



Waste Not Limited

Analysis of Kerbside Recycling Systems

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Trust

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Introduction

An increasing number of local authorities are looking to introduce kerbside recycling schemes as part of their waste minimisation strategies. This has put increased attention on determining the most effective systems for kerbside schemes. This paper provides an analysis of the different existing recycling systems, both in New Zealand and overseas, and assesses the benefits and shortcomings for application to New Zealand situations.

The paper aims to provide guidance on the types of kerbside recycling systems currently in operation. It is hoped that this will assist councils and other decision-makers to develop the most appropriate systems for their area of jurisdiction.

Methodology

Scope of Systems to be investigated

The following information was investigated during the study:

- A selected inventory of kerbside recycling systems in use in New Zealand and worldwide.
- Key features of each of the systems, such as materials collected, receptacle type, collection vehicle type, and tasks of collection personnel.
- In addition, information was analysed on the economics of each system, the quality of materials collected, participation rates, and the volume of materials collected. Information relating to problems encountered, and key success factors, are also noted.
- Note is also made of different container designs used in the different systems.

Limitations and exclusions

- Materials considered as part of the study are limited to those that are considered tradable as commodities. Organic waste is not considered as part of this study.
- The focus of this paper is on recycling collection systems. It is recognised that collection systems do not function in isolation from other parts of the waste management and processing industries. Although this is touched on in the report, evaluation of different waste management systems is considered outside the scope of the present study.
- The report will look only at systems for collection of materials. It will not assess systems for the sorting (other than at kerbside) and processing of materials, or provide any analysis of market requirements, except to note how a collection system will affect the quality of materials gathered.
- This report provides only an approximate guide as to the potential costs of each system and where those costs are likely to arise. It is beyond the scope of the report to consider the different cost parameters in detail.

Key Sources

- Internet
- In-house and external reference libraries
- Recycling Operators of New Zealand
- Zero Waste Councils
- Reports specifically obtained for the study

Background

General Factors Affecting Kerbside Recycling

There are a number of factors that can affect the viability of kerbside recycling schemes. A few of these key factors are discussed below.

Population size

Population size has a direct effect on the economics of the different types of recycling systems. This is the case at both the national level and at the local level. At the national level, large countries can support a wider base of recycling industries, and so domestic markets for commodities tend to be more important. For smaller or less industrialised countries, the capacity to process or market materials is generally lower and so the commodities that it is economic to recycle tend to be those for which viable international markets exist.

Large urban areas have different waste management requirements to smaller rural centres. Density of housing, traffic concerns, and the logistics of dealing with large volumes and collection areas in urban centres means there is often more emphasis placed on the efficiency of collection. Conversely, smaller rural centres will more readily support systems that require a higher level of household separation and education. The amount of recycling per capita increases as councils' population reduces.¹

Socio-economic factors

The effect of socio-economic factors on kerbside recycling schemes is complex and little research appears to have been done. In general, middle income groups tend to be well-educated and responsive to environmental messages.² Lower socioeconomic groups are generally less well-educated and generate smaller quantities of recyclable materials on a per capita basis.³ High-income groups, although usually well educated, also have a tendency to be prepared to pay for the convenience of throwing out their rubbish without sorting or separation.

Contract requirements

The contractual framework can be one of the biggest influences on how well a recycling system will work. The contract establishes the environment within which the recycling collection contractor must work, and so a lot depends on the objectives of the two parties. For example, if a council letting a contract has cost minimisation as a primary concern, that council would favour collectors who offer services that are efficient at collection but perhaps less efficient at recovery of materials.

Issues such as the quality of service, the expected diversion rates, ownership of materials, spreading the risks/benefits from commodity price fluctuations, and the costing of recycling as an alternative to landfill can all have an influence on the viability of the kerbside recycling service. Councils and contractors should ideally view recycling collection as the primary 'disposal' option, with refuse disposal a secondary consideration.

Refuse collection systems

Kerbside recycling systems are affected by the other waste management and recycling elements that operate in the council area. Normally councils offer kerbside recycling alongside a kerbside refuse collection system. The type of kerbside refuse collection system offered can have as big an influence on the success of recycling as the recycling system itself. A thorough analysis of these systems is not possible in this report, however some of the key factors that affect the success of recycling systems include:

User-pays or rates funded. User-pays systems provide an incentive for householders to separate and reduce their waste. If the recycling collection alongside it is “free” (i.e. rates funded), then this can boost recovery rates.⁴

The size of the refuse receptacle. A number of studies show that households provided with a large 240 litre wheelie bin for refuse put out lower amounts of recyclable material for collection.⁵

The frequency of the collection service. Broadly speaking, recycling collection needs to happen on the same frequency and timetable as refuse collection to achieve the best recovery rates.⁶

Secondary Materials Markets

For many years the lack of stable markets was seen as a barrier to widespread recycling. The range of material collected at kerbside is still largely dependent on the existence of viable markets for the collected and processed materials. The main materials collected by kerbside schemes (glass, paper, tin, aluminium, HDPE and PET) are those for which stable and viable markets exist. If the range of materials collected is to be expanded, then the potential markets and the costs and returns from collection of the additional materials need to be taken into consideration. Conversely, loss of a market for a key commodity (e.g. with glass in the South Island) can have a detrimental impact on the viability of a kerbside recycling scheme.

New Zealand-Specific Factors Affecting Recycling

When considering the effectiveness of recycling systems, it is necessary to consider that what works well in other countries will not necessarily translate well into the New Zealand context, and vice versa. Some of the factors that have to be taken into account are outlined below.

Low population density

New Zealand's small population restricts the size of the domestic markets for recovered materials. In addition, key buyers and traders of material are located predominantly in Auckland and, to a lesser extent, Christchurch. This means high transport costs for recovered materials must be factored in by other centres or other local uses for the materials must be developed..⁷

Existing Systems

The types of systems that will be introduced in the future will, to some extent, be dependent on the types of systems that are in use at present. Contractors' equipment and expertise will tend to be based around the operation of existing systems, and this will influence what is economic for them to offer. The same

can be said for the infrastructure of the recycling industry. Councils covering 55% of the population already provide a kerbside collection system to at least a portion of their ratepayers⁸ and so the effect of existing systems on future decisions should not be underestimated.

The types of refuse collection systems in place also have an impact. Most council collections are currently rates funded bag collections. Eleven New Zealand councils have user-pays bag collections. Only one municipality (Auckland) has an MGB based refuse collection service coupled with a kerbside recycling collection. The system currently uses predominantly 240 litre MGBs but it is planned to change this from a 240 litre service to 120 litre. The small number of contractors involved in city wide MGB based systems means that introducing MGB based recycling systems is likely to be less attractive due to the high capital and infrastructure costs associated with such systems.

