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A Waste Authority Program

Impacts and benefits of kerbside collection systems

Perth and Peel

A report to The Department of Water and Environmental Regulation for the Waste Authority WA

28 October 2021

MRA Consulting Group

Impacts and benefits of kerbside collection systems Perth and Peel

A report to the Department of Water and Environmental Regulation (ABN 28 420 443 065) for the Waste Authority WA
Job No. 1012451

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Disclaimer

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Glossary

Terminology	Definition
AWT	Alternative Waste Treatment
C&D	Construction and Demolition (waste)
C&I	Commercial and Industrial (waste)
CCM	Consolidated Cost Model
CO_2-e	Carbon dioxide equivalent
DWER	Department of Water and Environmental Regulation
EMRC	Eastern Metropolitan Regional Council
FO	Food Organics
FOGO	Food Organics and Garden Organics
GHG	Greenhouse Gas
GO	Garden Organics
HH	Household
LGA	Local Government Area
MGB	Mobile Garbage Bin
MRA	MRA Consulting Group
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
NPV	Net Present Value
pa	per annum

Terminology	Definition
Residual waste	Waste that remains after the application of a better practice source separation process and recycling system, consistent with the waste hierarchy as described in section 5 of the Waste Avoidance and Resource Recovery Act 2007 (WARR Act). Where better practice guidance is not available, an entity's material recovery performance will need to meet or exceed the relevant stream target (depending on its source - MSW, C&I or C&D) for the remaining non-recovered materials to be considered residual waste under the waste strategy.[1]
RRG	Resource Recovery Group (formerly Southern Metropolitan Regional Council – SMRC)
tpa	Tonnes Per Annum
Waste Strategy	Waste Avoidance and Resource Recovery Strategy 2030
WtE	Waste to Energy
WtL	Waste to Landfill

[1] Waste Avoidance and Resource Recovery Strategy 2030, Page 42

Executive Summary

Key objectives of Western Australia's *Waste Avoidance and Resource Recovery Strategy 2030*[2] (the Waste Strategy) are to avoid waste, to recover more value and resources from waste, and to protect the environment by managing waste responsibly. The Waste Strategy includes a material recovery target of 75% by 2030 and targets for municipal solid waste (MSW). The 2030 material recovery target for MSW is 70% in the Perth and Peel regions and 60% in major regional centres. Organics are a focus material because of the large quantities generated, providing opportunities to increase material recovery while minimising the impacts of disposal.

The Waste Strategy commits to pursuing better practice approaches to waste management, including a headline strategy to introduce three-bin food organics and garden organics (FOGO) collection in Perth and Peel by 2025. The Waste Authority's Better Practice FOGO Kerbside Collection Guidelines (V2) define these Best Practice three-bin kerbside collection services.

The Waste Authority engaged MRA Consulting Group (MRA) to report on the impacts and benefits of kerbside systems in WA metropolitan areas, specifically the Perth and Peel local government areas (LGAs). These LGAs were grouped into two categories (urban and peri-urban) and an assessment was undertaken on two-bin and three-bin GO/FOGO kerbside systems for each LGA using MRA's Consolidated Cost Model (CCM).

From discussion with the Waste Authority on available collection scenarios, MRA has modelled three main Options for each of urban and peri-urban categories, as shown in Table 1 below.

Table 1 Kerbside collection option summary

Option	General Waste	Recycling	GO / FOGO	General Waste destination
1	Weekly collection, 240L MGB	Fortnightly collection, 240L MGB	N/A	Landfill
	Weekly collection, 240L MGB	Fortnightly collection, 240L MGB	N/A	Waste to Energy
2	Weekly collection, 140L MGB	Fortnightly collection, 240L MGB	Fortnightly GO collection, 240L MGB	Landfill
	Weekly collection, 140L MGB	Fortnightly collection, 240L MGB	Fortnightly GO collection, 240L MGB	Waste to Energy
3	Fortnightly Collection, 140L MGB	Fortnightly collection, 240L MGB	Weekly FOGO collection, 240L MGB	Landfill
	Fortnightly Collection, 140L MGB	Fortnightly collection, 240L MGB	Weekly FOGO collection, 240L MGB	Waste to Energy

[2] Waste Avoidance and Resource Recovery Strategy 2030

Consolidated Cost Model

The Consolidated Cost Model (CCM) provides a quantitative simulation of outcomes for the options that are being considered for implementation, allowing a simplified comparison. This CCM produced the following outputs for each system being considered:

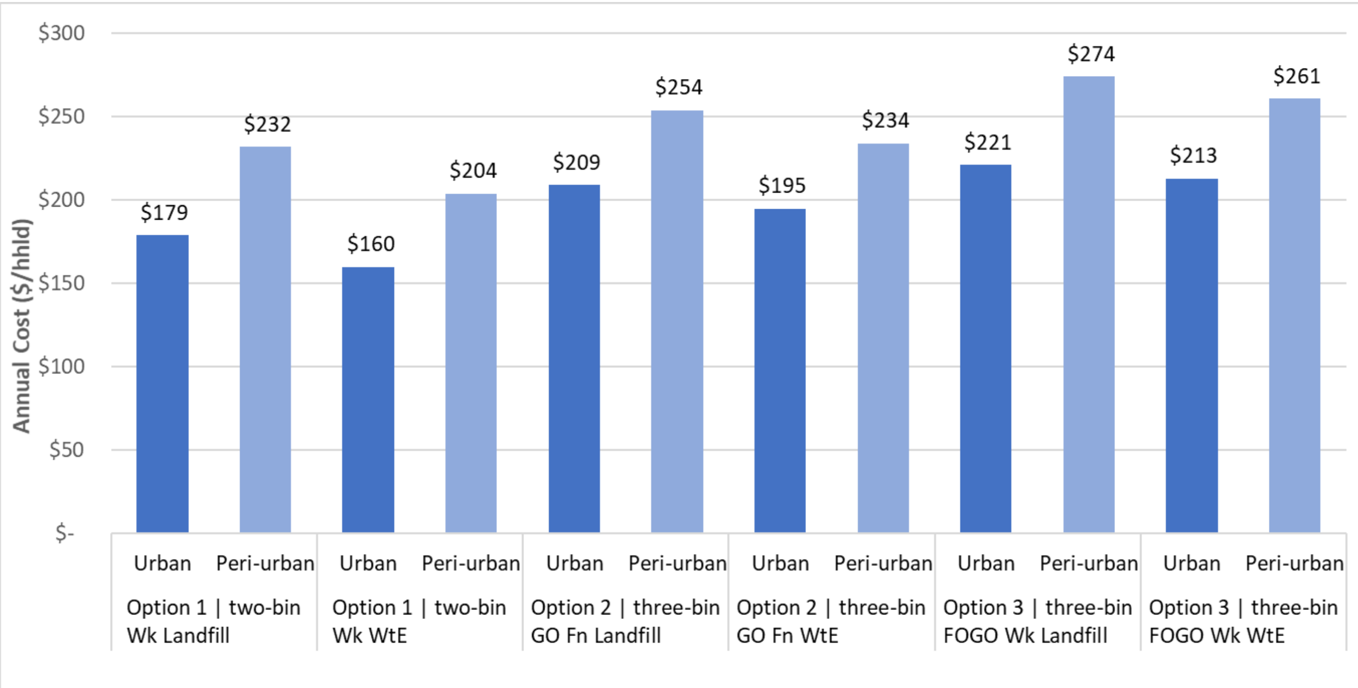
- Total system costs presented as:
  - Cost per household ($/household/annum);
  - Cost per tonne recovered ($/tonne); and
  - NPV per household ($) across a 10-year planning horizon.
- Material Recovery rate (%);
- Landfill diversion rate (%);
- Greenhouse gas emissions (t CO2 -e); and
- Vehicle kilometres travelled (km/annum on a per household basis).

Total system cost - Cost per household

The costs per household for each option are shown in Figure 1 below. The modelling showed:

- The introduction of GO services would, compared to a two bin option, increase cost per household per year by between $22 and $35, depending on suburb and residual waste disposal option;
- The addition of a FOGO bin would, compared to a two bin option, increase the cost per household per year by $29 - $42, depending on suburb and residual waste disposal option; and
- Options that include Waste to Energy (WtE) have a lower cost per household compared to options including waste to landfill (WtL).

Figure 1 Cost per household per year

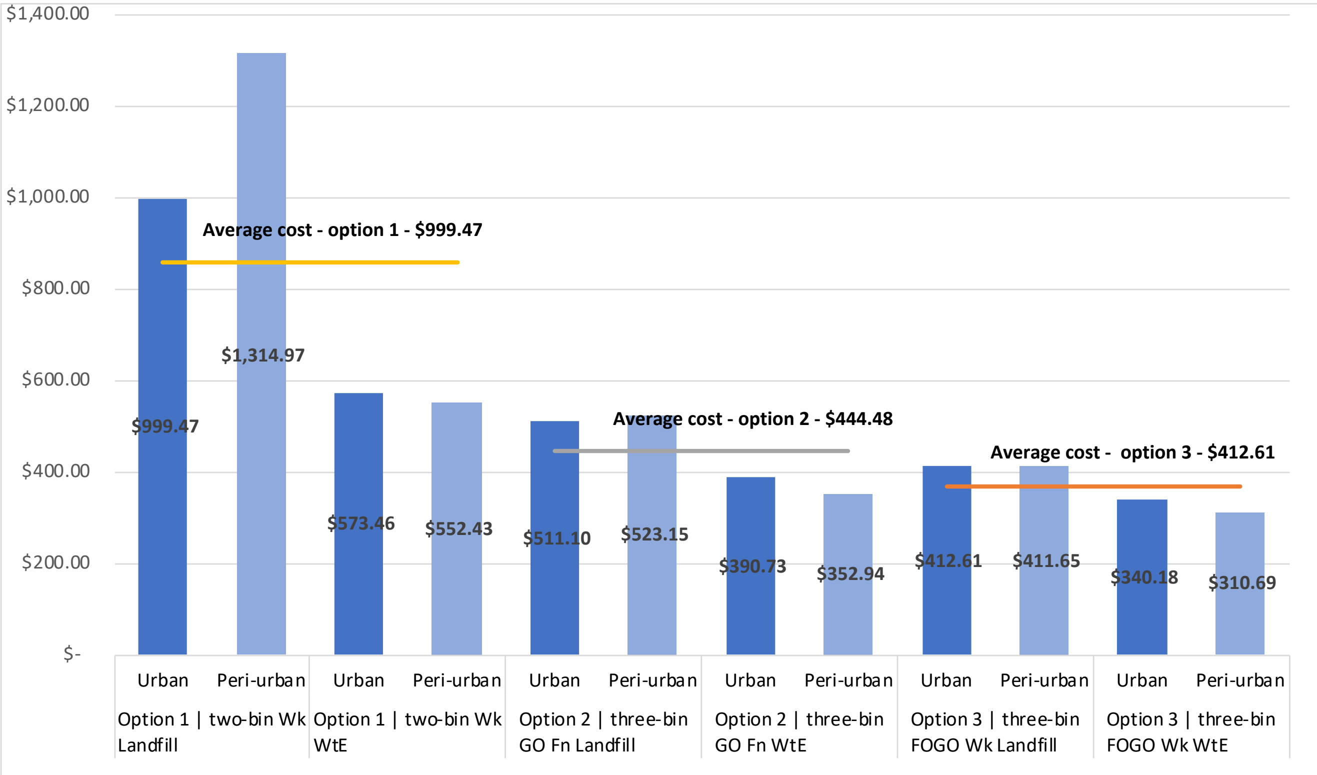


Total system cost - Cost per tonne recovered

The cost per tonne of recovered material for each option is provided in Figure 2 below. The average cost per tonne of materials recovered would be:

- Two-bins: $999 per tonne;
- Three-bin GO: $444 per tonne;
- Three-bin FOGO: $412 per tonne.

