Sustainability Victoria

Modelling and analysis of options for the Metropolitan Waste and Resource Recovery Strategic Plan

14 December 2007

Report no: 1

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1 Executive summary

The Victorian Government framework for management and resource recovery is detailed in the Sustainability in Action: Towards Zero Waste (**TZW Strategy**) released in 2005.

In implementing the TZW Strategy a key challenge of both Local and State Government is to plan effectively for waste handling, processing and disposal across metropolitan Melbourne.

As part of this planning process Sustainability Victoria is currently preparing an integrated waste management plan for metropolitan Melbourne (**the Metropolitan Plan**) from 2007/08 through to 2029/30. The development of the Metropolitan Plan is now at the point where a number of options require evaluation – taking a triple bottom line approach – and comparison to the current services.

Hyder Consulting was commissioned to undertake this review in September 2007. This report covers four waste service and disposals options and two sub-options for inner urban and outer suburban Melbourne.

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In this modelling the inner urban area was taken to be the area within seven kilometres of the city centre, the remaining area of Melbourne is outer suburban.

Using recent waste composition data and population projections provided by Department of Sustainability of Environment future waste quantities were forecast for 2013/14 (the expiry of the TZW Strategy), 2017/18 (the end of the next Landfill Schedule) and 2029/30 (the end of the 2030 plan).

The quantities are:

Stream	Base case			Option 1		Option 2		Option 3		Option 4	
	05/06	**13/14**	**29/30**	**13/14**	**29/30**	**13/14**	**29/30**	**13/14**	**29/30**	**13/14**	**29/30**
Co–mingled recyclables	393	471	626	471	626	471	626	471	626	471	626
Garden organics	201	237	315	375	512	-	-	375	512	-	-
Mixed food/garden	7	7	9	7	9	529	715	7	9	-	-
Residuals to landfill	716	830	1,103	-	-	425	541	-	-	-	-
Residuals to AWT	-	-	-	693	906	121	170	121	170	1075	1427
Residuals to EfW	-	-	-	-	-	-	-	572	736	-	-
Total	1,317	1,546	2,053	1,546	2,053	1,546	2,053	1,546	2,053	1,546	2,053

Having established these future volumes three studies were undertaken:

1 Development of Waste Services models which include transport needs, infrastructure locations and overall service costs

2 Development of Life Cycle Assessments (**LCAs**) evaluating greenhouse gas generation, energy usage, water consumption and landfill use

3 Review of social impacts including traffic, loss of amenity and job creation.

The results of these studies were then compared on a triple bottom line (**TBL**) - environment social and financial - approach to rank the modelled options.

This ranking shows that all options, although more expensive than the base case, offer improvements over the current service, comprising recycling, composting garden organics and disposal of the residual waste stream to landfill.

In addition to the TBL review the various options were also tested to determine if the TZW Strategy target for municipal solid waste would be achieved by 2013/14. This review indicates that only Options 1, 1A and 3, when fully implemented, would meet the strategy target.

Finally, the report notes that the modelling does not provide for possible benefits from future carbon trading.

2 Introduction

2.1 Background

The Victorian Government framework for management of waste and resource recovery is outlined in its *Sustainability in Action: Towards Zero Waste Strategy* (TZW Strategy) released in 2005. The 10 year strategy establishes goals and directions for Victoria's solid waste management and resource recovery. It has the following objectives and linked targets:

Objective 1: Generating less waste from our activities

> *Target 1 – A 1.5 million tonne reduction in the projected quantity of solid waste generation by 2014.*

Objective 2: Increase the sustainable recovery of materials for recycling and reprocessing

> *Target 2 – 75% by weight of solid waste recovered for reuse, recycling and/or energy generation by 2014.*

Objective 3: A reduction in damage to the environment caused by waste disposal

> *Target 4 – A 25% improvement, from 2003 levels, in littering behaviours by 2014.*

A range of targets, programs and actions for the Municipal and Business Sectors have been separately developed and included in the strategy.

Municipal Solid Waste Target

> *Target 5 – A 65% recovery (by weight) of municipal solid waste for reuse and recycling by 2014. An interim target of 45% is established for 2008-09.*

Business Sector: Commercial and Industrial Waste Target

> *Target 6 – An 80% recovery (by weight) of C&I solid waste for reuse and recycling by 2014. An interim target of 65% is established for 2008-09.*

Business Sector: Construction and Demolition Waste Target

> *Target 7 – A recovery rate of 80% (by weight) of C&D solid waste for reuse and recycling by 2014. An interim target of 65% is established for 2008-09.*

In implementing the TZW Strategy, a key challenge for Local and State Government is to plan effectively for waste handling; processing and disposal across Melbourne and to ensure the best approaches are used for the management of residual and organics waste from household and industry sources.

2.2 Metropolitan Waste and Resource Recovery Strategic Plan

The development of a Metropolitan Waste and Resource Recovery Strategic Plan (MWRRSP) is a requirement of the *Environmental Protection Act 1970*. The Plan is comprised of three parts; Part 1 – The Metropolitan Plan, Part 2 – The Infrastructure Schedule and Part 3 - The Landfill Schedule. Sustainability Victoria was appointed by the *Minister for Environment, Water and Climate Change* to develop Part 1, while the Metropolitan Waste Management Group (MWMG) is responsible for developing Parts 2 and 3. The *Act* also calls for the Metropolitan Plan to include "a social and economic assessment of the options identified".

A Steering Group with representation from DSE, SV, EPA and the MWMG is responsible for overseeing the development of the MWRRSP and ensuring inter–governmental agency coordination.

The development of the Metropolitan Plan and Schedules incorporates data/technical studies, workshops around a number of key issues, drafting of the Metropolitan Plan and Schedules and public consultations.

To date, the Agencies involved in the project have:

- undertaken a preliminary analysis of the long term trends for the generation of municipal solid waste, construction and demolition waste and commercial and industrial waste;
- identified future waste volumes and processing needs at the macro level;
- collected data and information on current infrastructure and local government contracts; and
- undertaken a program of briefings and initial stakeholder consultation.

This stakeholder consultation, and in particular the workshops held in July 2007, signalled the following issues as being important:

- an expectation from local government that changes to systems and infrastructure that increase costs will need to be soundly based and justifiable;
- transport of wastes and recyclables needs to be carefully considered from the perspectives of:
    - financial cost;
    - greenhouse gas emissions,
    - amenity/congestion.

- new technologies need to be carefully evaluated from a life cycle perspective.

2.3 Modelling study objectives

The objectives of this modelling study are to:

(a) provide an environmental, social and economic assessment of a number of pre–determined options; including economic costs and benefits, lifecycle assessment (greenhouse gas emissions, energy and water consumption and waste to landfill) and an assessment of transport options and impacts;

(b) analyse and evaluate the options against each other;

(c) work with the Steering Group (and nominated people) to assist in refining the options based on the outcomes of the analysis.

2.4 Study area

This study area comprises the 30 Local Government Areas (LGAs) that make up metropolitan Melbourne. These are the LGAs of:

Banyule	Hobsons Bay	Moonee Valley
Bayside	Hume	Moreland
Boroondara	Kingston	Nillumbik
Brimbank	Knox	Port Phillip
Cardinia	Manningham	Stonnington
Casey	Maribyrnong	Whitehorse
Darebin	Maroondah	Whittlesea
Frankston	Melbourne	Wyndham
Glen Eira	Melton	Yarra
Greater Dandenong	Monash	Yarra Ranges

2.5 Study scope

This study covers kerbside collected domestic waste only and does not include domestic waste delivered to transfer stations or other domestic/municipal wastes delivered directly to landfill.

The model is not an evaluation of actual infrastructure options. Sites and technologies have been selected to provide general guidance only.

2.6 Terminology

The following terminology is used in this report:

- ‘Co–mingled recyclables’ to describe mixed paper and packaging items collected from households for recycling;

- 'Garden organics' to describe mixed green waste collected from domestic gardens;
- 'Food organics' to describe sorted kitchen food waste collected from households;
- 'Residual waste' to describe the waste stream remaining after co-mingled recyclables and in some cases, garden organics or garden and food organics have been removed;
- 'Composting' describes aerobic processing of organics;
- 'Digestion' describes anaerobic processing of organics;
- 'Alternative Waste Treatment' or AWT describes new mechanical/biological processes for the treatment of residual wastes; and
- 'Fluidised bed' describes an energy from waste process employing mechanical separation and fluidised bed incineration for the treatment residual waste.

2.7 Abbreviations

AWT	Alternative Waste Treatment
C&I	Commercial and Industrial
C&D	Construction and Demolition
EfW	Energy from waste (see also WtE, W2E)
EPA	Environment Protection Authority
GWPF	Green waste processing facility
MGB	Mobile garbage bin (i.e. wheelie bin)
MRF	Materials recovery facility at which further sorting and separation of materials and processing of waste occurs
MSW	Municipal Solid Waste
WtE, W2E	Waste to energy (see also EfW)

3 Overview of current waste management services and infrastructure

3.1 Introduction

Domestic waste management and resource recovery in Melbourne comprises:

- supply of the storage bin
- collection and local transport
- waste transfer (in some cases)
- sorting co–mingled ‘recyclables’
- composting garden organics
- composting of garden/food organics (Nillumbik)
- landfilling residual waste

In this study, various options - including alternative waste treatment of ‘residuals’ and biological treatment of householder sorted ‘food and garden organics’ - are considered.

3.2 Supply of storage bin

Currently plastic mobile garbage bins (MGBs) are used throughout the metropolitan area for household storage of co–mingled recyclables, garden organics and residual wastes.

All costs related to supply and servicing of the household MGBs have been included in collection and transport.

3.3 Collection and local transport

Currently a range of collection vehicles are used across metropolitan Melbourne for domestic kerbside collection. These vary on truck size and loading systems, e.g.

Truck size	- single axle (5.5 tonnes net)
	- tandem axle (9.0 tonnes net)
Loading System	- mechanical side load
	- mechanical rear load.

In general terms transport travel time determines the choice of truck size and ease of access determines the loading system.

Side–loading systems are generally operated with only a driver whilst the rear–loading systems operate with a driver and 'runner'(s).

3.4 Transfer and long–haul transport

Waste transfer stations are introduced into a waste management system when travel distances in the collection vehicle become excessive. This varies with collection truck size and is generally introduced when travel times exceed 45 minutes for single axle collections trucks and 60 minutes for tandem axle trucks.

Waste transfer stations are generally of two types:

- Top loading
- Trailer compaction

Top loading transfer stations are generally used for short-haul transfer distances and trailer compaction transfer stations for long-haul transfer.

Typically 'top loading' transport vehicles utilise 'walking-floor' trailers and have a net load of 20 tonnes. Modern 'trailer compaction' transport vehicles delivering to landfills utilise on-site trailer tippers and have a net load of 23-24 tonnes.

3.5 Sorting co–mingled 'recyclables'

Domestic paper and container sorting has been greatly improved over the past 15 years and modern semi–automatic material recovery facilities (MRFs) now can sort 20 tonnes per hour with staff of sixteen and provide fortnightly service to 120 000 to 140 000 homes.

With optical sorting, productivity can be significantly increased.

3.6 Composting garden organics

Composting of garden organics to produce mulch or soil conditioner is undertaken using a variety of techniques with the choice primarily being dependent on the distances to sensitive areas e.g. 'in-vessel' composting can be successfully operated in an industrial area whilst open 'windrow' composting requires substantial buffer distances.

Notwithstanding that garden organic composting is well established, markets are still immature and considerable development effort is required to create viable all year round markets.

3.7 Best practice landfill

When modern landfills operate at 'best practice' as determined by the Waste Management Policy (Siting, Design and Management of Landfills) they incorporate multiple environmental protection systems. These include:

- Waste inspection;
- Composite plastic/clay base liner;
- Leachate collection system;
- Leachate treatment facility;
- Treated leachate disposal arrangements;
- Landfill gas collection system;
- Landfill gas energy conversion facility;
- Landfill cap;
- Noise abatement screening;
- Litter collection;
- Adequate buffers.

3.8 Biological processing of garden and food organics

Biological processing of garden and food organics is an emerging resource recovery activity in Australia with both digestion (anaerobic in the absence of air) and composting (aerobic in presence of air) facilities being constructed.

During digestion of garden and food organics, the waste stream generates methane for conversion to electricity (or heating) and a compost soil conditioner by–product, whilst composting produces only a compost soil conditioner.

Compost soil conditioners from combined garden and food organics contain higher nutrients and trace elements than composts produced from single stream garden organics.

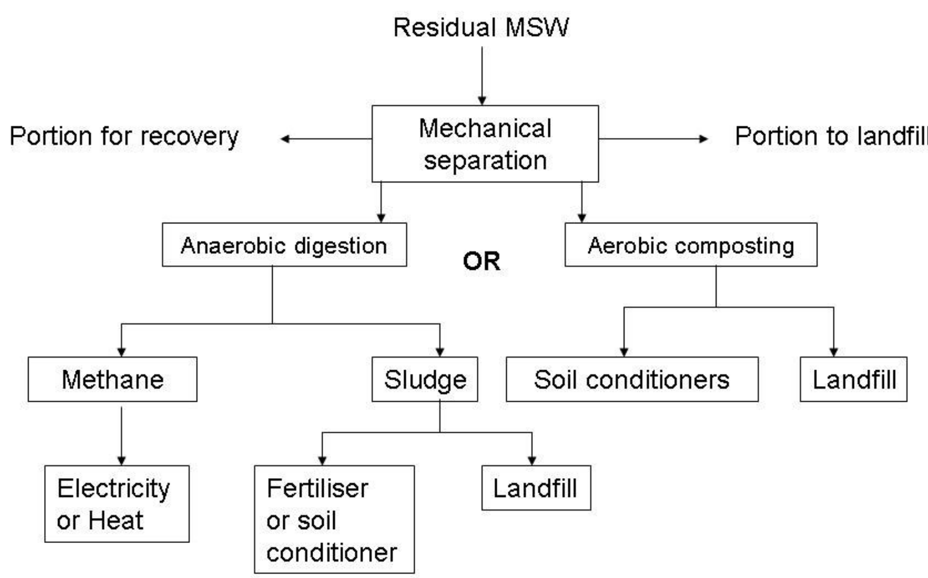
Domestic source separation of food waste requires a container and liner for use in the kitchen. The cost of this container and a supply of biodegradable liners (around $15.00 per annum per household) has not been included in the modelling.

3.9 Alternative waste treatment of residuals

3.9.1 Mechanical biological treatment

As residual residential waste generally contains substantial quantities of organic waste (food, paper and cardboard, garden organics and other putrescible materials) it is a valuable source for conversion to energy or (depending on contaminants) for the production of soil conditioners.

AWT processing is generally a two step procedure:



Various approaches are adopted to sort residual waste prior to biological treatment. Alternatives include screening/hand sorting followed by shredding, drum shredding followed by screening and immersion in water.

3.9.2 Energy from waste

As residual waste contains embodied energy incineration offers an opportunity to recover energy whilst significantly reducing waste volumes.

Historically, most incineration has been conducted in mass–burn facilities with ash as a by–product. More recently, 'fluidised bed' style facilities are becoming more common as these produce a 'slag' by–product rather than bottom ash.