Markets dominated by a single processor

The market for glass recycling in New Zealand is dominated by ACI glass located in Auckland. This means ACI can essentially set whatever price it wishes for material and can control the market supply according to its needs. The RMF in Christchurch has been developing alternative local markets for glass, partly in response to this. Carter Holt Harvey is the largest local processor of recovered paper, taking up to 70-80% of the material collected, but sufficient competition does exist from overseas markets to mitigate any monopoly situation.⁹

Small local processing base for materials

The local processing base for many materials, particularly post consumer plastic, is at present very small. This means that market for these commodities are driven by export demand. For example, the range of post consumer polymers that it is viable to collect and export is relatively limited. Clear PET and HDPE have the most ready export markets, although other grades of materials can be sold as part of a package deal with these materials. The minimum quantity that it is viable to export is considered to be a container load (20 tonnes). The limited number of grades which are viable for export restricts the types of materials that are collected at the kerbside.¹⁰

Immature markets

Kerbside recycling is still relatively new in New Zealand. The longest running citywide kerbside collection scheme (North Shore City) has been running only since 1990. This results in a population that is relatively uneducated when it comes to recycling. The implication of this is that new recycling schemes in New Zealand may require a relatively strong educational component in order to achieve high participation levels. By contrast, recycling is thoroughly engrained in most European cultures and so participation is high.

Growing Recycling Industry

New Zealand has a number of well established recycling industries, such as the metal recycling industry, that have been operating successfully for many years. In addition however, studies indicate that the recycling industry has been growing for a number of years and expects to continue growing in the foreseeable future.¹¹ There may be a number of factors driving this including higher waste costs, more stringent environmental laws, technical innovations,

greater levels of environmental awareness and the recognition of new business opportunities. The local recycling industry is being fostered by organisations such as the Recovered Materials Foundation in Christchurch who are working to develop new uses for recovered materials and foster local markets, and The Recovered Materials Enterprise Fund, who provide financial support for recycling innovations.

No large MRFs

New Zealand does not presently have any large scale material recovery facilities (MRFs) capable of processing a wide range of commingled material. This means that the construction of such a facility would be required prior to initiating a kerbside collection system based on collecting a commingled stream. This would add substantially to the capital cost of this type of system in New Zealand.

Decentralised decision making

A possible reason for the absence of large scale MRFs is the absence of regional bodies involved in the coordination of recycling efforts. For example, in Australia, state wide agencies (e.g. Ecorecycle Victoria) and legislation guide the development of recycling infrastructure and programmes. This has led to uniform approaches to education and the presence of large scale processing facilities. By contrast, in New Zealand recycling contracts are let independently by city councils and so contractors gear themselves with systems and equipment to meet only the requirements of that local authority. This is one reason for the prevalence of systems requiring lower initial capital expenditure (such as kerbside sort based systems) in New Zealand.

No national guidelines and targets

Unlike many overseas countries, which have national or state waste reduction targets, New Zealand has not yet set any national targets or legislation mandating waste reduction levels (although the current government has a 40% reduction target in its manifesto). This means that, in the past, waste reduction and recycling has been given a low priority. Recycling schemes have been seen as an added cost for councils introducing them, rather than as part of an integrated waste management strategy. There is however rapid change occurring in this area. Zero Waste New Zealand Trust has encouraged a third of the local authorities in New Zealand to commit to a goal of Zero Waste to Landfill by the year 2015. Government is showing signs of getting behind this type of initiative and has instituted the national Waste Working Party to help formulate a national waste management strategy.

Analysis

There are a number of ways to analyse the different types of recycling systems. For example, they could be analysed by the degree of sorting required at the household level, or by the types or range of materials they collect. For the purposes of this paper it was decided to analyse the systems according to the type of collection container that is used. There are two main reasons for this. Firstly, it is an intuitive way to distinguish systems as it is based on an obvious physical difference, and systems are often loosely compared by this characteristic. Secondly, the type of container used has a range of impacts in terms of what is required of the contractor and of the household and so provides a useful starting point for analysis.

The types of systems analysed are as follows:

Wheelie Bin Systems

- Split bin systems
- Commingled systems
- Multi-bin systems

Open Bin Systems

- Kerbside sorted systems
- MRF sorted systems
- Source separated systems

Bag Systems

- Reusable bag systems
- Disposable bag systems

There are many variations of each of these systems – some of the key variants will be noted in discussing each system type.

Each of these systems is evaluated according to the following criteria:

- Capital cost
- Operating cost
- Vehicle requirements
- Sorting requirements
- Education requirements
- Range of materials collected
- Versatility (expandability)
- Quality (degree of contamination of material)
- Participation rates
- Diversion rates
- Frequency of collection
- Effect of receptacle size
- Health and safety

Wheelie Bin – Split Bin Systems

<p>Brief Description</p>	<p>In this type of system householders are normally provided with a single 240 litre or 120 litre wheelie bin that is divided in the middle. There are a number of variations on this type of system. A wet/dry split, a rubbish/recyclables split and a paper/commingled containers split are the most common systems. Split bins are collected from the kerb by specially designed or modified trucks that lift the containers with a mechanical arm, emptying the contents automatically into separate compartments. Recyclables collected with this system require sorting at a MRF.</p>
<p>Capital Cost</p>	<p>Capital costs are high for this type of system. Each wheelie bin with the split modification wholesales for approx. \$60. The modified trucks are worth in the order of \$350,000 each new, and a relatively sophisticated MRF is required to handle the volumes of material collected. Depending on the volume of material processed, MRFs can cost upwards of \$1 million.</p>
<p>Operating Cost</p>	<p>These systems are generally considered to have relatively low operating costs, however payback on capital, and equipment maintenance may largely negate this. The mechanical arms on the trucks afford speedy pickup and collection times are substantially reduced over manual systems. Crew sizes are sharply reduced. Even greater savings on collection are possible if it is a wet/dry or rubbish/recyclables system as all household waste and recycling can be collected with a single pass. Because material has to be sorted at a MRF, double handling occurs, which is an inefficiency, however a MRF is a very efficient method of separating large quantities of material.</p>
<p>Vehicle Requirements</p>	<p>Single operator specially designed or modified compactor trucks with mechanical lift arms.</p>
<p>Sorting requirements</p>	<p>Requires MRF. Minimal household sorting.</p>
<p>Education Requirements</p>	<p>This depends on the variant of this system used. Under the wet/dry system households are required to perform a minimum of separation, and what is asked for is reasonably intuitive so education requirements are relatively low. The rubbish/recyclable split asks householders to correctly identify items that can be recycled and so slightly more education is required. If it is a paper/recyclables split a further separation is required (rubbish is put in a separate bag or container).</p>
<p>Range of Materials</p>	<p>Depending on the variation used, a wide range of materials can be collected by this system. The wet/dry system for example has the ability to collect organic waste for composting, as well as to collect all other materials for possible later separation. The containers are large enough to accommodate the needs of most households.</p>
<p>Versatility (expandability)</p>	<p>The system is capable of being easily expanded to take a wider variety of materials. Because materials are sorted at a MRF, the MRF can easily pick out additional materials with little disruption to the system. The most versatile variant is again the wet/dry system which, because the entire waste stream is being processed, is capable of pulling out different materials in response to market prices.¹² In other variants additional education is required to get householders to separate out the correct materials.</p>
<p>Quality (contamination)</p>	<p>This system suffers in terms of the quality of material that is collected. The biggest problem is the breakage of glass. This occurs when contents are tipped in the truck, compressed, and unloaded at the MRF. The inclusion of paper amongst the other recyclables reduces breakage but leads to contamination problems for the paper.¹³ Contaminated recyclables means additional disposal charges, reduced</p>

