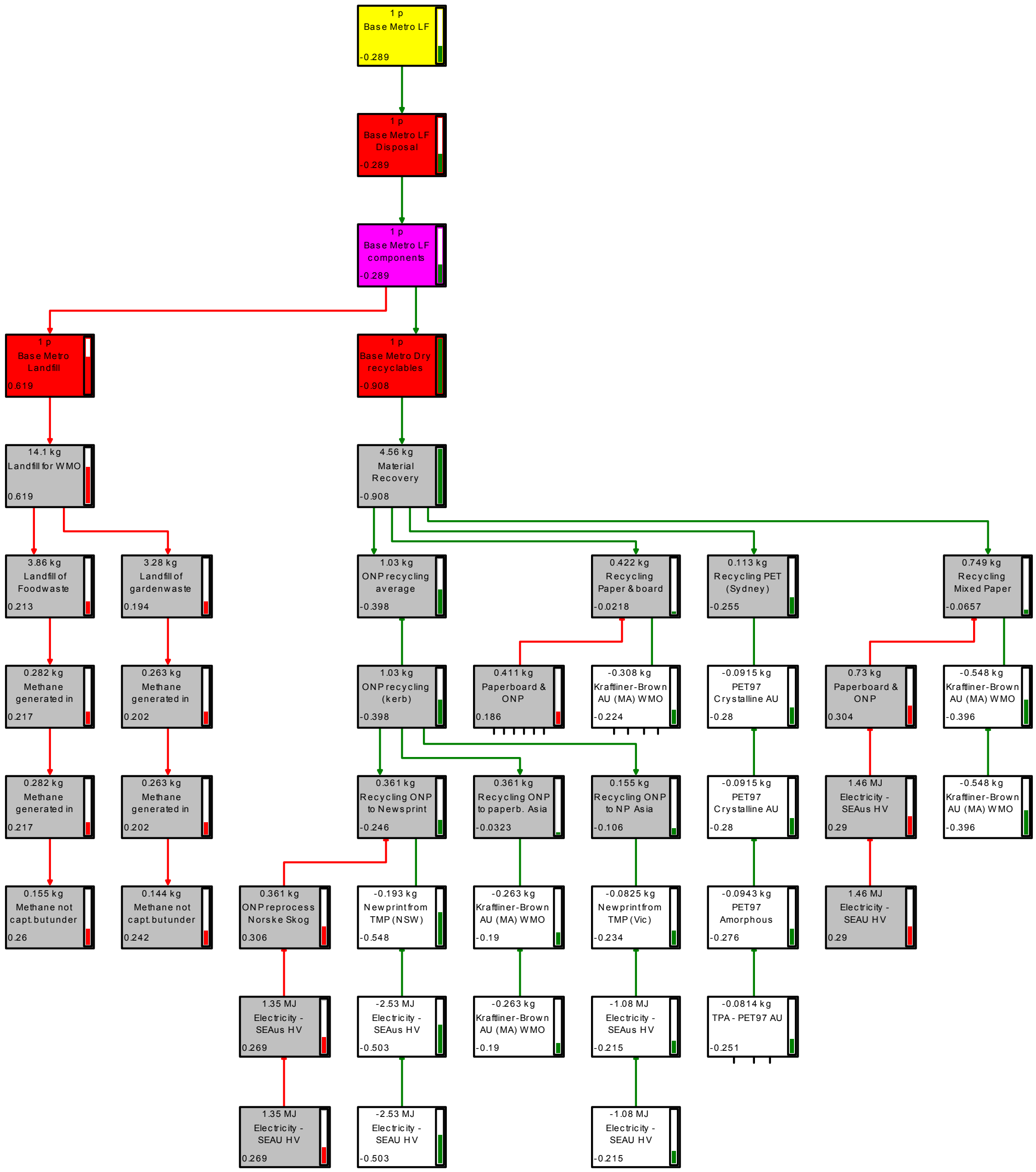


Figure 4.3: An example of a LCA process tree

4.1.2 Data sources

Table 4.1 lists the main data sources used for the environmental assessment. Data sources and parameters for systems characterisation are presented in Section 2.

Table 4.1: LCA Inventory data sources

System	Data Sources
Materials Recycling	RMIT & Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria. Nolan-ITU (2001): Independent Assessment of Kerbside Recycling in Australia Grant *et al* (2001): Life Cycle Assessment for Paper and Packaging Waste Management Scenarios in Victoria. Stage 1 & 2 Report. Melbourne. For Eco Recycle Victoria. CRC WMPC (1998): Life Cycle Inventories for Transport, Energy and Commodity Materials.
Collection	Nolan-ITU (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 & 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. DEC (2003) Alternative Waste Treatment Technologies Handbook and Assessment Tool
MBT – aerobic	RMIT & 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. Eco Recycle Victoria (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. Eco Recycle Victoria (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 & Nolan-ITU (2003): Life Cycle Assessment of Waste Management Options in Victoria. Nolan-ITU, 2002 Decision Support System for the Assessment of Integrated Resource

System	Data Sources
	Recovery System, Western Australian Municipal Association. Eco Recycle Victoria (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 & 2 Report for Life Cycle Assessment for Paper and Packaging Waste Management Scenarios in Victoria. Melbourne. For Eco Recycle Victoria.

Material flows were based on the data presented in Section 2. Material collection impacts were developed from this data using the *Australian Waste and Recycling Cost Model* (CRC for Waste Management and Pollution Control; 1997). Fuel production and transport emissions were similar to those used in Grant *et al* (2001) along with material reprocessing inventories and avoided materials. The transport distances travelled were based on estimated average distances (i.e., within municipalities, to transfer stations, landfills, from MRFs to markets).

Data on avoided product systems were developed directly from industry data, from previous LCAs (Grant *et al*., 2001, 2003) and from publicly available data both in Australia and internationally.

Some changes have been made to the life cycle inventory data sets since their use in the EcoRecycle Victoria study (2003). These include:

- Reducing the scope of electricity generation inventory data to be consistent with data sets used for materials recycling and alternative technologies;
- Reducing the net electricity generation from waste-to-energy facilities from 400 kWh/t input to 300 kWh/t;
- Expanding the boundaries of the waste-to-energy inventories in terms of management of residual process waste disposal, and including the major additives for flue gas cleaning.

4.1.3 Study limitations

The impact assessment methods (Eco Dollar and Eco Indicator methods) used by this study were selected in order to meet the goal of the study. Limitations apply to both methods, these are:

The models have not addressed a number of environmental issues. These include:

- Land use and bio-diversity impacts resulting particularly from forestry operations and mining of resources;
- Amenity impacts from landfill; and
- Noise, odours, victims of accidents, occupational health and safety, and impact of product residues during waste management.

4.1.4 Peer review

The environmental assessment component of this study has been peer reviewed by Tim Grant of RMIT's Centre for Design. This component has relied heavily upon the methodology developed by Mr Grant for the LCA recently undertaken for EcoRecycle Victoria. Mr Grant was consulted while setting up the framework for the assessment, and subsequently undertook the peer review in October 2003. Comments from the peer review have been addressed and incorporated into this report.

4.1.5 Interpretation

The International Standard on Life Cycle Interpretation (ISO 14043) has three stages of interpretation. These are: identification of significant issues; evaluation of issues through reference to all other stages of the LCA using a range of checks; and drawing conclusions and recommendations from the LCA.

During the interpretation stage significant information is extracted from the LCA inventory and impact assessment and then checked to see if it can be used to answer the questions set out in the goal and scope of the study. A series of checks are undertaken during the interpretation to determine if the significant issues identified from the inventory and impact assessment are supportable given the accuracy of the data, boundary conditions and assumptions made throughout the study.

4.1.6 Identification of significant issues

The environmental issues that will be discussed are greenhouse gases, photochemical smog, human toxics, eco toxics, water use, eutrophication, and depletion of fossil fuels and mineral resources. In the presentation of results that follow, ***identified environmental savings are presented as positive (+) values and the environmental impacts are presented as negative (-) values***.

The impacts and savings shown do not refer to a particular *waste management* baseline but are calculated from the point where waste is collected (i.e., entering the system). From this point, each scenario creates environmental impacts (e.g., landfilling) and/or benefits (e.g., recycling of materials, application of compost, electricity generation). In other words, a scenario where all waste is landfilled creates predominantly environmental *impacts* (with some relatively small savings if electricity is recovered from landfill gas) whereas a scenario with high recycling rates and energy recovery and reduced impacts from landfill shows high net *savings*.

4.2 LCA Results

4.2.1 Greenhouse gases

Global warming savings are presented for each scenario in Figure 4.4 and Figure 4.5. The three main greenhouse gases are CO_2, N_2O and methane. An additional greenhouse factor shown is carbon sequestration that occurs when carbon embodied in organic material such as timber, paper or food is placed in landfill and a portion of this material is assumed not to degrade. Carbon is also sequestered when organic material is used as compost as some of it becomes part of the soil humus. Results are expressed as CO_2 equivalents.

Key:

Baseline – 2 Bin System

Scenario A – Single Bin

Scenario B – 3 Bin System

Scenario C – 2 Bins, Paper to Garbage

Scenario D – 1 Split Bin

Scenario E – Bin & Crates

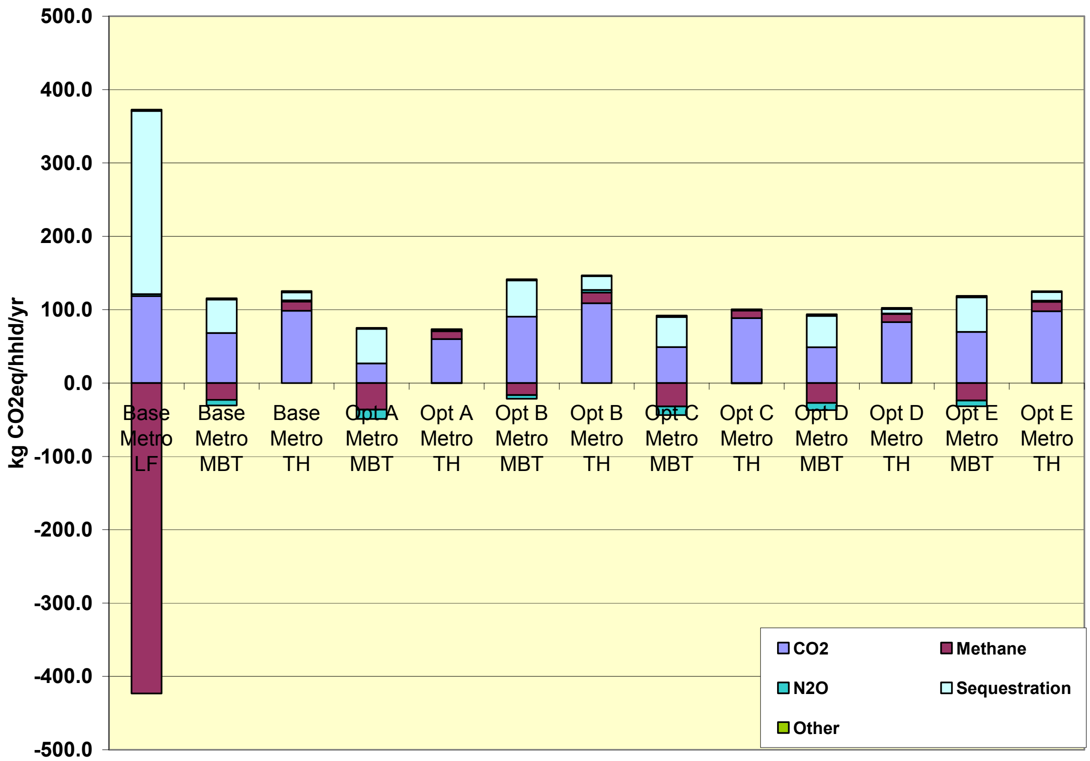


Figure 4.4: Greenhouse gas emissions/savings by substance (kg CO2eq/hhld/yr)

Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**

Scenario A – Single Bin **Scenario D – 1 Split Bin**

Scenario B – 3 Bin System **Scenario E – Bin & Crates**

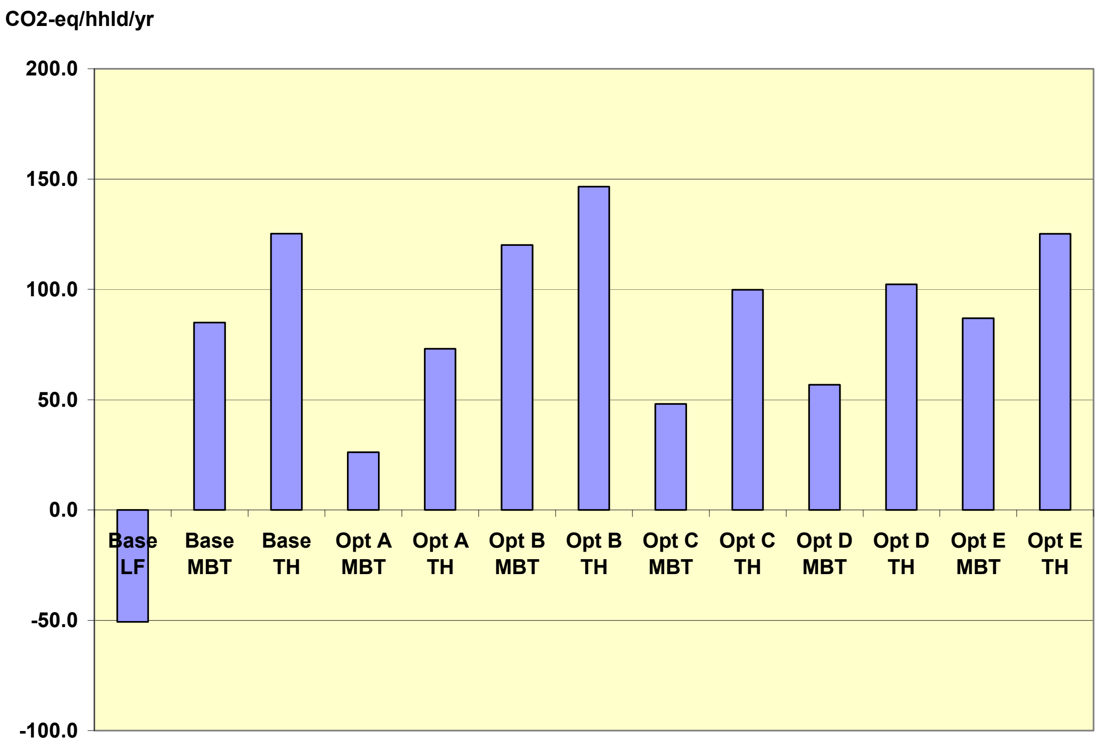


Figure 4.5: Total Net Greenhouse Savings (kg CO2eq/hhld/yr)

The graphs indicate that there is a net greenhouse gas *emission* (i.e., a negative saving) occurring for the Base Case Scenario where all garbage is sent to landfill untreated (methane emissions contribute more than the savings through electricity generation from the captured landfill gas). Although there are substantial greenhouse savings from recycling for this scenario, these do not entirely offset the uncaptured landfill gas emissions. All other scenarios show net greenhouse savings. For the MBT options, the savings are due to the significant reduction of methane emissions through the treatment plus some savings through carbon sequestration from application of compost. For the thermal options, additional savings are achieved through the replacement of conventional electricity generation.

It should be acknowledged that:

- Consistent with international best practice methods (IPCC, 2001), non-fossil CO_2 emissions are not accounted for in the greenhouse assessment method. Hence most CO_2 emissions from thermal technologies are excluded from the analysis.
- Any change in current waste management practice would deliver greenhouse benefits arising, not only from the credits associated with recycling and alternative technologies (as illustrated by the figures above), but the additional substantial benefits arising from avoided landfill.

- The high greenhouse performance of thermal technologies results from the electricity generating credit associated with the technology. If the marginal fuel being offset by waste generated electricity is cleaner than the current average fuel mix used as an offset in this study, then the greenhouse benefits would be reduced accordingly (refer Section 4.4.2).

4.2.2 Resource depletion/saving

This environmental indicator shows the depletion (or saving) of non-living (abiotic) resources from the environment taking account of the abundance of these resources and current usage patterns. The issue of resource depletion may also be seen partly as a social issue of intergenerational equity in that any resource use today restricts resource use for future generations. Direct environmental implications of resource use may also arise from more intensive production techniques required to find and exploit lower grade energy sources, as the higher grade reserves are depleted.

Figure 4.6 presents the resource savings for each scenario. There are savings for all scenarios with the highest savings occurring for those scenarios where more electricity is generated, thereby offsetting conventional electricity production (coal-dominated). Figure 4.7 shows resource savings expressed in dollar terms as per the model developed for the *Independent Assessment of Kerbside Recycling in Australia* (Nolan-ITU & SKM, 2001). Although the two methodologies are entirely different, both results show similar rankings across the scenarios.

The Eco Dollars method shows a slightly higher benefit associated with MBT processing as this method includes soil structure benefits associated with compost application as part of the net mineral resources savings.

It should be acknowledged that the resource savings associated with electricity credits are more tangible (e.g., tonnes of coal) than those associated with the application of MSW compost to soil which are less well defined (such as soil structure and microbial properties and nutrient supply). Hence both impact methods used in this study more comprehensively address the savings from thermal technologies.

Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin **Scenario D – 1 Split Bin**
Scenario B – 3 Bin System **Scenario E – Bin & Crates**

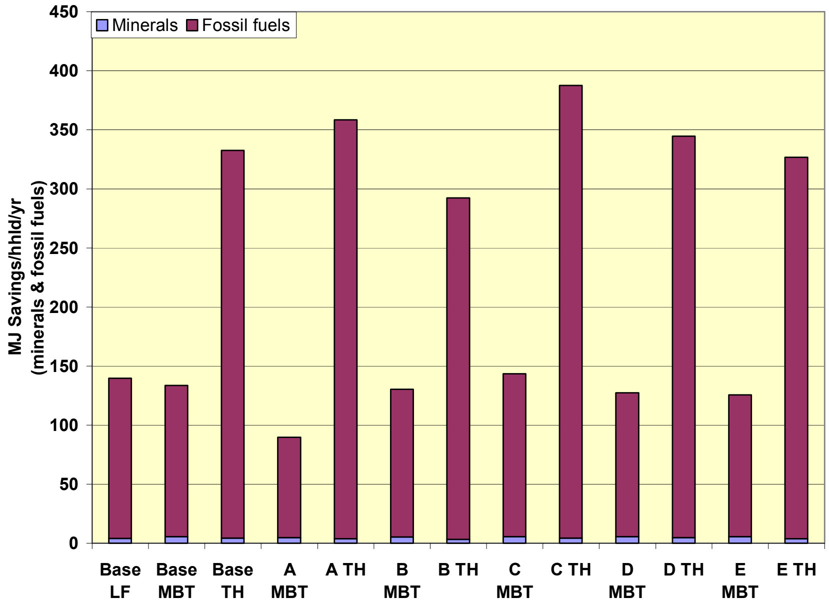


Figure 4.6: Resource savings expressed in MJ/hhld/yr (EcoIndicator 99 Model)

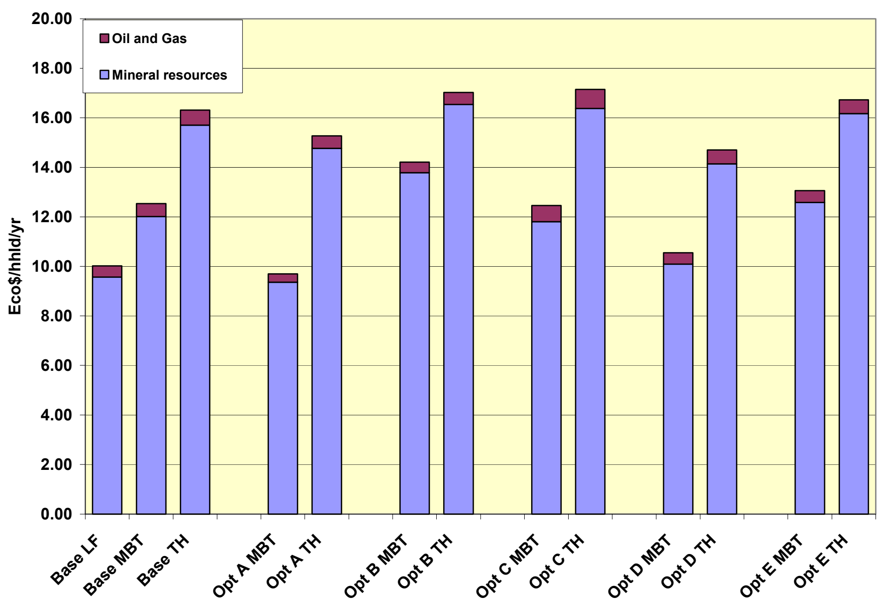


Figure 4.7: Resource savings expressed in Eco$

4.2.3 Human toxicity

The human toxicity savings through the various scenarios are presented Figure 4.8. In the Eco-indicator 99 method, normalisation and weighting are performed at damage category level (endpoint level in ISO terminology). The unit for Human Health is DALY (Disability Adjusted Life Years). This means different disabilities caused by diseases are weighted. The main contributing factors are carcinogens, respiratory organics, and respiratory inorganics. Air emission toxic substances to this environmental indicator include Se, PAHs, fluorides, including HF, ethylene oxide, dioxin, Cr (VI) and As.

The method is based on European fate analysis and should only be used as a relative indicator of the human toxicity impacts of scenarios rather than as an absolute measure.

The results indicate a dominant influence through material recycling credits, i.e., systems with higher net yields for material recycling show highest scores.

Key:

Baseline – 2 Bin System	**Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin	**Scenario D – 1 Split Bin**
Scenario B – 3 Bin System	**Scenario E – Bin & Crates**

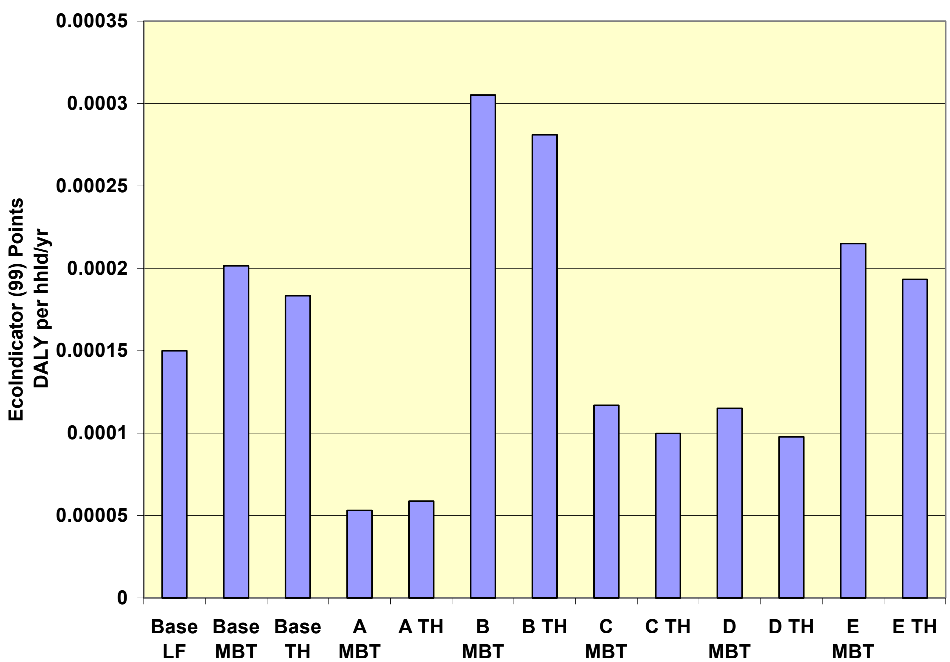


Figure 4.8: Human toxicity savings (DALY – EcoIndicator 99)

4.2.4 Eco-toxicity

The effects of a (reduced) release of toxins into ecosystems for the various scenarios, as expressed by the eco-toxicity indicator, are shown in Figure 4.9. For simplicity reasons, the subcategories of marine, freshwater and terrestrial eco-toxicity have been combined. The results are shown in kg 1,4 dichlorobenzene equivalents (1,4 DBeq).

As for human toxicity, the results are strongly influenced by the performance of the recycling systems. Fluoride emissions have not been accounted for. A significant factor is phenol emissions from PET production (and hence credits through PET recycling). However, there is a degree of uncertainty as all PET is imported into Australia from a range of different countries (with different environmental standards and regulations).

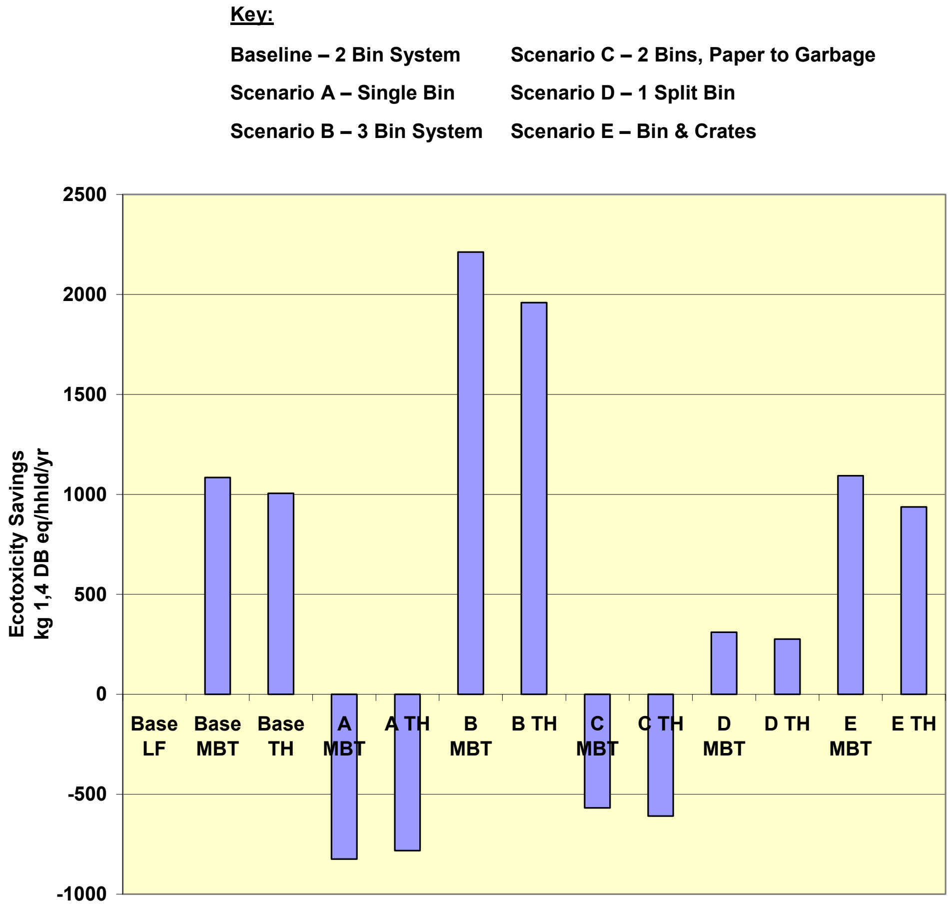


Figure 4.9: Eco-toxicity savings (kg 1,4 DB eq/hhld/yr)

4.2.5 Photochemical oxidation (smog)

Figure 4.10 presents the savings in photochemical oxidation (smog) potential. The main contributing substances to photochemical oxidation are NO_x, CO, methane and non-methane VOC's. The results and ranking show that, for photochemical oxidants, the scenarios that incorporate recycling of plastics and paper fractions perform well. There are also savings in photochemical oxidants from avoiding landfill gas emissions. These sources together overwhelm the emissions from transport that would otherwise be expected to contribute significantly to photochemical oxidants.

Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin **Scenario D – 1 Split Bin**
Scenario B – 3 Bin System **Scenario E – Bin & Crates**

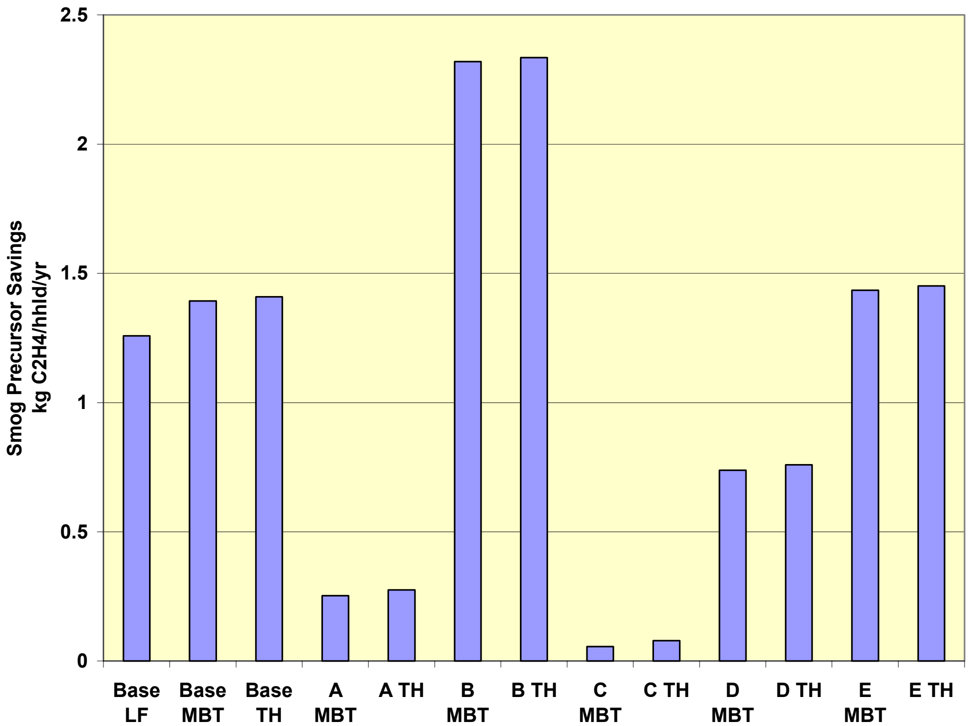


Figure 4.10: Net photochemical oxidation savings potential (kg C2H2/hhld/yr)

4.3 Environmental-Economic Valuation method

4.3.1 Methodology

The Environmental Economic Valuation method that was developed, and internationally peer reviewed, for the National Packaging Covenant Council in the *Independent Assessment of Kerbside Recycling in Australia* (Nolan-ITU, 2001) has been used as the basis of the environmental economic assessment for this study. The economic valuation of environmental impacts is undertaken by the application of life cycle inventory data and economic valuations for pollutant and resource impacts. Once LCA inventory data is modelled for each system, the output inventory data is aggregated into environmental impact categories. Pollutant loads within impact categories are assigned monetary values based on existing and published cost benefit studies by regulatory agencies.

The economic valuation model is applied on the basis of equivalence values between environmental loads (loads include all impact categories such as air and water pollution and resource depletion potential). Unless a government-published economic valuation exists for a load, the valuation is established on the basis of the relative impact with respect to a base factor. For example, global warming potential is set against the valuation of carbon dioxide; resource depletion valuation is established for all resources relative to coal; and the air pollution valuation is set against the value of fine particulates. Table 4.2 provides more details on the environmental economic valuation that underlies this assessment method.

a) Changes to LCIA valuation

Because impacts are defined *relatively*, it is important that undefined loads are not excluded from the valuation method, as this would bias results. For this study, new loads have been incorporated within the model in an attempt to avoid this bias. These include additional resources within the *resource depletion potential* impact category. Additional resources that have been included in the model include dolomite, phosphorus and gypsum. These have been included for the resource depletion value with the economic equivalence set at that of limestone. MSW Compost has been defined to provide credits in respect to the category of resource depletion potential. These include impacts of soil structure decline, acidification, soil erosion and water loss. Additional changes are listed below:

- The solid waste category has been expanded beyond MSW to landfill to include process residuals such as fly ash, bottom ash, inert contaminants from screen and any residual oversize fractions.
- The impact of noise as traffic has been moved to the social impact assessment component of the study.

b) Potential issues arising from the method

The environmental economic method used for the National Kerbside Assessment study was developed in order to meet the goal of the study that it was developed for and was not "intended" to be applied for studies with a different purpose or extended scope. Its application to this study has the potential to introduce some bias into the findings attributable to: the relatively low impact valuation of water borne pollutants, the relatively high valuation of mineral resources and the limited range of impact categories and inventory pollutant and resource loads. Modification of the method to meet the expanded study boundary was beyond the scope of the study. The key variations in terms of study boundary include:

- the scope of activity, in that, thermal and alternative treatment technologies are valued;
- the use of Life Cycle Inventory data well beyond the range of pollutant loads covered in the original model; and
- the use of different LCI data values for recycling and landfilling systems.

In order to compensate for differences arising from the application of this method to the expanded system, a weighting factor of 2 has been introduced on air and water pollutants[2]. This weighting is applied for the purpose of maintaining consistency with the findings of the original NPC study. The weighting is a compensatory factor in order to minimise deviation from previous findings. The alternative approach of revising inventory data for inconsistencies was beyond the scope of the study.

It is for the above reasons that the authors recommend research be sponsored into the establishment of more comprehensive and compatible life cycle inventories and data bases to improve the assessment of environmental performances of waste management technologies and systems, and to incorporate information on emerging systems.

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[2] The major change compared with applying a factor of 1 is an increase of the impacts of landfilling by approximately Eco$15. The ranking of scenarios does not change.

Table 4.2: Environmental-Economic Impact Assessment: Classification and Valuation

Category	Impact Classification	Environmental Economic Valuation
Water and Air Pollutant Loads	Pollutant loads from the inventory are classified as Water Pollutant Loads or Air Pollutant Loads if they have the potential to effect: human toxicity (air or water), aquatic ecotoxicity, nutrification, acidification and photochemical oxidant formation or to cause utility loss and nuisance[3]. Due to the limited range of pollutants these categories carry twice the weight of other categories to maintain consistency.	Environmental economic values from published government sources are used where possible. If values are not available, equivalence factors are used to scale the economic values for unknown pollutants relative to known pollutant values. Known pollutant values account for 92 – 95 % of air pollutant values and greater than 85% of the net value of pollutant loads. Equivalence factors are derived from local regulations and published international LCIA references. Sensitivity analysis reveals that the final values used for this study provide valuation results which are lower than would be if the “lowest” of a range of pollutant value were adopted from the comprehensive international valuation project, ExternE (European Union DGXI, 1998)..
Global Warming Potential	Global warming pollutants are common to all inventory data. The limited range of pollutants considered by the inventories mean that only global warming potentials for these pollutants are required.	Global Warming Potentials are determined using CO2 equivalence Factor. The estimated value used by the study is revised to $ 20.60/ tonne CO2 equivalents.
Mineral Resource values	A subset of resource inputs have been considered as part of the study due to data and modelling limitations. The resources modelled are the 5 most prevalent resources by weight in each inventory for the dominant packaging materials and for fuels. NB: This limitation may devalue the resource value assigned in the valuation of systems as some of the trace materials such as copper have a relatively high environmental value.	Resource values have been referenced from published Australian valuation studies or estimated based on the application of international ranking to Australian data. The environmental economic valuation of mineral resource use has included categories of resource sustainability and land use impacts. In the absence of data values, published valuation data on the avoided costs for black coal are ranked using international equivalence factors. The assessment of land use values has used two variables: net free primary productivity (fNPP) and land use impact on vascular plant diversity per tonne of mineral extraction ($\propto$). The final resource value cost of coal is $47.50 per tonne. This results in subsequent values (AUS $/t) of: bauxite: $111.55, coal: $47.51 crude oil: $34.84 iron (ore): $80.56 limestone $91.52 and natural gas $34.84 and sand $10.37, dolomite, phosphorus and gypsum: $91.52 and relating to MSW compost: soil structure decline $/t 1.69, acidification $/t 2.54 and salinity $/t 2.06 and avoided water loss $30.00/tonne.
Forestry Resource Values	Inventory data distinguishes between 3 pulp sources: native and regrowth forest and plantation forests.	No published data on environmental values of timber could be sourced. It was agreed to proceed with an environmental valuation of forest resources, in the hope that the adoption of a value would prompt further debate and research in the area. In order to develop a conservative value of forest resources for the production of paper an estimate by the then Industry Commission[4] (now Productivity Commission) for “hypothetical non-wood charges” for forest resources is used. The calculated harvested timber value assuming sustainable yield of 10.25% timber per year is 35.9 AUS$/t. The environmental value (AUS $/t) of timber from native forests is 35.9, for regrowth eucalypt timber 12.6 and plantation timber 6.5.
Landfill Values	The chemical stressor impacts associated with landfill are identified and valued as water and air pollution and global warming (as above). Further, the remaining impacts associated with landfill are valued based on amenity & intergenerational equity impacts. The inventory data classified is based on net weight of recyclables or waste.	Chemical stressors are valued as above for *water and air pollution and global warming*. The valuation used for landfill is based on amenity & intergenerational equity values. The final value used is $9.35 per tonne .

[3] New South Wales Environmental Protection Authority, Regulatory *Impact Statement, Proposed Pollution Control Regulation, 1998*

[4] Industry Commission, (Feb 1991) *Report No.6 Recycling in Australia,- Appendix H, Forestry*

4.3.2 The scenarios

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 (Grant *et al*; 2003), although care must be taken in comparing these two different impact models.

a) Performance of kerbside recycling

Figure 4.11 shows the results of the environmental economic evaluation by impact categories for all scenarios sending garbage to landfill. In other words, here the environmental benefits/impacts of the different *recycling* systems are illustrated, without the influence of the various residual waste (garbage) treatment technologies. The graph reflects the performance of the various recycling systems in accordance with their net diversion rates i.e., only those recyclable materials that contribute to the benefit that are actually reprocessed (contamination and sorting losses are deducted and are modelled as waste going to landfill).