4 The model framework

4.1 Base data

All modelling has been developed from:

- The 2005/06 Local Government Data Collection Survey;
- Current infrastructure and landfill data collected by Sustainability Victoria and the Metropolitan Waste Management Group;
- The most recent population projections to 2030 provided by DSE;
- Cost estimates developed by Hyder Consulting and based upon best available industry knowledge; and
- Waste generation growth consistent with TZW.

4.2 Model timeframes

Modelling has been conducted for the following timeframes:

2005/06 as this year is the most recent for which a complete set of data is available for kerbside–collected wastes

2013/14 the final year of the TZW Strategy

2016/17 the final stage of the current landfill schedule

2029/30 the final year of the Victorian Government's strategic growth plan: *Melbourne 2030: Planning for Sustainable Growth*

4.3 Division into inner urban and outer suburban areas

In developing options for assessment, differences in waste generation and management practices between inner urban and outer suburban areas have been recognised and taken into account. In inner urban areas, comprising the Melbourne CBD and surrounding high density suburbs, domestic waste typically contains little or no garden organics; there is little available space at dwellings for bin storage; and the lack of space on roads and alleyways hinders and, in some cases, prohibits the use of 'side-loader' collection vehicles employed in outer suburbs.

In general terms, this area is within seven kilometres of the city centre and encompasses around 250 000 households.

Accordingly, it was decided within each option to consider inner urban areas and outer suburban areas separately with regard to material streaming and processing/disposal. In addition, unit cost rates for collection trucks have been adjusted in inner urban areas to reflect the need to provide additional staffing.

5 Options for the management of waste and resource recovery

Options for the management of kerbside–collected domestic waste have been modelled and assessed in this study, comprising a base case, three alternatives and two sub–options, being 1A and 2A. A description of each option, including details of assumed collection systems and associated receival and processing infrastructure is provided in the following sections.

5.1 Base case

5.1.1 Overview

The base case assumes that existing collection systems and processing/disposal infrastructure across Melbourne will continue over the entire modelling period, with allowance for the closure of landfills once their capacities are reached.

For organics collection systems, diversion rates are assumed to remain unchanged. For co–mingled recycling services it is assumed that, by 2014, the mix of materials collected and recovered is expanded to include all plastic codes. Table 5-1 summarises the collection systems and associated infrastructure.

Table 5-1 Collection systems and infrastructure – base case

Stream	Assumed collection system	Receival / processing facilities
Co–mingled recyclables	As per existing systems	Existing material recovery facilities
Garden organics	As per existing systems	Existing composting facilities
Food organics	As per existing systems	Existing composting facilities
Residual waste	As per existing systems	Existing landfills

5.1.2 Receival / processing facilities – co–mingled recyclables

All material recovery facilities for co–mingled recyclables in the metropolitan area were reviewed for location and capability. The following were included in the assessment:

- Visy facilities at Laverton, Banyule and Springvale

- SKM facility at Coolaroo
- Thiess facilities at Hallam and Darebin
- Dasma facility at Lilydale

For collected co–mingled recyclables these facilities have been assumed to continue operation and expand and upgrade as quantities increase over time.

5.1.3 Receival / processing facilities – organics

All existing organics processing facilities in the metropolitan area were reviewed for location and capability. The following were included in the assessment:

- Transpacific Industries (TPI) facilities at Clayton (transfer station) and Pakenham
- Green Planet facility at Epping
- NRS facility at Dandenong South
- Pinegro facility at Deer Park
- ANL facility at Coldstream
- SITA facility at Brooklyn

For the base case, all of these facilities were assumed to operate at a standard equivalent to controlled environment composting, i.e. as a minimum, covered static pile composting with a controlled aeration system to prevent off–site odour.

5.1.4 Receival / processing facilities – residual waste

Landfills

All existing putrescible landfills in the metropolitan area were reviewed for location and capacity. The following included in the assessment:

- Boral landfill at Deer Park
- Hanson landfill at Wollert
- Wyndham City Council landfill at Werribee
- TPI landfill at Clayton (closure date 2020)
- Regional landfill at Clayton (closure date 2017)
- SITA landfill at Hallam
- Hume City Council landfill at Sunbury

It is assumed these facilities operate at best practice standard, fully compliant with the *Waste Management Policy (Siting, Design and Management of Landfills)* (Victorian Government; 2004).

For the base case, it is assumed these landfills will be available for receival and disposal of collected residual waste.

Transfer stations

All existing transfer stations receiving putrescible wastes in the metropolitan area were reviewed for location and capacity. The following were included in the assessment:

- Stonnington City Council's transfer station at Tooronga
- Booroondara Council's transfer station at Camberwell
- Banyule City Council's transfer station at Bellfield
- Citywide Transfer Station at Melbourne Port
- Whitehorse City Council's transfer station at Vermont South

5.2 Option 1

5.2.1 Overview

For option 1, the assumed collection systems and receival processing infrastructure are summarised in Table 5-2.

Table 5-2 Collection systems and infrastructure – option 1

Area	Stream	Assumed collection system	Receival / processing facilities
Inner urban (2 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing materials recovery facilities
	Residual waste	Weekly MGBs	Alternative Waste Treatment facility (anaerobic digestion)
Outer suburban (3 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing material recovery facilities
	Garden organics	Fortnightly MGBs	Existing composting facilities
	Residual waste	Weekly MGBs	Alternative Waste Treatment facilities (anaerobic digestion)

5.2.2 Receival / processing facilities – co–mingled recyclables

All areas

For all options, existing processing facilities for collected co–mingled recyclables (see Section 5.1.2) have been assumed to continue operation and expand and upgrade as quantities increase over time.

5.2.3 Receival / processing facilities – organics

Inner urban areas

For option 1 there is no separate collection of organics from inner urban areas hence there are no infrastructure needs.

Outer suburban areas

For collected garden organics from outer suburban areas under option 1, existing receival and processing facilities (see Section 5.1.3) have been assumed to continue operation and expand and upgrade as quantities increase over time. All facilities are assumed to operate at a standard equivalent to controlled environment composting.

5.2.4 Receival / processing facilities – residual waste

Alternative Waste Treatment facilities

Residual waste collected from all areas under option 1 is assumed to be delivered to a network of Alternative Waste Treatment (AWT) facilities. The assumed technology employed at these facilities is anaerobic digestion, Key features include:

- Facilities will be modular in nature allowing scale-up from a base processing unit with a capacity of 70 000 tonne/yr of residual waste input.
- Each site will have sufficient space to allow facility expansion as quantities increase over time
- Facilities will be fully established by 2013/14
- Facilities have been located at sites with current or historical waste activity.
- Facilities have been located to minimise average travel times for fully loaded collection vehicles to 30 minutes or less.
- Facilities have been assumed to be located at existing facilities in the following suburbs: Melbourne Port; Deer Park; Epping; Vermont South; Hallam; and Clayton.

Transfer stations

For option 1 it is assumed there is no need for transfer stations as the selected AWT localities allow delivery of residual wastes to the AWT facilities within an average travel time (for each LGA) of 30 minutes or less.

5.3 Option 1A

5.3.1 Overview

Option 1A is an extension of option 1, and varies with anaerobic digestion being replaced by aerobic composting for residual waste from outer suburban areas. All other parameters – including the inner urban services, collection, transport and site locations – remain unchanged from option 1. For option 1A, the assumed collection systems and receival processing infrastructure are summarised in Table 5-3.

Table 5-3 Collection systems and infrastructure – option 1A

Area	Stream	Assumed collection system	Receival / processing facilities
Inner urban (2 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing materials recovery facilities
	Residual waste	Weekly MGBs	Alternative Waste Treatment facility (anaerobic digestion)
Outer suburban (3 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing material recovery facilities
	Garden organics	Fortnightly MGBs	Existing composting facilities
	Residual waste	Weekly MGBs	Alternative Waste Treatment facilities (aerobic composting)

5.4 Option 2

5.4.1 Overview

For option 2, the assumed collection systems and receival processing infrastructure are summarised in Table 5-4.

Table 5-4 Collection systems and infrastructure – option 2

Area	Stream	Assumed collection system	Receival / processing facilities
Inner urban (2 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing material recovery facilities
	Residual waste	Weekly MGBs	Alternative Waste Treatment facility
Outer suburban (3 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing material recovery facilities
	Mixed garden and food organics	Weekly MGBs	Anaerobic treatment facilities
	Residual waste	Weekly MGBs	Existing landfills

5.4.2 Receival / processing facilities – co–mingled recyclables

All areas

For all options, existing processing facilities for collected co–mingled recyclables (see Section 5.1.2) have been assumed to continue operation and expand and upgrade as quantities increase over time.

5.4.3 Receival / processing facilities – organics

Inner urban areas

For option 2, there is no separate collection of organics from inner urban areas hence there are no infrastructure needs.

Outer suburban areas

For option 2, a combined weekly mixed green and food organics collection service is provided in outer suburban areas delivering to a newly established network of organics processing facilities. The facilities are assumed to employ anaerobic digestion technology with corresponding recovery of energy. Key features include:

- Facilities will be modular in nature allowing scale-up from a base processing unit with a capacity of 50 000 tonne/yr of mixed garden and food organics input.
- Each site will have sufficient space to allow facility expansion as quantities increase over time
- Facilities will be fully established by 2013/14
- Facilities have been located at existing organics processing sites

- Facilities have been assumed to be established at existing facilities in the following suburbs: Clayton; Epping; Pakenham; Brooklyn; Coldstream; and Dandenong

5.4.4 Receival / processing facilities – residual waste

Inner urban areas

For option 2, collected residual waste from inner urban areas is assumed to be delivered to a single AWT facility located in close proximity to the CBD. The assumed technology and facility characteristics are as for option 1 (see Section 5.2.4).

Outer suburban areas

For option 2, collected residual waste from outer suburban areas is assumed to be delivered to existing landfills.

5.5 Option 2A

Option 2A is an extension of option 2, and varies with anaerobic digestion being replaced by aerobic composting for residual waste from outer suburban areas. All other parameters – including the inner urban services, collection, transport and site locations – remain unchanged from option 2.

For option 2A, the assumed collection systems and receival processing infrastructure are summarised in Table 5-5.

Table 5-5 Collection systems and infrastructure – option 2A

Area	Stream	Assumed collection system	Receival / processing facilities
Inner urban (2 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing material recovery facilities
	Residual waste	Weekly MGBs	Alternative Waste Treatment facility (anaerobic digestion)
Outer suburban (3 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing material recovery facilities
	Mixed garden and food organics	Weekly MGBs	Aerobic composting
	Residual waste	Weekly MGBs	Existing landfills

5.6 Option 3

5.6.1 Overview

Option 3 is similar to option 1, with anaerobic digestion replaced by fluidised bed incineration for residual waste from outer suburban areas. All other parameters – including the inner urban services, collection, transport and site locations – are the same as for option 1. For option 3, the assumed collection systems and receival processing infrastructure are summarised inTable 5-6.

Table 5-6 Collection systems and infrastructure – option 3

Area	Stream	Assumed collection system	Receival / processing facilities
Inner urban (2 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing materials recovery facilities
	Residual waste	Weekly MGBs	Alternative Waste Treatment facility
Outer suburban (3 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing material recovery facilities
	Garden organics	Fortnightly MGBs	Existing composting facilities
	Residual waste	Weekly MGBs	Fluidised bed facilities

5.6.2 Receival / processing facilities – residual waste

Fluidised bed incineration facilities

Residual waste collected from outer suburban areas under option 3 is assumed to be delivered to a network of fluidised bed facilities. The assumed technology employed at these facilities is mechanical treatment followed by fluidised bed incineration with energy recovery. Key features include:

- Facilities will be modular in nature allowing scale-up from a base processing unit with a capacity of 100 000 tonne/yr of residual waste input.
- Each site will have sufficient space to allow facility expansion as quantities increase over time
- Facilities will be fully established by 2013/14
- Facilities have been located at sites within heavy industry zones in Laverton, Dandenong South and Coolaroo.

5.7 Option 4

5.7.1 Overview

For option 4, the assumed collection systems and receival processing infrastructure are summarised in Table 5-7.

Table 5-7 Collection systems and infrastructure – base case

Area	Stream	Assumed collection system	Receival / processing facilities
Inner urban and outer suburban (2 bin system)	Co–mingled recyclables	Fortnightly MGBs	Existing material recovery facilities
	Residual waste	Weekly MGBs	Alternative Waste Treatment facility

5.7.2 Receival / processing facilities – co–mingled recyclables

All areas

For all options, existing processing facilities for collected co–mingled recyclables (see Section 5.1.2) have been assumed to continue operation and expand and upgrade as quantities increase over time.

5.7.3 Receival / processing facilities - residual waste

Alternative Waste Treatment facilities

Residual waste collected from all areas under option 4 is assumed to be delivered to a network of Alternative Waste Treatment (AWT) facilities. The assumed technology employed at these facilities is anaerobic digestion, Key features include:

- Facilities will be modular in nature allowing scale-up from a base processing unit with a capacity of 70 000 tonne/yr of residual waste input.
- Each site will have sufficient space to allow facility expansion as quantities increase over time
- Facilities will be fully established by 2013/14
- Facilities have been located at sites with current or historical waste activity.
- Facilities will be located to minimise average travel times for fully loaded collection vehicles to 30 minutes or less.

- Facilities have been assumed to be located at existing facilities in the following suburbs: Melbourne Port; Deer Park; Epping; Vermont South; Hallam; and Clayton.

Transfer stations

For option 4 it is assumed there is no need for transfer stations as the selected AWT localities allow delivery of residual wastes to the AWT facilities within an average travel time (for each LGA) of 30 minutes or less.

5.8 Summary

A summary of the key components of each of the options is provided in Table 5-8.