	amounts of material for sale, and lower prices received for the materials.
Participation Rates	Participation rates for all wheelie bin systems are generally higher than for any other system. This is due to the convenience the system affords the householder.
Diversion Rates	Wheelie bins systems have been shown to collect more material than other systems as collection rates increase as container size increases and with commingled systems. ¹⁴ However, depending on the variation used, diversion rates are not as high as participation rates. This is due the relatively high levels of contamination generated by wheeled bin systems ¹⁵ .
Frequency	Wheelie bins systems have the ability to be collected fortnightly or weekly depending on what is being collected. The 240 litre bins in particular are large enough to accommodate 2 weeks worth of recycling. Studies indicate a small (12%) decrease in recyclables from a fortnightly collection ¹⁶
Effect of receptacle size and features	The larger size of the wheelie bin encourages householders to put out more material, but there are sometimes issues with contamination. The large size also allows for fortnightly collections ¹⁷ . Wheelie bins are not the most user friendly option in all situations, for example on steep streets, houses with steps, or for elderly or infirm people. ¹⁸
Health and Safety	The wheels on the bins mean householders do not have to lift the bins, avoiding potential back strains. The lid keeps odours in and vermin out. The mechanical arm system minimises risks during collection. ¹⁹ MRFs have to address a number of health and safety issues.
Examples	Concord, Shellharbour, and Ryde New South Wales ²⁰

Key features.

- High capital cost and infrastructure requirements
- Efficient collection
- High participation rates
- Flexibility of materials collected
- Avoids many health and safety issues compared to manual systems

Wheelie Bin – Commingled Systems

Brief Description	In commingled systems householders are provided with a single wheeled bin, most commonly a 120 litre, in which they place all of their recyclables. The wheelie bin is placed at the kerb for collection by a compactor truck (usually with a mechanical arm). Material collected is taken to an MRF for sorting. Rubbish is put out in a separate bag or container
Capital Cost	Capital costs are high. Wholesale prices for wheelie bins are approximately \$50 each. Compactor trucks with mechanical arms cost in the vicinity of \$250,000, and a large scale MRF can cost upwards of \$1 million.
Operating Cost	These systems are generally considered to have relatively low operating costs, however payback on capital, and equipment maintenance may largely negate this. Crew size is minimised if a mechanical arm is used. The mechanical arms on the trucks afford speedy pickup, and collection times are substantially reduced over manual systems. Because material has to be sorted at a MRF, double handling occurs which is an inefficiency, however a MRF is a very efficient method of separating large quantities of material.
Vehicle Requirements	Single operator compactor trucks with mechanical lift arms.
Sorting requirements	Requires MRF. Minimal household sorting.
Education Requirements	Education requirements are relatively light. Householders have to correctly identify items that can be recycled and place these in the container but no further separation is necessary
Range of Materials	A wide range of materials can be collected by this system as the containers are large and material is sorted at an MRF. Materials commonly collected include paper, glass, steel cans, aluminium cans, and plastic bottles.
Versatility (expandability)	The system is capable of being easily expanded to take a wider variety of materials. Because materials are sorted at an MRF, the MRF can easily pick out additional materials with little disruption to the system. ²¹ Additional education is required to get householders to separate out the correct materials.
Quality (contamination)	This system suffers in terms of the quality of material that is collected. The biggest problem is the breakage of glass, which occurs when contents are tipped in the truck, compressed, and unloaded at the MRF. The inclusion of paper amongst the recyclables reduces breakage but leads to contamination problems for the paper. ²² Contaminated recyclables means additional disposal charges, reduced amounts of material for sale and lower prices received for the materials.
Participation Rates	Participation rates for all wheelie bin systems are generally higher than for any other system. This is due to the convenience the system affords the householder.
Diversion Rates	Wheelie bins systems have been shown to collect more material than other systems as collection rates increase as container size increases and with commingled systems. ²³ However, depending on the variation used, diversion rates are not as high as participation rates. This is due to the relatively high levels of contamination generated by wheeled bin

	systems. ²⁴
Frequency	Wheelie bins systems have the ability to be collected fortnightly or weekly. The 120 litre bin is large enough to accommodate 2 weeks worth of recycling.
Effect of receptacle size and features	The larger size of the wheelie bin encourages householders to put out more material ²⁵ , but there are sometimes issues with contamination. The large size also allows for fortnightly collections
Health and Safety	The wheels on the bins mean householders do not have to lift the bins, avoiding potential back strains. The lid keeps odours in and vermin out. The mechanical arm system minimises risks during collection. ²⁶ MRFs have to address a number of health and safety issues.
Examples	Baulkham Hills and Ku-ring-gai New South Wales

Key features.

- High capital cost and infrastructure requirements
- Efficient collection
- High participation rates
- Flexibility of materials collected
- Avoids many health and safety issues compared to manual systems

Wheelie Bin – Multi Bin Systems

Brief Description	In multi bin systems, householders are provided with two or more bins (most commonly a 120 litre). They are asked to put different recyclable materials in each bin (a 2 bin system with one for paper and another for commingled containers is a common variant). The wheelie bins are placed at the kerb for collection by a compactor truck (usually with a mechanical arm). Multibin systems are often operated with alternating fortnightly collections for the different types of material. Material collected is taken to an MRF for sorting. Rubbish is put in a separate bag or container.
Capital Cost	Capital costs are high. Wholesale prices for 120 litre wheelie bins are approximately \$40 each. Compactor trucks with mechanical arms cost in the vicinity of \$250,000, and a large scale MRF can cost upwards of \$1 million.
Operating Cost	These systems are generally considered to have relatively low operating costs, however payback on capital, and equipment maintenance may largely negate this. The mechanical arms on the trucks afford speedy pickup and collection times are substantially reduced over manual systems. The use of mechanical arms allows for single person crews. Because material has to be sorted at a MRF, double handling occurs, which is an inefficiency, however a MRF is a very efficient method of separating large quantities of material.
Vehicle Requirements	Single operator compactor trucks with mechanical lift arms.
Sorting requirements	Requires MRF. Some household sorting.
Education Requirements	A higher level of education is required by multibin systems. Householders have to correctly identify items that can be recycled and place these in the correct container. Fortnightly collection adds a further complication.
Range of Materials	A wide range of materials can be collected by this system as the containers are large and material is sorted at an MRF. Materials commonly collected include paper, glass, tin cans, aluminium cans, and plastic bottles.
Versatility (expandability)	The system is capable of being expanded to take a wider variety of materials. Because the commingled streams are sorted at a MRF, the MRF can easily pick out additional materials with little disruption to the system. Additional education is required to get householders to separate out the correct materials. If substantially different streams are to be added (such as organic waste), further bins would be required.
Quality (contamination)	This system suffers in terms of the quality of material that is collected. The biggest problem is the breakage of glass, which occurs when contents are tipped in the truck, compressed and unloaded at the MRF. ²⁷ Contaminated recyclables means additional disposal charges, reduced amounts of material for sale, and lower prices received for the materials.
Participation Rates	Participation rates for all wheelie bin systems are generally higher than for any other system. This is due to the convenience the system affords the householder.
Diversion Rates	Wheelie bins systems have been shown to collect more material than other systems as collection rates increase as container size increases

	and with commingled systems. ²⁸ However, depending on the variation used, diversion rates are not as high as participation rates. This is due to the relatively high levels of contamination generated by wheeled bin systems. ²⁹
Frequency	Wheelie bins systems have the ability to be collected fortnightly or weekly. The 120 litre bin based systems are large enough to accommodate 2 weeks worth of recycling.
Effect of receptacle size and features	The larger size of the wheelie bin encourages householders to put out more material ³⁰ , but there are sometimes issues with contamination. The large size also allows for fortnightly collections.
Health and Safety	The wheels on the bins mean householders do not have to lift the bins, avoiding potential back strains. The lid keeps odours in and vermin out. The mechanical arm system minimises risks during collection. MRFs have to address a number of health and safety issues. ³¹
Examples	Hunters Hill New South Wales

Key features.