As emphasised in the *Independent Assessment of Kerbside Recycling*, higher net recycling yields provide greater environmental benefits (Note: In order to eliminate the influence of socio-demographic factors, total waste generation rates have been equalised across councils and systems for this study (see Section 2). Therefore, the terms "net recycling yield" and "net recovery rate" are interchangeable).

Figure 4.12 shows the net benefits for all options (with residual waste assumed going to landfill without any treatment or recovery). Note that Scenario A Landfill (i.e., all waste collected in one bin and going to landfill) has been set at zero to show the benefits of (kerbside) recycling over landfilling. Scenario B (separate bins for paper and containers) and the "Baseline" scenario (fully commingled recyclables) provide the highest benefits due to highest yields. Scenario E (separate crate for paper and containers) is a close third due to relatively high yields and very low contamination rates.

Key:

Baseline – 2 Bin System	**Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin	**Scenario D – 1 Split Bin**
Scenario B – 3 Bin System	**Scenario E – Bin & Crates**

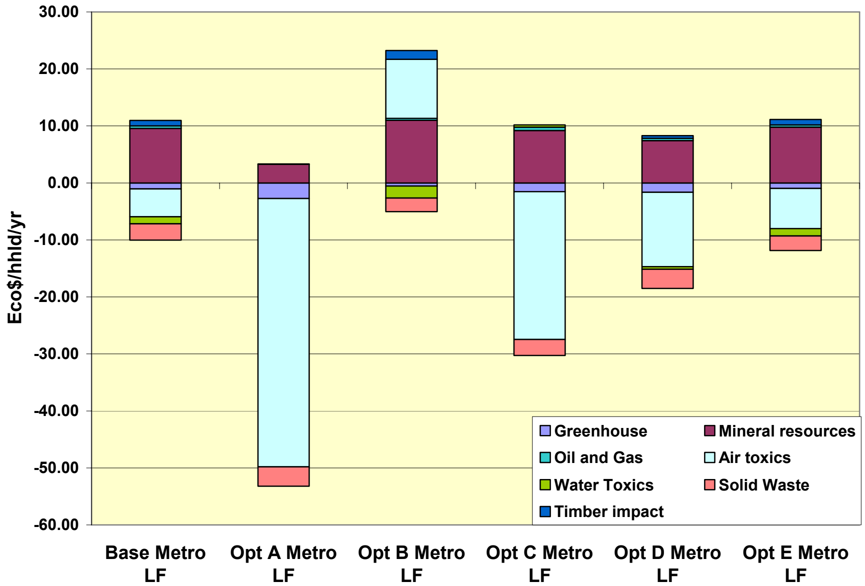

Figure 4.11: Environmental impacts and benefits of scenarios with different recycling schemes and garbage sent to Landfill (Eco$/hhld/yr)

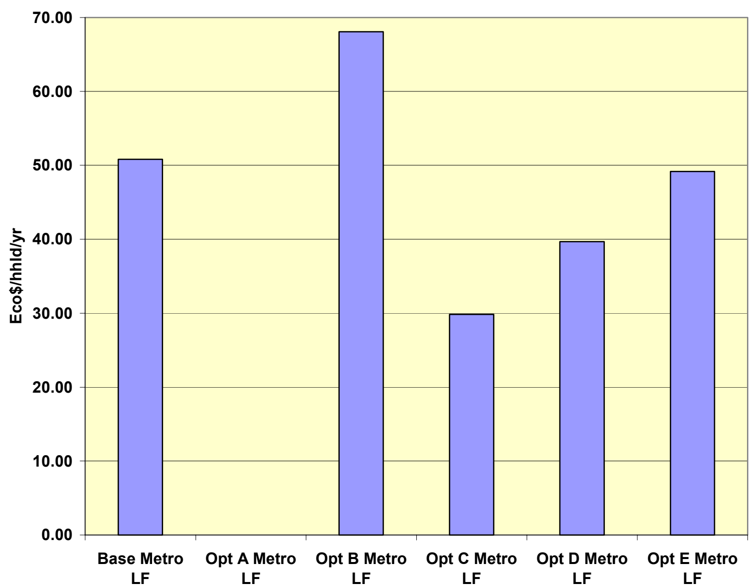

Figure 4.12: Net environmental impacts/benefits of scenarios with different recycling schemes and garbage sent to landfill (Eco$/hhld/yr)

b) Performance of residual waste management

In a final step, the environmental impacts and benefits of the generic residual waste (garbage) treatment options have been added through incorporation of those scenarios that were required to be assessed as per the project brief. Figure 4.13 illustrates the net results for these options (Note: landfilling of all waste set at zero). The figure indicates that both MBT and Thermal residual waste treatment systems provide considerable environmental benefits over landfilling however, the recycling credit is still a highly significant variable influencing the overall environmental performance of the systems.

The scenarios with the highest recovery rates, Scenarios B, Baseline and Scenario E, provide the highest benefits. The environmental performance of the “Base Case” is somewhat lower due to lower recycling yields and higher contamination rates. Scenario A (Single Bin System) shows the lowest performance however, these results are highly dependent on assumptions made about recovery rates from front-end sorting systems as has been shown in the sensitivity analysis. Scenario C is also a low performer which indicates that the production of mixed waste compost or energy from paper does not provide as high an environmental benefit as does the recycling of paper and cardboard back to paper and cardboard. Scenario D with low recycling yield attributable to system contamination delivers only average benefits.

NB: the findings of the analysis are consistent with those undertaken for EcoRecycle Victoria in the LCA of Waste Management Options with variations in finding arising due to:

- the incorporation of additional measures for valuing some of the benefits of compost application, and
- modification of the assessment of waste-to-energy (“thermal”) technologies with the electricity credits limited to the data range used by recycling and other alternative technologies and lower electricity generation based on system configuration assumptions.

All studies illustrate the significant role of recycling in the overall performance of the integrated waste management system.

Key:

Baseline – 2 Bin System
Scenario A – Single Bin
Scenario B – 3 Bin System
Scenario C – 2 Bins, Paper to Garbage
Scenario D – 1 Split Bin
Scenario E – Bin & Crates

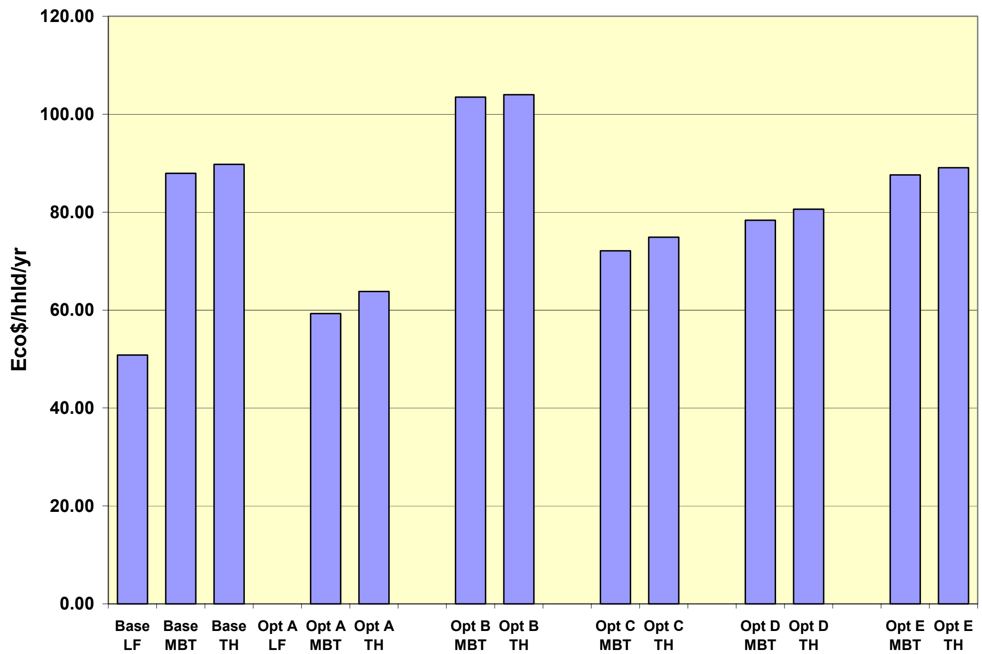

Figure 4.13: Net environmental impacts/benefits of all scenarios (Eco$/hhld/yr)

4.3.3 The impact of paper waste management

The environmental assessment was also extended to determine the performance of paper and cardboard in the following waste management systems:

- Paper separated at source and recycled into paper and board (Figure 4.14);
- Paper collected as part of the garbage stream (no source separation), and sent to an MBT facility with subsequent production of (mixed waste) compost (Figure 4.15); and
- Paper collected as part of the garbage stream (no source separation), and sent to an Thermal (waste-to-energy) facility (Figure 4.16).

Note on Paper Composition

Detailed paper and cardboard compositions for both metropolitan and regional / rural waste and recycling streams were determined from both in-house and publicly available audit information. Data sources included:

- In-house metropolitan domestic garbage compositional data;
- Metropolitan recycling compositional information for the Macarthur region (Resource NSW and Waste Service NSW; 2002); and
- Domestic garbage and kerbside recycling data for the NetWaste region (Nolan-ITU and RW Corkery & Co; 2001 and 2003).

From this data, paper and cardboard information was isolated to determine the percentage composition of the paper and cardboard stream entrained within both domestic garbage and kerbside recyclables. The four categories of material determined were newspaper, cardboard, magazine/flyers, and other paper including printing / writing. Once the breakdown of paper and cardboard streams were determined for each of the four streams, they were applied to the total paper and cardboard yields to determine the quantity of the above four materials. The calculated figures were then used to model results.

Note that, for the financial assessment, nappies have been included with "other wastes" within the domestic waste compositions. For the environmental assessment, nappies are included in the low-grade paper of the garbage fraction.

Figure 4.14 shows the benefits (green arrows) and impacts (red arrows) of material recycling of paper. The tree only shows the most significant contributors with the magnitude of the cost/benefit indicated by the width of the arrow). The graph clearly indicates that the recycling of ONP provides the highest environmental benefits. Both mixed paper and cardboard have significantly lower environmental benefits. Offsetting a component of the benefits, the largest impacts come from the energy required for reprocessing.

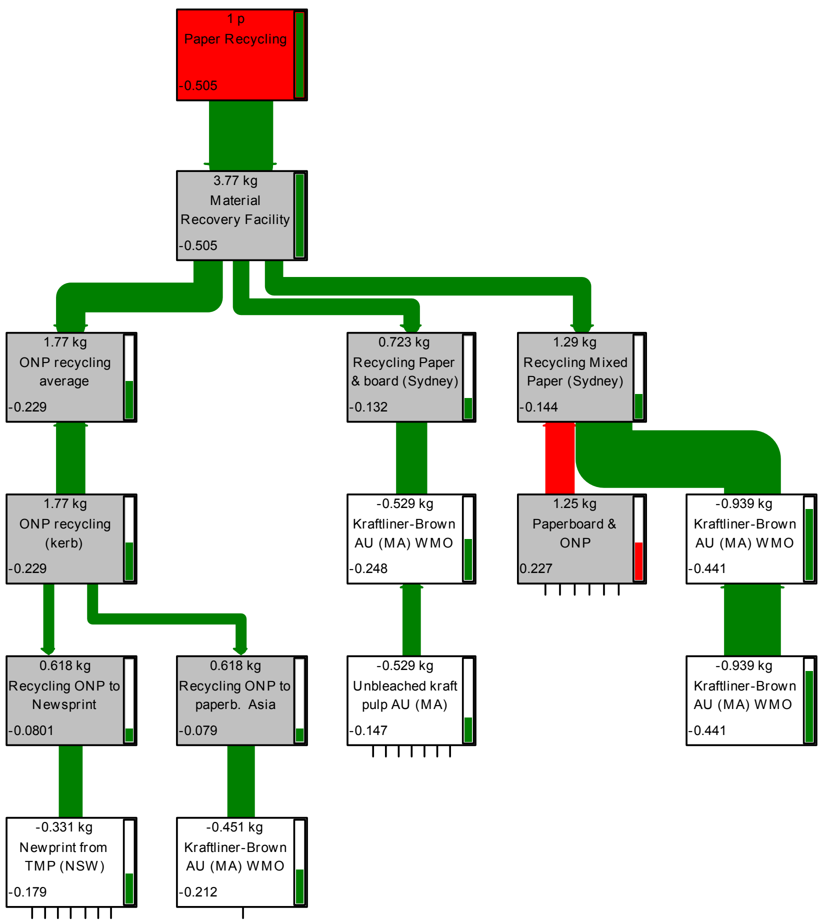

Figure 4.14: Environmental performance of paper recycling (Eco$ Model)

Figure 4.15 shows that the collection of paper with the garbage stream and the subsequent processing in an MBT facility provides environmental benefits through the production and application of (mixed waste derived) compost. However, the impacts dominate this system.

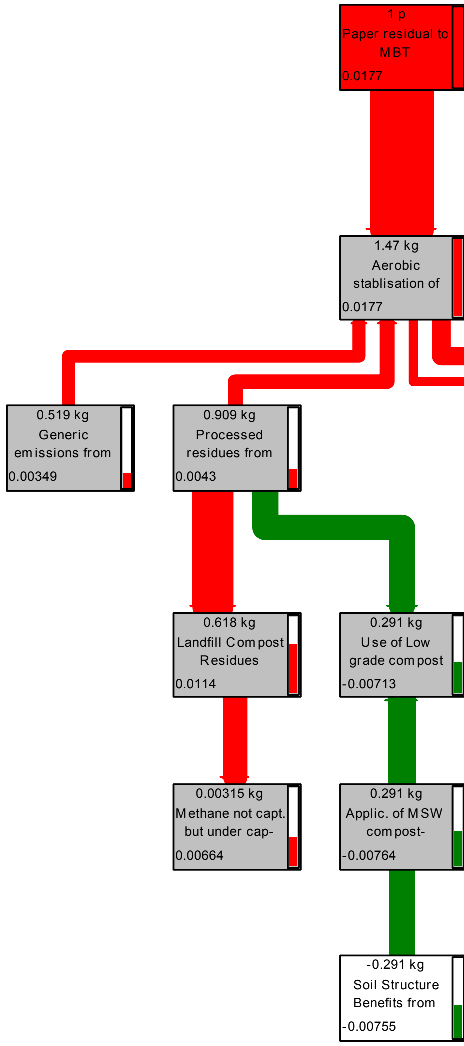

Figure 4.15: Environmental performance of paper to MBT (Eco$ Model)

Figure 4.16 shows the main impacts and benefits from a system where paper is collected with the garbage stream and sent to a thermal (waste-to-energy) facility. The relatively high calorific value of paper provides significant benefits through avoided electricity production (standard south eastern Australian mix), which outweigh the impacts generated through emissions.

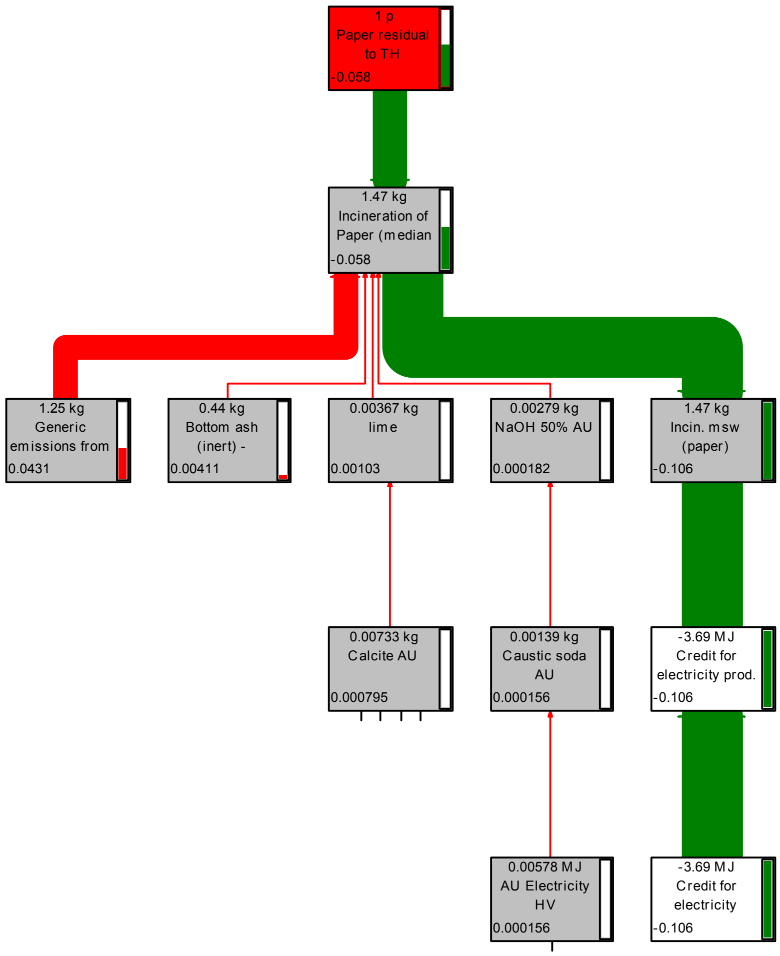

Figure 4.16: Environmental performance of paper to thermal energy recovery (Eco$ Model)

It is important to note that although the thickness of the arrows in the above figures indicates the relative contribution of a process, material or product stage, one cannot compare one graph directly with another. For direct comparison of the three systems investigated, Figure 4.17 and Figure 4.18 are presented below.

Both figures illustrate the strong performance of paper recycling over the alternatives. Paper collected with garbage and sent to a waste-to-energy plant still provides some, albeit much lower, net benefit. The collection of paper with garbage with subsequent processing in an MBT plant shows the lowest environmental performance (although it is still much higher than sending it straight to landfill).