Figure 2 Cost per tonne recovered



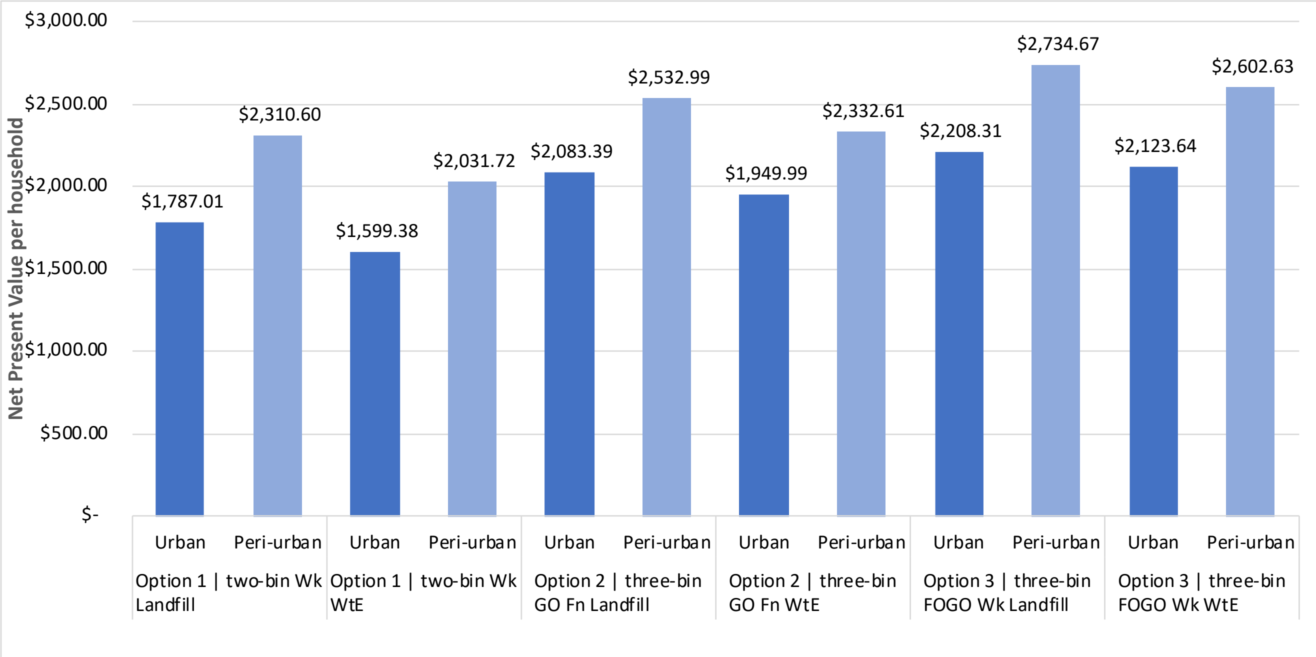
Total system cost for a 10-year planning horizon

System net present value (NPV) for each option has been normalised by the number of households and is shown as NPV cost per household in Figure 3.

The total cost of each option over 10 years (NPV, 5% discount rate[3]) amortises initial setup costs over 10 years. Option 3 for both urban and peri-urban local governments would be the highest cost option due to the addition of FOGO and the cost to landfill (Figure 3 below). Long term costs for peri-urban areas are higher due to larger waste quantities from peri-urban households.

[3] A higher discount rate reduces the NPV since the cost of each following year will be reduced by the cost occurring in that year discounted by the discount rate, accordingly will a lower discount rate inflate the NPV.

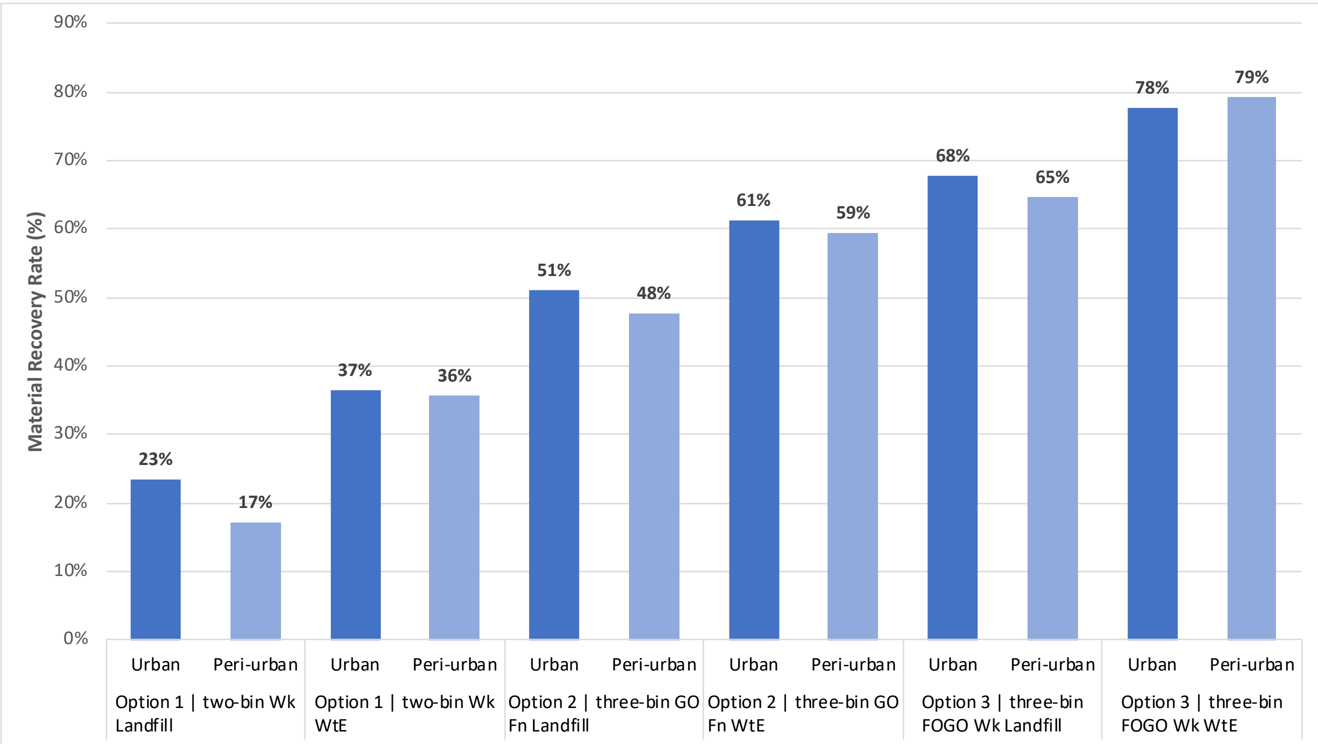
Figure 3 10 year NPV cost per household



Material Recovery Rate

As shown in Figure 4, both GO and FOGO services would improve material recovery rates through the recovery of organics. GO gains 28–31 percentage points and FOGO an additional 15 percentage points recovery over Optiion 1. For FOGO services, management of residual waste through WtE would increase material recovery rates by a further 10 percentage points for urban and 14 percentage points for peri-urban areas.

Figure 4 Material recovery rate (High Performance LGA)

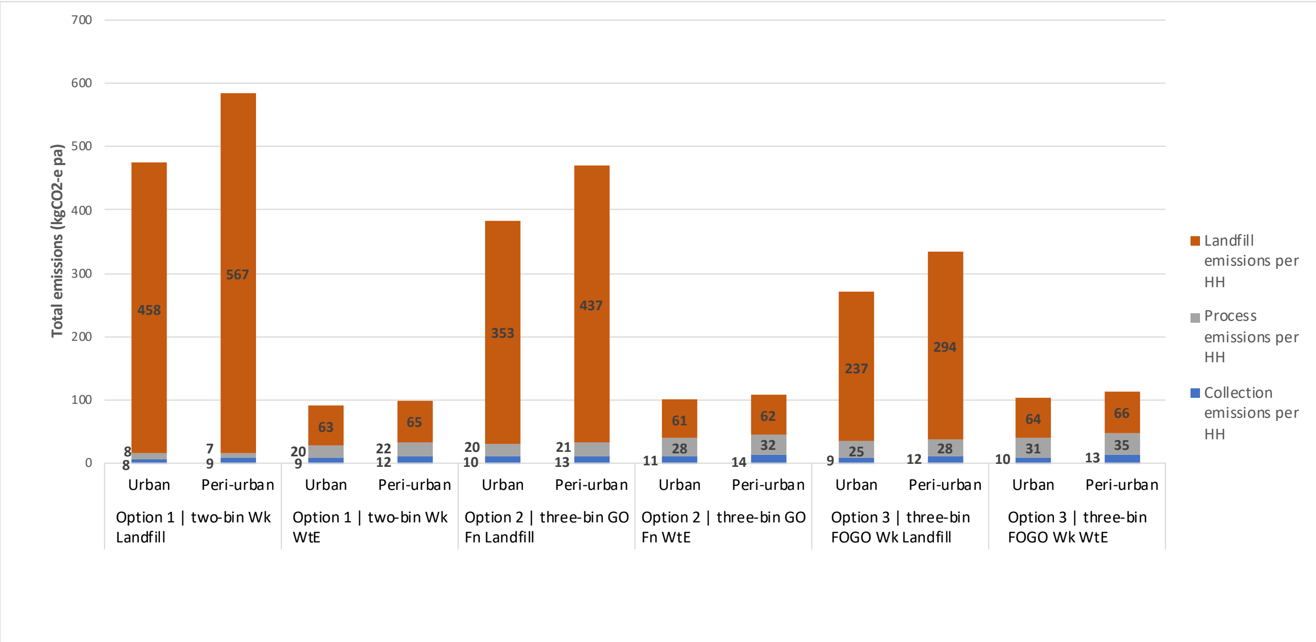


Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions for each option are presented in Figure 5 as annual emissions per household in kg. The key findings of the modelling include:

- Landfills are the biggest contributor to GHG emissions for all Options, due to general waste creating landfill gas under putrefaction conditions;
- Emissions from all material processing options (MRFs, organics and WtE) are low in comparison to landfill emissions;
- The GHG emissions from collection and transport are minor; and
- Landfill emissions from the WtE options are from contamination from the recyclables processing at the MRF and FOGO/GO processing at the organics facility[4].

Figure 5 Greenhouse gas emissions per household



Vehicle annual kilometres travelled (normalised on a per household basis)

Peri-urban waste transport distances are greater than urban due to the greater distances between the town centroids and the facilities. Processing collected waste through one of the two South-Eastern WtE facilities also increases travel distances for these options. Vehicle kilometres travelled (Figure 6) is greatest when providing a three-bin GO service and managing residual waste through a WtE facility.

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[4] This model assumed that all residuals from processing facilities went to landfill. It is likely that all the residuals or parts of the residuals from recyclables processing at the MRF and FOGO/GO processing at the organics facility go to WtE facilities rather than landfill if it makes commercial sense.

Figure 6 Vehicle km travelled (normalised on a per household basis)

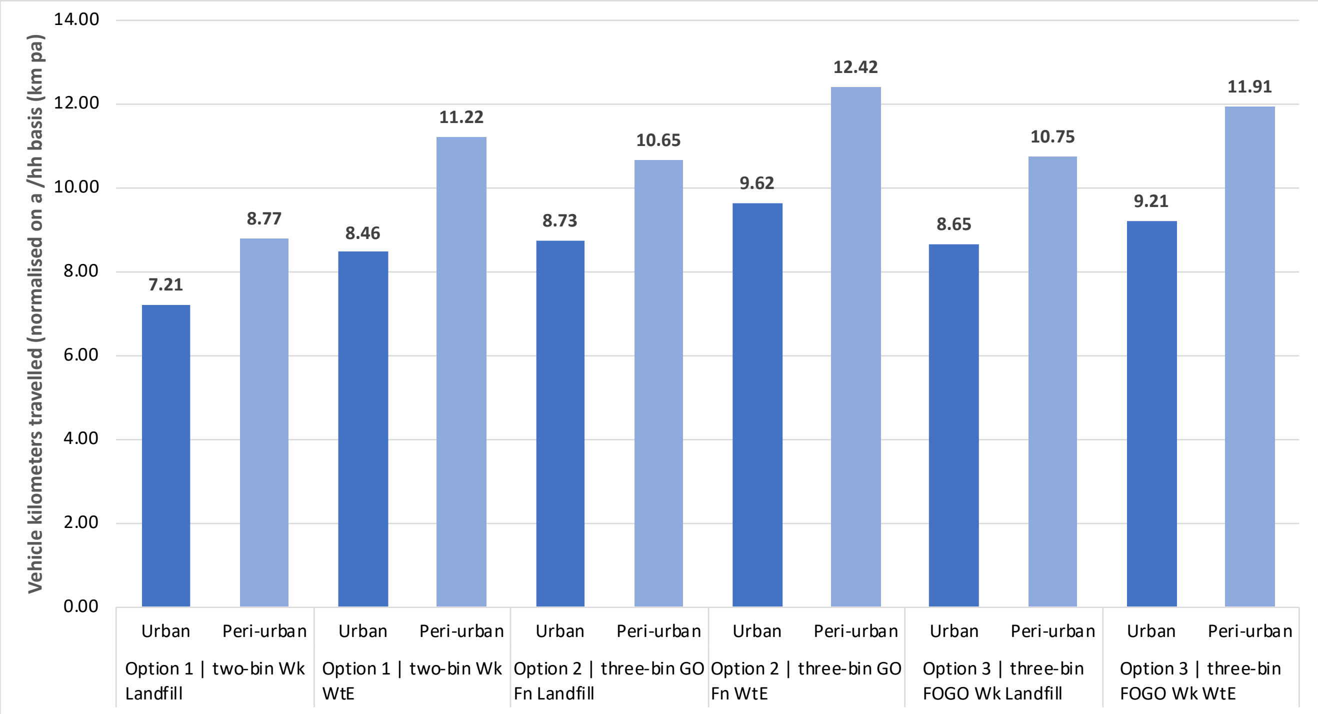


Table 2 Summary impacts table

	Option 1				Option 2				Option 3			
	2-Bin Weekly to Landfill		2-Bin Weekly to WtE		3-Bin GO Fortnightly to Landfill		3-Bin GO Fortnightly to WtE		3-Bin FOGO Fortnightly to Landfill		3-Bin FOGO Fortnightly to WtE	
	Urban	Peri-urban	Urban	Peri-urban	Urban	Peri-urban	Urban	Peri-urban	Urban	Peri-urban	Urban	Peri-urban
Cost per household ($/hh/ annum)	$179	$232	$160	$204	$209	$254	$195	$234	$221	$274	$213	$261
Cost per tonne recovered ($/tonne)	$999	$1,315	$573	$552	$511	$523	$391	$353	$413	$412	$340	$311
NPV ($) per hh across a 10-year planning horizon	$1,787	$2,311	$1,599	$2,032	$2,083	$2,533	$1,950	$2,333	$2,208	$2,735	$2,124	$2,603
Material Recovery rate (high performance LGA)	23%	17%	37%	36%	51%	48%	61%	59%	68%	65%	78%	79%
Landfill diversion rate	23%	17%	90%	91%	48%	43%	91%	92%	63%	59%	91%	91%
Greenhouse gas emissions per hh (kg CO2 -e)	474	583	92	99	383	470	101	109	272	333	104	114
Vehicle kilometres travelled on a per hh basis (km/annum)	7.21	8.77	8.46	11.22	8.73	10.65	9.62	12.42	8.65	10.75	9.21	11.91

1. Introduction

The Waste Authority engaged MRA consulting Group (MRA) to report on the impacts and benefits of kerbside systems in a West Australian metropolitan context. The Department of Water and Environmental Regulation (DWER) arranged Perth and Peel local governments into two categories (urban and peri-urban). MRA assessed current standard two-bin (general waste/recycling) kerbside collection systems against three-bin GO (general waste/recycling/Garden Organics (GO) systems and three bin FOGO (general waste/recycling/Food Organics & Garden Organics -FOGO) systems in each of the urban and peri-urban categories.