Table 5-8 Summary of system components for each option

Component	Base case		Options 1 and 1A		Options 2 and 2A		Option 3		Option 4	
Collection systems	As per existing systems		Inner urban (2 bin system	- Co–mingled recyclables - Residual waste	Inner urban (2 bin system	- Co–mingled recyclables - Residual waste	Inner urban (2 bin system	- Co–mingled recyclables - Residual waste	Inner urban and outer suburban (2 bin system)	- Co–mingled recyclables - Residual waste
			Outer suburban (3 bin system)	- Co–mingled recyclables - Garden organics - Residual waste	Outer suburban (3 bin system)	- Co–mingled recyclables - Mixed food and garden organics - Residual waste	Outer suburban (3 bin system)	- Co–mingled recyclables - Garden organics - Residual waste		
Material recovery facilities	Visy	Laverton	Visy	Laverton	Visy	Laverton	Visy	Laverton	Visy	Laverton
	Visy	Banyule	Visy	Banyule	Visy	Banyule	Visy	Banyule	Visy	Banyule
	Visy	Springvale	Visy	Springvale	Visy	Springvale	Visy	Springvale	Visy	Springvale
	SKM	Coolaroo	SKM	Coolaroo	SKM	Coolaroo	SKM	Coolaroo	SKM	Coolaroo
	Thiess	Hallam	Thiess	Hallam	Thiess	Hallam	Thiess	Hallam	Thiess	Hallam
	Thiess	Darebin	Thiess	Darebin	Thiess	Darebin	Thiess	Darebin	Thiess	Darebin
	Richards	Hallam	Richards	Hallam	Richards	Hallam	Richards	Hallam	Dasma	Lilydale
	Dasma	Lilydale	Dasma	Lilydale	Dasma	Lilydale	Dasma	Lilydale		

Component	Base case		Options 1 and 1A		Options 2 and 2A		Option 3		Option 4
Garden organics processing	TPI	Clayton T/S	TPI	Clayton T/S	NONE		TPI	Clayton T/S	NONE
	TPI	Pakenham	TPI	Pakenham			TPI	Pakenham	
	TPI	Epping	Green Planet	Epping			Green Planet	Epping	
	NRS	Dandenong	NRS	Dandenong			NRS	Dandenong	
	Pinegro	Deer Park	Pinegro	Deer Park			Pinegro	Deer Park	
	ANL	Coldstream	ANL	Coldstream			ANL	Coldstream	
	SITA	Brooklyn	SITA	Brooklyn			SITA	Brooklyn	
Mixed garden and food organics processing	NONE		NONE		Clayton		NONE		NONE
					Epping				
					Pakenham				
					Deer Park				
					Brooklyn				
					Coldstream				
					Dandenong				
Landfills	Boral	Deer Park	NONE (note that landfills will continue to be required under this option, however they will not receive unprocessed domestic residual waste from collection trucks or transfer vehicles)		Boral	Deer Park	NONE (note that landfills will continue to be required under this option, however they will not receive unprocessed domestic residual waste from collection trucks or transfer vehicles)		NONE
	Hanson	Wollert			Hanson	Wollert			
	WCC	Werribee			WCC	Werribee			
	TPI	Clayton (to 2017)			TPI	Clayton (to 2017)			
	Regional	Regional (to 2017)			Regional	Regional (to 2017)			
	SITA	Hallam			SITA	Hallam			

Component	Base case		Options 1 and 1A	Options 2 and 2A		Option 3	Option 4
	HCC	Sunbury		HCC	Sunbury		
AWT facilities	NONE		Melbourne Port Vermont South Epping Deer Park Hallam Clayton	Melbourne Port (serving Inner Urban areas only)		Melbourne Port Vermont South Epping Deer Park Hallam Clayton	Melbourne Port Vermont South Epping Deer Park Hallam Clayton
Fluidised bed EfW facilities	NONE		NONE	NONE		Laverton Dandenong South Coolaroo	NONE
Residual waste transfer stations	Stonnington Heidelberg Vermont South Dynon Road		NONE	Heidelberg Vermont South Post 2017 Heidelberg Vermont South Boroondara Stonnington		Heidelberg Vermont South Stonnington	NONE

6 Waste Profile

Microsoft® Excel-based models were developed to project waste quantities and composition at the relevant dates and under the different options. The underlying data and assumptions for these models are described below.

6.1 Waste generation

Waste data for 2005/06 was obtained from Sustainability Victoria's (2007) local government survey for the financial year 2005/06, and unpublished supporting worksheets. The data included council by council quantities of kerbside–collected co–mingled recyclables, separated organics and residual waste.

Waste quantities of all types were assumed to grow in relation to population plus 1%. Population data was obtained from the DSE website. This approach is intended to be broadly consistent with the *Towards Zero Waste* 'Waste Model' under the TZW Strategy Base Case, together with an allowance for waste reduction measures envisaged under the strategy[1]. The rationale for including waste reduction measures is that these generally occur 'upstream' and are independent of the options under consideration in this assessment. Total projected quantities of waste are given in Table 6-1.

Table 6-1 Projected quantities of domestic waste (millions of tonnes)

Year	2005/06	2013/14	2016/17	2029/30
Total kerbside–collected domestic waste	1.32	1.55	1.64	2.05

6.2 Diversion assumptions

6.2.1 Co–mingled recyclables

For the co–mingled recyclables stream the only assumed change in diversion from current levels is that plastics codes 4–7 will be recycled in the future. This increase in diversion has been applied in all options

Projecting domestic waste to grow by 'population + 1%' over the period 2005/06 to 2013/14 (end of the strategy period) increases the quantity of waste by within 2% of the projected growth of domestic waste under the corresponding TZW Waste Model assumptions. In other words, the assumptions are consistent on a total quantity basis.

The TZW Waste Model assumes that organics grow in proportion to population but also provides for an increase related to the expanded provision of garden organic collections. This effect is subsumed here in the overall 'population + 1%' growth assumption.

considered. Modelling assumes that by 2013/14 the metropolitan wide recovery rate of plastics 4-7 will be similar to that currently achieved for plastics 1-3.

The estimated quantities recovered are based on the extrapolated results of six recent compositional audits of between 150 and 300 houses. The audits were undertaken by the former North Regional Waste Management Group and relate to waste generated in Banyule, Darebin, Hume, Moreland, Nillumbik and Whittlesea (EnviroCom 2006a-d; Wastemin 2006a,b).

6.2.2 Organics

Base case

For the base case, no additional diversion of organics is assumed, with existing systems assumed to continue across the study area for the entire modelling period.

Options 1, 1A and 3

Options 1, 1A and 3 assume that by 2013/14 all outer suburban councils (except Nillumbik) provide a fortnightly garden organics service to at least 80% of those households receiving a kerbside residual waste service. Some outer suburban councils already meet this standard; others are assumed to upgrade their service accordingly. The quantity of garden organics collected per household within councils that upgrade their service was assumed to be equal to the projected average of those households within councils that currently (except Nillumbik) have this service. Based on the data provided by Sustainability Victoria, this quantity was assumed to be 114kg per capita per year in 2013/14. Nillumbik was assumed to continue its weekly combined garden and food organics service throughout the projection period.

In these options inner urban councils are assumed to abandon their garden organics programs by 2013/14 and divert this material to the residual waste stream, which will then be sent to an AWT facility for processing.

Options 2 and 2A

For options 2 and 2A it is assumed that 55% of the food organics generated by the outer suburban councils will be diverted from the residual waste stream to a combined food/garden organics stream. The assumed recovery rate of 55% of food organics takes into account that not all residents will participate in the envisaged diversion of food organics, and for those that do participate not all materials will end up in the correct bin. This recovery rate was based on an international literature review conducted as part of a study previously undertaken by Hyder Consulting (2006a).

The quantity of food organics generated per capita in 2005/06 was assumed to be 76kg per person per year based on the average generation per household in the Northern Region audits, and the average number of persons per household in the audited councils based on DSE (2004) data.

For inner urban areas, there is no separate organics collection provided, with affected councils assumed to abandon their organics programs by 2013/14 and divert this material to the residual waste stream, which is to be sent to an AWT facility for processing.

6.2.3 Mixed residuals

For option 4 it is assumed that all waste other than co–mingled recyclables will be deposited in a mixed residuals bin.

In this option, outer suburban councils are assumed to abandon their garden and food organics programs by 2013/14 and divert this material to the residual waste stream (as per inner urban), which will then be sent to an AWT for treatment.

6.2.4 Projected quantities

The projected kerbside collected quantities under the different options are shown in Table 6-2.

Table 6-2 Projected quantities of the three domestic waste streams under the different options (thousands of tonnes)

Stream	Base case				Option 1			Option 2			Option 3			Option 4		
	05/06	13/14	16/17	29/30	13/14	16/17	29/30	13/14	16/17	29/30	13/14	16/17	29/30	13/14	16/17	29/30
Co–mingled recyclables	393	471	499	626	471	499	626	471	499	626	471	499	626	471	499	626
Garden organics	201	237	250	315	375	399	512	-	-	-	375	399	512	-	-	-
Mixed food/garden	7	7	8	9	7	8	9	529	563	715	7	8	9	-	-	-
Residuals to landfill	716	830	879	1,103	-	-	-	425	445	541	-	-	-	-	-	-
Residuals to AWT	-	-	-	-	693	730	906	121	130	170	121	130	170	1075	1137	1427
Residuals to EfW	-	-	-	-	-	-	-	-	-	-	572	600	736	-	-	-
Total	1,317	1,546	1,636	2,053	1,546	1,636	2,053	1,546	1,636	2,053	1,546	1,636	2,053	1,546	1,636	2,053

7 Waste composition

The quantitative modelling outputs described above are used in the financial modelling and life-cycle assessment (LCA). The LCA required additional data on waste composition. The primary data used to estimate this was the detailed composition data obtained through the Northern Region audits (EnviroCom 2006a-d; Wastemin 2006a,b).

7.1 Co–mingled recyclables

For all recyclables, the 2005/06 percentage composition of co–mingled recyclables was assumed to be consistent with the weighted averages obtained through the Northern Region audit results. This percentage composition changed during the projection period only in that plastics 4–7 were assumed to be added by 2013/14.

Figure 7-1 shows the composition of kerbside co–mingled recyclables in inner urban and outer suburban.

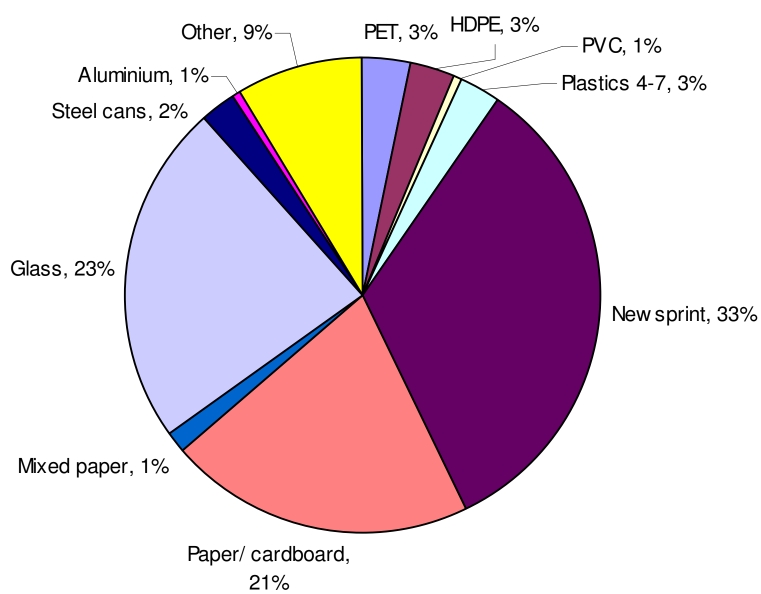


Figure 7-1 2005/06 composition of the co–mingled recyclables stream (both inner urban and outer suburban areas)

7.2 Organics

The percentage composition of the garden organics stream in 2005/06 was assumed to be the same as the weighted average of the Northern Region audits[2].

For Options 2 and 2A, this changes through the addition of food organics in the outer suburban areas. The assumed increment was 83kg per person per year in 2013/14.

Figure 7-2 shows the projected composition of mixed garden/food organics stream for outer suburban areas under option 2. This composition represents the in–feed to the anaerobic digestion facilities adopted in option 2.

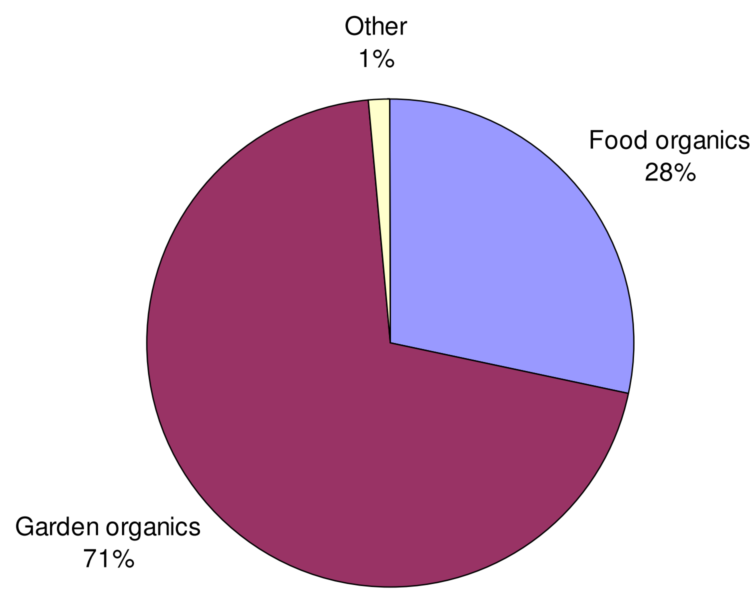


Figure 7-2 Projected 2013/14 composition of the mixed garden/food organics stream outer suburban areas, option 2

When considering the composition of garden/food organics, it is important to recognise that:

- the generation of garden organics is seasonal and that the composition shown in Figure 7-2 represents the yearly average;
- the contamination shown in Figure 4-2, although low by weight, is difficult to manage as it is primarily plastic;

[2] Excluding Nillumbik (which collects food organics) and Whittlesea (for which no organics audited results were reported).

- a system for gathering food waste from the kitchen and storing it prior to deposit in the garden/food organics bins will need to be put in place.

7.3 Residual waste

For the residual waste stream, different 2005/06 composition profiles were assumed for the materials generated in different areas. In local government areas in the inner urban and in outer suburban areas that currently meet the options 1 and 1A garden organics standard, the waste composition was assumed to equal that measured in the Banyule audit (EnviroCom Australia; 2006a). At the time of the audit Banyule was the only Northern Region council with organics services meeting the upgraded standard.

The 2005/06 residual waste composition in outer suburban areas that did not meet the option 1 garden organics standard were assumed to be better represented by the audits of Darebin, Hume, Moreland and Whittlesea, as none met the new standard at that time. These results, together with collated data on Melbourne–wide garbage generation, were used to derive the composition of collected residual waste in outer suburban areas.

The Northern Region audits also provided results in the aggregated categories plastics 1–3 and paper/cardboard. From an environmental perspective there are sensitivities dependent on what types of plastic (HDPE, PET and PVC) and paper (newsprint, paperboard, mixed paper) are present. To estimate the breakdown, the results of a previous audit in the Hume local government area were applied (Grant *et al.* 2003).

Charts showing 2005/06 composition of the residual streams in inner urban and outer suburban areas are in Figure 7-3 (inner urban) and Figure 7-4 (outer suburban). In both these charts the percentage of disposable nappies, obtained through the base audit data, is relatively high. Information published by SGS relating to their Noble Park nappy recycling service suggests that the Melbourne average should be 5%.

Also shown is the projected 2013/14 composition of the residual waste stream for options 1 and 1A for outer suburban areas (Figure 7-5). The impact of widespread garden organics collection systems under this option reduces the proportion of garden organics in the residual stream. The composition shown in Figure 7-5 represents the in–feed to the AWT facilities adopted for this option.