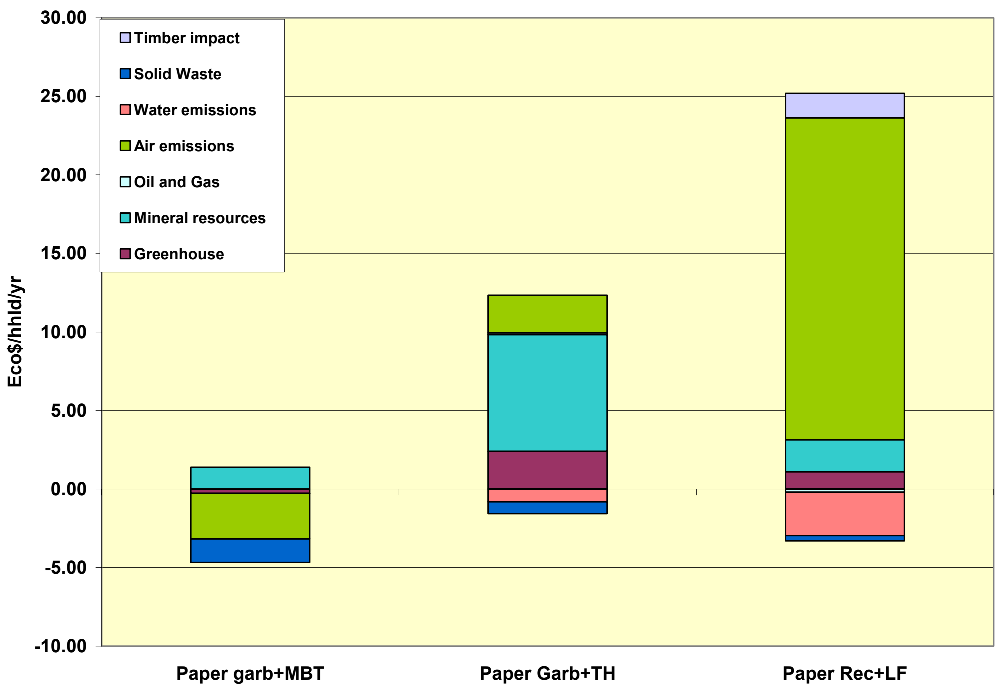

Figure 4.17: Comparison of environmental performance of paper waste management by impact category (Eco$ Model)

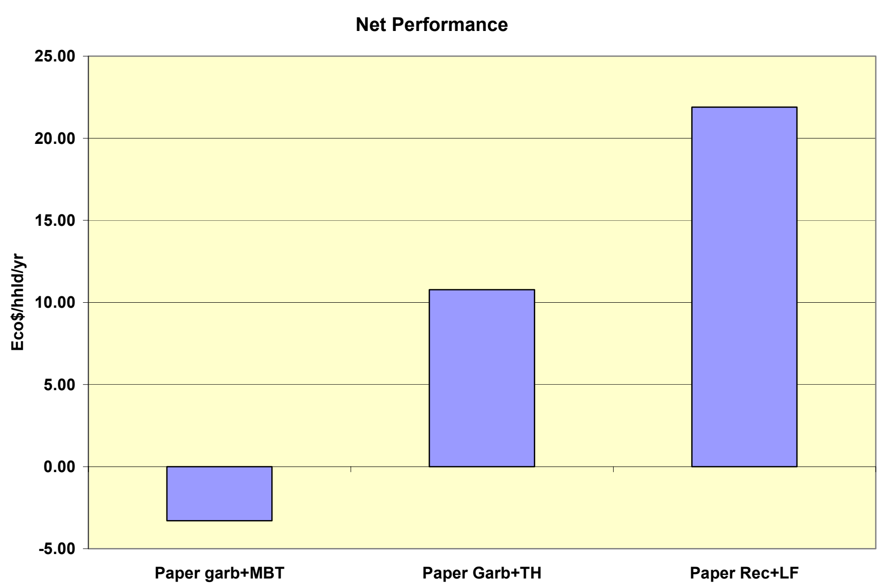

Figure 4.18: Net Environmental performance of paper waste management (Eco$ Model)

4.3.4 Waste management in regional/rural NSW

All scenarios modelled for the metropolitan region have also been modelled for regional / rural NSW. Data on waste composition, quantities and recycling rates in country NSW is more variable; there are fewer councils that have contributed to collating the data, and therefore the results are less reliable than for the metropolitan region. In general, the environmental analyses have shown similar trends as in the metropolitan area. It was agreed with the Steering Committee that a full presentation of all impact categories and results would not be justified. For the above reasons, only one summary chart is provided indicating the differences between regional and metropolitan scenarios. The main reason for the differences is different waste and recycling compositional data.

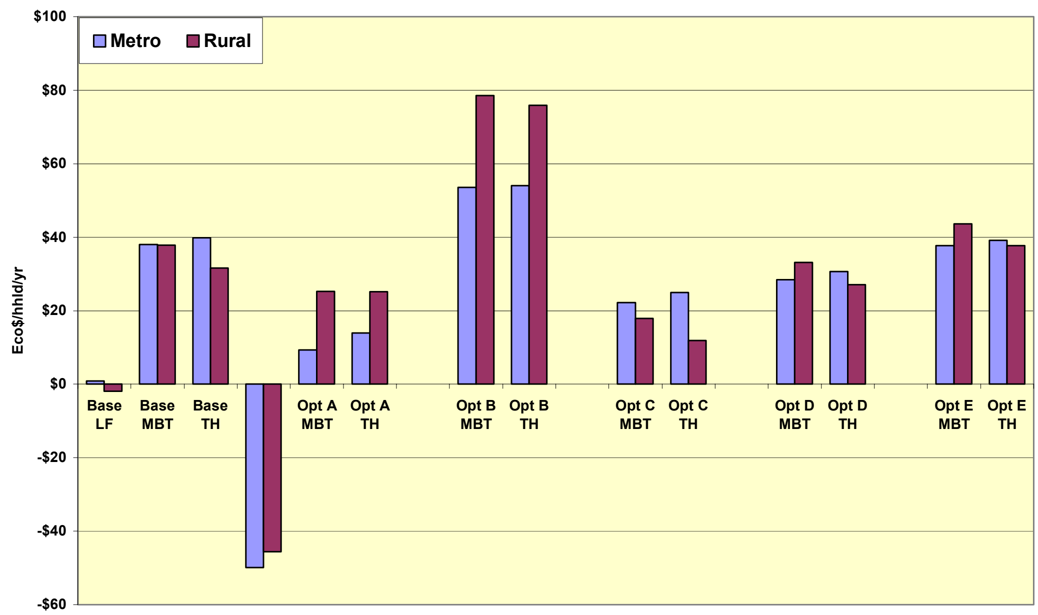

Figure 4.19: Comparison - metropolitan and rural/regional NSW environmental results

4.4 Sensitivity analyses

4.4.1 Hybrid Technologies – The GRL "UR-3R" Facility at Eastern Creek

In addition to generic residual waste treatment systems, recent developments have seen the emergence of a new generation of waste treatment technologies. In NSW, the most relevant of these technologies is the UR-3R facility currently being established by Global Renewables Limited (GRL) for Waste Service NSW at the Eastern Creek Waste Management Centre. This facility brings together a number of technologies in a new configuration. Frequently, these configurations are referred to as "Hybrid Technologies". Although no 'measured' performance data for this facility is available, a range of documents (e.g. NECS; 2001) is available which describe the performance of the facility.

The UR-3R facility is due to commence operations in mid-2004 and will source waste from a number of Western Sydney councils. For this study, the expected environmental performance of this ‘hybrid technology’ was modelled and compared against the scenarios described in previous sections.

Three additional scenarios have been modelled:

- Baseline (2 bin system) with UR-3R processing of garbage;
- Scenario A (single bin) with UR-3R processing of the entire waste stream; and
- Scenario B (3 bin system) with UR-3R processing of garbage.

Table 4.3 shows assumed material recovery rates in the process as advised by GRL. Allowance has been made to account for the energy generation through biogas production but the authors note that the modelling is an approximation rather than a detailed life cycle assessment of this particular technology, which was beyond the scope of this study.

Table 4.3: Assumed recovery rates (UR-3R)

Material	Recovery Rate (%)
Paper & Cardboard	60
Glass	60
Aluminium	80
PET	80
HDPE	80
Steel Cans	90

Figure 4.20 below shows the overall results of this modelling (LCA plus environmental economic valuation). For easier comparison, the bars indicating the UR-3R performance are depicted in orange and the corresponding scenarios employing generic MBT technology in light blue.

The results predict that in each case the performance of the hybrid technology is superior to conventional generic residual waste treatment technologies. It also becomes apparent that, with existing (Sydney) recovery rates for recyclables from kerbside collection, the single bin scenario (Scenario A) may not achieve an equivalent environmental benefit as a scenario where recyclables are collected and sorted separately.

It is noted that another option, which has been flagged by GRL, namely the separation of paper for kerbside collection in combination with processing of the remaining waste stream through the UR-3R technology, has not been modelled. Another unknown is the issue of (domestic) garden waste management, which has not been assessed under the terms of this study.

The above results will need to be verified with actual performance data once operations have commenced.

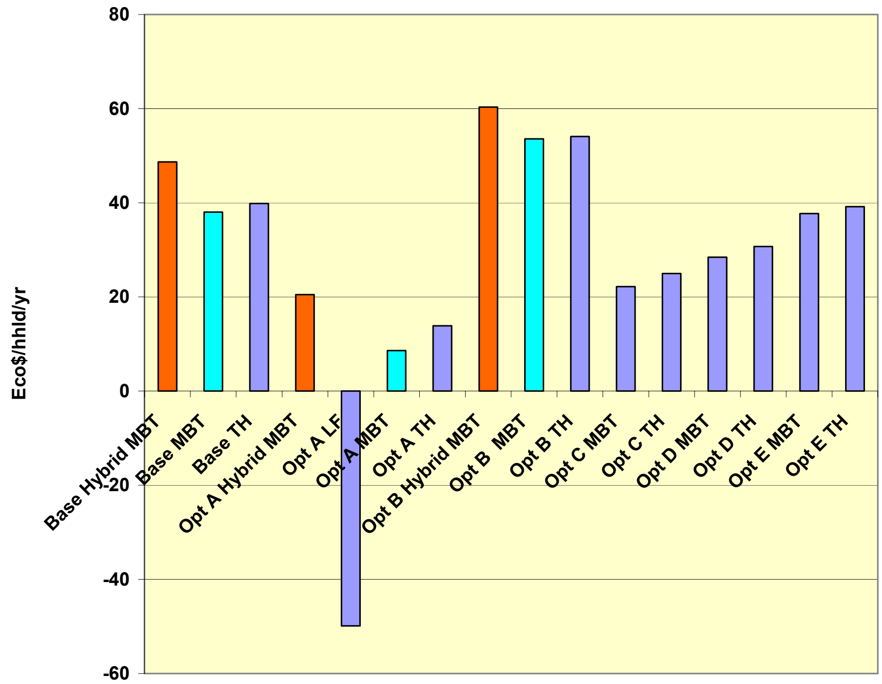

Figure 4.20: Environmental performance of GRL UR-3R System

4.4.2 Electricity mix

The question of which electricity mix to assume when replacing electricity through an alternative generation method at some time in the future is subject to much debate. As an example, for this sensitivity analysis, a "green" electricity mix as shown in Table 4.4 has been assumed.

Table 4.4: "Green" electricity mix

Source	Percentage
Oil	4.9%
Gas	16.6%
VIC coal	3.3%
NSW coal	6.2%
Hydro AU	69.0%

The results of the sensitivity analyses of modifying the electricity generation mix are shown in Figure 4.21. As would be expected, the environmental benefits of waste-to-energy scenarios are reduced as the 'replaced' electricity is assumed to be cleaner and hence the credits smaller. The impact of the mix on MBT scenarios is negligible as the energy consumption is very small compared to the credits from recycling.

Key:

Baseline – 2 Bin System	**Scenario C – 2 Bins, Paper to Garbage**
Scenario A – Single Bin	**Scenario D – 1 Split Bin**
Scenario B – 3 Bin System	**Scenario E – Bin & Crates**

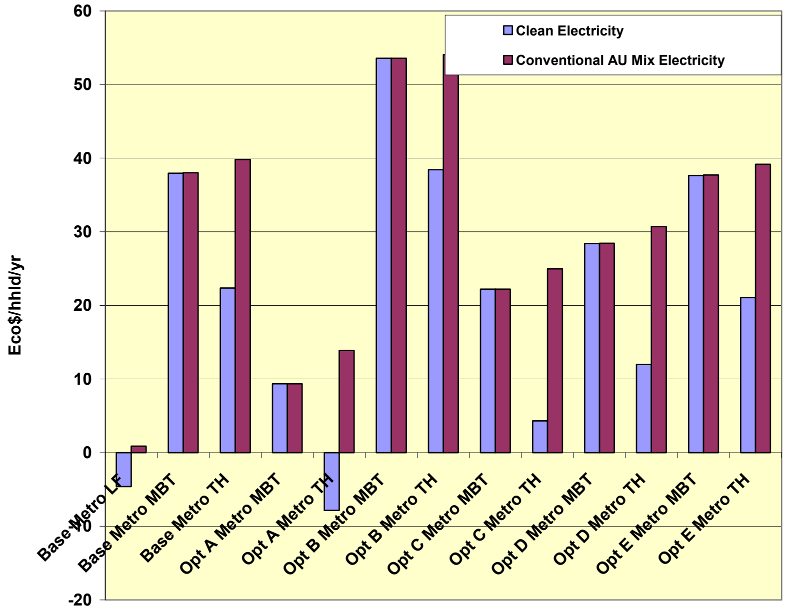

Figure 4.21: Impact of electricity mix

4.4.3 Transport distances

The *Life Cycle Assessment of Waste Management Options* study (Grant *et al*; 2003) examined the effects of transporting materials to processing facilities. Changing the assumed transport distances was found to have very little impact on the environmental performance of waste and recycling systems. A similar conclusion was reached in the *Independent Assessment of Kerbside Recycling* (Nolan-ITU *et al*; 2001). For these reasons, no separate sensitivity analysis was conducted for this study.

4.5 Summary

As with life cycle sciences, approaches and methodologies in all sectors, including the waste sector, experiences continuous improvement of databases and methodologies. This component of the study has brought together work in this area that has occurred over a five-year period, from the *Independent Economic Assessment of Kerbside Recycling in Australia* (Nolan-ITU; 2001) through to the various *LCAs for Packaging Materials* (Grant *et al*; 2001) and the recent study *Life Cycle Assessment of Waste Management Options in Victoria* (Grant & Nolan-ITU; 2003). Care has been taken to compare systems without bias, as waste management and recycling deals with a high number of different materials (almost all materials being used in our society) and requires consideration of many, often complex, processes.

Therefore, albeit having utilised improved data and methodologies, the results presented in this report should not be seen as 'the final numbers" of environmental performance of the various options assessed. The environmental savings expressed in dollar terms are likely to increase significantly in the future as, in general, a conservative approach has been taken here. Data gaps remain, which, once filled, will provide a more comprehensive picture. The results of the study should primarily be seen as a comparison between the various scenarios, which also provide an indication of the absolute costs and benefits expressed in dollar terms.

The more recycling the better: The more material that is recycled the higher the environmental benefits. Systems using two MGBs for recycling (one for paper, one for commingled containers, each collected fortnightly (or on alternate weeks) i.e., Scenario B) showed the highest recycling rates, followed by the 240L fully commingled recycling bin, followed by the two crate recycling system (lower yields but also low contamination). Split garbage/recycling bins are inferior due to low yields and high contamination.

Residual waste treatment provides additional benefits: Treatment of residual waste prior to landfilling provides environmental gains of a similar order of magnitude to recycling.

Mechanical-Biological Treatment (MBT) versus Thermal Treatment: Both MBT and thermal technologies provide overall environmental benefits of a similar order. Using current environmental accounting techniques, thermal treatment provides slightly greater greenhouse gas savings than MBT and slightly lower savings in other impact categories. This is however dependent on the type of energy source assumed when calculating electricity offsets.

Hybrid and New Technologies: There are a number of new waste treatment/resource recovery technologies entering the market, which are likely to achieve better environmental performance than the generic technologies used in this assessment.

The Fate of Paper: The recycling of paper to make paper provides significant environmental benefits. These are much higher than the use of paper for energy recovery. Systems that convert paper into mixed-waste derived compost provide the lowest benefits.

5 SOCIAL IMPACT ASSESSMENT (SIA)

5.1 Social trends in waste management

Waste and recycling collection and treatment systems have social costs and benefits in addition to their economic and environmental costs and benefits. At one end of the spectrum, an efficient and regular waste management system significantly contributes to social capital through the provision of health and amenity benefits, which are largely taken for granted in the contemporary era. At the other end of the spectrum, it is unfortunately the case that waste management can adversely affect the prevailing social fabric of a community, particularly in terms of the divisiveness that can be associated with the siting of some waste management infrastructure. It is therefore important – in considering optimal waste and recycling collection and treatment system options – to also consider their social ramifications.

While the efficiency of most Australian waste management systems makes waste from household activity increasingly “out of sight and out of mind” for many members of the community, waste management is nevertheless likely to become more relevant to the broader community going into the future for several reasons.

First, the increasing application of full (external) costs to landfill disposal – both in NSW and across Australia - is likely to, over time, increase the cost of waste management. The community will be exposed to this in the form of Council rates and charges. Secondly, the desire and drive for environmental protection, including resource conservation and greenhouse gas abatement, is likely to increase as more scientific evidence comes to light. Finally, the development of new technologies in the waste management sector will also create community debate and interest.

At the same time many members of the community are increasingly focussed on tangible aspects of their material lives and have increasingly high expectations about their quality of life. Nowhere is this more evident than in home improvement and asset appreciation. People are highly sensitised to the potential implications of any new development in their neighbourhood on property values and lifestyles.

5.2 Meeting the social challenge

The increasing challenge for waste managers is to meet their direct objectives - such as safe and sanitary disposal of waste and increased resource recovery - while minimising implications of waste management activities on communities and involving those communities as active partners. It is important at the planning and decision-making phases to carefully consider and weigh up the different social costs and benefits of alternative waste management collection and treatment systems. This project has made a preliminary attempt in that regard through the conduct of a modified *Social Impact Assessment (SIA)* and the partial economic valuation of the social costs and benefits of various impacts associated with waste management activity.

It is increasingly important to systematically factor the interests and viewpoints of different groups in our society into environmental management decision-making. Not only is social inclusiveness in decision-making in line with the “participation principle” of sustainability, it has also been shown at the practical level to be an effective risk management strategy for decision-makers.

While “community consultation” has long been a feature of local and State Government practice in NSW, many of its techniques have been limited in their efficacy. Communities or other stakeholder groupings are often asked to provide feedback but sometimes do not understand the issues well enough to be able to contribute in a meaningful way, or may feel that the outcome has been predetermined. Additionally, many of the techniques - for reasons of available time, resources and design - struggle to accurately capture a community's or stakeholder group's viewpoints and then somehow substantially include them in the decision-making dynamic. Better approaches are required that are more quantitatively based and repeatable.

While an objective economic evaluation (including environmental performance) can be developed for each waste management scenario, the reality is that some aspects of performance are more important to the community, and also other groups such as Councillors, than other aspects. For example, a system can be extremely affordable in a financial sense (such as disposal of all waste streams into a local tip), but could be rejected by the community and others as unacceptable due to environmental aspirations.

To that end, the project team has used a **Multi-Criteria Assessment (MCA)** model to factor in community and stakeholder viewpoints – with the main stakeholder group being local government waste managers. The method relies on a group assigning weightings to the areas of potential cost/benefit that are of greater or lesser concern. The MCA is the central part of the project's final integrated assessment of the different waste management scenarios.