- High capital cost and infrastructure requirements
- Efficient collection
- High participation rates
- High education requirement
- Flexibility of materials collected
- Avoids many health and safety issues compared to manual systems

Open Bin – Kerbside and Truck Sorting Systems

Brief Description	Householders are provided with an open topped recycling crate (some crate designs have a removable lid), usually between 34 litres and 60 litres in size. Commingled recyclables are placed in the crate, and the crate placed on the kerb for collection. Collectors manually pick up the bins and either sort directly from the crate into compartments on a specially designed truck, or truck and trailer, or tip the contents of the bin into a sorting tray on the truck where the material is manually sorted as the vehicle moves along. If material has been fully sorted it can be baled and processed upon discharge. Some systems sort certain items at the kerb (e.g. glass) and sort other items such as plastic at a small MRF. Rubbish is put in a separate bag or container and collected separately.
Capital Cost	Capital costs are reasonably low. Wholesale prices for recycling crates are between \$6 and \$9 each. Specially designed non-compactor trucks are around \$150,000.
Operating Cost	Operating costs are generally high in terms of the collection. The sorting into different categories makes compaction difficult and this means trucks fill up quickly and must make periodic trips to base to discharge their loads. Collection is also time consuming as it is manual and sorting is taking place simultaneously. Efficiencies are gained however in avoidance of double handling and the need for a large scale MRF.
Vehicle Requirements	Multi operator, multi compartment trucks, sometimes with multi compartment trailers.
Sorting requirements	Some household sorting is required. No MRF or only small MRFs are required as most sorting is done at kerbside.
Education Requirements	Education requirements are relatively light. Householders have to correctly identify items that can be recycled and place these in the container but no further separation is necessary
Range of Materials	Materials commonly collected include paper, glass, tin cans, aluminium cans, and plastic bottles. The range of materials that can be collected is limited by the size of the trucks and the number of compartments.
Versatility (expandability)	Most variants of the system cannot be easily expanded to take more material types as this would require modifications to the truck, and retraining of staff. In addition, the recycling crates are usually close to capacity when put out by households and the addition of materials could in some cases overload the capacity. Additional education is required to get householders to separate out the new materials.
Quality (contamination)	It is generally recognised that kerbside sorting systems produce the highest quality of recyclable material. ³² The operators doing the sorting are professionals and are able to correctly identify materials to a high degree of accuracy compared to householders. Breakages of glass can be avoided, and materials that are not recyclable can be left in householder's bins (sometimes together with a sticker or note) as a further education tool.
Participation Rates	Participation rates for crate systems are generally high. ³³
Diversion Rates	Diversion rates for crate systems show up as being lower than wheelie bin systems in terms of total volumes collected. However, when

	quality issues are taken into account the amount of materials making it to the end processors are not significantly different. ³⁴
Frequency	A typical household generates between 40 and 60 litres a week of recyclable material (including paper) ³⁵ . The size of most crates used means that a typical household will fill one up in a week, restricting the frequency to weekly.
Effect of receptacle size and features	Larger crate sizes encourage more recycling ³⁶ but this effect is not considered as significant as the effect of the size of the refuse receptacle (the larger the refuse bin the less recyclables) ³⁷ . Lidded bins keep out moisture and vermin and prevent windblown material.
Health and Safety	The weight of the full recycling crates is not usually sufficient to present health and safety issues to householders. A full crate of glass bottles is the possible exception, although less than 1% of loads weigh over 10kg. Collection operators, however, face a number of health and safety issues. These include working on the road, bending to lift, lifting and carrying heavy loads, and sorting of sharp materials (glass, tin). ³⁸
Examples	Waitakere City

Key features.

- Low capital cost and infrastructure requirements
- Time intensive collection
- Moderate participation rates
- Good recovered material quality
- Difficult to add new materials to the collection
- Moderate education requirement

Open Bin – Commingled Systems

Brief Description	Householders are provided with an open topped recycling crate (some crate designs have a removable lid) usually between 34 litres and 60 litres in size. Commingled recyclables are placed in the crate, and the crate placed on the kerb for collection. Collectors manually pick up the crate and tip the contents of the bin into the truck. A compactor truck is often used, applying light compaction to avoid breakages. Material is taken to an MRF for sorting. Rubbish is put in a separate bag or container and collected separately.
Capital Cost	Capital costs are relatively low. Wholesale prices for recycling crates are between \$6 and \$9 each. Compactor trucks are around \$200,000. A MRF capable of handling a fully commingled stream would be required.
Operating Cost	Collection costs are low relative to kerbside sorting systems. Collection is time consuming as it is manual, ³⁹ but compaction allows extended runs. The requirement for material to be processed at a MRF adds further operating costs.
Vehicle Requirements	Multi operator, back loading compactor trucks.
Sorting requirements	Some household sorting is required. A reasonably large scale MRF is required.
Education Requirements	Education requirements are relatively light. Householders have to correctly identify items that can be recycled and place these in the container but no further separation is necessary
Range of Materials	Materials commonly collected include paper, glass, tin cans, aluminium cans, and plastic bottles. The range of materials that can be collected is limited mostly by the size of the crates.
Versatility (expandability)	This system can be expanded to take wider variety of materials. Because materials are sorted at an MRF, the MRF can easily pick out additional materials with little disruption to the system. ⁴⁰ Additional education is required to get householders to separate out the correct materials. However, the recycling crates are usually close to capacity when put out by households and the addition of materials could in some cases overload the capacity. Additional education is required to get householders to separate out the new materials.
Quality (contamination)	This system suffers in terms of the quality of material that is collected. The biggest problem is the breakage of glass, which occurs when contents are tipped in the truck, compressed, and unloaded at the MRF. The inclusion of paper amongst the recyclables reduces breakage but leads to contamination problems for the paper ⁴¹ . Materials that are not recyclable can be left in householders' bins (sometimes together with a sticker or note) as a further education tool. Contaminated recyclables means additional disposal charges, reduced amounts of material for sale, and lower prices received for the materials.
Participation Rates	Participation rates for crate systems are generally high. ⁴²
Diversion Rates	Diversion rates for crate systems show up as being lower than wheelie bin systems in terms of total volumes collected. ⁴³

Frequency	A typical household generates between 40 and 60 litres a week of recyclable material (including paper) ⁴⁴ . The size of most crates used means that a typical household will fill one up in a week, restricting the frequency to weekly.
Effect of receptacle size and features	Larger crate sizes encourage more recycling ⁴⁵ but this effect is not considered as significant as the effect of the size of the refuse receptacle (the larger the refuse bin the less recyclables) ⁴⁶ . Lidded bins keep out moisture and vermin and prevent windblown material.
Health and Safety	The weight of the full recycling crates is not usually sufficient to present health and safety issues to householders. A full crate of glass bottles is the possible exception, although less than 1% of loads weigh over 10kg. Collection operators, however, face a number of health and safety issues. These include working on the road, bending to lift, lifting and carrying heavy loads, and sorting of sharp materials (glass, tin). ⁴⁷
Examples	Melbourne

Key features.