1.1 Project Background

The *Waste Avoidance and Resource Recovery Strategy 2030* (Waste Strategy) contains objectives to avoid waste, recover more value and resources from waste and to protect the environment, and includes a target to increase material recovery to 75 per cent by 2030 and targets for municipal solid waste (MSW). The 2030 material recovery target for MSW is 70% in the Perth and Peel regions and 60% in major regional centres. Organics are a focus material because of the large quantities generated, providing opportunities to increase recycling while minimising the impacts of disposal. The Strategy also contains commitments to practice better waste management.

The objectives and targets of the Waste Strategy are listed in Table 3.

Table 3 Waste Strategy 2030 objectives and targets

Objectives	Avoid Western Australians generate less waste	Recover Western Australians recover more value and resources from waste	Protect Western Australians protect the environment by managing waste responsibly.
Targets	• 2025 – 10% reduction in waste generation per capita • 2030 – 20% reduction in waste generation per capita	• 2025 – Increase material recovery to 70% • 2030 – Increase material recovery to 75% • From 2020 – Recover energy only from residual waste	• 2030 – No more than 15% of waste generated in Perth and Peel regions is landfilled • 2030 – All waste is managed and/or disposed to better practice facilities

The Waste Strategy contains eight headline strategies, including:

'A consistent three-bin kerbside collection system, which includes separation of food organics and garden organics from other waste categories, to be provided by all local governments in the Perth and Peel region by 2025 and supported by State Government through the application of financial mechanisms'

This report details modelling and analysis undertaken on kerbside service options (refer to Table 9), to explore their impacts and benefits in the context of the Waste Strategy.

1.2 Study Design

A typical urban and peri-urban areas were characterised using data provided by DWER. The characterisation considered key aspects which included:

- Number of households (HH);
- Population growth rate;
- Distance to facilities;
- Current lift rates;
- Waste and material quantities; and
- Disposal and processing cost.

1.2.1 Options Considerations

Kerbside service options were chosen to represent the common service configurations (two bin systems and three bin GO systems) and better practice three bin FOGO systems as described in the Waste Authority's *Better practice FOGO kerbside collection Guidelines:*

- Two-bin system, with weekly collection of General Waste (240L MGB, Red lid) and fortnightly collection of Co-mingled Recycling (240L MGB, Yellow lid);
- Three-bin system, with weekly collection of General Waste (140L MGB, Red lid), fortnightly collection of Co-mingled Recycling (240L MGB, Yellow lid), and fortnightly collection of GO (240L MGB, Lime Green lid).
- Three-bin system, with fortnightly collection of General Waste (140L MGB, Red lid), fortnightly collection of Co-mingled Recycling (240L MGB, Yellow lid), and weekly collection of FOGO (240L MGB, Lime Green lid).

Each of these options included two sub options – general waste disposed of to landfill and general waste sent to waste to energy (WtE).

1.2.2 Performance Characterisation

Material recovery performance can be categorised by the level of waste separation by residents. A "high-performance" local government is characterised by high waste separation compliance, i.e. residents are using the provided bin system well and diverting more materials from the general waste bin into the recycling and GO or FOGO bins than residents in a local government with average performance. To model this performance difference, diversion rates (diversion from the red lid waste bin to recycling and GO/FOGO bins) were increased from the base assumptions. Table 4 provides the degree of performance enhancement used in the model assumptions.

Table 4 Diversion assumptions comparing average performance and high performance

Additional diversion from waste bin of…	Recyclables to Recycling bin	FO to FOGO bin	GO to GO/FOGO bin
Average performance	30%	80%	90%
High performance	50%	85%	95%

1.2.3 Urban and Peri-urban Model Local Government

The local governments categorised as **urban** include:

- Town of Bassendean
- City of Bayswater

- City of Belmont
- Town of Cambridge
- City of Canning
- Town of Claremont
- City of Cockburn
- Town of Cottesloe
- Town of East Fremantle
- City of Fremantle
- City of Gosnells
- City of Joondalup
- City of Melville
- Town of Mosman Park
- City of Nedlands
- Shire of Peppermint Grove
- City of South Perth
- City of Stirling
- City of Subiaco
- Town of Victoria Park and
- City of Vincent.

The local governments categorised as **peri-urban** were:

- City of Armadale
- City of Kalamunda
- City of Kwinana
- City of Mandurah
- Shire of Murray
- Shire of Mundaring
- City of Rockingham
- Shire of Serpentine-Jarrahdale
- City of Swan
- City of Wanneroo
- Shire of Waroona.

To characterise the typical urban and peri-urban local government, the population and waste data was averaged for local governments in each grouping. The population data for each model local government is summarised in Table 5.

The key differences between urban and peri-urban local government characteristics are:

- The peri-urban local government has 44% more dwellings and waste services;
- Peri-urban growth is 7.7 times higher than urban growth; and
- The peri-urban household generates 160 kg more general waste and recovers 29 kg less comingled recycling per annum than the urban household.

Table 5 Model local government assumptions

Data type	Urban local government	Peri-urban local government
Current population (number of)	64,095	85,205
Households with waste services (number of)	23,951	34,481
Annual growth (%)	0.44%	3.4%
General Waste (tpa)	12,510 t	23,518 t
Comingled Recycling (tpa)	5,413 t	6,801 t

Data type	Urban local government	Peri-urban local government
General Waste per household (kg/year)	522 kg	682 kg
Comingled Recycling per household (kg/year)	226 kg	197 kg

1.2.4 Data and Document Review

DWER supplied a range of data which was reviewed to understand the current waste services in the Perth and Peel region and to set up a baseline model. A set of underlying assumptions was established. A summary of assumptions is provided in Table 6.

Table 6 Data review summary

Information type		Data supplied by
Waste facilities	• Landfill locations • MRF locations • FOGO facility locations • WtE facility locations	• DWER • Google Maps
Waste composition	• SMRC 2013/14 waste audit • EMRC 2019 waste audit	• DWER
Population data	• ABS Quickstats 2016 • DPLH WA population forecast[5]	• Australian Bureau of Statistics • Department of Planning Lands Heritage
Waste and Recycling tonnages	• DWER data tables	• DWER

All assumptions used in the modelling of kerbside service options for the Perth and Peel region can be found in Section 6.

1.2.5 Current Waste Management Systems

Current waste management systems provide the baseline data for modelling.

Generally, collection frequency for general waste is weekly using a 240L general waste bin and for recycling the frequency is fortnightly using a 240L recycling bin.

A Food Organics and Garden Organics (FOGO) collection service is provided by five out of 21 urban local governments (Fremantle, Melville, Bassendean, Bayswater and East Fremantle). FOGO services

[5] WA Government: Western Australia Tomorrow population forecasts

are not offered by peri-urban local governments. Eleven of the urban and one of the peri-urban local governments have introduced a Garden Organics (GO) collection. To model the better practice FOGO system, it was assumed that 80% of the residents require replacement of their 240L Red lid bin with a 140L Red lid bin.

The model assumes that any processing residuals created from any of the processing facilities are sent directly to landfill.

Waste materials are taken to several disposal and processing facilities in the region. Material transfer via transfer stations was not considered in the modelling as it is only undertaken by a few councils. The facilities considered are summarised in Table 7.

Table 7 Disposal and processing facility assumptions

Kerbside service	Relevant processing/disposal facilities	Address
General waste to landfill	Armadale landfill	145 Hopkinson Rd, Hilbert WA 6112
	Red Hill Waste Management Centre	1094 Toodyay Rd, Red Hill WA 6056
	Millar Road landfill	204 Millar Rd W, Baldivis WA 6171
	Henderson Waste Recovery Park	920 Rockingham Rd, Henderson WA 6166
	Tamala Park Rubbish Disposal Site	1700 Marmion Ave, Tamala Park WA 6030
General waste to WtE	Waste to Energy Facility, Avertas Energy,	Lot 9501 Leath Rd, Kwinana Beach WA 6167
	East Rockingham WtE facility	26 Office Rd, East Rockingham WA 6168
Recycling	Suez Bibra Lake Resource Recovery Park	65 Howson Way, Bibra Lake WA 6163
	Cleanaway Perth Material Recovery Facility (MRF)	72 Hyne Rd, South Guildford WA 6055
	RRG MRF	350 Bannister Road, Canning Vale, WA, 6155
GO	Henderson Waste Recovery Park	920 Rockingham Rd, Henderson WA 6166
	SUEZ North Bannister Resource Recovery Park	6364 Albany Highway, North Bannister WA 6390
	Western Tree Recyclers	Bannister Road, Canning Vale, WA, 6155
	Suez Bibra Lake Resource Recovery Park	65 Howson Way, Bibra Lake WA 6163
FOGO	Banksia Road Organic Processing Facility,	51 Stanley Road, Wellesley 6233
	Red Hill Waste Management Facility, Eastern Metropolitan Regional Council	1094 Toodyay Rd, Red Hill WA 6056

Kerbside service	Relevant processing/disposal facilities	Address
	RRG, Regional Resource Recovery Centre	350 Bannister Road, Canning Vale, WA, 6155

2. Options Analysis

2.1 Waste Service Options

Each of the kerbside collection options considered is summarised in the following Table 8. The Option diagrams illustrate the Options using images of bins with coloured bin lids associated with each waste stream, as per Australian Standard bin lid colours (AS 4123.7-2006 (R 2017) Mobile Waste Containers – Colours, markings, and designation requirements).

The figures provided represent kerbside mobile garbage bin services for Single Unit Dwellings (SUDs) only.

Currently the standard Mobile Garbage Bins (MGB's) issued to residents are 240L bins for both general waste (Red lid bin) and co-mingled recycling (Yellow lid bin), however it was noted that 22% of recycling bins are 360L.

Table 8 Waste service options

Option	Full description	Label description
1	Two-bin system • General Waste to landfill, 240L bin, **weekly** collection • Comingled Recycling, 240 L bin, **fortnightly** collection	
	Two-bin system • General Waste to energy, 240L bin, **weekly** collection • Comingled Recycling, 240L bin, **fortnightly** collection	

Option	Full description	Label description
2	Three-bin GO system • General Waste to landfill, 140L bin, **weekly** collection • Comingled Recycling, 240L bin, **fortnightly** collection • GO, 240L bin, **fortnightly** collection	
	Three-bin GO system • General Waste to WtE facility, 140L bin, **weekly** collection • Comingled Recycling, 240L bin, **fortnightly** collection • GO, 240L bin, **fortnightly** collection	
3	Three-bin FOGO system • General Waste to landfill, 140L bin, **fortnightly** collection • Comingled Recycling, 240L bin, **fortnightly** collection • FOGO, 240L bin, **weekly** collection	
	Three-bin FOGO system • General Waste to energy, 140L bin, **fortnightly** collection • Comingled Recycling, 240L bin, **fortnightly** collection • FOGO, 240L bin, **weekly** collection	

3. Quantitative Analysis Results

The options were modelled using MRA's Consolidated Cost Model (CCM). For each option, the quantitative CCM results cover:

1. Total system costs;
    a. Cost per household ($/hhld/annum);
    b. Cost per Tonne recovered ($/tonne); and
    c. NPV ($m) across a 10-year planning horizon.
2. Material Recovery Rate (%);
3. Landfill Diversion Rate (%);
4. Greenhouse gas emissions (t CO_2-e); and
5. Vehicle kilometres travelled (km/annum).

3.1 Options Labelling

Table 9 describes the labelling conventions used for each option. The Options labelling is provided for clarity in interpreting the CCM results.