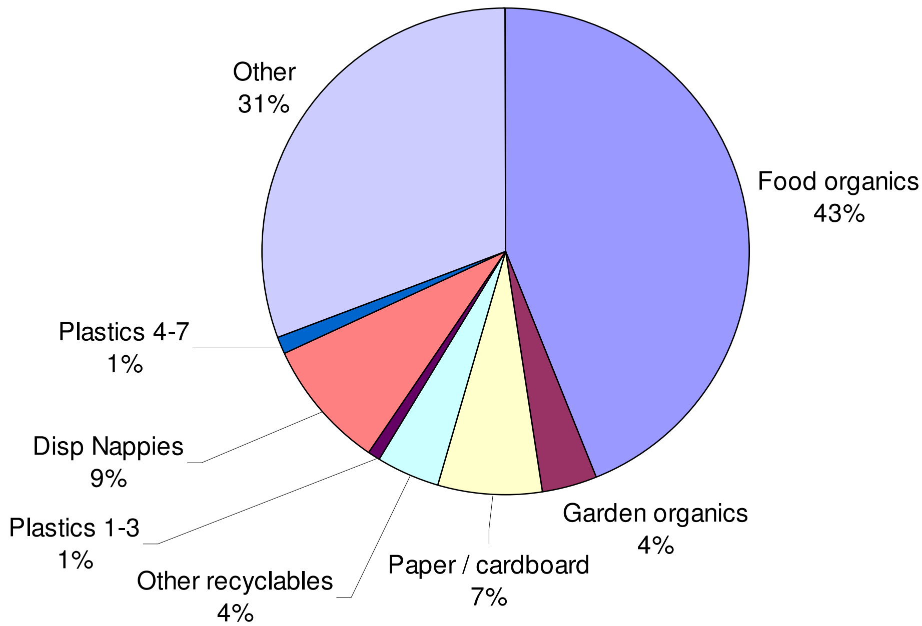


Figure 7-3 2005/06 composition of the residual waste stream
Inner urban areas

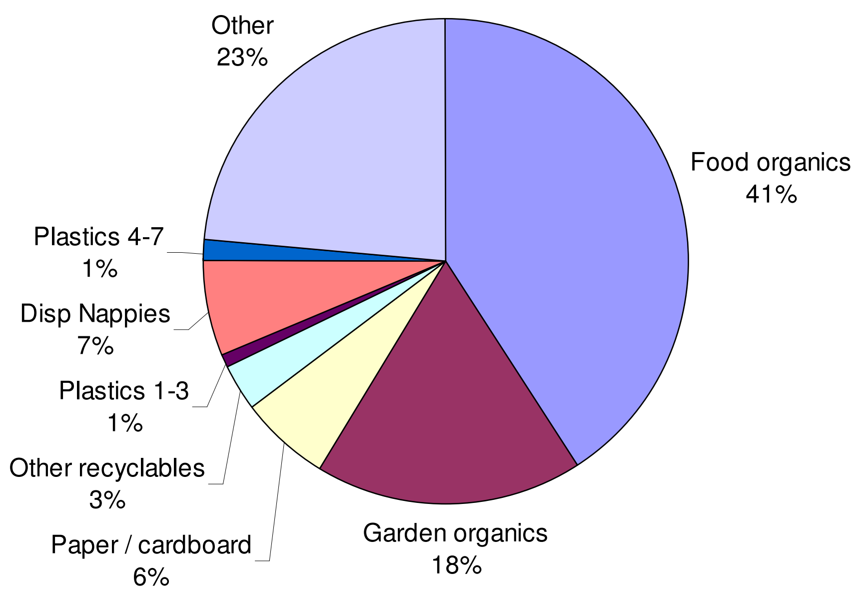


Figure 7-4 2005/06 composition of the residual waste stream
Outer suburban areas

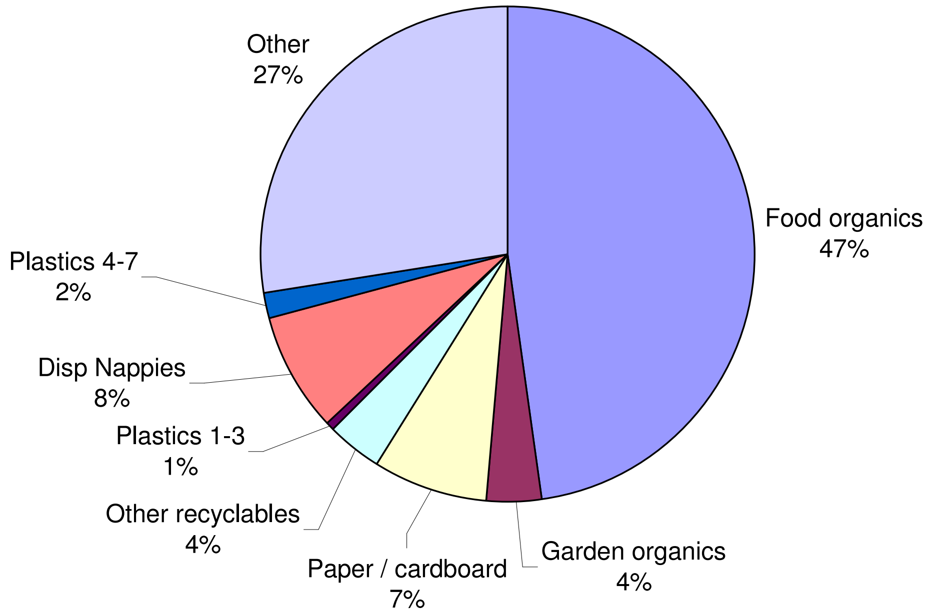


Figure 7-5 Projected 2013-14 composition of the residual waste stream, Outer suburban areas Options 1 and 1A (following upgrade of garden organics collections)

8 Waste management logistics

8.1 Introduction

To comprehensively manage municipal solid waste and assess alternative options, it is necessary to consider associated transport, processing and disposal operations in an integrated context rather than in isolation.

8.2 Waste Management Logistics Model

The Waste Management Logistics Model has been developed as a Microsoft® Excel workbook to estimate the costs of waste delivery, transfer and processing/disposal for a user-defined network of waste generation areas and receival facilities. The network may comprise a series of waste generation centres, or catchments, and surrounding waste transfer and processing/disposal facilities. For this study, the waste generation catchments are equivalent to local government areas (LGAs) within metropolitan areas. Waste quantity information is currently not collected at a geographical scale smaller than individual LGAs and hence is unavailable.

The cost of collection from kerbside is estimated separately using industry rates and market costs. Waste quantities used for modelling correspond to those estimated under the waste generation profile developed for the study at a LGA level.

The model can be applied to:

- optimise a network of waste transfer, processing and disposal facilities[3]; and
- undertake scenario modelling.

Model inputs and outputs are summarised below:

Inputs

- Waste generation rates by local government area (tonne/yr)
- Location of waste management facilities (by suburb)
- Type of waste management facility (i.e., transfer facility or processing facility)
- Facility capacity (tonne/yr)

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[3] As this was not a cost optimisation study, facility locations were selected manually to be consistent with transport requirements, facility viability and service scope.

- Collection truck payload capacities by local government area (tonne/vehicle)
- Collection vehicle running costs by local government area ($/hr)
- Waste processing / disposal cost by facility ($/tonne)
- Manual linking of individual waste catchments to facilities to account for any contractual / supplier arrangements.

Outputs

- Waste quantities delivered from each catchment to surrounding facilities;
- Total truck hours, direct delivery and transfer trailers
- For each collection catchment (i.e. Local Government Area):
  - Average travel time from catchment to facility (minutes)
  - Average one way distance (km)
  - Average one way speed (km/hr)
  - Annual costs of waste delivery and transfer ($/yr and $/tonne)
  - Annual cost of waste disposal ($/yr and $/tonne)

8.3 Methodology

For the purposes of modelling, facility locations need to be identified. To identify the locations, geographic clusters of waste generation were identified and tested to develop a comprehensive network of facilities across Melbourne. This test involved verification that an existing waste facility within the cluster could be utilised in order that the average travel distance is less than 30 minutes.

8.4 Base assumptions

8.4.1 Truck size

All collection trucks have been assumed to be single axle vehicles with maximum payloads of:

Material	Maximum Payload
Residual waste Garden organics Mixed garden and food organics	5.5 tonnes
Co-mingled recyclables	4.5 tonnes

Single axle collection trucks have been selected over tandem axle trucks due to their reduced impact on transport and road infrastructure.

Transfer trailers have been assumed to have a maximum payload capacity of 20 tonnes.

8.4.2 Truck productivity

Collection truck productivity has been assumed to be 175 'drive-by' collections per hour. No provision for travel to the first pick up has been made as it is assumed all vehicles will be operated from a depot located within each local government area.

8.4.3 Modelling costs

All costs are current industry average costs for metropolitan Melbourne and exclude GST.

In each case the average cost estimate is based on a tender being let in 2007/08 and is in 2007/08 terms.

Costs of all capital (including provision of the site) and product marketing and sales costs have been assumed to be included in the tendered price.

8.4.4 Truck costs

A unit cost of $75/hr has been assumed for single axle, driver-only, side-loader collection trucks operating in outer suburban areas. This cost has been increased to $120/hr for collections in inner suburban areas as it is assumed these will be provided by single axle trucks operated by a driver and runner.

A unit cost of $135/hr has been assumed for transfer trailers.

8.4.5 Receival / Processing costs

Material recovery facilities (MRF)

Material recovery facilities receiving and processing co–mingled recyclables are assumed to charge a zero gate fee for delivered co–mingled recyclables, with profitable operation achievable based on income from the sale of processed material.

Garden organics processing facilities

A processing fee of $55/tonne is assumed to apply at facilities receiving and processing garden organics at a standard equivalent to controlled environmental composting. This figure assumes that cost includes transport of the product out of Melbourne for sale to agriculture.

Mixed food and garden organics processing facilities

Processing costs at facilities receiving mixed food and garden organics will reduce with greater input quantities. The following costs have been assumed for cost modelling:

	Facility Input (tonne/yr)	Processing Cost ($/tonne)
Anaerobic digestion	< 75,000	$95
	> 75,000	$75
Aerobic composting	< 75,000	$85
	> 75,000	$65

As with garden organics, processing these cost estimates include provision for transport of a portion of the product out of Melbourne for sale to agriculture.

Putrescible landfills

Landfills receiving residual waste have been assumed to operate at best practice standard with methane capture of 60% and a gate fee (including EPA landfill levy of $9 per tonne) of $70/tonne.

Transfer stations

A cost of $25/tonne has been assumed to cover transfer station operation, excluding bulk haulage of transferred waste in transfer trailers; and excluding disposal costs.

Alternative Waste Treatment facilities

Processing costs at AWT facilities will reduce with greater input quantities. The cost rates adopted for modelling are listed below. These include all operating costs as well as annualised capital costs for site acquisition and facility establishment.

	Facility input (tonne/yr)	Processing cost ($/tonne)
Anaerobic digestion	< 125,000	$130
	> 125,000	$110
Aerobic composting	< 125,000	$110
	> 125,000	$90

Fluidised bed Energy from Waste

The cost of operation of mechanical separation and fluidised bed incineration has been assumed as $170 per tonne. This is based on current data from Austria and Germany.

8.4.6 Bin costs

Collections for all materials have been assumed to be from rigid mobile garbage bins (MGBs), with provision of the bin assumed to be the responsibility of the collection provider. An average rate of $0.15 per MGB per week has been assumed to cover bin provision and maintenance costs.

8.4.7 Collection frequencies

The following collection frequencies have been assumed:

Material	**Collection frequency**
Residual waste	Weekly
Garden organics only	Fortnightly
Mixed garden and food organics	Weekly
Co–mingled recyclables	Fortnightly

8.4.8 Travel times

To undertake the cost analyses, the ‘Waste Management Logistics Model’ uses travel distances and times between population centres and existing and proposed waste management facilities. The model includes a database of travel times and distances for 488 localities in and around metropolitan Melbourne. Travel times are taken from the population ‘centre’ of each locality.

In researching the availability of travel time and distance data, a range of potential data suppliers were considered, including VicRoads and specialist mapping companies.

VicRoads ‘Traffic Analyst Group’ advised that, while they possess average speed data for individual reaches of Melbourne freeways and arterial roads, consolidated travel time and distance data between localities is not readily available. According to VicRoads, the overall average vehicle speed in metropolitan Melbourne is 42 km/hr.

Travel time and distance data between localities can be obtained from a range of websites[4].

[4] Examples include: www.travelmate.com.au, www.mynrma.com.au, www.whereis.com

For this project travel time and distance data provided by specialist mapping company MapData Sciences was used. The provided data represents road distances and average travel times on existing roads for the shortest route between two localities. No distinction is made between vehicle types or times of day as this data is unavailable.

In undertaking cost analyses for this project, no correction to the travel time data was made for congestion periods as it is assumed that most collection truck material deliveries occur outside the morning and evening traffic peaks.

8.4.9 Alternative waste treatment facility capital costs

Many variables impact on the capital cost of AWT facilities. These include:

- Waste composition
- Treatment method
- Environmental constraints
- 'Output' markets
- Scale
- Site costs

In general terms, capital costs for anaerobic facilities currently range between $700 and $1 000 per annual 'input' tonne, e.g. the capital cost of a 100,000 tonne facility is likely to range from $70 million to $100 million. Capital costs for aerobic facilities currently are less and in the range of $500-$700 per annual 'input' tonne.

8.4.10 Fluidised bed Energy from Waste capital costs

In general terms, capital costs of fluidised bed Energy from Waste facilities currently range from $1 000 to $1 200 per annual input tonne.

9 Environmental, social, transport and financial outcomes

9.1 Environmental

9.1.1 Scope

The environmental costs and benefits for each option have been assessed using a Life Cycle Assessment (LCA) approach. This LCA included all activities from the collection of waste materials from households, to the transport, sorting, processing and disposal of these materials, and the recovery of commodities. It also includes credits for the production of virgin materials (including water), fertilisers and electricity which would be needed in the economy if the waste had not been recovered. The LCA system boundary and the associated waste collection and management system are shown in Figure 9.1.

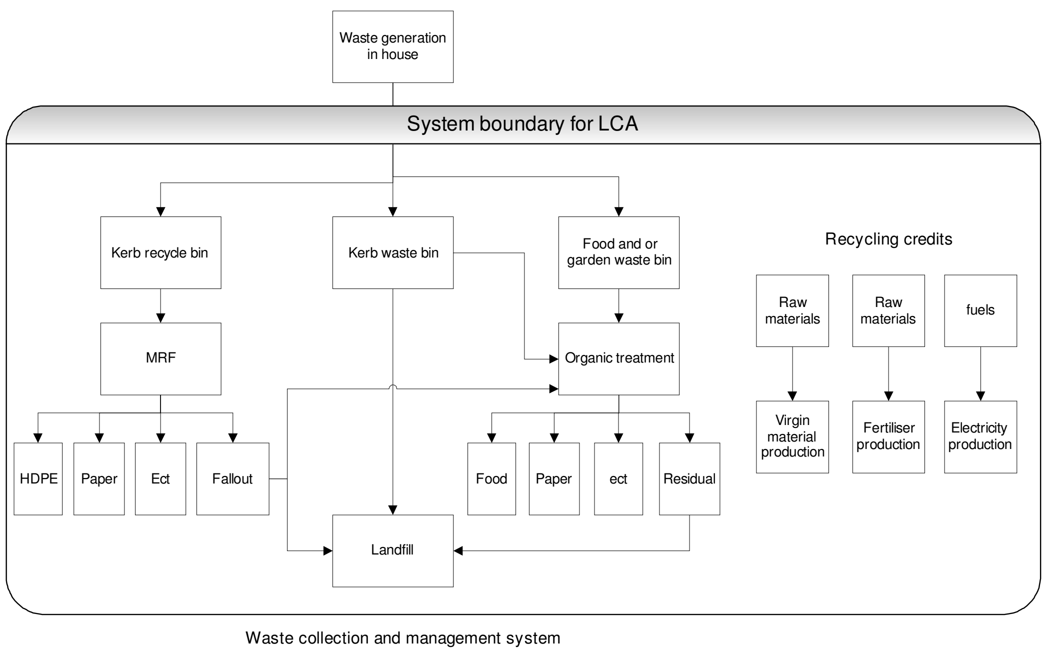

Figure 9-1: LCA System Boundary

A number of output assumptions are used in the LCA modelling. The most significant of these are summarised in Table 9.2 below.