- Moderate capital cost and infrastructure requirements
- Relatively efficient collection
- Moderate participation rates
- Moderate recovered material quality
- Relatively easy to add new materials to the collection
- Moderate education requirement

Open Bin – Multi Bin Systems

Brief Description	Householders are provided with two or more open topped recycling crates, usually between 34 litres and 60 litres in size. A common feature is for the crates to be stackable. Source separated recyclables are placed in the crates. There are a number of variations on the system. Paper is commonly separated, as is glass. The crates are placed on the kerb for manual collection. The bins are usually sorted directly from the crate into compartments on a specially designed truck or truck and trailer. If material has been fully sorted it can be baled and processed upon discharge. Some systems sort certain items at the kerb (e.g. glass) and sort other items such as plastic at a small MRF. Rubbish is put in a separate bag or container and collected separately.
Capital Cost	Capital costs are reasonably low. Wholesale prices for recycling crates are between \$6 and \$9 each. Specially designed non-compactor trucks are around \$150,000.
Operating Cost	Operating costs are generally high in terms of the collection. The sorting into different categories makes compaction difficult and this means trucks fill up quickly and must make periodic trips to base to discharge their loads. Collection is also time consuming as it is manual, although the multi bin system reduces sorting time compared to other kerbside sort systems. Efficiencies are gained in avoidance of double handling and the need for a large scale MRF. Multi-crate systems lend themselves to fortnightly collections, which can reduce collection costs.
Vehicle Requirements	Multi operator, multi compartment trucks, sometimes with multi compartment trailers.
Sorting requirements	A reasonably high degree of household sorting is required. No MRF or only small MRFs are required as most sorting is done at kerbside.
Education Requirements	A higher level of education is required by multibin systems. Householders have to correctly identify items that can be recycled and place these in the correct container. If the collection is fortnightly this adds a further complication
Range of Materials	Materials commonly collected include paper, glass, tin cans, aluminium cans, and plastic bottles. The number of bins, the size of the trucks, and the number of compartments limit the range of materials that can be collected.
Versatility (expandability)	Most variants of the system cannot be easily expanded to take more materials as this would require additional bins, modifications to the truck, and retraining of staff. Additional education is required to get householders to separate out the new materials.
Quality (contamination)	It is generally recognised that kerbside sorting systems produce the highest quality of recyclable material. ⁴⁸ Breakages of glass can be avoided, and materials that are not recyclable can be left in householders' bins (sometimes together with a sticker or note) as a further education tool.
Participation Rates	Participation rates for multi-crate systems are lower than other crate systems ⁴⁹ due to perceived inconvenience and added requirements for the householders.

<p>Diversion Rates</p>	<p>Diversion rates for crate systems show up as being lower than wheelie bin systems in terms of total volumes collected. However, when quality issues are taken into account the amount of materials making it to the end processors are not significantly different⁵⁰.</p>
<p>Frequency</p>	<p>A typical household generates between 40 and 60 litres a week of recyclable material (including paper)⁵¹. Most multi-crate systems would have a total capacity of 80-120 litres, which means that they lend themselves to fortnightly collections or collections of materials on alternate weeks. Fortnightly collections can reduce collection costs</p>
<p>Effect of receptacle size and features</p>	<p>Colour coded crates assist in household separation. Stackable crates assist in storage.</p>
<p>Health and Safety</p>	<p>The weight of full recycling crates is not usually enough to present health and safety issues to householders. A full crate of glass bottles is the possible exception, although less than 1% of loads weigh over 10kg. Collection operators however face a number of health and safety issues. These include working on the road, bending to lift, lifting and carrying heavy loads, and sorting of sharp materials (glass, tin).⁵²</p>
<p>Examples</p>	<p>Drummoyne, Sydney</p>

Key features.

- Low capital cost and infrastructure requirements
- Time intensive collection
- Moderate participation rates
- Good recovered material quality
- Difficult to add new materials to the collection
- High education requirement

Bag Systems – Reusable bag

Brief Description	Householders are provided with a woven polypropylene sack or similar, usually between 40 litres and 60 litres in size. Commingled recyclables are placed in the bag, and the bag placed on the kerb for collection. Collectors manually pick up the bags and tip the contents of the bag into a sorting tray on the truck where the material is manually sorted as the vehicle moves along, or tip the contents into a truck for later sorting at a MRF. If material has been fully sorted it can be baled and processed upon discharge. Rubbish is put in a separate bag or container and collected separately.
Capital Cost	Capital costs are low. Wholesale prices for bags are less than \$1 each. Specially designed non-compactor trucks are around \$150,000 new. Compactor trucks cost a similar amount
Operating Cost	Operating costs are relatively low in terms of the collection. Collection is time consuming as it is manual, but compaction can allow extended runs. If material is not sorted on the truck the requirement for material to be processed at a MRF adds further operating costs. Bags, although cheap to buy, require a high level of replacement and this must be factored into the operating cost.
Vehicle Requirements	Multi operator, back loading compactor trucks, or specially designed multi compartment trucks.
Sorting requirements	Some household sorting is required. A reasonably large scale MRF may be required.
Education Requirements	Education requirements are relatively light. Householders have to correctly identify items that can be recycled and place these in the bag but no further separation is necessary
Range of Materials	Materials commonly collected include paper, glass, tin cans, aluminium cans, and plastic bottles.
Versatility (expandability)	If materials are sorted at a MRF this system can be expanded to take a wider variety of materials. Additional education is required to get householders to separate out the correct materials.
Quality (contamination)	This system suffers in terms of the quality of material that is collected. The biggest problem is the breakage of glass, which occurs when contents are tipped in the truck, compressed, and unloaded at the MRF. The inclusion of paper amongst the recyclables reduces breakage but leads to contamination problems for the paper.
Participation Rates	Participation rates for bag systems are usually the lowest of the different types of systems looked at in this report. ⁵³ This is because the bags are seen to be less convenient by householders.
Diversion Rates	The low participation rate is also reflected in a low diversion rate.
Frequency	A typical household generates between 40 and 60 litres a week of recyclable material (including paper). The size of most bags used means that a typical household will fill one up in a week, restricting the frequency to weekly unless more than one bag is issued to households.
Effect of receptacle	The flexible nature of the bags and their relative impermanence make them less user friendly and less valued by households. Studies show

size and features	that the provision of bags can actually decrease the amount of recyclables collected compared to providing no container. ⁵⁴ As new bags can be issued on a regular basis this provides the opportunity to print recycling messages and educational material on the bags.
Health and Safety	The weight of the full recycling bags is not usually enough to present health and safety issues to householders. Collection operators, however, face a number of health and safety issues. These include working on the road, bending to lift, lifting and carrying heavy loads, and sorting of sharp materials (glass, tin). ⁵⁵
Examples	Amberly

Key features.