Table 9 Options Labelling

Option	Full description	Label description
1	Two-bin system • General Waste to landfill, 240L bin, weekly collection • Comingled Recycling, 240 L bin, fortnightly collection	Option 1 | two-bin Wk Landfill
	Two-bin system • General Waste to energy, 240L bin, weekly collection • Comingled Recycling, 240L bin, fortnightly collection	Option 1 | two-bin Wk WtE
2	Three-bin GO system • General Waste to landfill, 140L bin, weekly collection • Comingled Recycling, 240L bin, fortnightly collection • GO, 240L bin, fortnightly collection	Option 2 | three-bin GO Fn Landfill
	Three-bin GO system • General Waste to WtE facility, 140L bin, weekly collection • Comingled Recycling, 240L bin, fortnightly collection	Option 2 | three-bin GO Fn WtE

Option	Full description	Label description
	• GO, 240L bin, fortnightly collection	
3	Three-bin FOGO system • General Waste to landfill, 140L bin, fortnightly collection • Comingled Recycling, 240L bin, fortnightly collection • FOGO, 240L bin, weekly collection	Option 3 | three-bin FOGO Wk Landfill
	Three-bin FOGO system • General Waste to energy, 140L bin, fortnightly collection • Comingled Recycling, 240L bin, fortnightly collection • FOGO, 240L bin, weekly collection	Option 3 | three-bin FOGO Wk WtE

3.2 Total System Cost

3.2.1 Cost per Household

Cost per household was calculated by dividing the system's 10-year Net Present Value[6] (NPV) by the number of households and the number of years modelled, for both urban and peri-urban local governments. Factors such as cost of new bins, kitchen caddies and liners, collection and transport cost and facility gate fees were included and the displayed numbers are an average.

A 5% discount rate was used for the purposes of calculating NPV. A higher discount rate would reduce the NPV cost of service provision for all options over the modelled period but would not impact the relative cost differential between options. The reason for this is that all options exhibit a relative constant profile of expenditure escalating with the same CPI and waste growth/population growth factors from year 2 onwards.

The cost calculations have been made from a local government perspective and can be used by local governments to inform about general impacts and benefits of service configurations.

Figure 7 shows the annual average cost per household. Figure 8 breaks down the annual cost per household per year by service type.

[6] Net Present Value (NPV) is the value of all future cash flows (positive and negative) over the entire life of an investment discounted to the present value. NPV analysis is a form of intrinsic valuation and is used extensively across finance and accounting for determining the value of a business, capital project, or anything that involves cash flow.

The introduction of GO services would, compared to a two bin option, increase cost per household per year by between $22 and $35 (depending on suburb and residual waste disposal option);

The additional cost of changing from a two bin system to a three bin FOGO service is $42 per household per year, resulting in annual waste service cost per household of $221 (urban) and $274 (peri-urban).

While the introduction of a new kerbside service adds to the total cost for local governments, the cost of material recovery per tonne is reduced by about 50%. Cost per tonne of material recovered is discussed in more detail in Section 3.2.2.

Key differences and contributing factors include:

- The cost for the additional FOGO service is partially compensated for by a reduction in general waste service cost, due principally to a significant reduction in general waste volumes and a reduced collection frequency of general waste bins.
- The introduction of a GO service is similar in that there is a reduction in general waste, however the weekly general waste service and costs are retained. The additional costs of GO transport and processing are spread across a fortnight, less than the weekly FOGO service.
- Option 3 to Landfill is the highest cost option due to additional costs of the FOGO service and the landfill facility gate fee being higher than the WtE facility gate fee.
- Option 2 with disposal to WtE is the lowest cost option as it does not include an organics collection service and it benefits from lower gate fees for WtE.
- The cost for peri-urban local governments is generally higher due to longer travel distances to facilities and between households, principally resulting from a lower population density.
- Option 3 to WtE is lower in cost than Option 3 to Landfill due to lower gate fees for WtE in comparison to Landfills.

Figure 7 Annual cost per household per year averaged over 10 years at net present value.

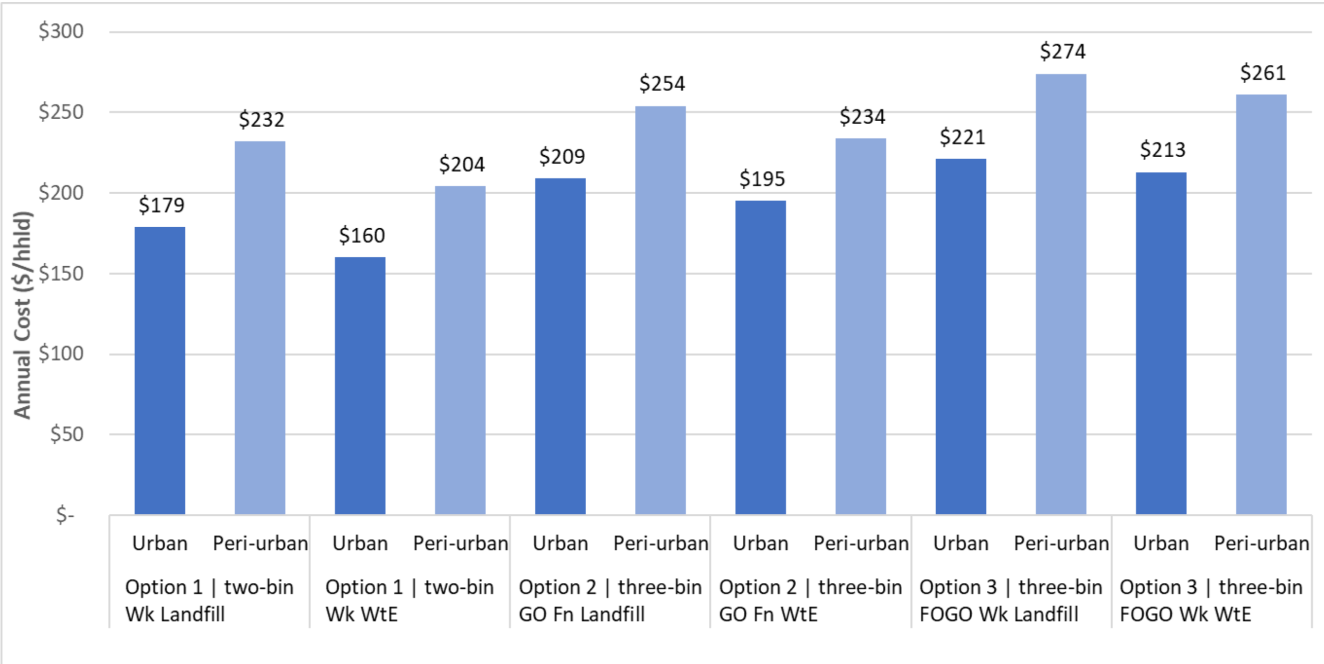
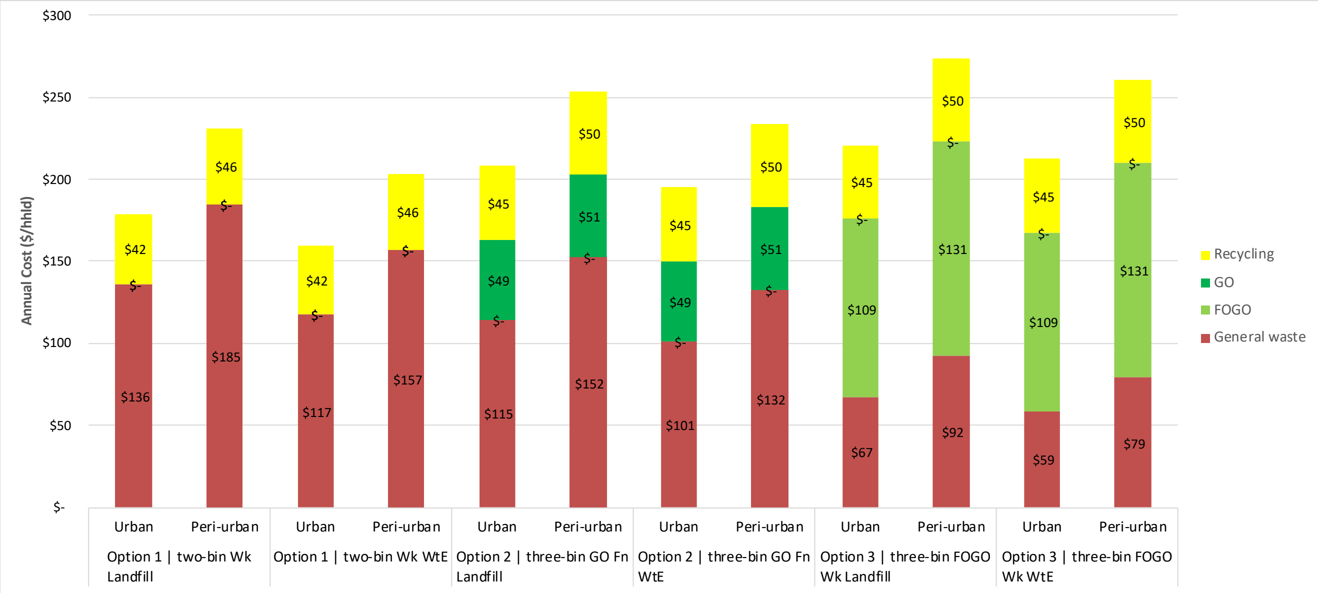


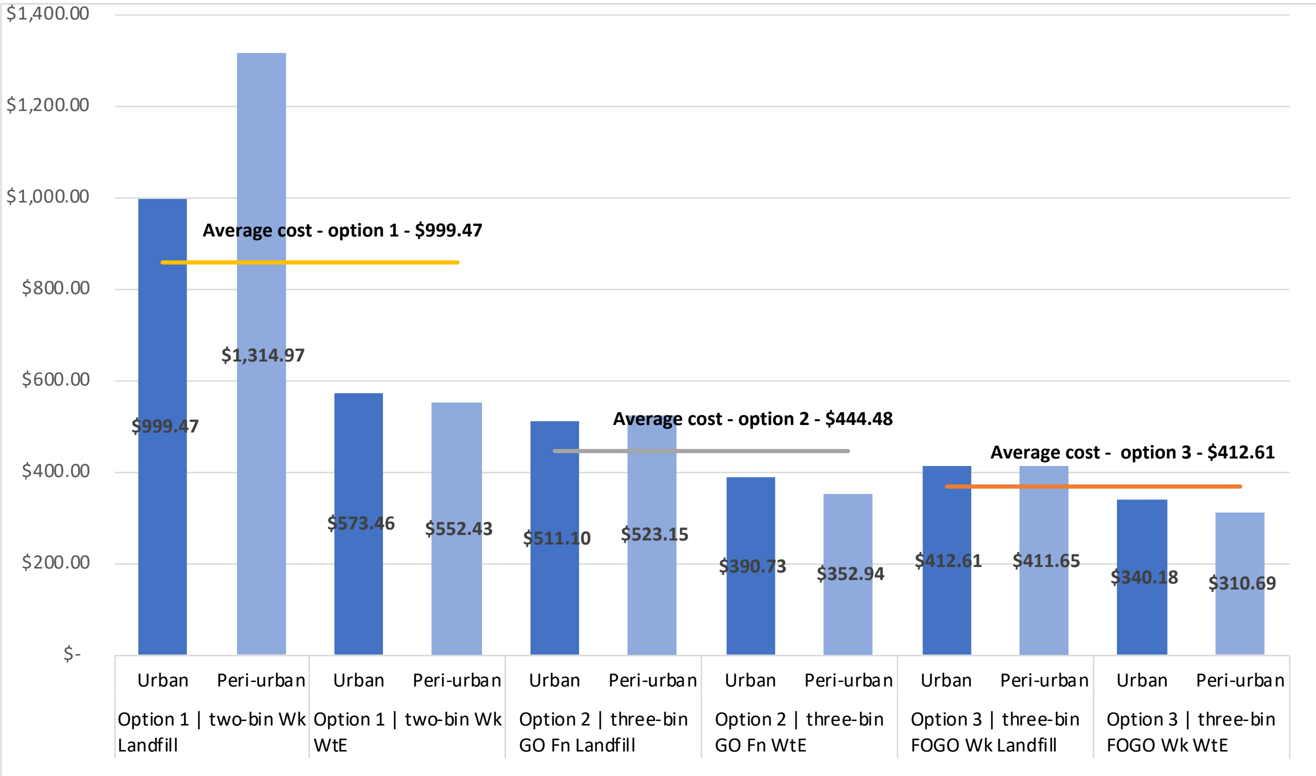
Figure 8 Annual cost per household per year by service averaged over 10 years at net present value



3.2.2 Cost per Tonne of Material Recovered

Figure 9 shows the cost per tonne of recovered materials, based on a 10 year NPV. The introduction of FOGO reduces the cost of material recovery per tonne by more than 50% for urban and peri urban local governments, from an average of $999 per tonne recovered for the two-bin options (Option 1) to an average of $444 per tonne recovered for GO (Option 2) and $412 per tonne recovered for FOGO options (Option 3).