5.3 Social impacts identification

In terms of identification of potential social impacts from waste management collection and treatment systems, four approaches were followed. Firstly, the project team decided on a "limited boundaries" approach to social impacts, e.g., those that are most directly associated with the introduction and conduct of a waste management system. As a result, aspects such as macro-economic costs or benefits have not been included. Secondly, the project team considered a standard set of social impact categories commonly used when conducting SIA as suggested by the widely recognised *Guidelines and Principles for Social Impact Assessment* developed by US Government agencies (1994). Thirdly, the project team conducted a contextual scan of its own experience and asked local government decision-makers what community-related implications Councils consider when planning or deciding on a waste management system. The project team used the results to modify the categories of analysis suggested by the US guidelines to suit local circumstances.

Also, appropriate modifications were made to reflect a system-wide analysis as opposed to a technology-specific analysis, and maintain consistency with past precedents, including the social impact categories in the NSW Department of Environment and Conservation's *Waste Treatment Technologies Handbook and Assessment Tool* and the NSW Government's *Alternative Waste Management Technologies and Practices Inquiry Report* (2000).

In this regard, the relationship between the community relations 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 “base” list of social impacts to be assessed (as initially developed by the project team) is as follows:

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
Natural and Cultural Heritage Impacts
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.

Finally, having developed this potential “base” list of social impacts, the project team then sought the views of local government professionals. A survey was sent out to all 172 Councils in NSW. Councils were asked to identify whether the impacts identified above were relevant or whether others should be considered. A consultative meeting was also held with representatives of some 20 metropolitan and regional.

Both the survey and the consultative session confirmed that the identified social impacts are relevant to Councils in the planning and decision-making phases of their waste management cycles. It is noted that not all of the impacts presented can be applied in a generic assessment of systems however, it was deemed important to cover all impacts to provide this information back to Local Government.

5.4 Impact assessment framework

There is considerable debate about the valuation of social costs and benefits. For example, how can a value be determined on a community’s residential amenity or on the preservation of a natural asset? A variety of techniques can be utilised including establishing a measure of communities’ “willingness to pay” (WTP) for different social goods and outcomes. However, the project team recommended against the conduct of a specific monetary valuation of the social cost or benefit of different scenarios. Given the number of values and variables involved, it would be less than robust to apply a comparative WTP methodology such as ‘revealed-preference’ or ‘cognitive valuation’. For example, seeking to assign a dollar value to an individual ratepayer to feel he/she is making a contribution to environmental protection through source segregation would be highly subjective and open to wide interpretation.

O’Connor (UNEP; 2002) is worth bearing in mind in this context:

> “People in different cultural settings articulate their sense of value about nature in multi-layered ways. The significance of nature, and of built environments, is embodied in a person’s or a community’s way of life, in their institutions and taboos, in their principles and precepts of right conduct, their habits and forms of cooperation. Very often, explicit value statements about the environment emerge

> only when these principles are compromised or ways of life threatened… So, valuation should be taken broadly to refer *to people's notions of what matters for the future and why*."

While there is strong merit in further work in the area of social costing in waste management, the project team and steering committee decided that, in light of the current non-existence of established objective costings, an alternative approach should be developed that allowed comparative assessment of each scenario. The adopted approach enabled the evaluation and scoring of the social impact of each of the scenarios under scrutiny.

For each social impact category, a series of performance indicators was developed and applied. Care was taken to ensure that wherever possible the performance indicators had a factual basis rather than a value judgement. The social impact assessment categories were also developed to be useable in the MCA, e.g., in soliciting community and stakeholder preferences about preferred system outcomes. 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.

Hence, the project team looked for past precedents and broader trends in terms of community behaviours and perceptions in conducting the assessment of the different scenarios. Where there was doubt, or where differences would only occur through specific technologies and their proponents in a particular situation (which cannot be generalised), the criteria have not been applied. They are, however, relevant in the assessment of individual systems and therefore they are also included in the criteria description below.

a) Individual and family impacts

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 criteria - 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

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 criteria - 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

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

Social impact assessment criteria - Householder convenience

Description	Score
Weekly service; all bins highly mobile & easily handled by vast majority of community members	5
Fortnightly service; all bins highly mobile & easily handled by vast majority of community members	4
Weekly service; some bins highly mobile & 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 recyclables)	1

d) Employment

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.

Social impact assessment criteria - 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

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

Social impact assessment criteria – OH&S

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

This category cannot be (and has not been) considered in this study, which deals with generic systems as opposed to individual technologies/proponents.

Social impact assessment criteria - 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

This category cannot be (and has not been) considered in this study, which deals with generic systems as opposed to individual technologies/proponents.

Social impact assessment criteria - 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

5.5 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 considered for the MCA in this study are community relations, labour relations and employment as these can only be determined for a specific project. They have been described above to indicate the range requiring consideration in such projects, and to inform the reader of weightings assigned to them by stakeholders in the consultative process (refer Section 7).

Table 5.1: Social assessment scores

	Base LF	Base MBT	A MBT	B MBT	C MBT	D MBT	E MBT	Base TH	A TH	B TH	C TH	D TH	E TH
Individual and Family Impacts	1.5	3	2	3	2	3	3	1	1	1	1	1	1
Residential Amenity	3	3	4	2	3	4	2	3	4	2	3	4	2
Householder Convenience	3	3	4	3	3	2	2	3	4	3	3	2	2
OHS	3	3	1	3	3	1.5	2	3	1	3	3	1.5	2
1…. worst 5…. Best													

The main differences between scenarios modelled are discussed below:

Individual and Family Impacts: Historically, thermal treatment technologies have a much higher perceived health risk than non-thermal technologies. Scenario A would appear to have a more significant social impact than the others in terms of individual and family impacts i.e., perceived loss of control over how householders can contribute to a 'better environment' as kerbside recycling is either 'taken away' (significant number of written complaints in Sterling, WA) or significantly reduced. The reason for assigning these ranks is as follows: On the one hand, given community polling and stated support for kerbside recycling, it is likely that a system that does not give householders the opportunity to feel that they are making an environmental contribution will be controversial with a significant part of the community.

Residential Amenity: Resulting from the number of truck passes.

Householder Convenience: Split garbage/recycling bins and crates are less convenient, one single bin more convenient as it is indisputable that a system based on one bin will require less householder effort.

OH&S: Scenario A has high OH&S impacts derived from manual sorting of mixed waste. Crate based systems score lower than bin based systems.

6 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 5, there is insufficient literature and research conducted in Australia that would allow a robust monetary valuation of social factors.

6.1 Metropolitan area

Table 6.1 shows the results of the cost benefit analysis grouped into 'MBT' scenarios and 'Thermal' scenarios. The financial costs (garbage and recycling collection, transport, disposal and/or recovery as per Section 3) have been expressed as the difference between the calculated system costs and the scenario where all waste is collected in one bin and disposed of to landfill. Environmental benefits have been expressed in dollar terms over the landfill only option (for details refer to Section 4.3). Figure 6.1 shows the costs and benefits whereby the "baseline' costs have been set at zero. All options are listed in order of overall performance (red bars) from left (highest) to right (lowest).

Table 6.1: Cost-benefit summary - Metropolitan options

Metro **MBT**	Baseline LF	Baseline MBT	A – MBT	B - MBT	C - MBT	D - MBT	E - MBT
Financial Cost over "All waste in one bin to landfill"	-$22	-$29	-$33	-$29	-$33	-$30	-$34
Environmental Benefit	$51	$88	$59	$103	$72	$78	$88
Net Cost/Benefit	$28	$59	$26	$75	$39	$49	$53
Metro **Thermal**	Baseline LF	Baseline TH	A – Thermal	B – Thermal	C – Thermal	D – Thermal	E - Thermal
Financial Cost over "All waste in one bin to landfill"	-$22	-$84	-$106	-$78	-$98	-$92	-$91
Environmental Benefit	$51	$90	$64	$104	$75	$81	$89
Net Cost/Benefit	$28	$6	-$42	$26	-$23	-$11	-$2

Key:

Baseline – 2 Bin System
Scenario A – Single Bin
Scenario B – 3 Bin System
Scenario C – 2 Bins, Paper to Garbage
Scenario D – 1 Split Bin
Scenario E – Bin & Crates

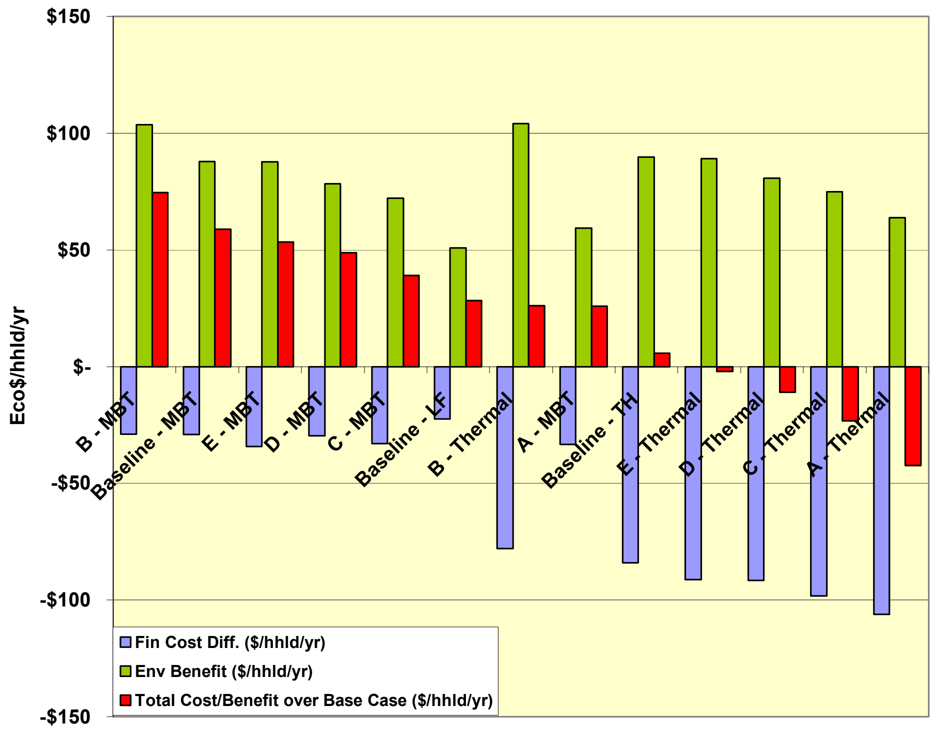

Figure 6.1: Cost-benefit summary – Metropolitan scenarios

Combining the financial costs of domestic waste management scenarios with the environmental costs and benefits expressed in dollar terms, the following three scenarios show the best overall performance for the metropolitan area:

1. **Scenario B with MBT:** Collection of recyclables from two separate MGBs, one for paper/cardboard and one for containers, with the residual waste (garbage) sent to an MBT facility.
2. **Baseline with MBT:** Collection of recyclables in one MGB (commingled), with the residual waste (garbage) sent to an MBT facility.
3. **Scenario E with MBT:** Collection of recyclables from two separate crates, one for paper/cardboard and one for containers, with the residual waste (garbage) sent to an MBT facility.

6.2 Rural/regional NSW

Table 6.2 and Figure 6.2 summarise the outcomes of the assessment of options for rural/regional NSW.

Table 6.2: Cost-benefit summary - Rural/regional options

Rural **MBT**	Baseline - LF	Baseline - MBT	A - MBT	B - MBT	C - MBT	D - MBT	E - MBT
Financial Cost over "All waste in one bin to landfill"	-$34	-$68	-$67	-$78	-$66	-$56	-$75
Environmental Benefit	$45	$78	$67	$110	$62	$74	$82
Net Cost/Benefit	$11	$9	$1	$31	-$4	$18	$7
Rural **Thermal**	Baseline – LF	Baseline – TH	A – Thermal	B – Thermal	C – Thermal	D – Thermal	E - Thermal
Financial Cost over "All waste in one bin to landfill"	-$34	-$120	-$133	-$122	-$128	-$105	-$126
Environmental Benefit	$45	$72	$68	$107	$57	$68	$77
Net Cost/Benefit	$11	-$48	-$65	-$14	-$71	-$36	-$49

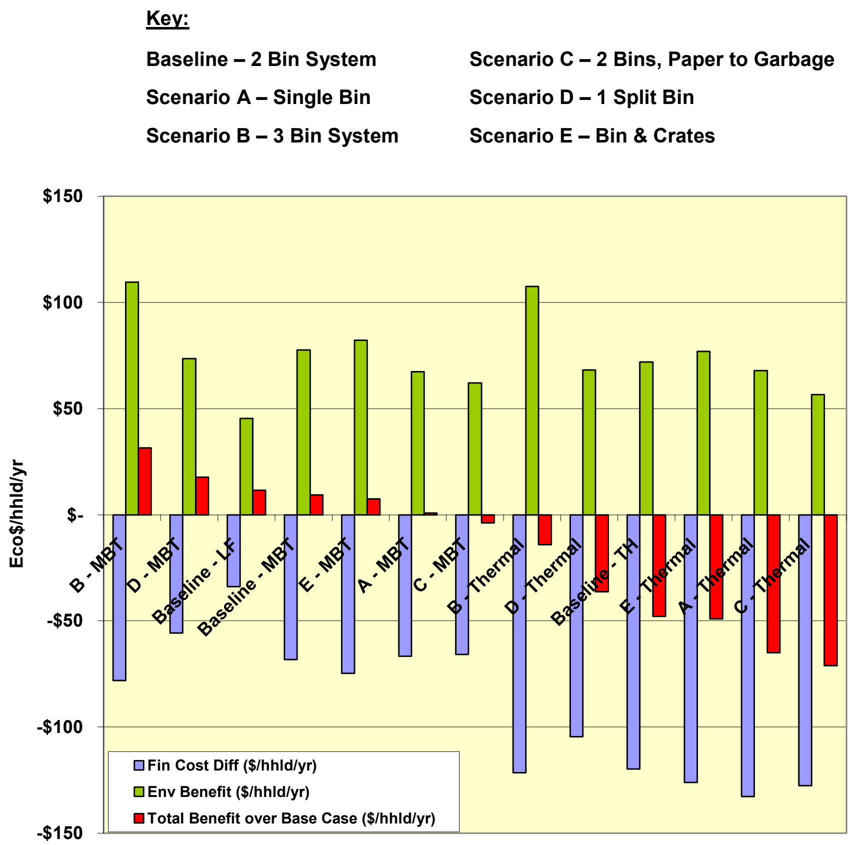

Figure 6.2: Cost-benefit summary – Rural/regional options

As indicated earlier, the results of the scenarios modelled for rural / regional NSW are based on less reliable data as only a relatively small number of Councils contributed to the averages. This, in addition to the fact that recovery rates of recyclables have a significant impact on the overall performance, should be borne in mind when interpreting these results.

In summary, it can be concluded that recycling without any additional waste treatment ("Baseline LF") shows a better cost-benefit ratio in rural / regional areas than in metropolitan areas, mainly due to the lower landfill disposal costs in those areas. Thermal waste treatment options are less favourable than MBT scenarios. This is true even without considering the fact that some rural / regional areas do not generate waste in quantities sufficient to achieve the required economies of scale for the establishment of thermal facilities.

7 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. As such, 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.

To quote Funtowicz, Martinez-Alier, Munda and Ravetz (UNEP; 2002):

> "As a tool for conflict management, multi criteria evaluation has demonstrated its usefulness in many environmental management problems. From an operational point of view, the major strength of multi criteria methods is their ability to address problems marked by various conflicting evaluations. Multi criteria evaluation techniques cannot solve all conflicts, but they can help to provide more insight into the nature of conflicts and into ways in which to arrive at political compromises in case of divergent preferences, thereby increasing the transparency of the choice process. The main advantage of multi criteria models is that they make it possible to consider a large number of data, relations, and objectives that are generally present in specific real-world decision problems, so that the decision problem at hand can be studied in a multi-dimensional fashion."

MCA techniques have the advantage that they can be used to assess alternatives using criteria that have different units (e.g., $, tonne, km, etc). This is a significant advantage over traditional methods, for example, cost-benefit analysis, where all criteria need to be converted to the same unit (e.g. dollars). Some MCA techniques also have the capacity to analyse both quantitative and 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.

MCA was also valuable for the project because it provided a vehicle for stakeholder input. This took place through giving stakeholders the opportunity to assign "weights" to different criteria, i.e., to indicate which system outcome is the most / least important to them. To quote Annandale(2003):

> "Assigning weights to the criteria is possibly the most valuable aspect of MCA because it allows different views and their impact on the ranking of alternatives to be expressed explicitly. In other words, it is possible for stakeholders to decide that an economic cost criterion is more important than an environmental deterioration criterion [or vice versa]. Appropriate weights can be attached to the criteria to measure their relative importance."

During the project “weight series” were gathered, collated and incorporated from two key stakeholder groups for the purposes of the final integrated assessment – local government waste managers and ‘typical’ NSW householders. Both groups were asked to nominate the aspects that are most important or least important to them when considering waste management alternatives. This was done on two-levels. First, both stakeholder groups needed to nominate the overall or “bigger picture” considerations of greatest / least importance, i.e., environmental performance, social/amenity performance, financial performance, or operational/technical performance. Then, within each major performance area, both stakeholder groups needed to nominate the considerations of greatest / least importance. These were as follows:

Environmental Performance

Global warming impacts
Air Pollution impacts
Water Pollution impacts
Resource Conservation

Operational/Technical Performance

Flexibility in Feedstock Quality
Modularity of System
Process Control
Staff Requirements
Proven Technology / Reference Facilities
Efficiency in Waste Reduction
Operational Reliability
Alignment with State Govt policy
Alignment with Council’s Strategy

Financial Performance

System Cost
Financial Capacity (of service provider)

Social/Amenity Performance

Individual and Family Impacts
Residential Amenity
Householder Convenience
Employment
Natural and Cultural Heritage Impacts
Occupational Health and Safety
Labour Relations
Community Relations

The process whereby weightings were gathered and its outcomes are outlined in the following sections.

7.1 Local government preferences

A survey (attached at Appendix A) was distributed to all Councils in NSW. 115 Councils (67% of total) completed and returned the survey. Of these, 14% can be classified as metropolitan and 76% as regional/rural.

The survey asked Councils to provide their preferences with regard to waste management and recycling service outcomes, and some basic information about their waste management and recycling services. The following text featured in the explanatory section of the survey:

> "When Councils evaluate which system of waste and recycling collection / treatment to use, they often apply various evaluation criteria in both the planning and tendering stages. The below lists of evaluation criteria have been developed based on a selection of NSW Councils' current practices and other information.
>
> You can also consider evaluation criteria to be the objectives that you want a waste and recycling system to deliver for your Council. Your points can be distributed in any combination that you wish; scores of zero for some categories are permissible. Remember that your top level "weighting" of the four major categories will have a significant influence on your overall scoring outcome."

The overall "weightings" provided by local government respondents are provided in Figure 7.1.