- Low to moderate capital cost and infrastructure requirements
- High to moderate collection times
- Low participation rates
- Good recovered material quality
- Moderate education requirement

Bag Systems – Disposable Bag

Brief Description	Householders are not provided with any receptacles but are asked to place separated recyclables into plastic shopping bags or the like and tie off the tops before placing on the kerb for collection. The operator collects the bags at kerbside, and places them in a truck, either compactor or non-compactor. Sometimes the glass bottles are separated out at the kerb to avoid breakages. The collected material, still in its bags, is taken back to a MRF for sorting. As most of the sorting has been done at the household, contamination levels are reasonably low and sorting is more efficient. Rubbish is put in a separate bag or container and collected separately.
Capital Cost	Capital costs are reasonably low. There are no bag or bin costs. Compactor trucks are around \$200,000. A MRF is required for sorting.
Operating Cost	Operating costs are reasonably low. Collection is manual but as no or minimal sorting is done at kerbside it is relatively efficient. Material can be compacted which increases the length of runs. Substantial household sorting means sorting at the MRF is relatively efficient and the quality of material high.
Vehicle Requirements	Multi operator, standard compactor trucks.
Sorting requirements	A high degree of household sorting is required. Only small MRFs are required as most sorting is done by the household.
Education Requirements	A high level of education is required by this system. Householders have to correctly identify items that can be recycled and place these in separate bags.
Range of Materials	Materials commonly collected include paper, glass, tin cans, aluminium cans, and plastic bottles. The range of materials that can be taken is limited mostly by the education requirements for households.
Versatility (expandability)	The system can be expanded to include new materials but it is limited primarily by what householders can be educated to separate.
Quality (contamination)	The quality of materials achieved by this system is considered to be high. Those who participate generally take the trouble to do it properly. The system does not allow for feedback to residents who sort incorrectly as bags are not opened at kerbside.
Participation Rates	Participation rates for bag systems are among the lowest looked at in this study. ⁵⁶ This is because of the extra effort required of the householder wishing to participate.
Diversion Rates	Because participation rates are low, overall diversion rates are low as well. ⁵⁷
Frequency	Weekly collections are recommended, as householders do not have a convenient receptacle to store their recycling in while it awaits collection. Fortnightly or longer collection periods will tend to reduce participation and diversion rates further.
Effect of receptacle size and features	N/A
Health and Safety	Broken glass or sharp tin cans could present a hazard to householders or collection operators when handling the bags. Collection operators

	face a number of additional health and safety issues. These include working on the road, bending to lift, and lifting and carrying heavy loads. ⁵⁸
Examples	Napier

Key features.

- Very low capital cost and infrastructure requirements
- Time intensive collection
- Low participation rates
- Good recovered material quality
- High education requirement

Discussion

The important point to note arising from this report is that there is no one single 'best' system. All systems appear to have their advantages and disadvantages and it is clear that whichever system works best in a given situation depends on a range of factors.

It would appear that wheelie bin type systems and commingled systems have the highest participation rates and generate the highest volumes of material collected for recycling, but that these systems generally suffer in terms of the quality of materials and their relatively high capital requirements and servicing costs. By contrast, systems that require a higher level of household and kerbside sorting don't collect as high volumes of material. This is compensated for in the quality of material they collect. These systems have higher labour costs and tend to require a greater degree of education to maintain them.

In general, larger centres, which have to collect and process large volumes of material over a wide area, tend to favour systems with a high level of collection efficiency, while small centres seem to favour systems with a greater degree of household and kerbside separation.

It should be noted that there are a great many variations on the basic types of systems outlined in this report. Some of these variations may give rise to different operational characteristics than those noted here. In addition, there will always be exceptions to the rule – one particular operator or council may be able to make a system work well, where others in similar circumstances have struggled.

Appendices

New Zealand examples

North Shore City

North Shore City Council's waste management system incorporates both rates funded and user-pays activities. The cost of waste management in North Shore City is \$4.1 million dollars, or \$68 for each of the 60,498 households in the City. The refuse collection is operated on a user-pays basis, while recycling is funded from the Uniform Annual Charge for refuse and recycling. Residents pay \$1 for an official sticker to affix to each bag (no larger than 60 L) they put out, or pay \$1.30 at the local supermarket for an official bag. Council discourages the use of Mobile Garbage Bins (MGBs), which are collected by private contractors, but at present has no way of enforcing its policy against them.

As the first council in New Zealand to introduce a kerbside recycling scheme, in October 1990, North Shore City has been rewarded with a 40% decrease in landfilled refuse. Since the Council has user-pays refuse collection for both domestic and commercial waste, and does not own any landfills (Rosedale Landfill is operated by EnviroWaste), this does not correspond to any financial savings, but Council is still taking steps to continue to reduce waste. For example, in 1999 Council investigated the possible reduction that could be attained by recovering the organic waste component from the waste stream. The Council has also recently implemented an in-house recycling system. Paper, cardboard, and the recyclables collected in the normal Council collection are all included. The Council is also investigating the possibility of purchasing recycled materials (including paper) and the viability of a double-sided printer.

North Shore City Council also undertakes communication and community education on waste management issues in the City. It was the first Council in the Auckland region to put in place a program for the promotion of home composting.

Illegal dumping is not such an issue on the North Shore. In fact, there are no major problems of any sort with waste management in the City (as compared to other local authorities). Perhaps the biggest issue is the proportion of organic waste in the waste stream (27% of the total or 48% of the household collection), although this is being dealt with. The biggest success has been the kerbside recycling collection, its impact on the amount of waste being landfilled, and its assimilation into the routine of most North Shore residents (almost certainly due to the fact that it has been around for 10 years). Green bins lining North Shore streets are testament to residents' willingness to sort their rubbish into refuse and recycling at the source.

Auckland City

Auckland City Council has the most expensive waste management system of the Councils covered in this report - \$14 million in total or \$115 for each of

the 121,752 households. Approximately \$4.5 million of this was in landfill fees, \$1 million was spent on the recyclables collection, and the annual inorganic collection cost \$1.6 million. This was entirely covered by rates.

Auckland City provides a good example of a failed initiative - the introduction of MGBs (Mobile Garbage Bins) saw a huge increase in domestic waste. Auckland City residents, with rates-funded MGBs, produce twice as much waste as North Shore residents (with a user-pays bag collection). However, to do it justice, the City does aim to halve its waste to landfill by 2003, targeting businesses and households equally. This target is based on 1996/7 figures of 7.1 tonnes per business per annum and 750 kg per household per annum. Illegal dumping is not a major problem in Auckland, but definitely occurs, costing Council something in the order of tens of thousands of dollars a year. Litter and street sweeping amounts to approximately 8,500 tonnes each year.

The refuse and recyclable collections are *managed* by Council but subcontracted out to private companies (apart from the paper and cardboard collection), which means that Council has access to statistics associated with collection. The City is currently investigating alternative options for dealing with inorganic waste. At this stage it is looking into providing seed funding for the development of a Resource Recovery Estate and discontinuing the annual inorganic collection. Auckland City Council is also looking at applying a levy to fund waste minimisation education and promotions. User-pays refuse collection is expected to be in place by 2003, and a levy charged to all ratepayers will continue to fund the recyclables collection.