Figure 9 Cost per Tonne Recovered (10 Yr NPV basis)



3.2.3 Net Present Value (per household), 10 Year Period

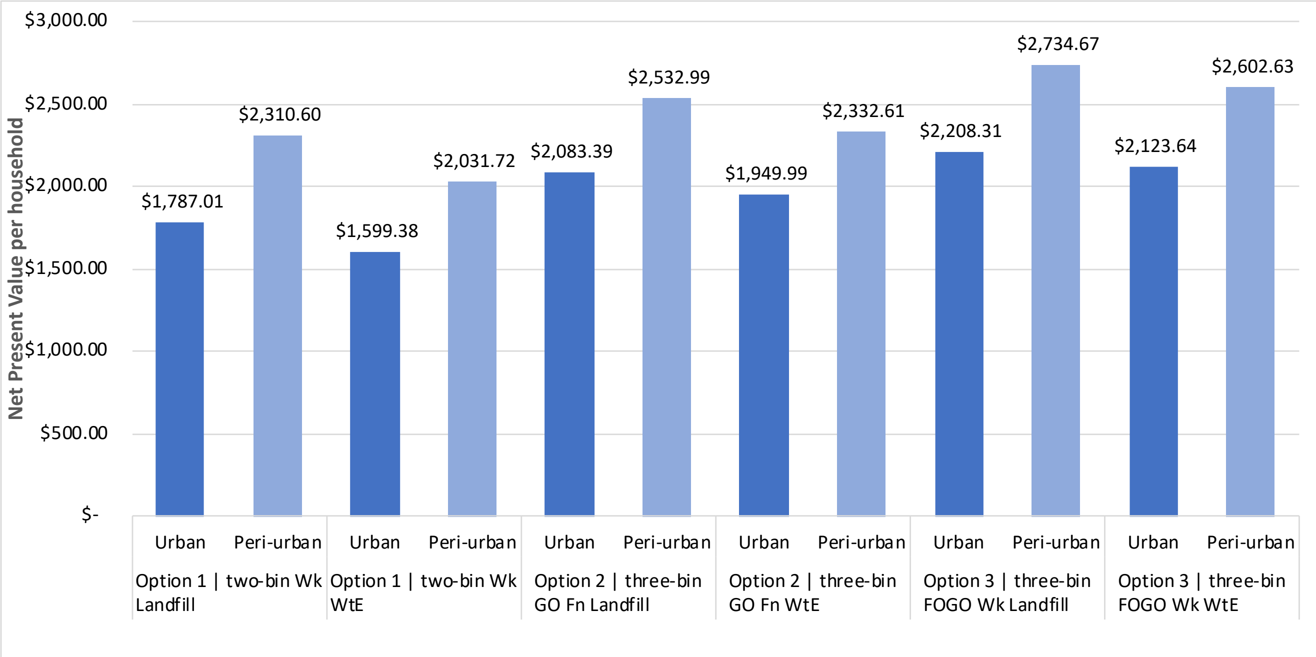
There are several one-off costs incurred in year one of service introduction, including new bin infrastructure, caddies and waste system education. To amortise these one-off costs, the sum of the present values of the incoming and outgoing cash flows of each option is presented as a 10 year NPV in Figure 10. The NPV was calculated using 10 one-year periods with a discount rate of 5%[7].

Key differences and contributing factors to variations include:

- Option 3 for both urban and peri-urban local governments is the highest cost option due to the addition of weekly FOGO. The higher landfill gate fee means that WtE is cheaper by $132 for peri-urban areas;
- GO services to WtE are cheaper by $134 and nearly $200 compared to Landfill, for urban and peri-urban areas respectively;
- The NPVs for the peri-urban local government's options were higher due to the larger amounts of waste generated and greater distances between LGA centroids and facilities;
- When Urban and Peri-Urban costs are averaged, introducing a GO or FOGO service costs only $293 and $485 more respectively, when compared to existing averaged cost of 2-bin system to Landfill.

[7] A higher discount rate reduces the NPV since the cost of each following year will be reduced by the cost occurring in that year discounted by the rate, accordingly will a lower discount rate inflate the NPV.

Figure 10 Total cost based on 10 Yr NPV (normalised on a per household basis)



3.3 System Material Recovery Rate

3.3.1 Modelling Results – Material Recovery Rate

The Material Recovery Rate (MRR) from the waste streams are shown in Figure 11 (average performance local government) and Figure 12 (high performance local government). The definitions of High Performance and Average Performance are given in Section 1.2.2.

Material Recovery Rates achieved by each option includes the materials recovered from each of the processing options (MRFs, organics processing and some material recovery achieved by waste to energy) and does not include energy recovery.

Key differences and contributing factors to variations include:

- The MRR for WtE general waste management options (Options 1, 2 and 3 to WtE) is slightly higher (between 11 and 16 percentage points) due to recovery of metals from the waste stream for reprocessing, recovery of bottom ash for use in civil construction;
- FOGO services provide a higher recovery rate than GO because Food Organics is a substantial part of general waste stream composition;
- The assumptions did consider the amount of bottom ash produced in the WtE process (approximately 18% of the wet weight input) which could potentially be used in road construction;
- Fly ash (approximately 5% of the wet weight input) is assumed to be landfilled;
- Residuals of the other processes (contamination in the comingled recyclables and FOGO) sent to landfill have not been attributed to the recovery rate; and
- Conservative assumptions were made for contamination of GO/FOGO and recycling bins, organics content in the general waste bin and GO/FOGO capture rates.

Figure 11 Material recovery rate average performance

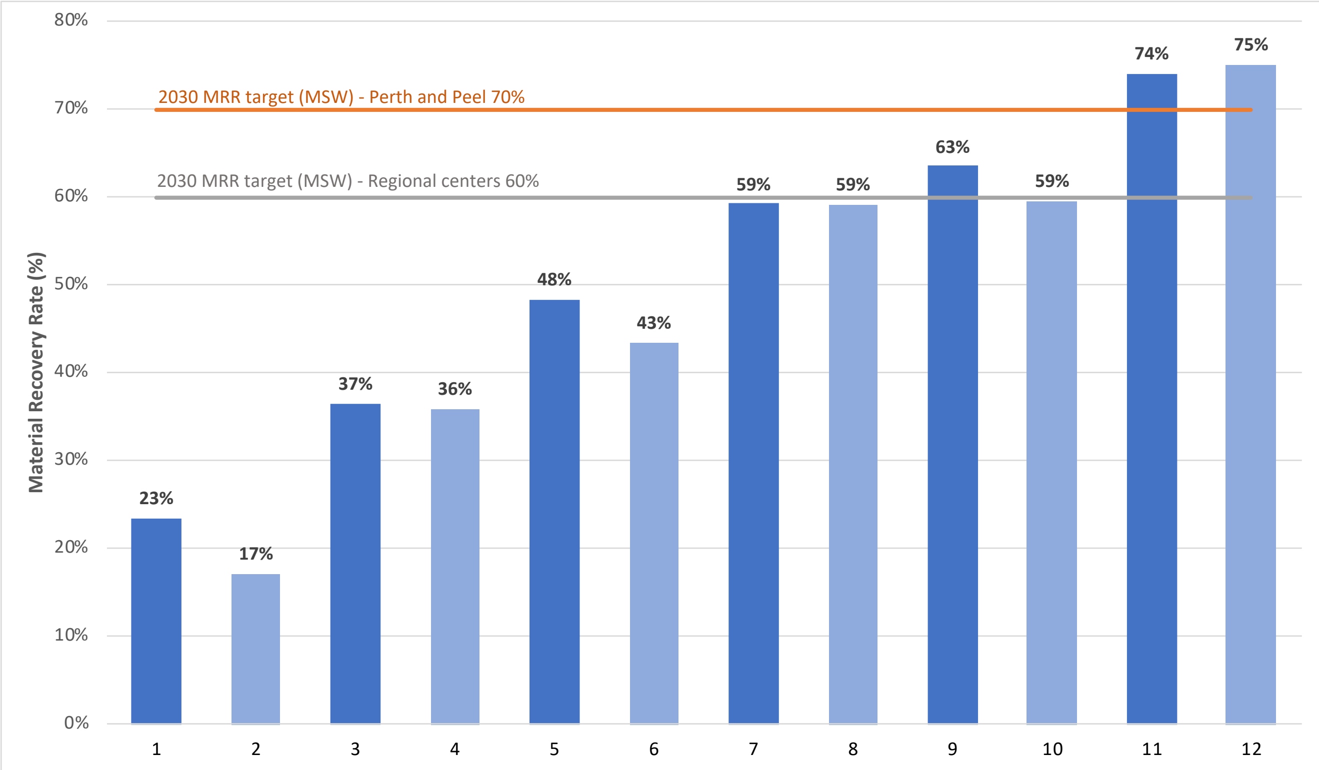
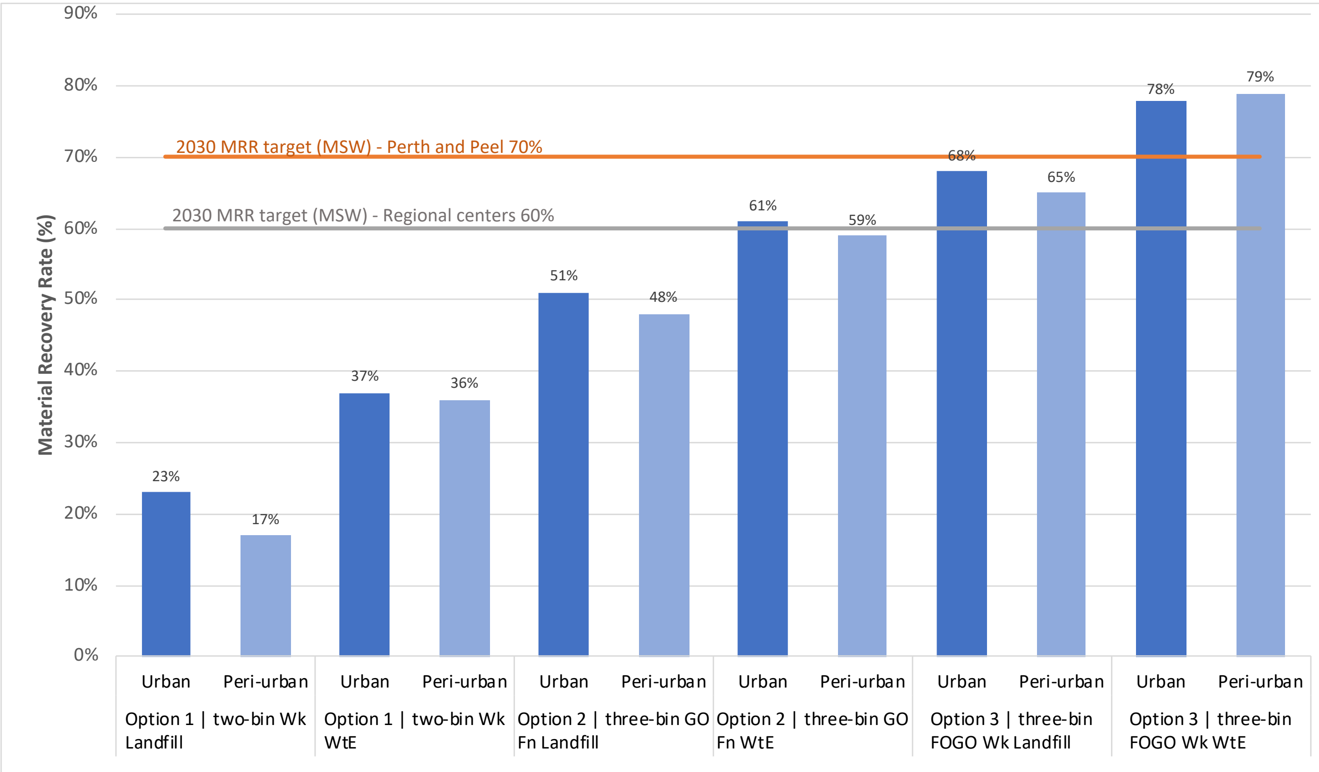


Figure 12 Material recovery rate high performance



Adding a weekly FOGO service increases the overall waste capacity for households; however, the change in MSW service frequency (from weekly to fortnightly) and reduction in size of the general (red lid) waste bin from 240L to 140L reduces the general waste capacity and is assumed to cause households to be more conscious of the available general waste capacity. This is assumed to result in better source separation behaviour by residents using the Better Practice FOGO options than would occur in the two-bin options.

The implementation of a three-bin system reduces general waste quantities significantly and improves material recovery rates from 17%-37% for Option 1, to 65%-79% for Option 3 (Figure 11). Consequently, the implementation of a FOGO bin results in a significant improvement in material recovery rates.

The results modelled here are practically exemplified by local government performance in LGAs where similar systems have been implemented. SMRC has achieved a MRR of 65% (2018/19) and 70.9% (2019/20) for their local governments in the 2020 annual report[8]. The City of Bunbury 2018/19 annual report[9] states a MRR of 63%.