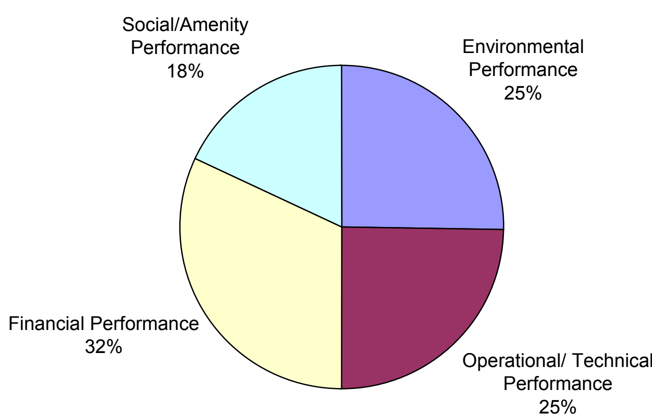

Figure 7.1: Overall weightings by all Councils

The overall weightings provided by metropolitan Councils are provided in Figure 7.2.

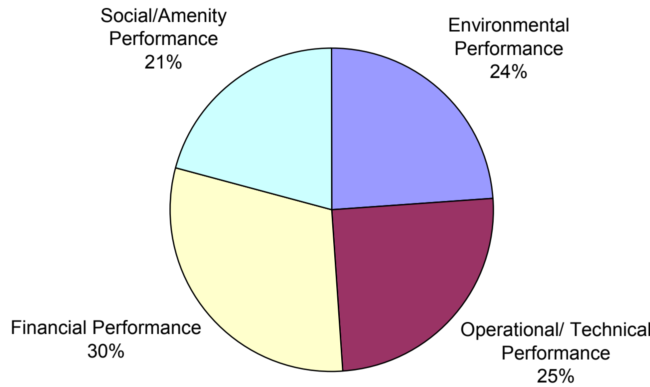

Figure 7.2: Overall weightings by metropolitan Councils

The overall weightings provided by rural/regional Councils are provided in Figure 7.3.

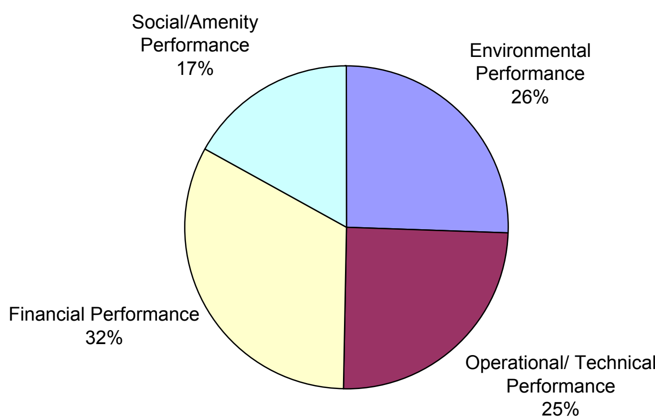

Figure 7.3: Overall weightings by rural/ regional Councils

The “weightings” for each category provided by Councils are in Table 7.1 to Table 7.4:

Table 7.1: Environmental weightings by Councils

	Global Warming impacts	Air Pollution Impacts	Water Pollution Impacts	Resource Conservation
Metropolitan	18%	23%	24%	36%
Rural	15%	24%	31%	30%
Combined (metropolitan and rural Councils)	16%	24%	28%	32%

Table 7.2: Operational/technical performance weightings by Councils

	Flexibility in Feedstock Quality	Modularity of System	Process Control	Staff Requirements	Proven Technology /Ref Facilities	Efficiency in Waste Reduction	Operational Reliability	Alignment with State Govt Policy	Alignment with Council's Strategy
Metropolitan	12%	9%	5%	5%	16%	14%	17%	9%	13%
Rural	8%	8%	6%	10%	12%	18%	17%	9%	12%
Combined	10%	8%	6%	8%	13%	16%	17%	9%	12%

Table 7.3: Financial Performance Weightings by Local Government

	System Cost	Financial Capacity (of service provider)
Metropolitan	58%	42%
Rural	58%	42%
Combined	58%	42%

Table 7.4: Social performance weightings by Councils

	Individual & family impacts	Residential amenity	Householder convenience	Employment	Natural & cultural heritage impacts	OH&S	Labour relations	Community relations
Metropolitan	17%	23%	19%	5%	6%	13%	6%	12%
Rural	12%	17%	22%	8%	6%	16%	6%	14%
Combined	14%	19%	21%	7%	6%	15%	6%	13%

7.2 Community preferences

Using a market research organisation, Nolan-ITU recruited two focus groups, each comprising nine participants. One group was based in metropolitan Sydney; the other group was based in Orange. The participants represented a cross section of "typical" metropolitan and regional communities based on occupational mix, educational levels, gender, ethnic background, and age mix. The participants were also pre-screened according to worldview (a set of major assumptions about how the world works with regard to three broad variables: resilience of the ecosystem; future of technological development, and; flexibility of individuals and social institutions) to ensure balance.

Focus group participants were asked to fill out a survey (Appendix B) twice seeking their preferences with regard to waste management outcomes. Using a 100-point allocation system, they were asked to "weight" the major evaluation criteria being used by the project, e.g., technical, financial, environmental, and social. Fundamentally, they will be asked to say – through the allocation of points as weights – which of these aspects do they most want to see their waste management system delivering?

When participants were requested to complete the first survey they were given a minimum amount of instruction. This served the purpose of gathering "unstructured" or "top of mind" responses. After the first survey was completed, the group was given an oral and a written briefing covering the project (attached at Appendix C), its objectives, the issues that it is examining, and the role of community input. The content of the briefing and the terminology in the survey were discussed to ensure that the group participants had an improved understanding when undertaking the survey again. The survey was then administered a second time. This served the purpose of gathering "structured" or "considered" responses.

The overall "weightings" provided by the metropolitan group are provided, both before (Figure 7.4) and after (Figure 7.5) instruction:

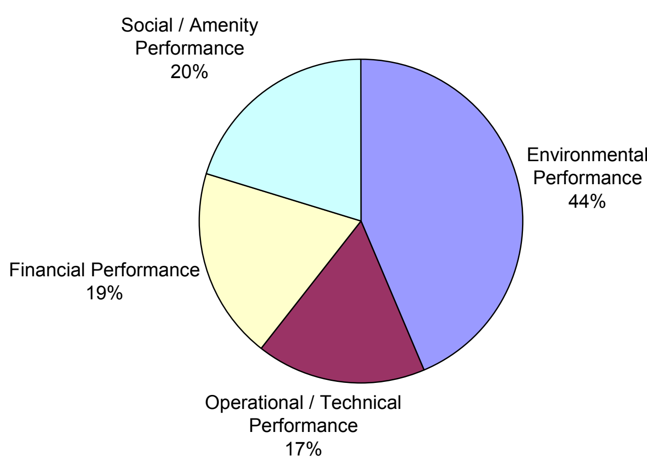

Figure 7.4: Overall weightings by metropolitan community (1st survey)

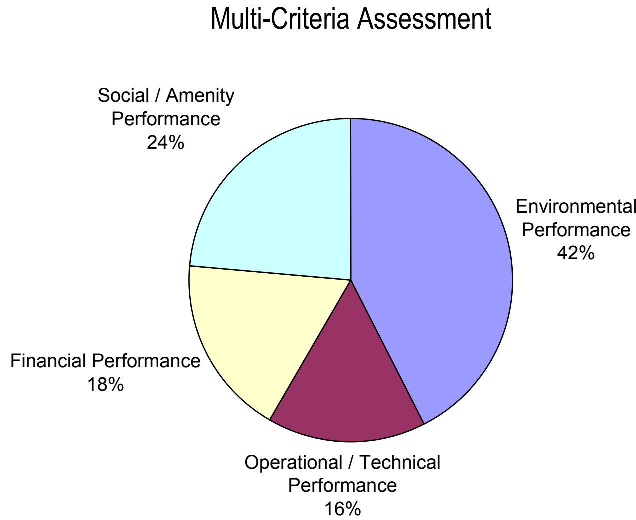

Figure 7.5: Overall weightings by metropolitan community (2nd survey)

The category-based “weightings” provided by the metropolitan group are provided in Table 7.5 to Table 7.8:

Table 7.5: Environmental weightings by metropolitan community

	Global Warming impacts	Air Pollution Impacts	Water Pollution Impacts	Resource Conservation
1st survey (before instruction)	18%	26%	30%	26%
2nd survey (after instruction)	19%	27%	29%	26%
Difference	+1%	+1%	-1%	0%

Table 7.6: Operational/technical performance weightings by metropolitan community

	Flexibility in Feedstock Quality	Modularity of System	Process Control	Staff Requirement	Proven Technology/Ref Facilities	Efficiency in Waste Reduction	Operational Reliability	Alignment with State Govt Policy	Alignment with Council's Strategy
1st survey	12%	20%	9%	4%	7%	25%	14%	5%	4%
2nd survey	14%	16%	9%	3%	13%	21%	16%	6%	4%
Difference	+2%	-4%	0%	-1%	+6%	-4%	+2%	+1%	0%

Table 7.7: Financial Performance Weightings by Metropolitan Community

	System Cost	Financial Capacity (of service provider)
1st survey (before instruction)	54%	46%
2nd survey (after instruction)	61%	39%
Difference	+7%	-7%

Table 7.8: Social performance weightings by metropolitan community

	Individual & Family Impacts	Residential Amenity	Householder Convenience	Employment	Natural & Cultural Heritage Impacts	OH&S	Labour Relations	Community Relations
1st survey	22%	17%	24%	8%	9%	6%	5%	9%
2nd survey	31%	16%	23%	6%	8%	6%	3%	7%
Difference	+9%	-1%	-1%	-2%	-1%	0%	-2%	-2%

The overall "weightings" provided by the regional group are provided, both before (Figure 7.6) and after (Figure 7.7) instruction:

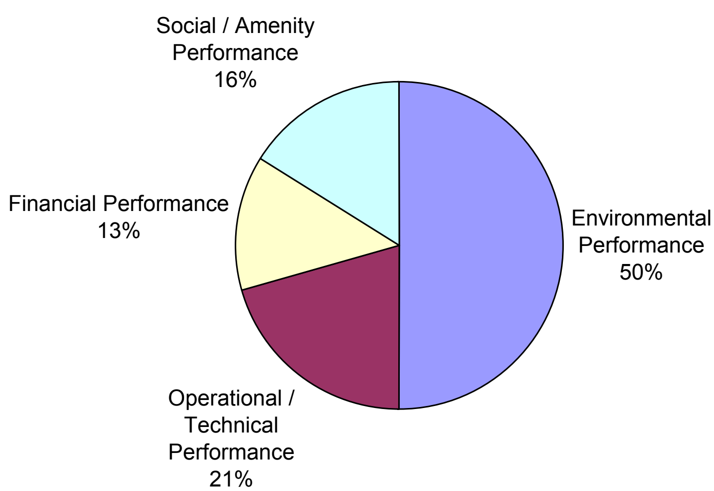

Figure 7.6: Overall weightings by regional community (1st survey)

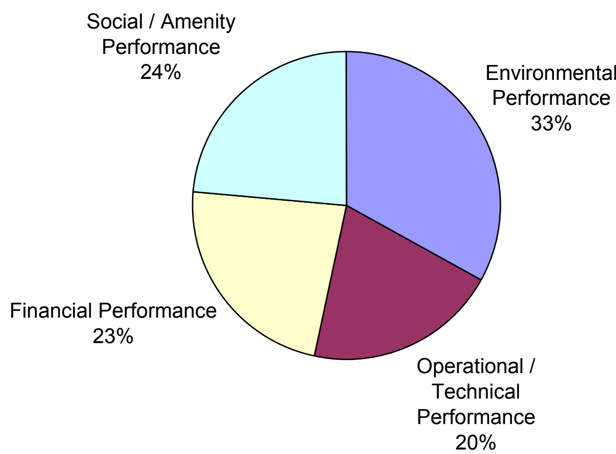

Figure 7.7: Overall weightings by regional community (2nd survey)

The category-based "weightings" provided by the regional group are provided below:

Table 7.9: Environmental weightings by regional community

	Global Warming impacts	Air Pollution Impacts	Water Pollution Impacts	Resource Conservation
1st survey (before instruction)	25%	21%	28%	26%
2nd survey (after instruction)	32%	26%	23%	19%
Difference	+7%	+5%	-5%	-7%

Table 7.10: Operational/technical performance weightings by regional community

	Flexibility in Feedstock Quality	Modularity of System	Process Control	Staff Requirements	Proven Technology/Re f Facilities	Efficiency in Waste Reduction	Operational Reliability	Alignment with State Govt Policy	Alignment with Council's Strategy
1st survey	12%	13%	4%	8%	9%	37%	7%	6%	4%
2nd survey	17%	18%	11%	4%	13%	23%	9%	2%	3%
Difference	+5%	+5%	+7%	-4%	+4%	-14%	+2%	-4%	-1%

Table 7.11: Financial performance weightings by regional community

	System Cost	Financial Capacity (of service provider)
1st survey	59%	41%
2nd survey	59%	41%
Difference	0%	0%

Table 7.12: Social performance weightings by regional community

	Individual & Family Impacts	Residential Amenity	Householder Convenience	Employment	Natural & Cultural Heritage Impacts	OH&S	Labour Relations	Community Relations
1st survey (before instruction)	26%	9%	29%	6%	7%	10%	2%	12%
2nd survey (after instruction)	25%	12%	26%	7%	6%	8%	1%	14%
Difference	-1%	+3%	-3%	+1%	-1%	-2%	-1%	+2%

Based on the survey responses, only a small change in the results between the first and second set of surveys was observed. Effectively, environmental considerations went down in the second survey and financial considerations rose. This is clearly a function of the focus groups' prior knowledge and assumptions about waste management and recycling compared to the perhaps more holistic information gained from the briefing.

It is fair to assume that many people in the community have little awareness of the cost of waste management and recycling services. When informed of the costs, as they were during the briefing, financial aspects become more important to them. (As a reality check, Nolan-ITU asked participants in both groups to nominate what their annual waste management charge was. Of 18 participants, only 5 could either do so or even recall a waste management charge on their Council rates notice.)

7.3 Variation between "weight series"

There appeared to be some variation between the "weightings" provided by the local government waste managers and the community focus groups. The variation reflects obvious differences between the two groups in terms of overall knowledge about waste management and recycling; and different roles and responsibilities in the overall waste management and recycling value chain.

On the one hand, Council officers have access to significant amounts of information about waste management and recycling and therefore have the capacity to more broadly view and consider all its performance aspects. For their part, most community members have been exposed to the environmental dimension of waste management and recycling; they relate to waste management and recycling services as an environmental program *per se.*

On the other hand, Council officers have duty of care and direct professional responsibilities for managing costs and risks associated with the services provided by their Councils. In other words, it is part of their job to be concerned about the financial performance and operational reliability of waste management and recycling. Anecdotal evidence would suggest that they, in part, see environmental outcomes as a given that flows from appropriate management. Alternatively, most community members access waste management and recycling services well after the financial and operational aspects are addressed. Therefore, they are more concerned with the outputs from their direct efforts in delivery of services, rather than overall ('theoretical') environmental performance.

7.4 'Technical' scores

In the consultative part of this 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 7.13. A brief explanation is given below.

Table 7.13: Technical scores

	Base LF	Base MBT	A MBT	B MBT	C MBT	D MBT	E MBT	Base TH	A TH	B TH	C TH	D TH	E TH
Flexibility in Feedstock	5	3	3	3	3	3	3	3	3	3	3	3	3
Modularity	1	3	3	3	3	3	3	2	2	2	2	2	2
Process Control	1	3	3	3	3	3	3	4	4	4	4	4	4
Efficiency in Waste Reduction	1	3	2	4	2	2	3	5	5	5	5	5	5
Operational Reliability	5	3	2	3	3	2	3	3	2	3	3	2	3
Alignment with Govt Policy	1	3	2	3	1	3	3	3	2	3	1	3	3
1…. worst 5…. best													

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 t/yr) - than thermal facilities (>80,000 t/yr). Landfills are the least 'modular'.

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

Efficiency in waste reduction: Thermal facilities produce fewer 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 fail' at an operational level. MBT and Thermal are equal, 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 lower due to difficulties with contamination in MRFs.

Alignment with Government policy: Landfill ranks lower; MBT and Thermal have equal score, as State Government policy has not expressed a preference for either technology on this issue.

7.5 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; 2003), 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.

Additive weighting is the technique applied in the *NSW Alternative Waste Management Technologies and Practices Inquiry Report* (NSW Government; 2000). However, 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. recycling using crates versus commingled MGBs) 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, and adherence to relevant environmental emission standards.

The weights that were determined through the consultative process and have been applied to the MCA are listed in Table 7.14. Where not all sub criteria were applicable to this study (e.g.. “labour relations”), the weightings of the remaining sub criteria have been adjusted so their total equals the weighting of the main criterion (e.g., “social”).

Table 7.14: Weights for criteria used

Criterion	Adopted Weight	
	Community	Local Government
System Cost	18.1%	31.8%
Greenhouse gases	8.0%	4.0%
Air Pollution	11.3%	6.0%
Water Pollution	12.3%	7.2%
Resource Conservation	10.9%	8.1%
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 Govt policy	1.2%	3.5%
Individual & 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%	100%

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 6.2), and to perform an MCA only based on the situation in a specific Council (or group of Councils) area.

7.6 Results

7.6.1 Community preferences

Table 7.15 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:

- MBT technologies for residual wastes rank higher than Thermal technologies; and
- Well performing kerbside recycling systems rank generally higher than systems with lower recovery rates (i.e. single bin systems (Scenario A) are at the bottom).
- There are some minor variations compared with the cost-benefit analysis (Section 6), which are due to the performance regarding residential amenity (number of truck passes) and householder convenience.

Table 7.15: Scenario rankings using community weightings

Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**

Scenario A – Single Bin **Scenario D – 1 Split Bin**

Scenario B – 3 Bin System **Scenario E – Bin & Crates**

Rank	Concordance	Additive Weighting
1	B MBT	B MBT
2	Base MBT	Base MBT
3	D MBT	E MBT
4	C MBT	D MBT
5	A MBT	C MBT
6	E MBT	A MBT
7	B TH	B TH
8	Base LF	Base TH
9	Base TH	Base LF
10	E TH	C TH
11	D TH	A TH
12	C TH	E TH
13	A TH	D TH

7.6.2 Local government preferences

Table 7.15 shows the rankings when the weightings of the NSW councils participating in the survey are applied. The results are similar to the ones with the community weightings. The greater emphasis by Local Government on operational reliability and financial performance however, pushed the "Classic Sydney System" (Baseline LF i.e.. garbage bin to landfill and one commingled recycling bin) to the top in the concordance analysis.