Like the other Councils in the Auckland Region, Auckland City does not own or operate a solid waste disposal facility. The transfer station and composting operation at Pikes Point in Onehunga is the only facility within the City boundaries.

Palmerston North City

Palmerston North places emphasis on the 'waste management hierarchy' as a structure. Reduction is achieved through education, policy change, and a waste minimisation levy. Reuse, recycling, and recovery are lumped together, with expanded kerbside recyclable collections, the operation of drop off recycling centres, the provision of incentives for diversion of recyclables from commercial reuse, and the establishment and operation of a materials recovery facility (if proved feasible). Composting is included as a separate category: the options are the promotion of backyard composting, separated garden waste composting, composting of mixed urban waste and worm composting, with a discount being applied to landfill fees for separated garden waste. Council is also investigating long-term disposal options, due to the limited capacity of the existing landfill. The preferred option is a joint facility with other councils of the Manawatu-Wanganui region.

Perhaps the most interesting aspect of Palmerston North's waste management strategy is the recycling operations. At present, Council shares in the net returns from the kerbside recycling operation when net prices received for materials exceed the costs of collection process and sale, but also underwrites the net cost of recycling when market returns do not cover costs. Currently Council is receiving approximately \$120,000 a

year from the sale of recyclables; collection costs are almost \$400,000, which means a cost to Council of \$280,000. Originally the collection was intended to be self-funding.

Council operates a domestic refuse collection (52 official bags issued a year), a transfer station facility in Ashhurst, 2 recycling centres (in the City and at the landfill), a scrap metal drop off facility, as well as Awapuni landfill and the recyclables collection.

Council promotes cleaner production principles and waste reduction plans for businesses, and education material and information is provided to the public and schools. This educational material concentrates on recycling. There is potential for Council to improve their education program, especially through the extensive Council website. Wastewater services are described in great detail but there is only a fleeting mention of solid waste services.

A full cost recovery charging regime at the landfill (Awapuni, owned by Council) has been developed and implemented by Palmerston North City. This revenue, along with the \$40 per household uniform annual charge, pays for the entire waste management system.

Christchurch City

Christchurch has a similar bag system to Palmerston North - 52 bags are delivered to households in April each year. After the property has used these bags, they can buy them for \$4.25 for 5 bags from the local supermarket.

However, the council has a reuse centre at each of its 3 refuse stations; they accept recyclables and reusables free of charge. Council also has a garden waste facility, with 3 locations at which residents can drop off their green waste (thus saving up to 65% of their refuse station disposal charges).

The targets of the Christchurch City Council Solid Waste Management Plan are to reduce the rate per person of solid waste going to landfill by 14% by 2000, 30% by 2005, and by 100% by 2020 (or by the time the new regional landfill is filled). The Plan's key strategies are:

1. Grants of money, or advances, to be made for the purpose of the promotion or assistance of the reduction, recycling, recovery, treatment, or disposal of waste.
2. Bylaws to license operations (and evaluation).
3. Implementation of waste management will be ensured through regular evaluation.
4. Evaluation of international and national strategies, guidelines and practices, local use where suitable, and appropriate lobbying where necessary.
5. Implementation of environmental management programmes at waste related facilities controlled by the Council and support of such programmes in other organisations that deal with waste.
6. Regular review of waste management strategies.

The Council itself has an 'Environmental Policy Statement' (November 1997), which deals with the council's own activities, including the purchasing of recycled materials where possible.

Christchurch City Council's waste management budget is well set out, divided into the categories of the waste management hierarchy. Strategies to reduce waste (a commercial waste reduction program) cost \$400,000. The 3 Resource Reuse Centres cost \$250,000. Recycling is the most interesting - an income of \$230,000 - in terms of budget: \$1.76 million income from the kerbside collection, \$40,000 spent on information and publicity and \$1.48 million to the RMF. The Council compost facility and domestic composting promotion mean that \$560,000 is spent on recovery, and collection, transfer and disposal cost the City \$4.96 million in terms of residual treatment and disposal. The Council also spends \$160,000 on planning for waste management. This budget - which includes all salaries and overheads - comes to \$6 million dollars, or \$53 for each of the 114,000 households.

Christchurch City has probably the best example (of those covered) of a public education program, with brochures, posters, information to schools and an extensive section of their website (www.ccc.govt.nz/waste/) devoted to waste management. This is almost certainly helped by its involvement in 'Target Zero'. Council is developing a formal public education plan, with the focus on waste minimisation.

Christchurch City's recycling system is of interest; it has produced a hybrid of three management options. It uses a contractor, Onyx, to collect and sort the recyclable material. A Trust has been set up - the Christchurch Recovered Materials Foundation - *"to place itself between the public and private sectors assisting both to ensure that value is created from recycled materials and that industries' acceptance and use of these materials as a valuable feedstock is increased."* This Trust is funded by the Christchurch City Council, and its trustees include representatives from the Council, Canterbury Development Corporation, Canterbury Employers Chamber of Commerce, Canterbury Manufacturers Association, Sustainable Cities Trust, Clean Washington Centre (USA) and the New Zealand recycling industry. Most of the revenue from recycling operations goes back into the RMF, but this revenue was first generated by markets created by the RMF - an ever-increasing upwards spiral. The success of the scheme seems to be in the use of local markets. Christchurch's recycling system has been a great success, considering that not many council-owned recycling services make a profit (in fact there may be no other in New Zealand).

It appears that the refuse and recycling collection contractors work with rather than for Council, which helps Council to increase efficiency and improve its services. That is, Christchurch City Council manages operations (in a similar manner to Auckland City, although it appears that Christchurch has more control over its contractors) and subcontracts activities out.

Overseas examples

Guelph, Ontario, Canada

The wet/dry collection system used in Guelph has attracted a large amount of attention since its initial piloting in 1989. The system relies on household separation of the waste stream into two components – the wet, all material, such as food scraps, that is compostable – and the dry, all other material. The refuse

is placed into one of two transparent, colour-coded bags that are collected at kerbside.

The collection contractors use side-loading, two-compartment trucks to collect the wet and dry in a single pass. The 37 cubic yard trucks are split 25 percent for wet waste and 75 percent for dry waste. Independent compaction in the two compartments allow the dry side to receive half the compaction of the wet, producing less glass breakage.

At the MRF, the wet bags are opened and the material mixed with a bulking agent prior to being composted in a channel composting system. The dry refuse is manually sorted to recover recyclables prior to being landfilled.

The major success of the program is reflected in the high participation rate – 98% - and the high diversion from landfill rate. In 1997 the wet/dry recycling programme diverted 75% of wet waste and 45% of dry waste from landfill, with an overall diversion rate of 58%.¹

San Francisco

San Francisco initiated its kerbside recycling programme in 1989 and claims enthusiastic participation rates ever since. Given the high-population density, different containers were distributed for households and apartments. Residents of building with fewer than five units were given 50 litre bins for weekly collection of containers such as glass jars and bottles, cans, and plastic bottles. Mixed paper is put kerbside in either bags or tied with string. Apartment buildings with more than five units were supplied with a set of rolling carts – one colour for mixed paper and another for containers. This system regularly achieved a diversion rate of 20% of the domestic waste stream.