Table 9-2 LCA assumptions

Dynamics at landfill (MSW)	▪ Landfill gas capture is in place for all landfills, with 60% of methane captured
Open composting	▪ 45% of input to process is output compost
Anaerobic digestion (green and food organics)	▪ 35% of input to process is output high quality compost. ▪ 80–100 kWh/t net electricity output
Anaerobic digestion (AWT)	▪ 50% of input to process is output. Of this 28% is low-grade compost and 72% is stabilised residue sent to landfill. ▪ 0–20 kWh/t input net electricity output
Aerobic composting (AWT)	▪ 60-70% of input to process is output. Of this 32% is low grade compost and 68% is stabilised residue sent to landfill ▪ No electricity output
Recovery rates in front-end separation	▪ 50% for plastics and 75% for metals.
EfW incineration	▪ 9% bulky fraction to landfill, 66% higher calorific to fluidised bed incinerator, 22% lower calorific value to landfill. ▪ 3% metal recovery ▪ Cement stabilisation of fly ash prior to landfill

Environmental impacts and benefits have been assessed for each option using the following key indicators:

- Greenhouse gas emissions (expressed as tonnes of CO_2 equivalents)
- Energy consumption from fossil fuels (joules)
- Water consumption (litres)
- Waste to landfill (tonnes)

9.1.2 Results

Results for the options modelled are presented below for each of the four indicators and across the four time periods in the study. The greenhouse results are presented in Figure 9-3 and it can be seen that all options are better than the base case. Option 4 is slightly better than option 1 in terms of greenhouse gas emissions, and this trend continues in the four time periods.

These greenhouse results also have been tested against varying energy consumption assumptions. This analysis showed that energy consumption has a low impact on the overall greenhouse result in each model.

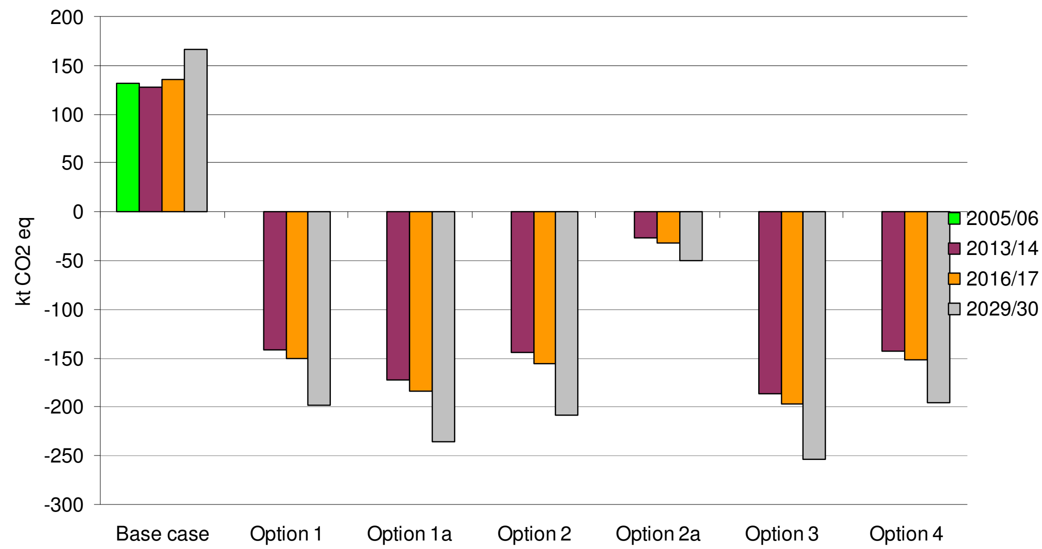

Figure 9-3: Greenhouse results for five scenarios over four different time points.

Greenhouse gas emissions

The difference in greenhouse gas emissions between options 1, 1A and 4 and option 2 is principally caused by:

- Reduced landfill in options 1, 1A and 4 leads to lower methane emissions from landfill; and
- Increased recycling results from increased front–end recycling in options 1, 1A and 4, as all residual waste streams are processed.

The difference in greenhouse gas emissions between option 2 and 2A results from composting the food and garden organics in preference to anaerobic processing with electricity generation.

Breakdown of greenhouse impacts for different options

Figure 9- shows the greenhouse gas emissions from different processes within each option modelled. The results are absolute emissions or avoided emissions as a result of the management of the waste fractions. The ‘impacts’ of waste management above the line consists of methane from landfill[5], transport emissions and anaerobic digestion of mixed waste in option 1. Kerbside recycling produces the largest ‘benefit’ in the waste management system, but is consistent across all options. Front–end recycling produces a smaller benefit where is it available, and is particularly important in option 1. The anaerobic digestion of green and food organics is

[5] These emissions were calculated using a method consistent with IPCC guidance. In this method, carbon storage is not counted as sequestration.

a major benefit of option 2. Figure 9.4 indicates that options 1, 1A and 4 are substantially better than the base case. A key to this improvement is the elimination of greenhouse gas emission from landfill in options 1, 1A and 4.

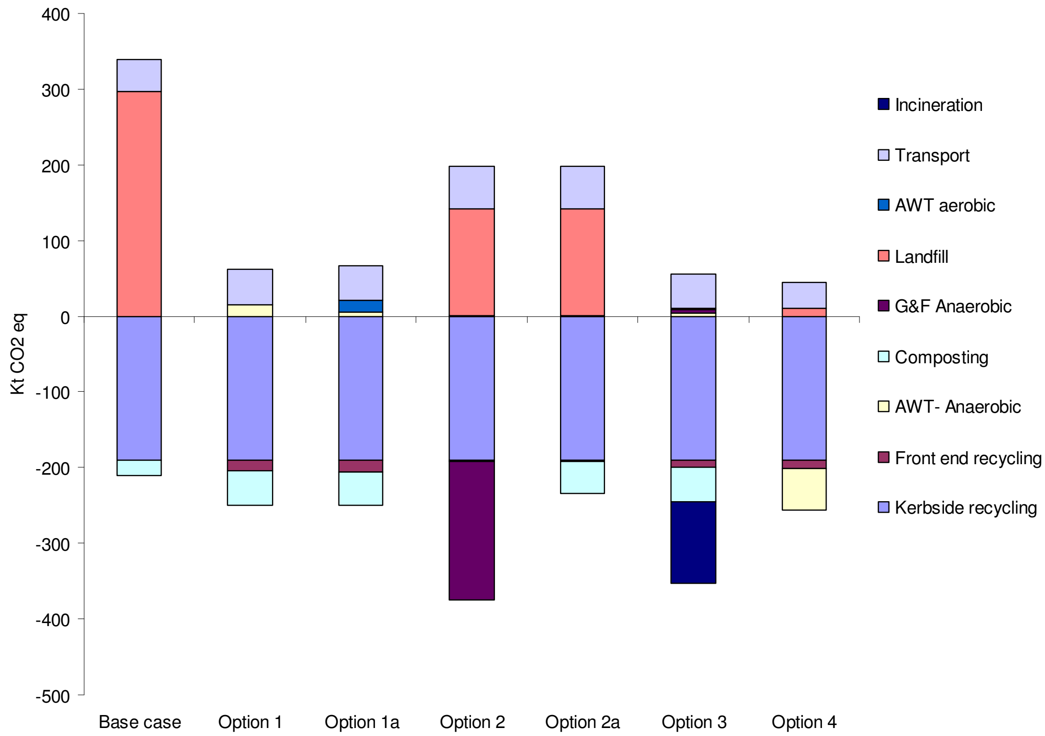

Figure 9-4: Breakdown of greenhouse gas emissions, 2013/14

Energy consumption from fossil fuels

Figure 9.5 shows the results for fossil energy use. There is a positive outcome for all options, but fossil energy savings are highest for option 2, which generates the most electricity for export from the anaerobic digestion of green and food organics. The base case shows marginally higher fossil energy savings than option 1, due to electricity production from landfill gas which is not available in option 1.

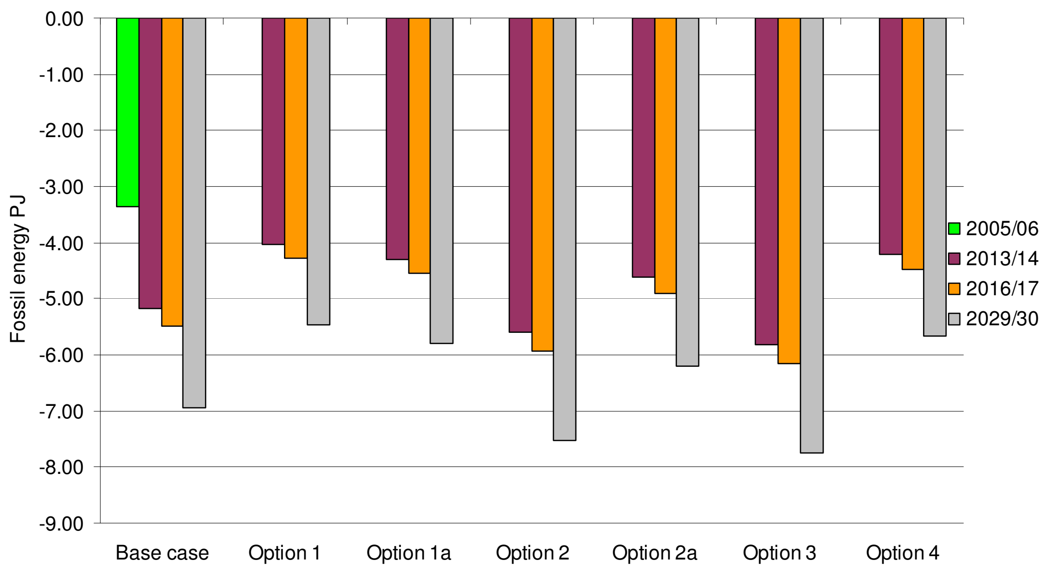

Figure 9-5: Energy consumption from fossil fuel use results

Water consumption

Figure 9.6 shows the results for water consumption. Water savings occur predominantly through recycling (newsprint, paperboard, glass, aluminium and compost production (and consequent avoided fertiliser production). This occurs with all options. Options 1, 2 and 4 also generate electricity which contributes to water savings.

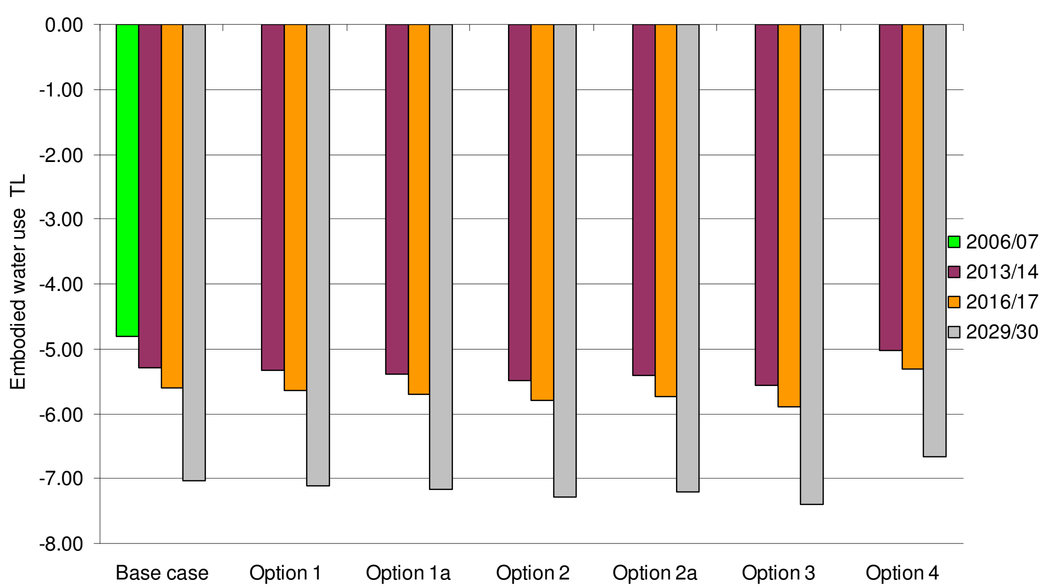

Figure 9-6: Water consumption results

Air emissions

Figure 9.7 shows that air emissions are beneficial for all options and the total results do not vary substantially between options. The reason for this is that kerbside recycling dominates the savings and most options have approximately the same recycling result. These kerbside recycling benefits are due to savings created by steel, aluminium, paper and PET reprocessing.

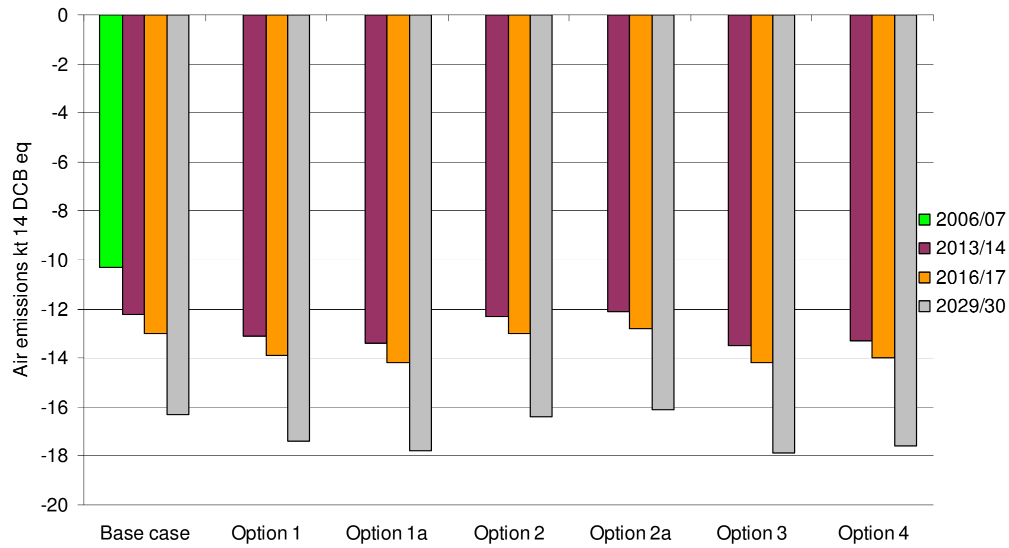

Figure 9-7: Air emissions results

Waste to landfill

Figure 9.8 shows the impacts of waste to landfill. Option 1 is the best option as garden organics composting offers higher recovery than mixed waste processing through an AWT. The base case produces the worst outcome for waste to landfill.