Table 7.16: Local government options ranking

Key:

Baseline – 2 Bin System **Scenario C – 2 Bins, Paper to Garbage**

Scenario A – Single Bin **Scenario D – 1 Split Bin**

Scenario B – 3 Bin System **Scenario E – Bin & Crates**

Rank	Concordance	Additive Weighting
1	Base LF	B MBT
2	B MBT	Base MBT
3	Base MBT	E MBT
4	D MBT	C MBT
5	C MBT	D MBT
6	A MBT	Base LF
7	E MBT	A MBT
8	B TH	B TH
9	Base TH	Base TH
10	E TH	C TH
11	D TH	E TH
12	C TH	D TH
13	A TH	A TH

8 CONCLUSIONS AND RECOMMENDATIONS

Kerbside recycling data

Of the six domestic waste management collection scenarios considered in this study, and based on the latest available recycling and waste generation data, recyclables diversion is highest for the kerbside recycling system employing fortnightly collection of commingled containers in an MGB and fortnightly collection of paper cardboard in a separate MGB. Relatively high yields are also achieved through fully commingled recycling collections and also through crate systems (which have the lowest contamination rates).

Financial performance

In metropolitan areas, the estimated cost of domestic garbage and recycling including MBT waste treatment of the garbage stream varied between $178 and $183 per household per year for the six scenarios investigated. For systems involving thermal treatment of collected domestic garbage, estimated costs varied between $227 and $255 per household per year.

In regional/rural areas, the estimated cost of domestic garbage and recycling including MBT waste treatment of the garbage stream varied between $141 and $163 per household per year for the six scenarios investigated. For systems involving thermal treatment of collected domestic garbage, estimated costs varied between $190 and $218 per household per year.

In metropolitan areas, for the base case collection system (fortnightly 240 L MGB commingled kerbside recyclables collection and weekly 120 L MGB garbage collection), the introduction of MBT and thermal treatment processes to the garbage stream increases domestic waste management costs by an estimated $7/hhld/yr and $62/hhld/yr respectively. The corresponding cost increases in rural areas, where current disposal costs are significantly lower, were estimated at $34/hhld/yr (MBT) and $86/hhld/yr (thermal).

As the cost of garbage treatment/disposal increases the *net* cost of kerbside recycling reduces (i.e., the (higher) *avoided* costs of garbage treatment make kerbside recycling cheaper). For some collection scenarios modelled where garbage is thermally treated, the provision of a separate recyclables collection service *reduced* overall waste management costs.

For single bin systems (Scenario A) where recyclables are recovered through front end sorting prior to waste treatment, the savings in avoided recyclables collection costs need to be measured against the increased costs of processing the mixed garbage stream. When taking into account the increased costs of processing (from front end sorting) the overall cost of the single bin system was found to be similar to the other systems modelled. It is also noted that the quality of materials (e.g. paper) recovered through front end sorting may substantially restrict its use.

Regional / rural collection garbage and recyclables systems are typically cheaper than metropolitan systems mainly due to increased efficiencies of collection vehicles from reduced traffic congestion and lower waste generation per household.

Environmental performance

This study confirms the key finding of the *Independent Assessment of Kerbside Recycling*: that the environmental benefits of kerbside recycling clearly outweigh the net financial costs of providing the service.

The more recycling the better: The more material that is recycled the higher the environmental benefits. Systems using two MGBs for recycling (one for paper, one for commingled containers, each collected fortnightly (or on alternate weeks) i.e. Scenario B) showed the highest recycling rates, followed by the 240L fully commingled recycling bin, followed by the two crate recycling system (lower yields but also low contamination). Split garbage/recycling bins are inferior due to low yields and high contamination.

Residual waste treatment provides additional benefits: Treatment of residual waste prior to landfilling provides environmental gains of a similar order of magnitude to recycling.

Mechanical-Biological Treatment (MBT) versus Thermal Treatment: Both MBT and thermal technologies provide overall environmental benefits of a similar order. Using current environmental accounting techniques, thermal treatment provides slightly greater greenhouse gas savings than MBT and slightly lower savings in other impact categories. This is however dependent on the type of energy source assumed when calculating electricity offsets.

Hybrid and New Technologies: There are a number of new waste treatment/resource recovery technologies entering the market, which are likely to achieve better environmental performance than the generic technologies used in this assessment. However, kerbside recycling is an important part of the system.

The Fate of Paper: The recycling of paper to make paper provides significant environmental benefits. These are much higher than the use of paper for energy recovery. Systems that convert paper into mixed-waste derived compost provide the lowest benefits.

Social assessment

In conducting the social impact assessment against a set of social performance criteria, there was found to be limited major variation in social impacts between each scenario. This is because the scenarios considered were not fundamentally different from each other in their overall design. They all require the basic processes of presentation of material, collection of material, transport of material, and treatment of material.

From a social impact perspective, the main difference between scenarios was between Scenario A (e.g., single bin collection of all material) and all other collection scenarios. Scenario A would appear to have a more significant social impact than the other scenarios in terms of individual and family impacts and OHS (sorting of mixed waste) and a lower social impact in terms of residential amenity and householder convenience. On the one hand, given community polling and stated support for kerbside recycling, it is likely that a system that does not give householders the opportunity to feel that they are making an environmental contribution will be controversial with a significant part of the community. On the other hand, it is indisputable that a system based on one bin will require less truck movements and less householder effort.

Cost-benefit analysis

Combining the financial costs of domestic waste management scenarios with the environmental costs and benefits expressed in dollar terms, the following three options showed the best overall performance for the metropolitan area:

1. **Scenario B with MBT:** Collection of recyclables from two separate MGBs, one for paper/cardboard and one for containers, with the residual waste (garbage) sent to an MBT facility.
2. **Baseline with MBT:** Collection of recyclables in one MGB (commingled), with the residual waste (garbage) sent to an MBT facility.
3. **Scenario E with MBT:** Collection of recyclables from two separate crates, one for paper/cardboard and one for containers, with the residual waste (garbage) sent to an MBT facility.

Consultative process and preferences

During the study the importance attributed by stakeholders to the various criteria used to evaluate the domestic waste management scenarios was elicited from two stakeholder groups: local government and the broader community.

For local government a survey was distributed to waste managers in all Councils in NSW, asking them to provide their preferences with regard to waste management and recycling service outcomes, as well as to provide some basic information about their waste management and recycling services. 115 responses were received (67% of all Councils).

For the broader community two focus group sessions were held: One group was based in metropolitan Sydney; the other group was based in Orange. The recruited focus group participants represented a cross section of "typical" metropolitan and regional communities based on occupational mix, educational levels, gender, ethnic background, and age mix.

The outcomes of the consultation found some variation between the "weightings" provided by the local government waste managers and the community focus groups, with local government placing a higher emphasis on financial and technical/operational aspects, while the community focus groups placed a higher emphasis on environmental outcomes. The variation reflects differences between the two groups in terms of: a) overall knowledge about waste management and recycling, and; b) different roles and responsibilities in the overall waste management and recycling value chain.

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 13 scenarios , are highly complex, some clear trends become apparent, namely,

- MBT technologies for residual wastes rank higher than thermal technologies; and
- Well performing kerbside recycling systems rank generally higher than systems with lower recovery rates (i.e. single bin systems (Scenario A) are at the bottom).

Some minor variations in the MCA outcomes were evident compared with the cost-benefit analysis. These are due to the variances in social impacts associated with residential amenity (number of truck passes) and householder convenience (not considered in the cost-benefit analysis).

Table 8.1 compares the highest-ranking options using different approaches i.e. Cost-Benefit Analysis and two Multi-Criteria Assessment techniques with different weightings. Regardless of the approach, the following conclusions can be drawn:

- High net diversion rates for kerbside recycling are the most significant influencing factor in the overall performance of all scenarios assessed;
- These are (currently) best achieved through two recycling bins, with the 'classic' commingled bin following closely behind; and
- MBT is the preferred approach for residual wastes.

Table 8.1: Highest Ranking Options from Different Approaches

Rank	Cost-benefit analysis	Multi-criteria assessment			
		Community weightings		Local government weightings	
		Concordance	Additive weighting	Concordance	Additive weighting
1	B MBT	B MBT	B MBT	Base LF	B MBT
2	Base MBT	Base MBT	Base MBT	B MBT	Base MBT
3	E MBT	D MBT	E MBT	Base MBT	E MBT

Recommendations

- Support for kerbside recycling be continued and best practice systems introduced which lead to the highest possible net diversion of recyclables for reprocessing.
- Support for the recovery of paper and cardboard for recycling into paper products be continued.
- A policy be developed for the treatment of residual waste 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 come on line.
- Based on feedback from Local Government representatives at a workshop during the conduct of this study, organics management be incorporated into the assessment to provide a comprehensive appraisal and decision support tool to Councils.
- Research is sponsored into the establishment of more comprehensive and compatible life cycle inventories and databases to improve the assessment of environmental performances of waste management technologies and systems, and to incorporate information on emerging systems.
- 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.

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Appendix A1
Local government survey

Appendix A2
Letter to Councils

RESOURCE NSW

Our reference:	[Click **here** and type reference]
Your	[Click **here** and type reference]
Reference:	[Click **here** and type name]
Contact:	[Click **here** and type phone number]

16 July 2003

(The General Manager)
(Council Name)

Dear [Click **here** and type name]

RE: INDEPENDENT SUSTAINABILITY ASSESSMENT OF WASTE & RECYCLING SYSTEM OPTIONS STUDY

A study into the economic, environmental and social benefits and costs of different configurations of waste and recycling collection and processing systems in NSW is underway. The *Triple Bottom Line Assessment of Waste & Recyclables Management Options Study* has been commissioned by the NSW Jurisdictional Recycling Group (JRG) of the National Packaging Covenant. The project is being undertaken in partnership with Resource NSW and the Publishers National Environment Bureau (PNEB).

Your input into this project is sought by requesting that Council's Waste Manager co-ordinate completion of the attached survey on behalf of the Council and send it back to Neil Chapman, Director Programs, at Resource NSW by **Friday 8th August 2003.**

I acknowledge that local Councils are currently being asked to complete a number of data surveys. Whilst the nature of this survey is specific to the objectives of the project, I would like to re-assure you however, that Resource NSW is working closely with other agencies to consolidate data reporting requirements for Councils.

The *Triple Bottom Line Assessment of Waste & Recyclables Management Options Study* examines six different types of waste/recycling collection systems in combination with various waste treatment technology categories. The schemes have been selected to reflect current practices, as well as emerging models that are under consideration by some Councils. The results of the survey are important in providing a profile of the qualitative measures that Councils may use in making key decisions about future waste management systems and options.

I would also like to provide details of project consultation sessions that will take place from 12.00 p.m. to 3.00 p.m. at Resource NSW's offices at Level 2, 1 Fitzwilliam Street, Parramatta on:

- Tuesday 29th July (project overview, policy context and discussion on systems),
- Thursday 21st August (presentation of findings and draft report for feedback).

Resource NSW believes that the project is very timely due to emerging policy, commercial, and technological developments in waste management and recycling systems in NSW. The increasing range and number of technologies and systems approaches becoming available and the long-term commitments and capital requirements for such facilities demands that a sound basis for decision-making is established.

A thorough and objective understanding of the economic, environmental and social benefits and costs of different configurations of waste and recycling collection and processing and an independent sustainability assessment will provide much needed information to assist Councils, communities and system operators.

I strongly encourage your Council to respond, both to the survey and also to the consultative sessions.

Should you have any questions or would like a copy of the overall project brief, please feel free to contact Neil Chapman on (02) 8837 6000 or the consultants engaged to undertake the study, Hannes Partl or Peter Shmigel at Nolan-ITU on (02) 9283 9361.

Yours sincerely,

Tim Rogers
Chief Executive

Local Government Survey:

Triple Bottom Line Assessment of Waste Management Options

What is the purpose of this survey?

The purpose of this survey is:

1. To establish trends in NSW Council waste management practices; and

2. To determine NSW Council priorities in selecting waste management systems.

The results will be directly incorporated into an independent sustainability assessment of six different waste and recycling collection / treatment systems currently in use or under consideration by NSW Councils

How to fill out this survey?

- The survey should take approximately 10 to 15 minutes to complete.

- The survey has been sent to all NSW Councils. It is requested that the survey be completed by the waste manager or other senior officer.

- All survey responses will be kept fully confidential. The results will only be used in aggregated form and will not identify individual Councils.

- The survey asks you to “weight” different aspects that you consider when selecting a waste management system. This simply means that you should give the greatest share of 100 points to the aspects that you believe are the most essential to your community. Your total “weightings” must always add up to a total of 100 points.

- Some Councils may have recent information regarding community attitudes to different systems from community surveys and the like. Where recent information is not available it would be useful to consult the Mayor or General Manager in relation to perceptions of community attitude to desirable performance outcomes from waste management systems.

What is the deadline?

- Surveys should be returned to Neil Chapman at Resource NSW by Friday 8th August, 2003. A return postage envelope is attached.

- Any questions regarding the content of the survey or any needed explanation of the performance categories can be directed to Peter Shmigel or Hannes Partl at Nolan-ITU on (02 9283 9361).

Local Government Survey:

Triple Bottom Line Assessment of Waste Management Options:

Name of Respondent:

Council:

Position:

SECTION A: CURRENT TRENDS IN COUNCIL PRACTICES

Question 1: Has your Council changed its waste and recycling collection system in the last 12 months?

- ☐ Yes
- ☐ No - go to Question 3

Question 2: **Part A:** If you answered yes to Question 1, please indicate which collection system you have changed to.

Tick box	***Single-unit Dwelling System Characteristics***
	Two bins (one for all recyclables; one for garbage)
	Single bin (one bin for recyclables and garbage - commingled)
	Three bins (one for container recyclables; one for paper recyclables; one for garbage)
	Two bins (one bin for garbage and container recyclables; one bin for paper recyclables)
	One split bin (one vertically split bin for recyclables and garbage)
	One bin for garbage and two crates for recyclables (or a crate or container with paper tied & bundled)
	Other. Please describe:

Tick box	*Multi-unit Dwelling System Characteristics*
	Two bins (one for all recyclables; one for garbage)
	Single bin (one bin for recyclables and garbage - commingled)
	Three bins (one for container recyclables; one for paper recyclables; one for garbage)
	Two bins (one bin for garbage and container recyclables; one bin for paper recyclables)
	One split bin (one vertically split bin for recyclables and garbage)
	One bin for garbage and two crates for recyclables (or a crate or container with paper tied & bundled)
	Other. Please describe:

Question 2: **Part B:** What is the percentage split in the total number of households/dwellings between single-unit dwellings and multi-unit dwellings?
(e.g. SUD = 75%MUD = 25%)

☐ SUD = %

☐ MUD = %

Question 3: Is your Council considering changing its waste and recycling collection / treatment system in the next 12 – 24 months?

☐ Yes
☐ No - go to Question 5

Question 4: If you answered yes to Question 3, please indicate the collection systems that you are considering in rank order (ie with ‘1’ indicating highest consideration, through to ‘7’ for lowest consideration) where possible. If rankings have not been considered, please indicate with a tick which systems Council may consider presenting as options to its community.

Rank or Tick	*Single – unit Dwelling System Characteristics*
	Two bins (one for all recyclables; one for garbage)
	Single bin (one bin for recyclables and garbage - commingled)
	Three bins (one for container recyclables; one for paper recyclables; one for garbage)
	Two bins (one bin for garbage and container recyclables; one bin for paper recyclables)
	One split bin (one vertically split bin for recyclables and garbage)
	One bin for garbage and two crates for recyclables (or a crate or container with paper tied & bundled)
	Other. Please describe:

Tick box	*Multi-unit Dwelling System Characteristics*
	Two bins (one for all recyclables; one for garbage)
	Single bin (one bin for recyclables and garbage - commingled)
	Three bins (one for container recyclables; one for paper recyclables; one for garbage)
	Two bins (one bin for garbage and container recyclables; one bin for paper recyclables)
	One split bin (one vertically split bin for recyclables and garbage)
	One bin for garbage and two crates for recyclables (or a crate or container with paper tied & bundled)
	Other. Please describe:

Question 5: Alternative waste treatment options may include waste processing and disposal systems, other than landfill. Does your Council currently use or is it generally considering alternative waste treatment options as a part of your future system?

- ☐ Yes
- ☐ No

Question 6: Based on the current thinking within Council, which of the following "residual" waste treatment options would you prefer?

- ☐ Thermal waste treatment (with energy recovery)
- ☐ Mechanical-biological treatment
- ☐ Combination
- ☐ Other. Please describe: ________________________________

SECTION B: COUNCIL EVALUATION OF SYSTEM OPTIONS

When Councils evaluate which system of waste and recycling collection / treatment to use, they often apply various evaluation criteria in both the planning and tendering stages. The following evaluation criteria have been developed based on a selection of NSW Councils' current practices and other information.

Question 7: Based on your experience, please indicate which major category of criteria you believe is more important / less important for your Council. Please distribute 100 points accordingly, by giving the greatest share of points to the aspects that you believe are the more important. Your total "weightings" must always add up to a total of 100 points

Environmental Performance	
Operational / Technical Performance	
Financial Performance;	
Social / Amenity Performance	
Total	***100 points***

(Note: You can also consider evaluation criteria to be the objectives that you want a waste and recycling system to deliver for your Council. You can distribute your points in any combination that you wish; scores of zero for some categories are permissible. Remember that your weighting of the major categories in Question 7 will have a significant influence on your overall scoring outcome.)

Question 8: Within each category, please indicate which criteria is more important / less important for your Council by allocating points which make a total of 100:

8a. Environmental Performance

Global warming impacts	
Air Pollution impacts	
Water Pollution impacts	
Resource Conservation	
Total	***100 points***

8b. Operational/Technical Performance of Technology

Flexibility in Feedstock Quality, eg, capacity to accommodate changes in waste stream composition	
Modularity of System, eg, capacity to accommodate changes in waste stream size	
Process Control, eg, level of automation	
Staff Requirements	
Proven Technology / Reference Facilities	
Efficiency in Waste Reduction	
Operational Reliability	
Alignment with State Govt policy	
Alignment with Council's Strategy	
Total	***100 points***

8c. Financial Performance

System Cost	
Financial Capacity (of service provider)	
Total	***100 points***

8d. Social Performance

Individual and Family Impacts, eg, 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, eg, degree of ***objectively measurable*** noise, odour, and dust from system and related traffic movements.	
Householder Convenience, eg, potential for system to be convenient and accessible to householders including bin types and collection frequencies	
Employment, eg, job creation	
Natural and Cultural Heritage Impacts	
Occupational Health and Safety	
Labour Relations	

Community Relations, eg, capacity of system service provider to positively engage with community, providing / supporting community education	
Total	***100 points***

Question 9: Are there any other evaluation criteria that your Council applies, will or would like to apply evaluating waste and recycling collection / treatment systems? If so, please describe:

Question 10: Are you interested in receiving an invitation for this project's consultative sessions?

- ☐ Yes
- ☐ No

Thank you for taking the time to complete this survey. Please forward the completed survey in the return addressed envelope by **Friday 8th August, 2003 to:**

Resource NSW
Enterprise House
Level 2, 1 Fitzwilliam Street
PARRAMATTA NSW 2150

Attention: Mr Neil Chapman, Director Programs

Appendix B

Community survey

Weighting Criteria for Assessment

Based on your experience, please indicate which major category of criteria you believe is more important / less important for you.