8 SMRC Annual Report 2019-2020

9 City of Bunbury Annual Report 2018-2019

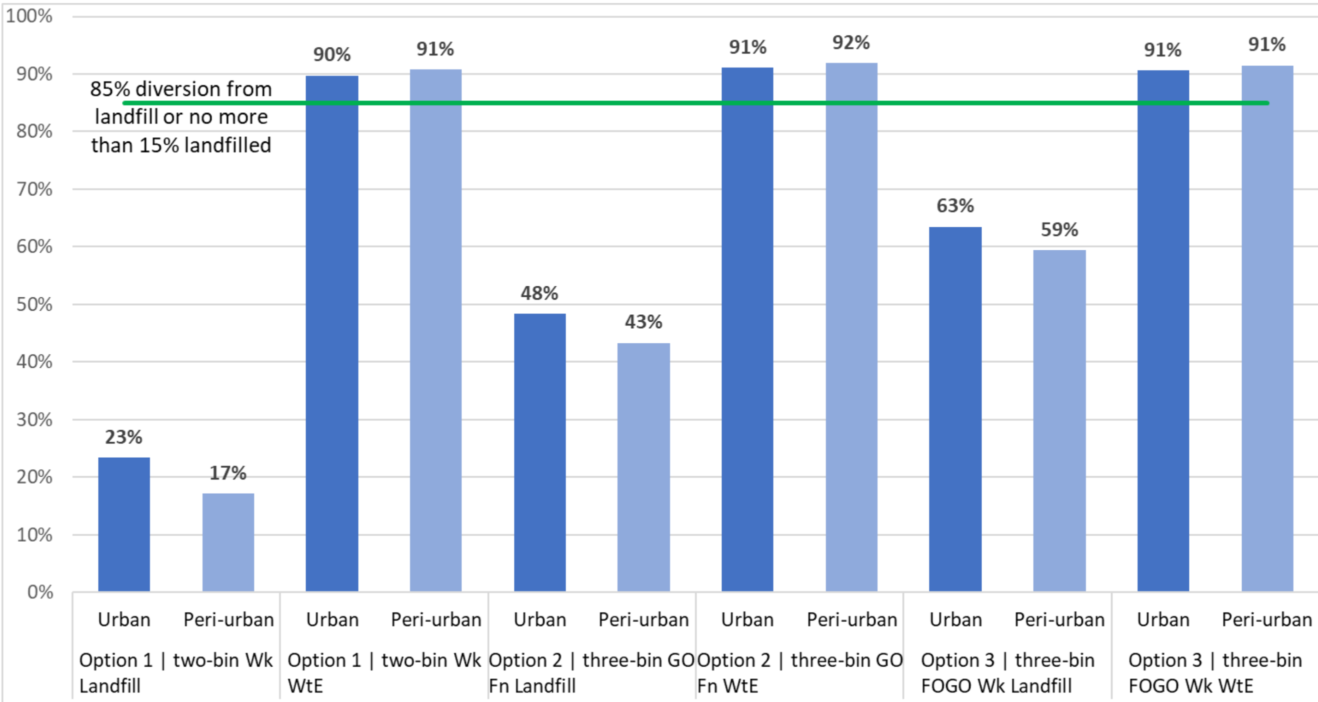
3.4 System Landfill Diversion Rates

Figure 13 shows the landfill diversion rate achieved by each option. The green line in the chart represents the Waste Strategy target: *'No more than 15% of Perth and Peel regions' waste is disposed to landfill'*. Any results under this line do not meet the Waste Strategy target. All options where WtE is the disposal option for general waste divert over 90% from landfill.

In this model, air pollution control residues including fly ash (approximately 5% of the wet weight input) were assumed to be landfilled. The model assumes that metal and bottom ash resulting from the process were diverted from landfill as metal could be recovered for reprocessing and other residues could be added to roadbase.

Note that while Option 1 to WtE supports the 2030 target for Landfill Diversion, it does not support the Material Recovery target of 75% by 2030.

Figure 13 Landfill diversion rate



3.5 System Greenhouse Gas Emissions

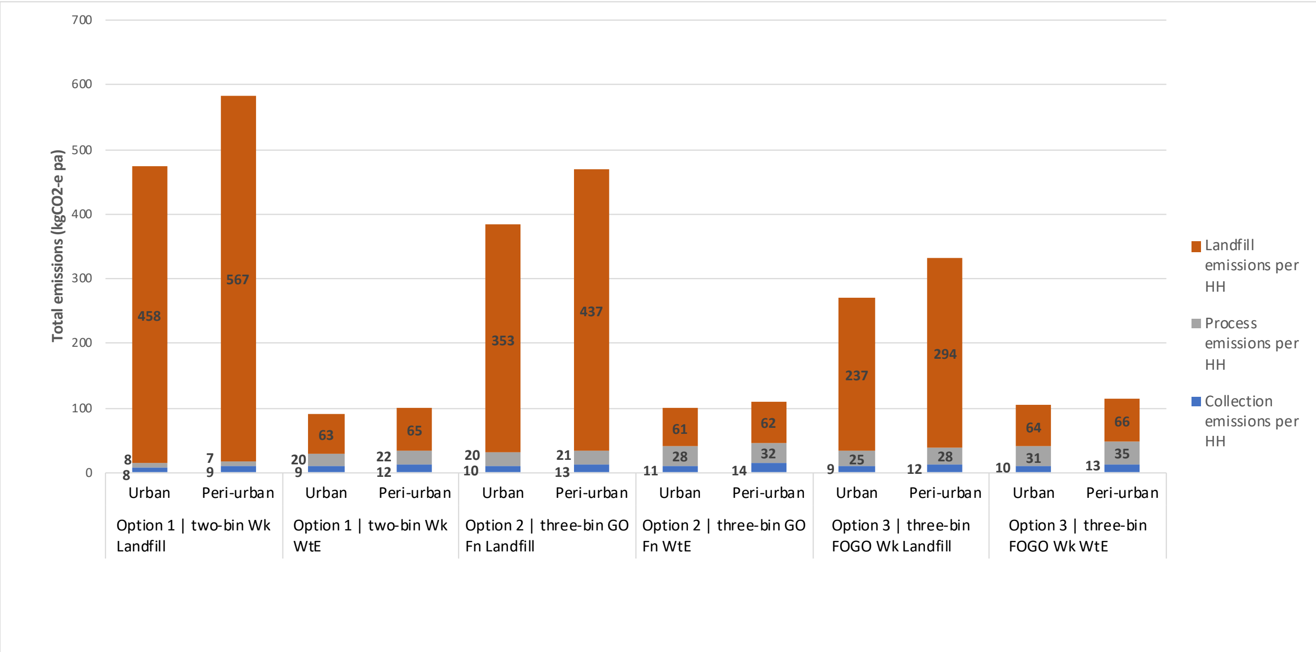
Figure 14 displays the expected GHG emissions for the modelled options. The GHG emissions of each option included collection, processing, and landfill emissions. The emissions have been normalised by households to show the emissions per household per year (kg) for each option.

A gas capture rate[10] at the landfill site of 50% was assumed for the modelling of GHG emissions. Landfills are the biggest contributor to GHG emissions. Processing emissions from processing recycling, organics, and general waste (WtE) were low in comparison and the emissions from collection and transport were minor.

Option 1 to Landfill for each local government generated the highest amount of GHG, as organics also went to landfill. Option 3 (the introduction of a FOGO bin) results in a reduction of emissions in comparison to Option 1 by about 40%. The best performing options were the WtE disposal options where residuals from the MRF or GO/FOGO processes go to landfill and general waste was thermally treated.

Vehicle kilometres travelled had a minor influence on GHG emission, although generally doubling for peri-urban compared to urban collections.

Figure 14 Greenhouse gas emissions per household



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[10] Australian Govt Clean Energy Regulator: Landfill Gas Method

3.6 System Vehicle Kilometres Travelled

Figure 15 shows the modelled vehicle kilometres travelled per year normalised on a per household basis, based on distances (a) between residences, (b) from collection areas to waste facilities.

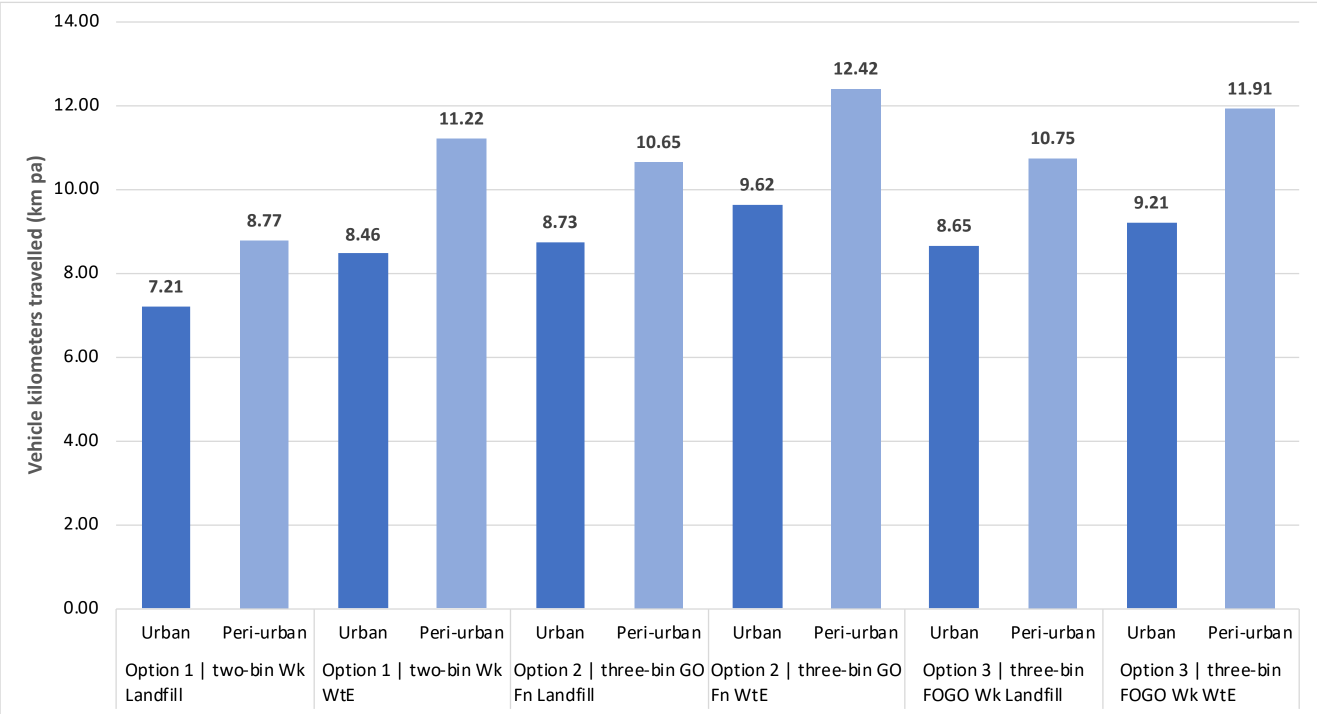
The annual vehicle kilometres travelled were higher for WtE disposal options for both urban and peri-urban local governments due to the location of the two WtE facilities in the South-West of the region, resulting in longer travel distances for the modelled local governments.

The averagely longer travel distances from peri-urban LGAs to the facilities resulted in increased vehicle kilometres for the peri-urban local government.

Option 1 resulted in the lowest overall vehicle kilometres.

The introduction of GO and FOGO services in Options 2 and 3 are partially compensated for by the reduction in general waste volumes and collection vehicle travel distances, resulting in relatively low increases in vehicle kilometres travelled considering the added weekly service.

Figure 15 Vehicle kilometres travelled per annum normalised on per household basis



4. Policy Integration

4.1 Policy Alignment

This section examines how well each option aligns with the strategic requirements set out by the Waste Avoidance and Resource Recovery Strategy 2030.

Table 10 gives an overview of the alignment of each option with the Waste Strategy.

Option 1 and 2 are not well aligned with the Waste Strategy, in comparison with Option 3 which is well aligned.