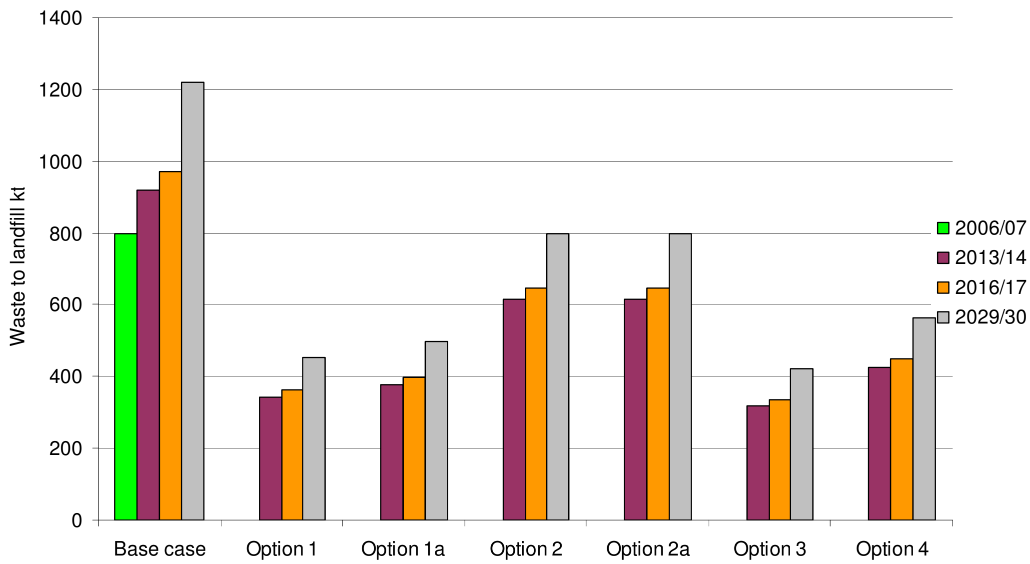

Figure 9-8: Waste to landfill results

9.2 Social

9.2.1 Scope

This social assessment includes impacts to amenities (including transport impacts) and job creation.

9.2.2 Job creation

The development of new waste processing facilities in options 1-4 will result in significant job creation both in the construction phase and later during operations.

The number of positions created during construction will depend on the technology selected, but will be large, whilst the number of permanent positions created, once all facilities become operational, will be in the order of 250.

9.2.3 Quality of life

The introduction of increased and uniform garden organic household services in the outer suburban area and the use of a two-bin system in the inner urban area included in options 1, 1A, 2 and 2A has been well received where introduced in the past.

A return to the two-bin system as required under option 4 is likely to be seen as a reduced service by residents in the outer suburban areas who currently have this expanded service.

The introduction of additional household sorting of food waste as provided in option 2 is considered to be less desirable to the current collection arrangement of placing food into the residual waste stream. This concern relates to the impost on householders to appropriately sort waste for processing, and the need to provide suitable wrapping material to carry the waste from the kitchen to the MGB.

9.2.4 Transport noise

No significant noise impacts are expected from the various options, as truck numbers will not increase and all collections are expected to be completed during normal working hours.

9.2.5 Traffic congestion

During modelling, congestion around each facility was assessed to determine likely congested locations.

Following consideration of the access at each of the facilities in 2013/14, only the Vermont South AWT was identified as a concern. However, as this facility has excellent access to the new EastLink this issue should easily be managed.

9.2.6 Facility siting

It is anticipated that the fluidised bed EfW facilities would be opposed by environment groups and the community, and the granting of planning approvals would be uncertain at best.

In this study these facilities have been nominally located in heavy industry zones.

9.3 Financial

9.3.1 Options comparison

The outcomes of the financial assessment have been estimated in total dollars; dollars per tonne; and dollar per household per year bases. For each option, costs for waste collection, delivery, transfer and disposal have been estimated for the years 2013/14, 2016/17, 2029/30. For comparison purposes, current costs for existing systems have also been estimated.

Total current costs of kerbside-collected domestic waste management services have been estimated at $169M, or $124/hhld/yr. By comparison, the 2005/06 total cost of kerbside services across metropolitan Melbourne, as derived from Sustainability Victoria's annual survey of Councils, is $161M or $122/hhld/yr (Sustainability Victoria; 2007). The difference between the estimated cost and the surveyed cost is likely to be attributable to:

- the assumed cost of (best practice) landfill of $70/tonne being higher than that currently charged by landfill operators; and
- the assumed cost of recyclables processing of $0/tonne is likely to be lower than the average being paid by councils across Melbourne.

A summary of total estimated costs for kerbside collected services is provided in Table 9.9.

Table 9-9: Cost summary

	Year	Base case	Option 1	Option 1A	Option 2	Option 2A	Option 3	Option 4
Total cost ($)	2005/06	$169M	$169M	$169M	$169M	$169M	$169M	$169M
	2013/14	$194M	$232M	$221M	$233M	$226M	$268M	$221M
	2016/17	$203M	$241M	$228M	$242M	$237M	$279M	$221M
	2029/30	$252M	$284M	$269M	$291M	$283M	$336M	$279M
Cost per household per year	2005/06	$124	$124	$124	$124	$124	$124	$124
	2013/14	$126	$151	$144	$152	$148	$175	$144
	2016/17	$127	$151	$143	$151	$148	$174	$144
	2029/30	$137	$154	$146	$158	$154	$183	$152

A breakdown of costs by waste stream is shown in Figure 9.10, Figure 9.11 and Figure 9.12 ($ per household per year). Estimated total system costs on a $ per tonne basis for each option are shown in Figure 9.13, Figure 9.14 and Figure 9.15.

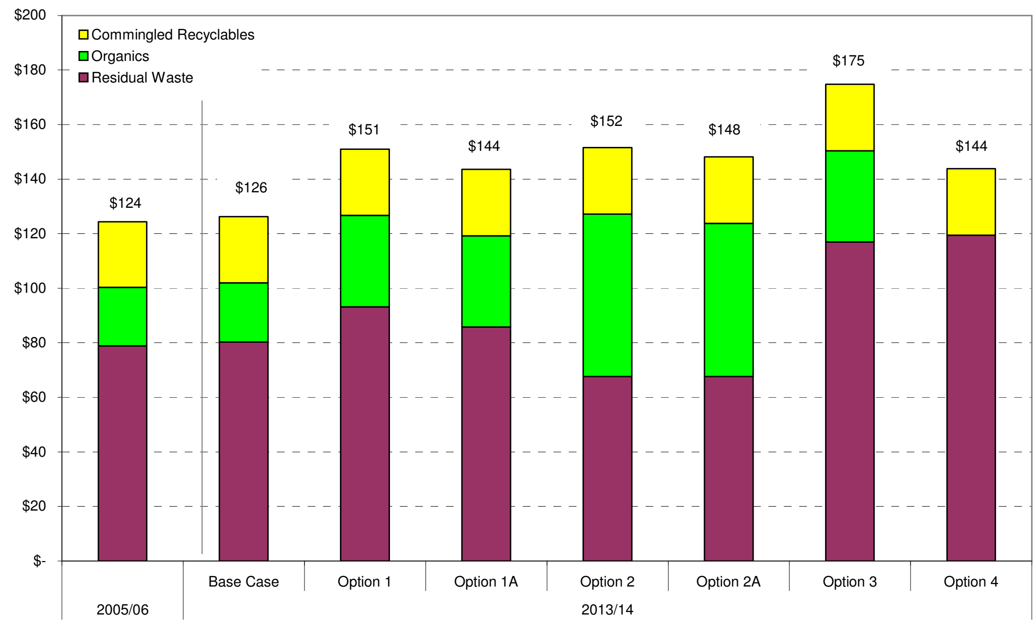

Figure 9-10: Breakdown of total system costs, 2013/14, ($ / household / year)

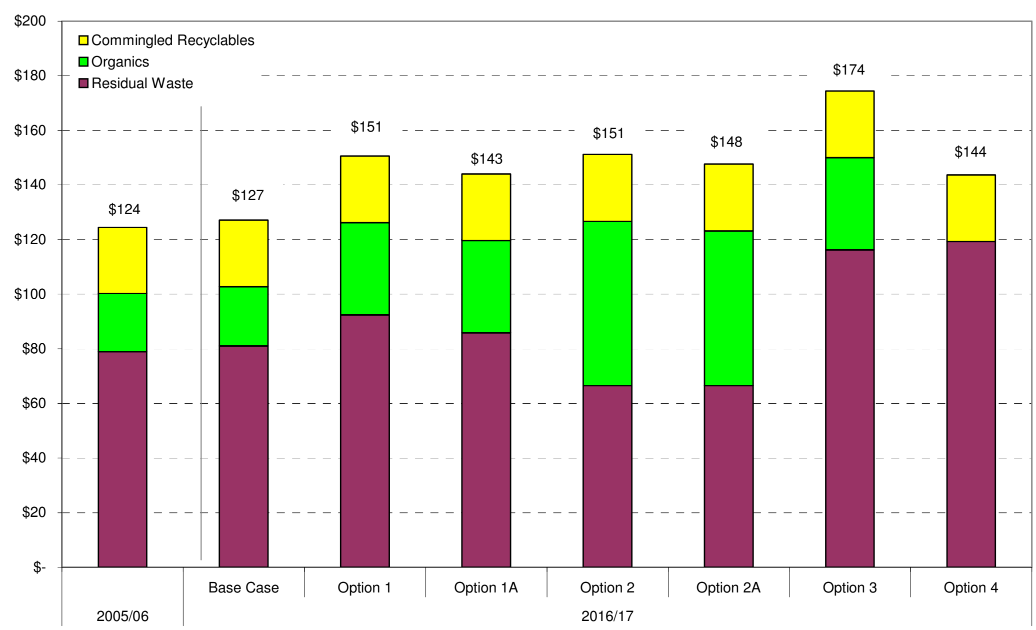

Figure 9-11: Breakdown of total system costs, 2016/17, ($ / household / year)

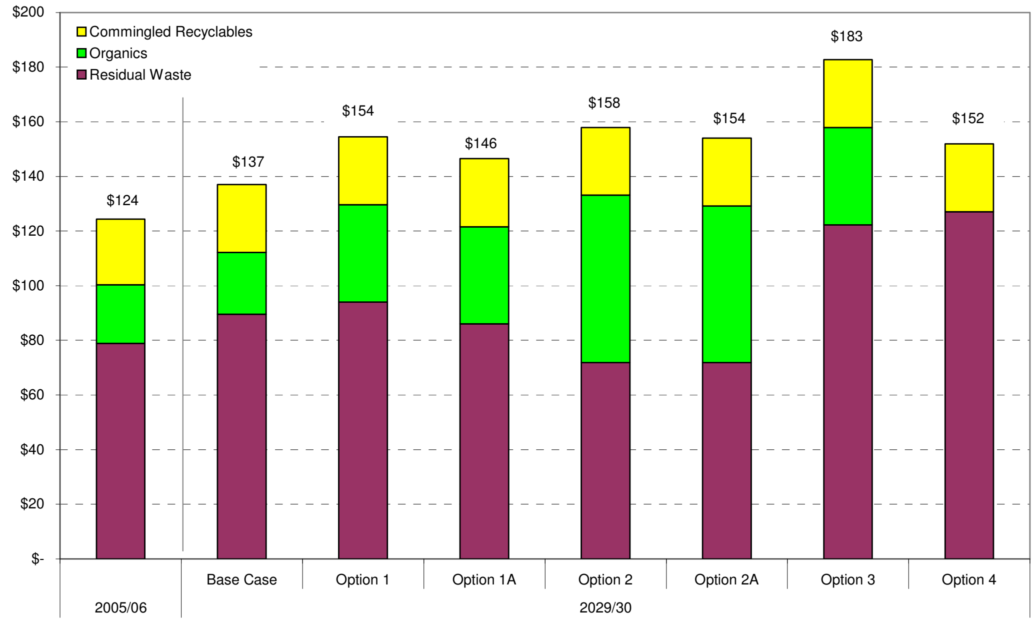

Figure 9-12: Breakdown of total system costs, 2029/30 ($ / household / year)

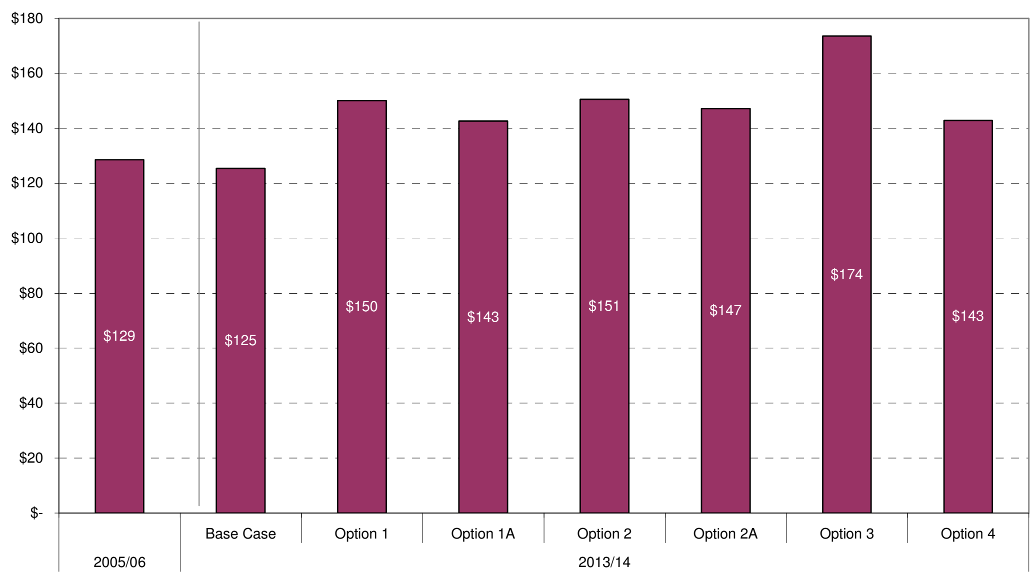

Figure 9-13: Total system cost, 2013/14 ($ / tonne)

Figure 9-14: Total system cost, 2016/17 ($ / tonne)

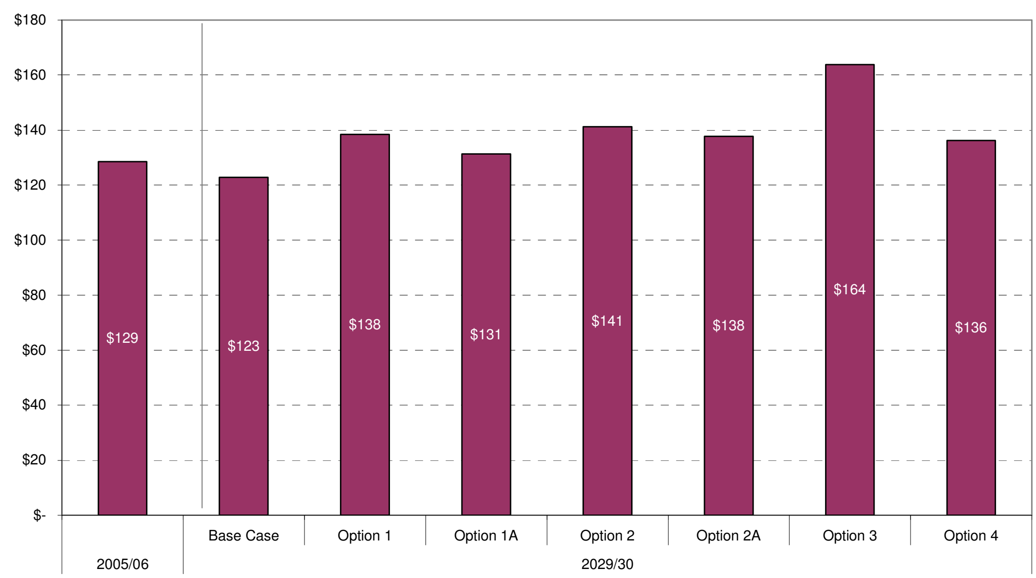

Figure 9-15: Total system cost, 20029/30 ($ / tonne)

Base case

For the base case, costs of kerbside collected waste management services across metropolitan Melbourne are estimated to be in the order of $126 - $137 per household per year. The increase in costs between 2016/17 and 2029/30 is primarily a reflection of the closure of two landfills (Regional and TPI landfills, Clayton) with the subsequent need to dispose of wastes via transfer stations for councils previously delivering residual waste to these landfills.