Please distribute 100 points accordingly, by giving the greatest share of points to the aspects that you believe are the more important. Your total "weightings" must always add up to a total of 100 points

Environmental Performance	
Operational / Technical Performance	
Financial Performance;	
Social / Amenity Performance	
Total	***100 points***

(Note: You can also consider evaluation criteria to be the objectives that you want a waste and recycling system to deliver for your Council. You can distribute your points in any combination that you wish; scores of zero for some categories are permissible. Remember that your weighting of the major categories in Question 7 will have a significant influence on your overall scoring outcome.)

Within each category, please indicate which criteria is more important / less important for your Council by allocating points which make a total of 100:

Environmental Performance

Global warming impacts	
Air Pollution impacts	
Water Pollution impacts	
Resource Conservation	
Total	***100 points***

Operational/Technical Performance of Technology

Flexibility in Feedstock Quality, eg, capacity to accommodate changes in waste stream composition	
Modularity of System, eg, capacity to accommodate changes in waste stream size	
Process Control, eg, level of automation	
Staff Requirements	
Proven Technology / Reference Facilities	
Efficiency in Waste Reduction	
Operational Reliability	
Alignment with State Govt policy	
Alignment with Council's Strategy	
Total	***100 points***

Financial Performance

System Cost	
Financial Capacity (of service provider)	
Total	***100 points***

Social Performance

Individual and Family Impacts, eg, 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, eg, degree of ***objectively measurable*** noise, odour, and dust from system and related traffic movements.	
Householder Convenience, eg, potential for system to be convenient and accessible to householders including bin types and collection frequencies	
Employment, eg, job creation	
Natural and Cultural Heritage Impacts	
Occupational Health and Safety	
Labour Relations	
Community Relations, eg, capacity of system service provider to positively engage with community, providing / supporting community education	
Total	***100 points***

Appendix C

Community briefing

Assessment of Domestic Waste and Recycling Collection Systems

Information Pack

1. What does this pack achieve?

As you are aware, you have volunteered to participate in a consultation session about **household garbage and recycling (or "waste") collection and processing options in NSW**. Your participation, views and comments will contribute to the way waste is managed in NSW into the future.

This pack provides you with information to help you prepare for the consultation session, by answering the following questions:

- What is the project about?
- What is the project's overall goal?
- Why is your input important?
- What does waste collection involve?
- What does waste processing involve?
- What options are being considered?
- How will the best approach be chosen?

2. What is the project about?

The "Assessment of Domestic Waste Collection and Processing" Project aims to investigate the **best way to collect** waste, as well as to come up with a **better alternative to traditional landfilling** for the garbage produced by households in NSW.

3. What is the project's overall goal?

The goal of the project is to find out which collection and processing system for waste is the most suitable, taking into account technical, financial, environmental and social costs and benefits.

4. Why is your input important?

The role of the community in this process is to prioritise the technical, financial, environmental and social costs and benefits of the proposed waste collection and processing systems.

A list of costs and benefits will be presented to you during the workshop. You will be asked to score these costs and benefits throughout the meeting.

5. What is waste?

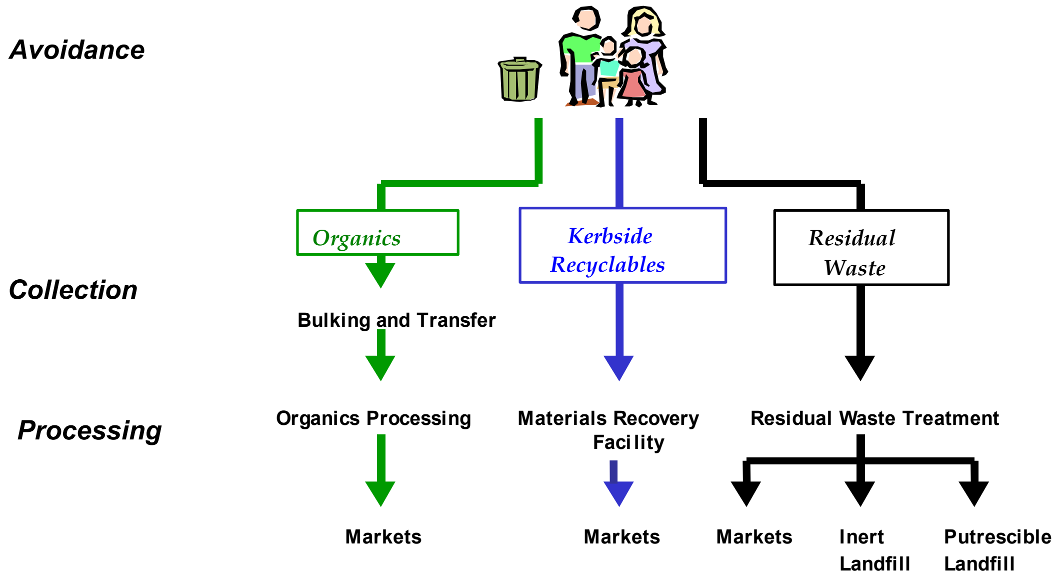
According to a dictionary definition, 'waste' is 'something which is not or cannot be used'. As a society, we are realising that a great deal of material called 'waste' can in fact **be used**. That material is a **resource** that can be recovered. Only a smaller proportion of material cannot be used and is genuinely waste.

Domestic waste (or “householder” waste) (see figure below) represents about one third of all waste that our society produces, but it is the most highly visible and has a high degree of ‘putrescible’ material in it, ie, it rots. Domestic waste can be divided into three parts:

1. Organics – garden clippings, lawn clippings.

2. Kerbside Recyclables – paper, cardboard, plastic containers, glass, aluminium and steel.

3. Residual Waste – material in garbage bins.



Domestic Waste Flow

In NSW, a large proportion of Councils collect organics and kerbside recyclables which are re-processed into new products.

However, residual waste is most commonly disposed of to landfill in NSW. This represents a loss of resources, as well as significant potential for pollution for up to 100 years as the organic material decomposes in the landfill. Up until now, we have called residual waste “garbage” – but it doesn’t have to be. Residual waste contains large amounts of organic material, such as food scraps and garden clippings, therefore, **more than half of the material in our garbage bins can be re-made into resources**.

This project is focusing on how we collect recyclables and residual waste, and the opportunity to turn them into resources, rather than send them to landfill.

6. What does waste collection involve?

The term “collection” refers to the gathering, pick up, hauling and unloading of both waste which is generated by every household in NSW. Collection is a complex logistical process and needs to be well planned, taking into account increasing waste generation by an increasing number of households, and the costs involved with fuel and labour in the pick up of garbage and recyclables.

The most common type of collection from urban areas is where the homeowner sets out containers at the kerbside for pick up, hauling and unloading by waste contractors.

Recyclables are commonly placed in a separate bin or crate to residual waste, and are picked up, hauled and unloaded at a “Materials Recovery Facility” (see **Error! Reference source not found.**). Here they are sorted into material type and sold to reprocessors, who create new products out of the material.

Residual waste is commonly picked up, hauled and unloaded at a landfill.

At present, collection systems such as these differ from Council to Council, in terms of the receptacle used (e.g a "wheelie" bin or crate) and the frequency of collection (e.g weekly or fortnightly). As a result, each collection system requires different equipment and personnel.

The type of collection system in place has environmental (e.g the amount of garbage and recyclables collected), economic (e.g the cost of labour and fuel) and social (e.g poor aesthetics) implications. You will be asked to comment and "score" these implications during the workshop.

7. What does waste processing involve?

Processing refers to the separation and transformation of residual waste into other useful products. This is also called "Alternative Waste Treatment". In other words, by processing waste into useful products, we are using an alternative to disposal to landfill.

Alternative waste treatment uses any number of different systems and technologies using mechanical, biological, and/or heat methods. The technologies try to **'shrink' the residual waste, 'change' the residual waste** into new products (such as compost or energy) and **'clean' the residual waste**, so less overall material goes to landfill.

Two types of technologies are being considered in this project:

1. Mechanical Biological Treatment

2. Thermal Treatment

8. What is Mechanical Biological Treatment?

Mechanical Biological Treatment (MBT) is a term which covers a range of technologies, most of which are based on what basically happens in a backyard compost bin. For all these technologies, there is first a 'pre-treatment' stage. Mechanical processes are used to screen out metals and sometimes plastics; the organic material gets conditioned, shredded and separated to make it ready for the next step.

Then, by using water, light, temperature and motion controls, a biological reaction is created to further break down the material into carbon dioxide and water and the remaining organic matter.

MBT technologies use one of two different kinds of 'break down' techniques: **aerobic (using oxygen)** or **anaerobic (without oxygen).** Common aerobic technologies include rotating drum composting systems and tunnel composting systems. Anaerobic technologies are known as 'anaerobic digestion' systems and primarily involve the breakdown of material in a sealed vessel. Some examples of these facilities are shown below.

In addition to reducing the amount of material going to a landfill, and making it environmentally safer, MBT technologies can also convert waste into resources. By-products can include different varieties of **compost for use in different sorts of applications, including site rehabilitation, land remediation, and agriculture**. The organic matter that MBT technologies produce can also be converted into fuel briquettes for energy.

The top image is of a drum composting facility; bottom left is a tunnel composting facility; and bottom right is an anaerobic digester.

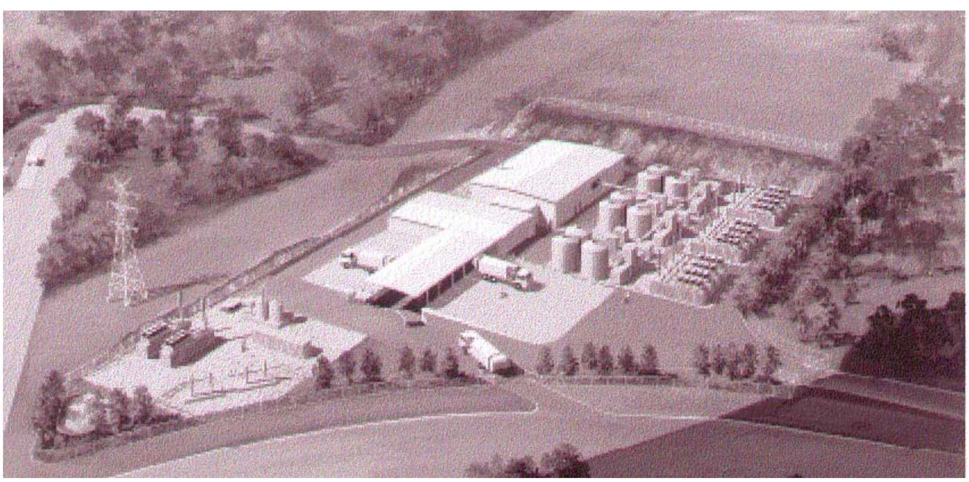
9. What is Thermal Treatment?

Thermal treatment methods primarily involve **the use of indirect heat and pressure to break down residual waste**. Sometimes referred to as 'waste-to-energy' plants, among the different technologies are:

- **Gasification** – The conversion of organic material into combustible gases using very high temperature and air. This method is commonly used in the production of electricity from coal.

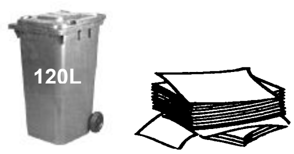
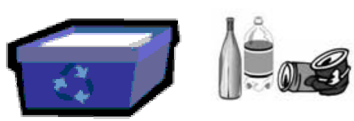
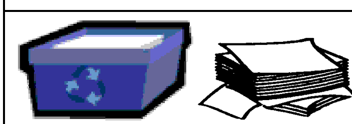
- **Pyrolysis** – The thermal break down or 'thermal cracking' of organic material in the absence of air at high temperatures. The process produces gas, liquid and solid char.

An example gasification / pyrolysis plant is shown below.



In addition to reducing the amount of material going to a landfill, and making it environmentally safer, thermal treatment technologies can also convert waste into resources, primarily **energy.**

10. What approaches are being considered?

APPROACH	COLLECTION		PROCESSING
	GARBAGE	RECYCLABLES	
Baseline	 Weekly pick up	 Fortnightly pick up, commingled containers and paper/cardboard	Garbage (not recyclables) to landfill
Scenario A	 Weekly pick up (no separate recycling)		
Scenario B	 Weekly pick up	  Fortnightly pick up, commingled containers and paper/cardboard in separate bins	
Scenario C	 Weekly pick up	 Fortnightly pick up, commingled containers only (no paper/ cardboard)	Garbage (not recyclables) to Mechanical Biological Treatment (MBT) and Thermal Treatment
Scenario D	 Weekly pick up. Split bin, garbage in front half and all recyclables in back half		
Scenario E		 	
	Weekly pick up	Weekly pick up, commingled containers and paper/cardboard in separate crates	

11. How will the best approach be chosen?

Historically, the establishment of any waste collection and processing system has been a sensitive community issue. Community input is crucial for the best possible way forward to be established. The following broad criteria would be relevant as the Project proceeds:

- Financial implications: system cost, financial capacity (of service provider);
- Environmental performance; global warming impacts, air pollution impacts, water pollution impacts, resource conservation;
- Processing technology; Flexibility in feedstock quality, (eg, capacity to accommodate changes in waste stream composition), modularity of system, (eg, capacity to accommodate changes in waste stream size), process control (e.g level of automations), staff requirements, proven technologies / reference facilities, efficiency in waste reduction, operational reliability, alignment with state government, alignment with Council's strategy;
- Social implications: individual and family impacts, (eg, 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), householder convenience, (eg, potential for system to be convenient and accessible to householders including bin types and collection frequencies), residential amenity, (eg, degree of *objectively measurable* noise, odour, and dust from system and related traffic movements), householder convenience, (eg, potential for system to be convenient and accessible to householders including bin types and collection frequencies), employment, (eg, job creation), natural and cultural heritage impacts, occupational health and safety, labour relations, community relations (e.g capacity of system service provider to positively engage with community, providing / supporting community education).

Appendix D

Changes to Environmental-Economic Valuation model

ADDITIONS TO THE ENVIRONMENTAL ECONOMIC VALUATION METHOD

The economic valuation method has been updated for the purpose of this study in an attempt to provide a more complete assessment of inventory data used for the study. The range of inventory data has been expanded from the original application of the method[1] and the economic valuation method has been updated to incorporate the most significant of the new inventory loads. These include compost and process residuals such as fly ash and bottom ash for their solid waste to landfill impact.

The economic valuation method is applied on the basis of equivalence values between potential[2] environmental impacts.

1.1 Water loss saving

The water loss saving from compost arises due to the water retention capacity of organic matter when applied to soil. 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. 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.

1.1.1 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 the calculations is 9%.

Table 0.1: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 this study.	9.25%	
Source: Pers Comms. Dr Simon Lott (EA Systems) September, 2003 used for Australian soils and consistent with other data (Eunomia, 2003).		

[1] Environmental Economic Valuation method developed and peer reviewed for the National Packaging Covenant Council in the Independent Assessment of Kerbside Recycling in Australia (Nolan-ITU, 2001).

[2] All impact categories measure the potential for impact rather than the actual impact and hence maintaining equivalence between resource and pollutant loads is key to ensuring the validity of the method.

1.1.2 Environmental economic value of water

The true ecological value of water is variable and difficult to calculate[3]. The value used for this study is 600 $/ML which is median of a widely accepted range of between 300 and 900 $/ML[4].

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 the Hassall report (1998) by Francis Grey of the Australian National University. Environmental groups through the Nature Conservation Council of NSW highlighted the "uncosted", Benefits and Costs of Water Use and Extraction Activities[5] in NSW to be upwards of $400 million/yr for indirect subsidies and upwards of $600 million/yr for direct subsidies[6].

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/yr in 1994-95 dollars[7].

Table 0.2: From Hassall and Associates (1998) -Selective Rough Estimates of Annual Costs of River Degradation in NSW

Type of Degradation[a]	NSW Cost $m/yr
Damage costs caused by salinity (non-dryland)[b]	77
Damage costs caused by eutrophication (blue green algae)[c]	98
Damage costs of turbidity	Not available
Damage costs due to streambank erosion	Not available
Damage costs caused by toxicants and contamination	Not available
Damage costs for acid sulfate soils	Not available
Damage costs for wetlands[d]	88 (approximately)
Loss of fisheries	Not available
Loss of tourism[e]	41 (estimate)
Social impact costs	Not available
Total (based on available figures)[f]	**Assume almost 300**

[3] Submission to the Independent Pricing and Regulatory Tribunal (Bulk Water Pricing: 2001/02 – 2003/04). A Submission prepared jointly by the: World Wide Fund for Nature (WWF) – Australia, Australian Conservation Foundation (ACF), Nature Conservation Council of NSW (NCC). Inland Rivers Network.

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

[5] Hassall and Associates (1998) Taxpayer Support of the Irrigation Industry, Nature Conservation Council.

[6] Sydney Morning Herald 4/8/03, Page 1 reported Sydney's water consumption at 630 GL/yr. Considered along side agricultural consumption in NSW, this points to an ecological cost consistent with the estimated range of $300 – $900/Ml.

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

1.1.3 Water valuation assumptions and final valuation

Table 0.3: Water valuation assumptions and final valuation

Water valuation - assumptions and valuation	Amount	Units
Temporary water transfer flow	8	ML/ha
Water saving (retention at 9.25%)	0.74	ML/ha
Environmental economic saving (Eco$/ha)	444	$/ha/yr
Compost application	5	t compost/ha/yr
Theoretical saving if all attributed to compost	88.80	$/t compost
Water loss saving (25% of savings attributable to compost)	**22.20**	**$/t compost**

1.2 Soil structure decline, acidification & salinity

Table 0.4: Avoided Product – resource depletion valuation

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

1.3 Compost environmental economic valuation overview

A new environmental economic valuation for compost has been developed for the assessment. The valuation seeks to maintain an equivalence relationship within the impact category of *resource valuation* with respect to the depletion potential of coal @ $/t 47.50. The newly derived compost valuation is presented in Table 0.5 and detailed below. The factors that contribute to the net economic value are further detailed in following sections.

Table 0.5: Compost Resource Depletion Valuation Summary (Eco dollars per tonne of compost)

Resource Depletion – Contributing Factors	Valuation (Eco $/t compost)
Water loss saving	22.20
Soil structure decline	1.69
Acidification	2.54
Salinity	2.06
Total MSW Compost	**28.50**

1.4 External costs/benefits

External costs/benefits not included in the study are listed in Table 0.6. Further re

Table 0.6: Compost external costs/benefits

Resource Depletion Factors
Avoided limestone rock (lime) **
Pollutant leaching**
Soil conditioning – porosity and aeration
Micronutrient supply
Effects on Nitrate leaching from soil
Avoided phosphate rock**
** Applicable for non-MSW compost only