Table 10 Policy alignment

Option	Policy alignment			
Targets	**Avoid** • 2025 – 10% reduction in waste generation per capita • 2030 – 20% reduction in waste generation per capita	**Recover** • 2025 – Increase material recovery to 70% • 2030 – Increase material recovery to 75% • From 2020 – Recover energy only from residual waste	**Protect** • 2030 – No more than 15% of waste generated in Perth and Peel regions is landfilled • 2030 – All waste is managed and/or disposed to better practice facilities	**Headline strategy 2** *'A consistent three-bin kerbside collection system, which includes separation of food organics and garden organics from other waste categories, to be provided by all local governments in the Perth and Peel region by 2025 and supported by State Government through the application of financial mechanisms'*
Option 1 to Landfill	N/A	✗ **Not aligned:** No increase in material recovery	✗ **Not aligned:** more than 15% landfilled	✗ **Not achieved**
Option 1 to WtE	N/A	✗ **Not aligned:** No increase in material recovery; recoverable material going to WTE	✓ **Well aligned**	✗ **Not achieved**
Option 2 to Landfill	N/A	**Partial alignment:** Increase in material recovery compared to two bin service	✗ **Not Aligned:** More than 15% waste to landfill	✗ **Not achieved**
Option 2 to WtE	N/A	**Partial alignment:** Increase in material recovery compared to two bin service	✓ **Well aligned**	✗ **Not achieved**
Option 3 to Landfill	N/A	✓ **Well aligned:** increased recovery through Better Practice FOGO service	✗ **Not Aligned:** More than 15% waste to landfill	✓ **Achieved**
Option 3 to WtE	N/A	✓ **Well aligned:** increased recovery through Better Practice FOGO service	✓ **Well aligned**	✓ **Achieved**

5. Conclusions

- The modelling concludes that high performing three-bin FOGO kerbside services achieve material recovery rates of around 75%, or 79% if waste to energy is used to process residual waste.
- The cost per tonne recovered decreases significantly (by 59%) by implementing the Better Practice FOGO Kerbside Collection.
- Option 3 rates highly for policy integration as it aligns with a headline strategy in the waste strategy, for all local governments in the Perth and Peel regions to have better practice 3-bin kerbside collection services that include FOGO collections by 2025; modelling confirmed that Option 3 would make the biggest contribution to achieving the waste strategy's material recovery targets.
- Landfilling is the biggest contributor to greenhouse gas emissions. All options that use WtE for residual waste show much reduced greenhouse gas emissions compared to landfill.
- Greenhouse gas emissions from processing (co-mingled recycling, organics, and WtE) and from transport are low in comparison to greenhouse gas emissions from disposing waste to landfill.
- The use of waste to energy (WtE) in Options 1 and 2 supports the 2030 target for Landfill Diversion (no more than 15% of Perth Peel regions' waste is disposed of to landfill), however these options do not make a substantial contribution to the waste strategy's material recovery targets.
- Implementation of the Better Practice FOGO system adds around $42 per household per year compared to the existing two-bin system, when the initial setup costs (bins, caddies, public education) are amortised over a 10-year term.

6. Consolidated Cost Modelling Assumptions

6.1 General

General assumptions applied throughout the model are listed in Section 6.9.

6.2 Methodology to Determine a Typical Population Growth Index

To determine a growth index for the typical urban and peri-urban local government, MRA (a) determined the typical growth rate for each local government based on the latest population forecast from DPLH WA[11], (b) extrapolated the population for each local government to FY2022/23 and (c) averaged the resulting population number from each local government for this year to determine the population figure for the typical urban and peri-urban local government. The typical urban and peri-urban annual growth rate was then calculated by dividing the 5-year growth rate by the number of years (5 years). The resulting growth rates are depicted in

Table 11.

Table 11 Annual growth rates

Category	Residents FY2016/17	Residents FY2022/23	Average annual pop growth rate
Urban Local government	58,052	59,332	0.44%
Peri-urban Local government	77,173	90,294	3.40%

6.3 Methodology to Determine Number of Dwellings in FY2022/23

To determine the estimated number of dwellings in the typical urban and peri-urban local governments, MRA averaged the number of people per household from all local governments in each category. The resulting number of dwellings and the average people per household figure is shown in Table 12. It was assumed for the purpose of this CCM that each dwelling has one waste service assigned to it.

Table 12 Number of dwellings

Category	Dwellings in FY2016/17 ABS 2016	Dwellings in FY2022/23 calculated	Residents FY2022/23	Average number of people per Household
Urban Local government	22,862	23,951	59,332	2.48
Peri-urban Local government	28,853	34,481	91,218	2.65

[11] WA Government: Western Australia Tomorrow population forecasts

Table 13 General assumptions

Parameter	Urban	Peri-urban	Comments	Source
Number of residential services modelled	23,951	34,481	ABS data was projected using population growth rates from DPLH	ABS Quickstats DPLH WA population forecast
Number of households; education materials	23,951	34,481	Calculated data	ABS Quickstats DPLH WA population forecast
Current population	59,332	90,294	Calculated data	ABS Quickstats DPLH WA population forecast
Annual urban population increase (%)	0.44%	3.40%	Applied across each model local government's area	DPLH WA population forecast
Consumer Price Index	2.5%	2.5%	Applied across the region	MRA

Other scenario-specific assumptions applied to urban and peri-urban modelling are shown below:

Table 14 Additional diversion assumptions

Option Number	Option Description	% of food waste in Option 1 residual diverted to GO/FOGO bin %	% of garden waste in Option 1 residual diverted to GO/FOGO bin %	% of Recycling in Option 1 residual diverted to Recycling bin %
1	Two-bin System - waste to landfill	0%	0%	0%
	Two-bin System – waste to WtE	0%	0%	0%
2	Three-bin fortnightly GO - waste to landfill	80%	90%	30%
	Three-bin fortnightly GO – waste to WtE	80%	90%	30%
3	Three-bin weekly FOGO - waste to landfill	80%	90%	30%
	Three-bin weekly FOGO – waste to WtE	80%	90%	30%

6.4 General Waste Stream Composition

Figure 16 and Figure 17 show the assumed composition of the current general waste streams. A two-bin system was assumed for all suburbs and audit data was chosen to represent the two-bin WM system. Waste composition of the general waste stream was sourced from the 2013/14 SMRC audit and the 2019 EMRC audit. The data was averaged by local government for urban local governments (7 data sets) and peri-urban local governments (5 data sets). The urban composition contains a higher (63%) organics content than the peri-urban local government (58%).

Figure 16 Urban General Waste Bin

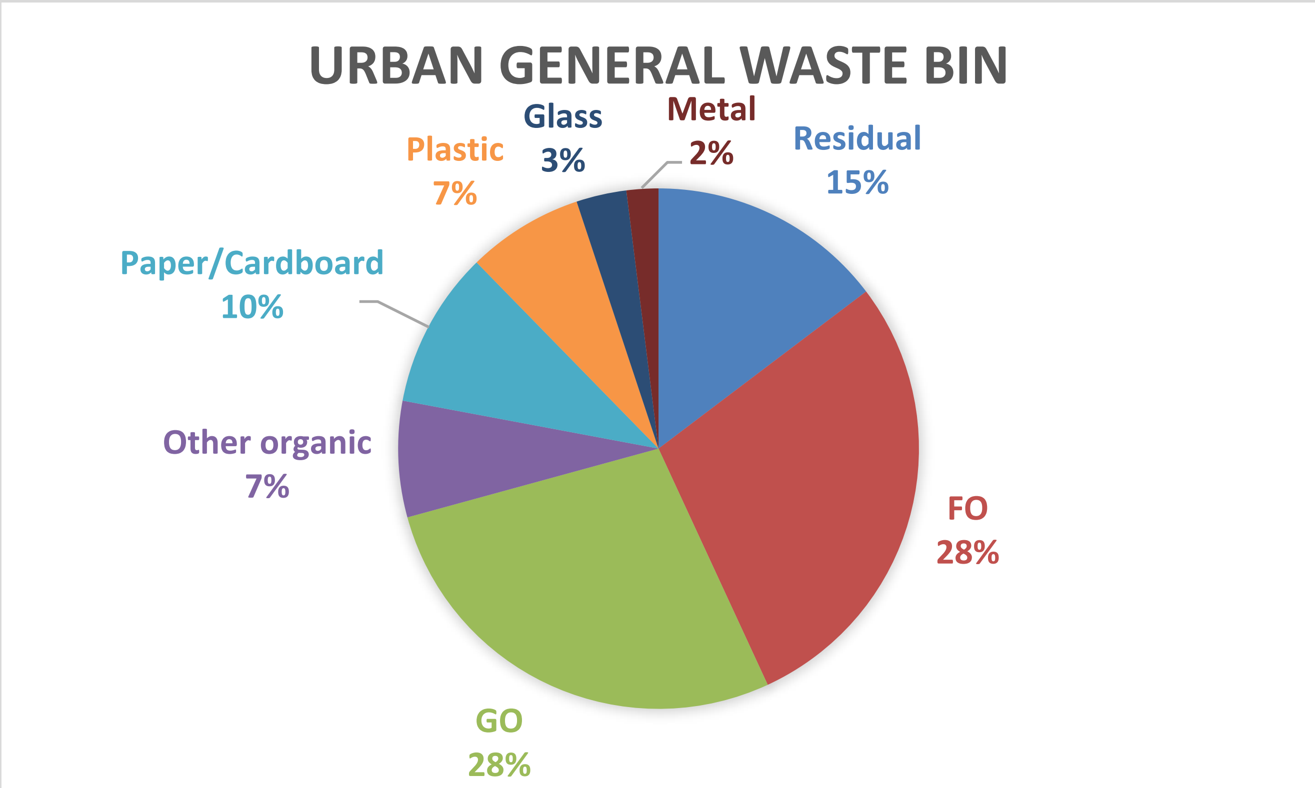
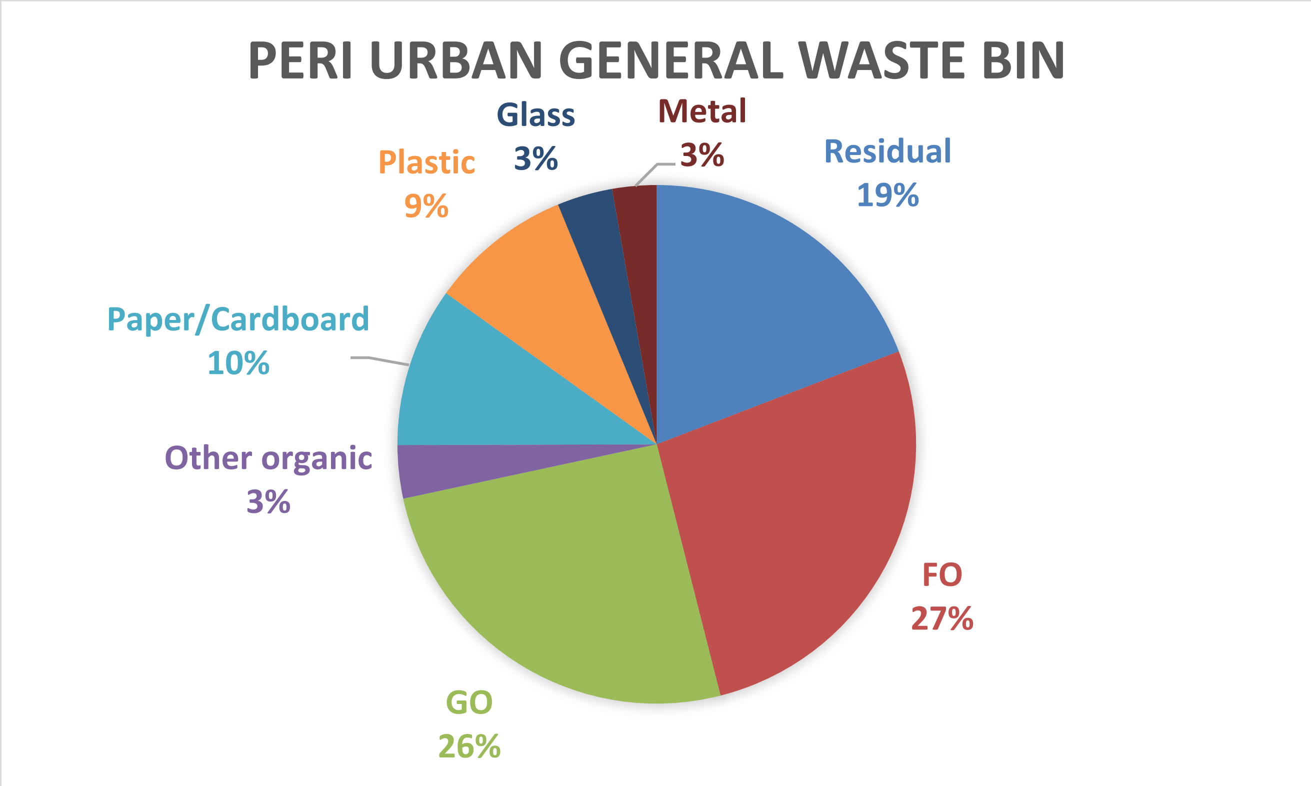


Figure 17 Peri-urban General Waste Bin



6.5 Comingled Recycling Composition

Figure 18 and Figure 19 show the composition of the kerbside comingled recycling stream. A two-bin system was assumed for all suburbs and audit data was chosen to represent the two-bin WM system. recycling composition of the recycling stream was sourced from the 2013/14 SMRC audit and the 2019 EMRC audit. The data was averaged by local government for urban local governments (7 data sets) and peri-urban local governments (5 data sets). The composition varies only slightly between the two model local governments.