Option 1

For option 1, costs of kerbside collected wastes are estimated to be in the order of $151 - $154 per household per year.

Option 1A

For option 1A costs of kerbside collected waste reduces from option 1 as the anaerobic AWT process is replaced by a lower cost aerobic process.

Option 2

For option 2, costs of kerbside collected wastes are estimated to be in the order of $151 - $158 per household per year. For this option the closure of the two landfills in Clayton also causes an increase in costs in the interval between 2016/17 and 2029/30.

Option 2A

For option 2A cost of kerbside collected waste reduces from option 2 as the anaerobic process of food and garden organics is replaced by the lower cost aerobic process.

Option 3

For option 3 cost of kerbside collected waste is in the order of $174 to $183 per household per year. This is $45 to $50 per household per year above the base case.

Option 4

For option 4 cost of kerbside collected waste reduces to the same cost as option 1A as its two-bin system reduces collection costs which offset the higher cost of anaerobic processing.

In summary, the costs for options 1, 1A, 2, 2A and 4 are of the same order, i.e. typically $20 - $25 per household per year more than the base case and option 3 is significantly higher at $45 to 50 above the base case.

9.3.2 Inner urban versus outer suburban

For each option separate cost estimates have been prepared for inner urban and outer suburban areas that reflect the different waste generation characteristics and collection and processing systems employed. The difference in per household cost for each option, for the year 2013/14, is shown in Figure 9.16.

For the base case, costs for kerbside-collection services in inner urban areas are estimated to be in the order of $10/hhld/yr more than outer suburban households. This is a reflection mainly of the increased costs of collection due to the need for additional staffing on collection trucks compared to outer suburban areas.

For option 4 total cost for kerbside collection in the outer suburban area is lower than option 1 as a two-bin system is used and no separation collection of garden organics occurs.

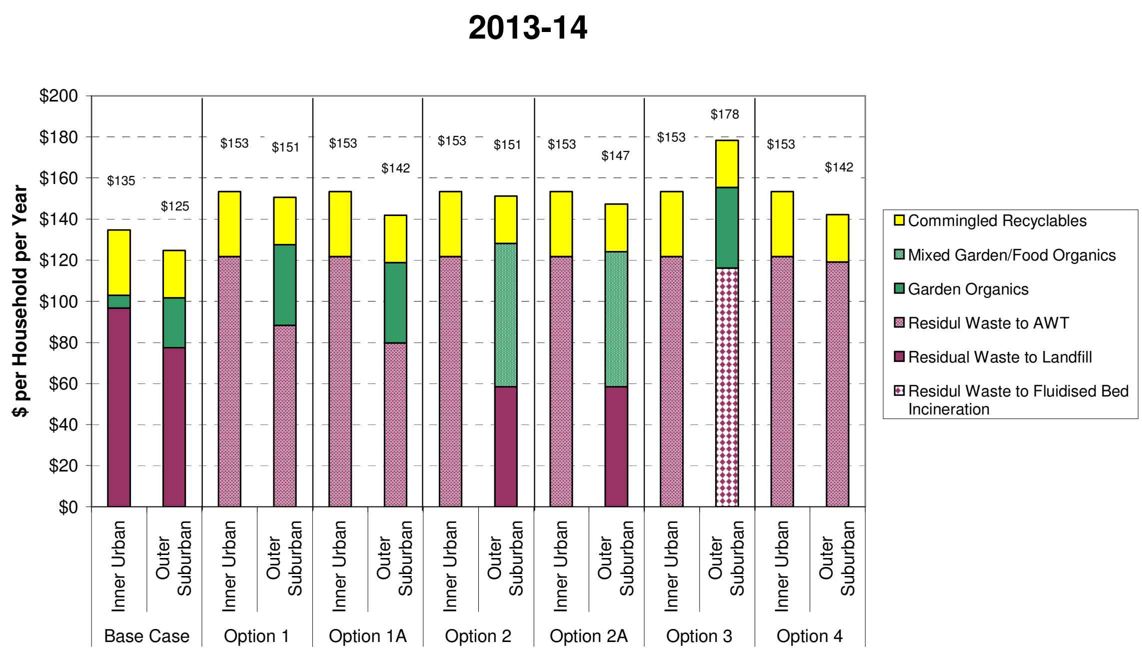

Figure 9-16: Cost comparison - inner urban versus outer suburban, 2013/14

9.3.3 Sensitivity to landfill cost impacts

The modelling above assumes an average landfill cost of $70 ($60 plus levy) per tonne across the metropolitan area. This assumption is based on improving landfill standards – especially in respect to methane capture – and increases in landfill value.

Acknowledging the significance of landfill costs, a sensitivity analysis has been prepared assuming a landfill charge of $55 ($45 plus levy) per tonne.

In this analysis, completed for options 1, 1A, 2 and 2A, AWT costs were also reduced in line with the reduced landfill charge.

The results of this analysis are shown in Figure 9.17 and Table 9.18 and indicate that the landfill charge does not significantly impact on the weekly household cost.

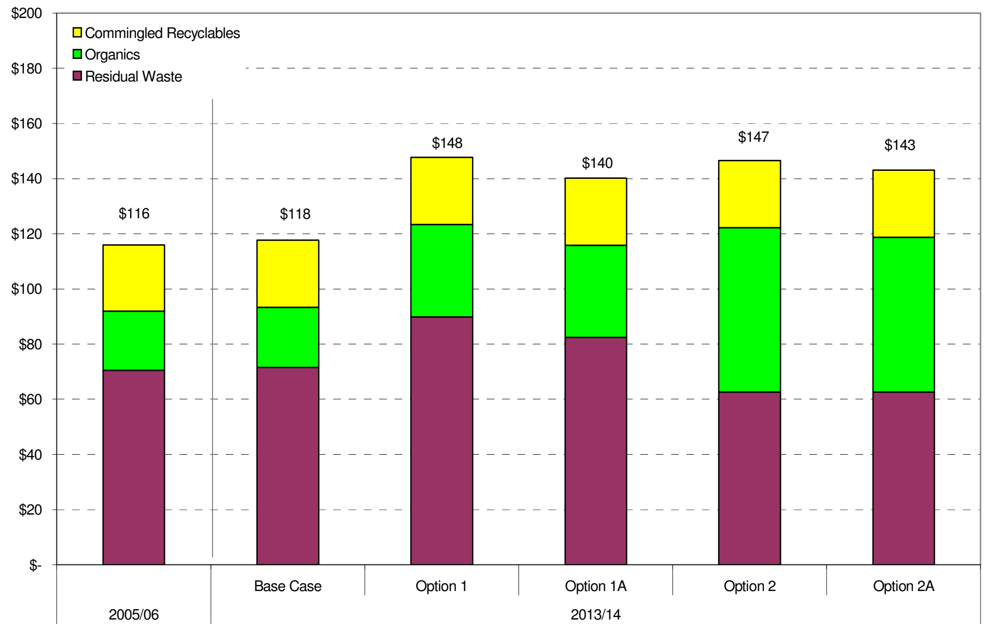

Figure 9-17: Breakdown of total system costs, 2013/14,landfill disposal cost $45 + Levy - ($/household/year)

Table 9-18 Sensitivity analysis results on assumed landfill disposal costs

Scenario	Item	Base case	Option 1	Option 1A	Option 2	Option 2A
Landfill Disposal Cost $60 + Levy	Additional cost per household per week (2013/14)	$0	$0.48	$0.35	$0.49	$0.42
	Cost per household per year (2013/14)	$126	$151	$144	$152	$148
Landfill Disposal Cost $45 + Levy	Additional cost per household per week (2013/14)	$0	$0.57	$0.43	$0.56	$0.49
	Cost per household per year (2013/14)	$118	$148	$140	$147	$143

10 Analysis of options against Towards Zero Waste targets

The TZW Strategy envisages that by 2013/14, the proportion of municipal waste materials recovered for reuse or recycling across Victoria will be 65%. The strategy states an expectation that “urban areas will out–perform against the targets, while rural and regional Victoria is expected to sit below the targets in terms of resource recovery parameters”. Specific recovery targets for Melbourne were not set.

The waste quantity modelling undertaken for this project enables mass balances to be calculated, allowing recovery rates projections under the different options.

The figures overleaf show projected mass flows of material in 2013/14 under the various options. Apart from the five models presented, an additional mass balance has been shown comprising the base case with upgraded garden organics collection throughout the outer suburban area.

For each mass balance three steps are shown with material quantities in kilotonnes listed at each stage.

The results are summarised in Table 10-1.

Table 10-1: Projected recovery rates in 2013/14 under the different options

	Base case	Base case with upgraded GO recovery	Option 1	Option 1A	Option 2	Option 2A	Option 3	Option 4
Recovery rate	42%	51%	76%	76%	64%	64%	80%	67%
Consistent with *TZW Strategy target*?	×	×	✓	✓	**0**	**0**	✓	**0**

Legend: × does not meet target, ✓ meets target, **0** close to target

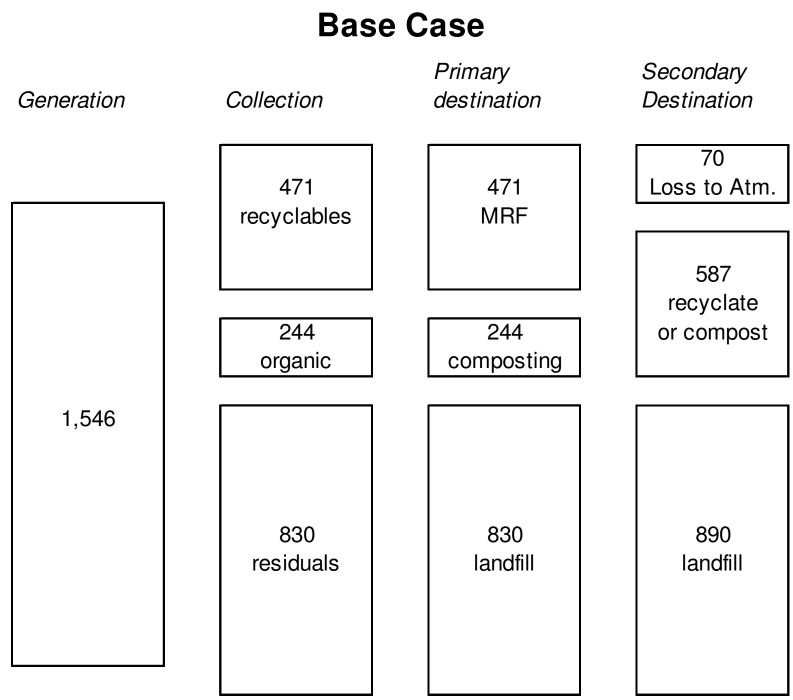

Figure 10.2: Projected mass flows, base case, 2013/14 (kilotonnes)

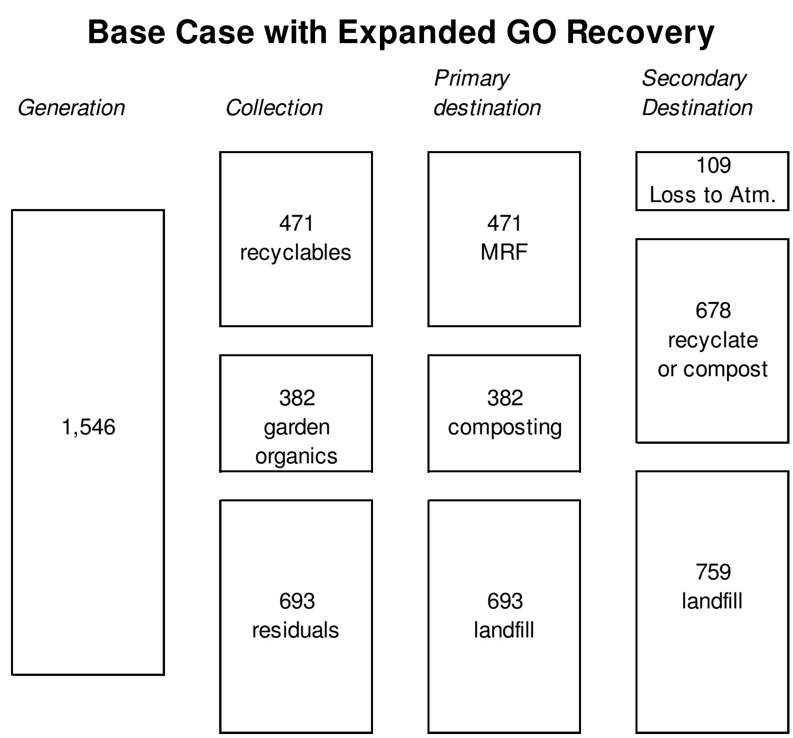

Figure 10.3: Projected mass flows, base case with expanded organics recovery, 2013/14 (kilotonnes)

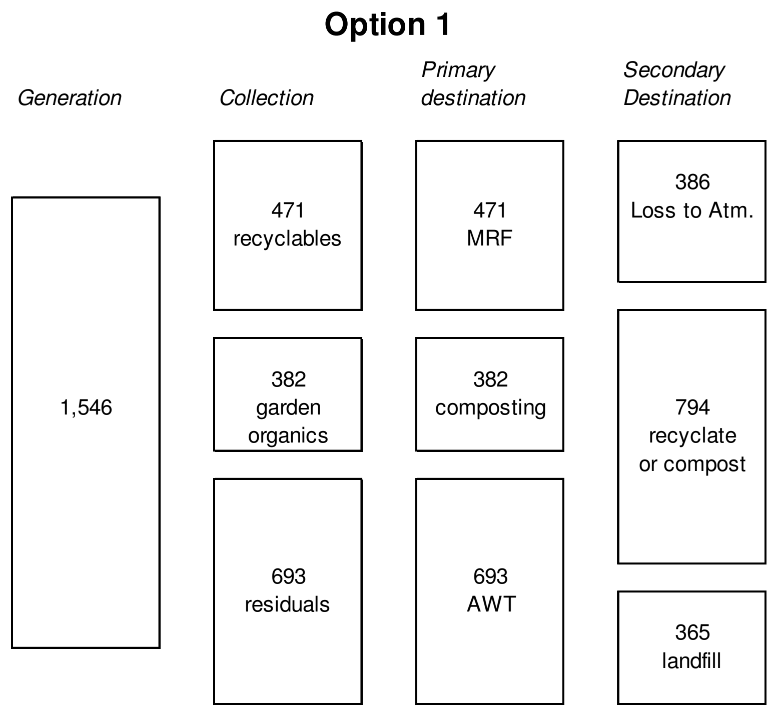

Figure 10.4: Projected mass flows, option 1, 213/14 (kilotonnes)