Despite this success, the city decided to trial several different systems in an effort to increase the diversion rate. One of the pilots involved giving residents 240 litre wheelie bins split into two compartments. One side was used for rubbish and the other for recyclables. The average amount of recyclables per drive-by collection increased by nearly one-fifth. Other pilots involved using split bins for collecting different combinations of organics, yard waste, and recyclables.

All of the pilots increased diversion rates. Further analysis will determine which system best balances diversion, cost, and residents' satisfaction. The final solution may be a hybrid of several systems, reflecting the city's range of geography and population densities.²

Chicago

In the early 1990s, several American cities, including Chicago, introduced the Blue Bag programme for collection of recyclables from residential buildings. The plan calls for residents to place their recyclable materials in blue plastic bags that are collected along with the rest of the waste stream by regular collection vehicles. All of the refuse is sorted at a MRF. The blue bags are removed from the waste stream, opened, and the recyclables separated. Other recyclable material is also separated from the waste stream.

¹ Roumpf, J 1998 Wet – and dry – all over, *Resource Recycling*, April 1998

² Assmann, D 1998 Making recycling collection more effective, *Resource Recycling*, September 1998

The system has the advantage that it is simple for the householder as only a single rubbish container needs to be put out. It allows simple and inexpensive collection as automated collection is possible, the system requires only a single vehicle pass, and no vehicle modification is required.

However, the system has a poor retrieval rate at the MRF with a substantial portion of bags either broken or not retrieved. Glass retrieval is low as compaction of glass results in breakage. Mingling of recyclables results in poor quality material that is difficult to recycle – paper contaminated with glass shards is especially problematic

Savings on collection costs gained by using a single compactor vehicle are offset by higher running costs of compactor vehicles compared to dedicated recycling collection vehicle. Processing costs of the recyclables are high compared to kerbside or at-source separation.

Baulkham Hills, Sydney

The Baulkham Hills council provides a weekly refuse collection for residents' 240 litre wheelie bins. A separate 240 litre bin is provided for recycling and is collected on a fortnightly basis. No green waste service is provided.

Recyclables are fully commingled in the bin. The council collects paper, glass, PET, HDPE, aluminium, steel, and paperboard. Waste audit results show that the recycling diversion rate is 26.8%.³

Concord, Sydney

The Concord council provides a weekly refuse/recycling service based on a divided 240 litre bin. One side of the bin is for refuse, the other for commingled recyclables. A separate 240 litre bin is provided for a fortnightly green waste collection.

The body of the collection vehicle is divided horizontally with the upper compartment for recyclables and the lower compartment for refuse. The recyclables compartment is not compacted. The bins are lifted mechanically by a remote-controlled hydraulic arm and the lids opened by a jet of water. As the recyclables compartment is above the refuse compartment, there is no cross-contamination of the recyclables.

The council accepts for recycling paper and cardboard, glass, PET, HDPE, PVC, aluminium, steel, and paperboard. The recycling diversion rate for Concord, excluding green waste, is 19.3%. Including green waste, the diversion rate is 63.3%. Green waste has the highest recovery rate at 93%, with glass 79%, PET 78%, and paper and cardboard 75%.⁴

Drummoyne, Sydney

The Drummoyne council provides a weekly refuse collection using 120 litre bins. The kerbside recycling programme uses two 55 litre crates per household, one red and one green. The council also provides a regular green waste collection.

³ North Sydney Waste Board, 1998, Best Practice Systems Study

⁴ North Sydney Waste Board, 1998, Best Practice Systems Study

The red recycling container is used for glass, PET, HDPE, and aluminium containers, and the green for paper and cardboard. The recycling crates are collected in alternate weeks.

The paper is collected in a compactor truck with a single bin lifter at the rear. The containers are collected in a truck with the body divided into compartments for glass, PET, and aluminium. When the PET compartment is full, the contents are emptied into a woolpack, which is left on the side of the road and collected later.

The recycling diversion rate for Drummoyne is 28.6%.⁵

North Sydney

The North Sydney Council provides residents with a 55 litre handbin for refuse, which is collected weekly. A 50 litre crate is provided for recyclables, which is also collected weekly. A fortnightly, on-call green waste collection is offered.

The recycling programme accepts paper, cardboard, glass, PET, HDPE, PVC, aluminium, and steel. The collection vehicles have segregated bodies for sorting recyclables at kerbside. The bodies are divided into compartments for green, clear, and brown glass, and paper. Woolpacks hanging from the rear of the truck are used to collect PET, aluminium and steel cans and plastic bags.

The recycling diversion rate in North Sydney is 45.2%.⁶

Ryde, Sydney

The Ryde council provides residents with a 240 litre bin for refuse which is collected weekly. A 240 litre bin for recyclables, divided for paper and containers, is collected fortnightly.

The recycling programme collects paper, glass, PET, HDPE, aluminium, steel, and paperboard. The recycling collection vehicle is divided into horizontal compartments. The material in both is lightly compacted, with the lower paper compartment receiving a higher degree of compaction.

The recycling diversion rate for Ryde is 22.1%.⁷

Ku-ring-gai, Sydney

On a trial basis, the Ku-ring-gai council provided a portion of its residents with a 340 litre bin for refuse, which was collected weekly, a 240 litre bin for commingled recyclables, and a 50 litre crate for glass.

The commingled bin was used for paper, PET, HDPE, and aluminium. The vehicle used for collection was equipped with a hydraulic arm and a paddle packer mechanism for compaction. The glass collection truck was divided into three compartments for different coloured glass.

The recycling diversion rate for the trial system was 21.6%.⁸

⁵ North Sydney Waste Board, 1998, Best Practice Systems Study

⁶ North Sydney Waste Board, 1998, Best Practice Systems Study

⁷ North Sydney Waste Board, 1998, Best Practice Systems Study

⁸ North Sydney Waste Board, 1998, Best Practice Systems Study

Seattle, Washington

Seattle provides a weekly refuse collection service. Residents are offered a choice of five different sizes of refuse containers. Green waste is banned from refuse containers and a fortnightly collection is offered. Residents may use either a 120 litre container for green waste or put out tied bundles. A wheeled cart is provided for containers and paper and a 55 litre bin for glass. Recycling containers are collected in alternate weeks.

Overall, Seattle has achieved a 48.5% recycling rate for its residential waste stream.⁹

Olympia, Washington

Olympia, Washington switched from weekly to biweekly collection of refuse in 1998 when the volume of refuse put out no longer justified weekly collection. This reduction in volume was achieved through earlier introduction of a pay-as-you-throw system, in which the second refuse container was charged at twice the rate of the first container, and then an expanded recycling programme and a green waste collection.

Previously, residents opting for weekly refuse collection were given a 120 litre MGB, those wishing biweekly collection had a choice of 240- or 120- litre MGBs. The council moved to biweekly refuse collection after the introduction of 350-litre carts for green waste. Refuse is now collected one week, and recyclables and green waste the next.

The kerbside recycling programme is based on split 240-litre bins, with one side used for paper and the other for containers. Collection vehicles are semi-automated, with vertically split compartments for the different recyclables collected.

Olympia has an overall recycling rate of 50%.¹⁰

⁹ Available online at www.cityofseattle.net/util

¹⁰ PAYT Leads Olympia to Decreased Collection Frequency, *BioCycle*, December 1998

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