Figure 18 Urban Recycling bin

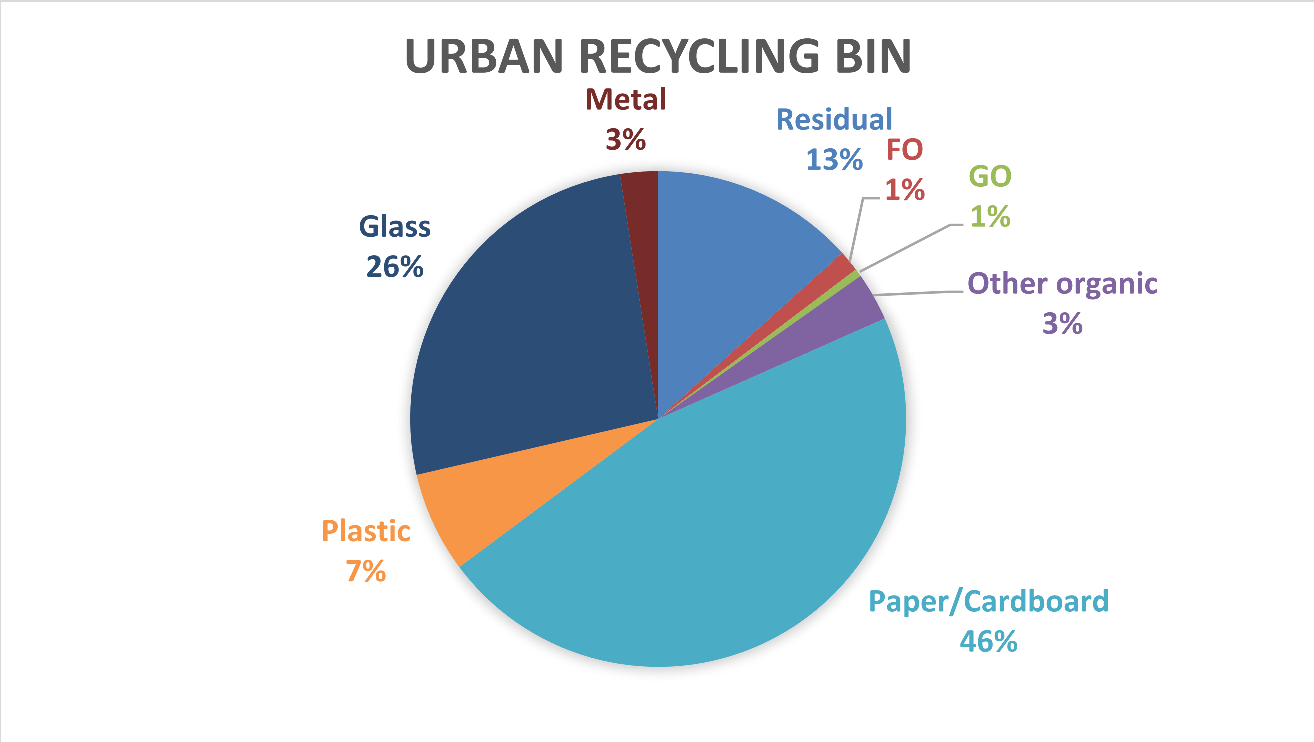
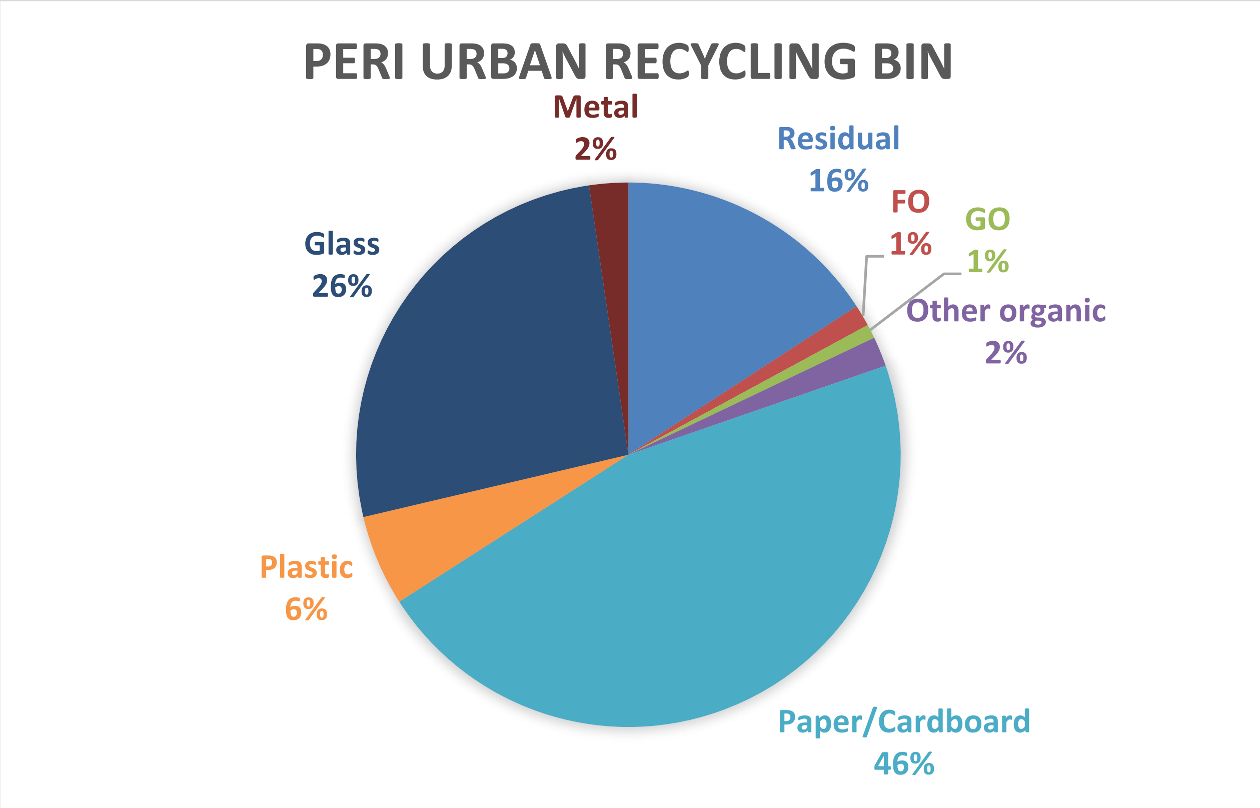


Figure 19 Peri-urban Recycling bin



6.6 Collection, Transfer and Haulage

Table 15 Lift cost and haulage cost assumptions

Collection Vehicle	Capacity (t)	Fuel	Lift/service cost range (excl. GST)	Assumed cost per lift (excl. GST)	Source
General Waste	10	Diesel	$0.84-$1.26	$1.05	Mean from DWER provided data
Comingled	10	Diesel	$0.68-$1.80	$1.106	Mean from DWER provided data
GO/FOGO	10	Diesel	$1.01-$1.36	$1.172	Mean from DWER provided data

The assumed distances between lifts (in metres) for collection trucks are summarised in Table 16.

While travel distances between services in urban areas are assumed to be 50m in line with urban local governments in NSW and VIC, the peri-urban travel distances have been assumed to be 70m to compensate for travelling between collection areas in the larger peri-urban LGAs.

Table 16 Distance between services assumptions

Waste Stream	Distance travelled per lift (m) urban	Distance travelled per lift (m) peri-urban
General Waste	50	70
Comingled	50	70
GO/FOGO	50	70

The onward distances travelled to each facility are summarised in Table 17. These values were determined using Google Maps and considering the population centres of the LGAs. As this project investigates a region with several possible destinations and several possible source locations, the typical distance to a landfill and to a WTE facility for the urban local governments and peri-urban local governments was determined by averaging the shortest distance from each LGA to each of the facilities. For recycling and FOGO facilities the distances were estimated. Calculations are attached as 'Facilities and LGA distances.xlsx'.

Haulage costs for all materials direct to processing facilities are assumed to be included in the lift rate.

No transfer stations or transfer vehicles are used in relation to the provision of kerbside services.

Table 17 Haulage distance assumptions

Waste Stream	Journey Start	Journey End	Distance, one-way (km) urban	Distance, one-way (km) Peri-urban
General Waste Landfill	LGA Centroid	One of four Landfills in the peri-urban areas	23	27
General Waste WTE	LGA Centroid	Avertas Waste to Energy Facility, or East Rockingham WTE facility	35	45
Recycling	LGA Centroid	One of three MRFs grouped around the urban area	20	30
GO	LGA Centroid	One of five organics processing facilities grouped around the urban area	20	30
FOGO	LGA Centroid	Currently 4 FOGO Facilities[12] in the region are licensed to receive FOGO and have been considered.	20	30

[12] Regional Resource Recovery Centre, SMRC; Red Hill Waste Management Facility, EMRC; Brockwaste WA, Brockwaste WA Operations Pty Ltd, Banksia Road Organics facility.

As more GO and FOGO facilities come online travel distances will decrease and gate fees will also decrease due to increased competition.

Table 18 summarises the assumptions regarding the consumption of diesel and emissions.

Table 18 Diesel consumption and GHG emission assumptions

Item	Value	Source
Average rate of diesel consumption for rigid and articulated trucks in Australia	40L per 100km	ABS, 2010
Diesel emissions	2.68 t CO_2-e per kL of diesel	DCCEE, 2012

6.7 Facility Costs and Diversion Performance

Facility gate fees (expressed as *cost per tonne of material processed/landfilled/transferred*) and diversion rates are presented in

Table 19. All gate fees have been set to the rates provided by DWER[13] plus adjustment for inflation (2.5%p.a.) to the 2021-22 financial year. These rates are taken to apply in the first year of modelling (FY2021-22).

It should be noted that in 2020, the WA government commenced a review of the waste levy and consulted on issues including future rates, geographic area, and the waste management options that may be subject to the levy. The findings of the review are not yet published. Future changes to the waste levy are likely to affect the costs of the options in this analysis.

[13] Spreadsheet 'Local Government Cost DataV3' DWER

Table 19 Facility cost and diversion rate assumptions

					FY 2021-22 gate fee ex. GST)		Landfill Diversion (%)							
Facility	**Facility type**	**Existing/ Hypo-thetical**	**Waste**	**Gas capture rate**	**Gate fee per tonne**	**Source**	**Food Organics**	**Garden Organics**	**Paper/ Cardboard**	**Plastic**	**Metal**	**Glass**	**Residual**	**Other Organics**
Landfill	Landfill	Existing	General Waste	50%	$180 (includes levy)	DWER (estimated)	0%	0%	0%	0%	0%	0%	0%	0%
Avertas Energy or East Rockingham WTE facility	WtE	Existing	General Waste	N/A	$141 (no levy)	estimated	95%	95%	95%	95%	95%	95%	95%	95%
MRF	MRF	Existing	Recycling	N/A	$78	DWER/MRA	0%	0%	95%	95%	95%	95%	0%	0%
GO Facility	Compost facility	Existing	GO	N/A	$80.00	DWER GO 3-bin Kerbside Collection 7/10/21 & MRA calcs	0%	98%	0%	0%	0%	0%	0%	95%
FOGO Facility	Compost Facility	Existing	FOGO	N/A	$140	DWER-averaged organics processing cost for landfills in Perth & Peel region	95%	98%	0%	0%	0%	0%	0%	95%

6.8 Material Recovery

Waste to energy primarily aims to recover energy from waste, and material recovery is normally a secondary objective. Thermal treatment technologies can recover some materials from mixed-waste streams; however, the material recovery rate is generally far lower than the rate achieved by facilities dedicated to recovering materials, such as composting facilities or Recycling facilities. MRA assumptions regarding material recovery for the modelled facilities are summarised in Table 20.

Table 20 Material recovery assumptions

Facility type	Food Organics	Garden Organics	Paper/ Cardboard	Plastic	Metal	Glass	Residual	Other Organics
Landfill	0%	0%	0%	0%	0%	0%	0%	0%
WtE facility	0%	0%	0%	0%	95%	95%	95%	0%
MRF	0%	0%	95%	95%	95%	95%	0%	0%
GO Facility	0%	98%	0%	0%	0%	0%	0%	95%
FOGO Facility	95%	98%	0%	0%	0%	0%	0%	95%

6.9 General Assumptions

General assumptions applied throughout the model are listed in Table 21.

The service transition costs are an estimate of both the additional education program and staffing costs associated with the rollout and implementation of each new service option. Correlation between education spend and contamination can be observed, however there are many variables that influence contamination. MRA has used past experience for the education cost estimate.

Table 21 Service transition cost assumptions

Cost component	Unit cost per household (exc. GST)	Source
Mobile Garbage Bin (140L bin)	$40.30	Averaged DWER data provided
Mobile Garbage Bin Organics (240L)	$47.30	Averaged DWER data provided
Food liners: FOGO (inc. delivery)	$9.30 (inc. delivery) per roll of 150 liners	Averaged DWER data provided
Kitchen Caddies: FOGO (inc. delivery)	$6.37 (inc. delivery) per caddy	Averaged DWER data provided

Education and waste audit budget allocated within the model for each option:					
Option	Ongoing education annual costs				
	Program costs		Staff Costs		
Options 2&3 – Fortnightly GO or Weekly FOGO Services with Fortnightly General Waste	$4 per household		0.8 x FTE ($100k p.a.)		
Option	Service transition education costs				
	Year 1	Year 2	Year 3	Year 4	Year 5
Options 2&3 – Fortnightly GO or Weekly FOGO Services with Fortnightly General Waste	$4 per household	-	-	-	-

6.10 Net Present Value Calculations

The CCM calculates a net present value (NPV) as part of its output. This calculation looks to assess the value of local governments' investment in a waste management system over several time periods and presents a $ value of the investment at the present day $ value.

The NPV is calculated by applying a discount rate to expenditures to each of the future expenditures to compensate for inflationary loss of monetary value. The variables used for the NPV calculations are shown in Table 22.

Table 22 NPV assumptions

Time period	Number of time periods	Discount rate	Consumer price index
Year	10	5%	2.5%

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