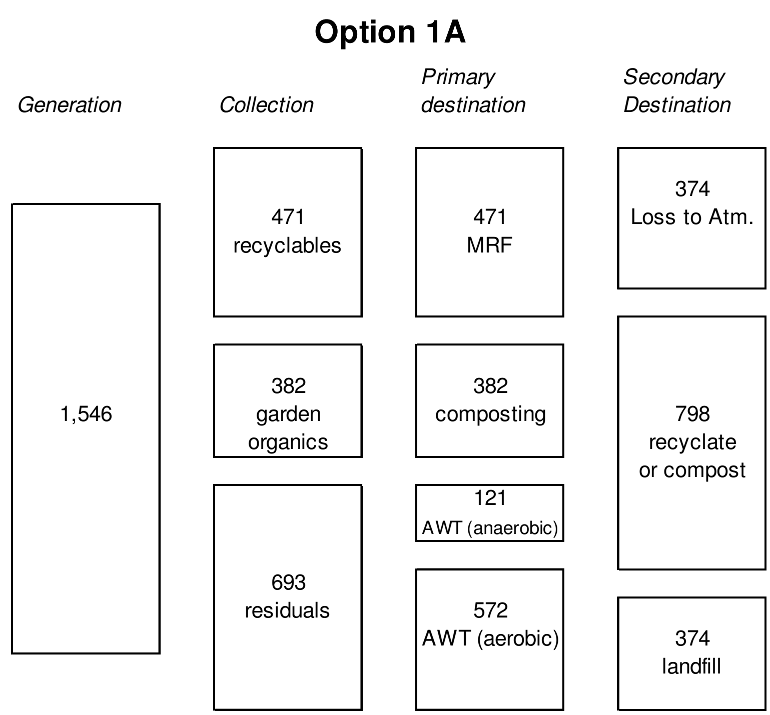

Figure 10.5: Projected mass flows, option 1A, 2013/14 (kilotonnes)

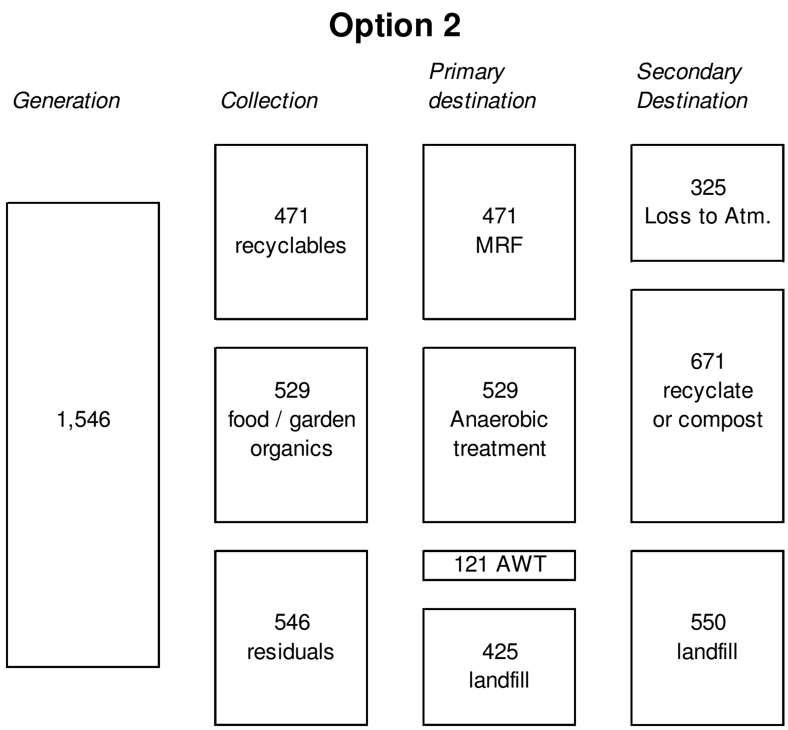

Figure 10.6: Projected mass flows, option 2, 2013/14 (kilotonnes)

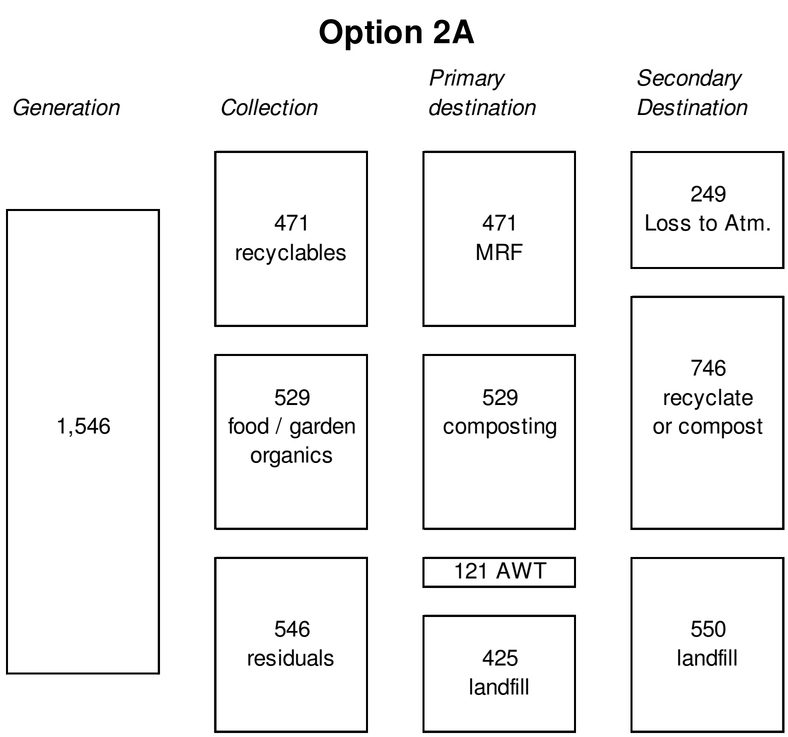

Figure 10.7: Projected mass flows, option 2A, 2013/14 (kilotonnes)

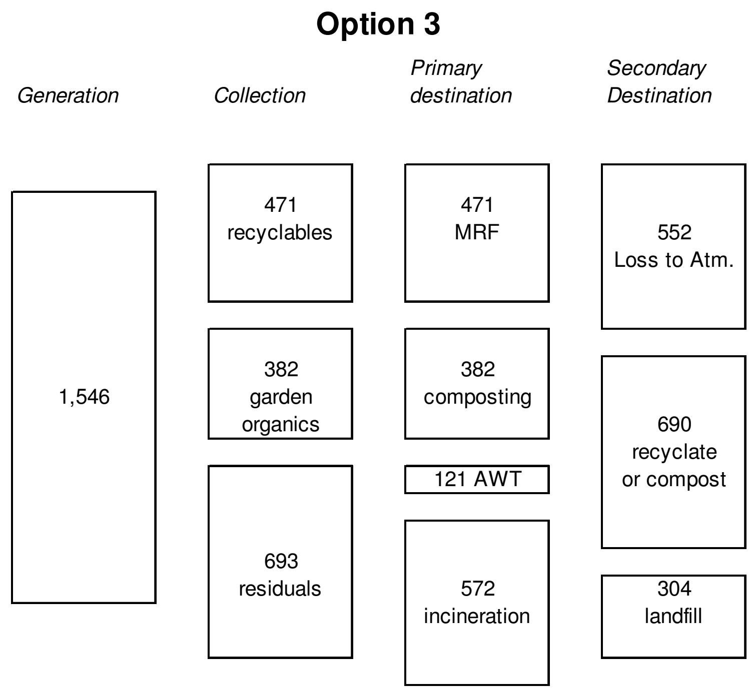

Figure 10.8: Projected mass flows, option 3, 2013/14 (kilotonnes)

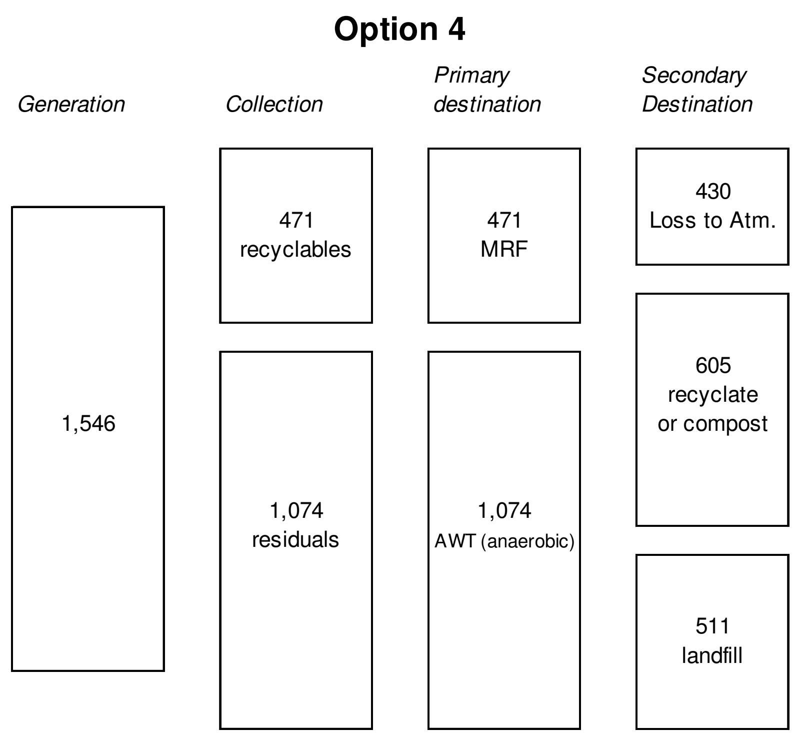

Figure 10.9: Projected mass flows, option 4, 2013/14 (kilotonnes)

11 Summary of outcomes

A summary of the outcomes of the assessment, showing the relative performance of each option for the key indicators of significance, is shown in Table 11-1.

Based on the assessment, except for overall cost and energy from fossil fuel use, all options provide a better outcome than the base case. Further, all options significantly outperform the base case in the areas of greenhouse impacts and waste diversion from landfill, but all incur incremental costs in the order of 50c per household per week more than the base case by 2013/14.

The four options modelled in the study all highlight the need to divert the organic waste stream away from landfill to avoid creation of harmful greenhouse gas emissions.

When ranking the results for each, options 1 and 1A offer the best overall performance. This is achieved by keeping costs down by retaining low cost composting of the garden organics stream and maximising greenhouse gas reduction by processing all residues.

This is followed by option 2 that maximises energy generation by digesting food and garden organics and producing a high quality soil conditioner and retaining low cost landfilling for the disposal of residuals.

This is then followed by option 4 that, although it reduces transport costs by the use of a two-bin system, fails to produce soil conditioner for return to agriculture and option 3 that is considerably more expensive.

It is clear from this assessment that the base case option will not meet the TZW Strategy resource recovery target of 65% by 2013/14. This is also expected to be the case even if garden organics collections were upgraded to a fortnightly service standard across outer suburban Melbourne.

With a projected recovery rate of 76% by 2013/14, options 1 and 1A easily achieve the TZW target.

Options 2 and 2A, with their significant landfill component for residual wastes from outer suburban areas, are projected to be close to meeting the TZW Strategy target. When considering that the TZW Strategy target represents an aggregated target for Victoria as a whole, and that metropolitan Melbourne is expected to perform better than the statewide average, option 2 can be considered to under–perform against the TZW target.

Option 4, due to its high post–processing landfill requirement, is projected to fall short of the TZW target.

Table 11-1 Relative Performance of Options

	Base Case	Option 1	Option 1A	Option 2	Option 2A	Option 3	Option 4
Waste Stream – Inner urban		**2 bin service**	**2 bin service**	**2 bin service**	**2 bin service**	**2 bin service**	**2 bin service**
Recyclables	To MRFs	To MRFs	To MRFs	To MRFs	To MRFs	To MRFs	To MRFs
Residuals	Assume current approach	To AWT (anaerobic digestion)	To AWT (anaerobic digestion)	To AWT (anaerobic digestion)	To AWT (anaerobic digestion)	To AWT (anaerobic digestion)	To AWT (anaerobic digestion)
Waste Stream – Outer suburban		**3 bin service**	**3 bin service**	**3 bin service**	**3 bin service**	**3 bin service**	**2 bin service**
Recyclables	To MRFs	To MRFs	To MRFs	To MRFs	To MRFs	To MRFs	To MRFs
Green waste	Assume current approach	To aerobic composting (controlled environment)	To aerobic composting (controlled environment)	To anaerobic digestion	To aerobic composting (controlled environment)	To aerobic composting (controlled environment)	To AWT (anaerobic digestion)
Food waste	To landfill	To AWT (anaerobic digestion)	To AWT (aerobic composting)	To anaerobic digestion	To aerobic composting (controlled environment)	To AWT (fluidised bed)	To AWT (anaerobic digestion)
Residuals	To landfill	To AWT (anaerobic digestion)	To AWT (aerobic composting)	To landfill	To landfill	To AWT (fluidised bed)	To AWT (anaerobic digestion)

	Base Case	Option 1	Option 1A	Option 2	Option 2A	Option 3	Option 4
Recovery rate	42%	76%	76%	64%	64%	80%	67%
Waste to landfill		✓✓	✓✓	✓	✓	✓✓	✓✓
Greenhouse gas emissions		✓✓	✓✓	✓✓	✓	✓✓	✓✓
Air emissions		✓	✓	✓	✓	✓	✓
Energy from fossil fuel use		×	×	✓✓	×	✓✓	×
Water consumption		✓✓	✓✓	✓✓	✓✓	✓✓	✓
Additional cost per household per week (2013/14)		$0.48	$0.35	$0.49	$0.42	$0.94	$0.35
Cost per household per year (2013/14)	$126	$151	$144	$152	$148	$175	$144

Legend: Performance compared to base case: x means poor outcome, ✓ means acceptable outcome, ✓✓ means desirable outcome..

12 Factors that may impact on the modelling projections

When modelling over a twenty plus year time frame there are a number of impacts that are difficult to predict with any certainty.

For this study there are several issues that should be noted. These include:

Generation of garden organics

The waste audits used to project future volumes were conducted in 2005/06 prior to the water restrictions and drought conditions. Should these conditions continue, the volume and composition of future garden organic collections could be impacted significantly.

Introduction of carbon trading

As all options offer large CO_2 equivalent reductions over the landfill case, there is potential for cost savings from the sale of carbon credits once carbon trading is introduced nationally.

Table 12-1 CO_2 equivalent reduction, 2013/14

Option	Ktonne CO_2 equivalent
1	288
1A	287
2	154
2A	154
4	275

These potential costs savings have not been modelled at this time as it is currently unclear whether waste management activities - and in particular those that commence before the new regime is in place - will be included in the new schemes.

Sale of soil conditioners

As all options are likely to produce significant quantities of soil conditioners, it is necessary that new markets are established to consume the output of the proposed facilities.

In the event these markets are not established, operating costs of the modelled facilities will increase from the assumed rates, for both digestion and composting.

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