WALGA

MUNICIPAL WASTE ADVISORY COUNCIL
"Getting the Environment Right"

Municipal Waste Advisory Council
Battery Collection Study
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Prepared on behalf of the Waste Management Board under Strategic Waste Initiatives Funding

Executive Summary

Special management practices for household batteries are gaining acceptance as a desirable enhancement to traditional waste management systems. This is generally based on the desire to limit either direct environmental impacts caused by pollution resulting from the waste disposal practices or the upstream environmental impacts caused by the production and distribution process. In Western Australia, 18 million household batteries are disposed of annually. Currently, no comprehensive collection strategy or legislation for these batteries has been developed.

Understanding this, the Municipal Waste Advisory Council gained funding under the Strategic Waste Initiatives Scheme (SWIS) from the Waste Management Board of Western Australia to investigate models for reducing the disposal of consumer batteries to general household waste and for collecting consumer batteries for specialised disposal and/or recycling.

The key objectives of the study were:

- To minimise the disposal of untreated consumer batteries to landfill; and/or
- To minimise interference by consumer batteries with resource recovery operations; and/or
- To minimise the resource consumption associated with consumer batteries.

The study addressed these key objectives using two different strategies. The first, undertaken in this paper, researched models for the collection of consumer batteries to develop a set of recommendations on the best collection models. The second strategy focused upon avoidance as a method for reduction in the consumption and hence disposal of household batteries into general household waste; this strategy is addressed separately in the accompanying *Battery Avoidance Strategies* paper.

It was found that household batteries have a number of potential impacts when disposed of into general household waste. These are: contamination in landfill; interference with alternative waste treatment and secondary resource recovery operations; and upstream environmental impacts associated with a failure to recover the materials in used batteries.

Programs to divert batteries from general household waste have been piecemeal to date in Western Australia. Several Regional Councils have started collection programs through the schools in their region with a view to disposing of the batteries with increased safeguards against environmental impacts. Traditionally recycling of batteries in Australia has been considered too expensive and commercially unviable. Some rechargeable batteries are collected and sent to the facility in France (SNAM) for recycling but it is estimated that this currently diverts only a small amount.

A survey of community attitudes found that almost all respondents would be interested in disposing of their batteries separately to their normal household waste. Despite this, at least 80% still disposed of their batteries into general household waste. This suggests a willingness in the community to recycle batteries but a lack of opportunity, or ease, to do so.

To explore possible models for the collection of household batteries the main collection systems for waste and recyclables operating nationally and intenationally were reviewed. They are: kerbside collection; vergeside collection, institution collection programs, retailer take-back schemes, public amenity sites, periodic collection days at temporary sites; permanent collection facilities; pay-as-you-throw; and on demand service with a mobile collection vehicle. Each of the collection models were then assessed in a multi-criteria analysis against the following criteria: efficiency; equity; education; practicality; cost; participation; convenience; and sorting.

In the multi-criteria analysis, institution collection programs and retailer-take-back schemes were found to be the most appropriate for the collection of batteries in Western Australia. This was reinforced by the use of institutional collection programs by some metropolitan Regional Councils. There are also retailer-take-back schemes that a battery collection model could build upon in Western Australia such as the MobileMuster program and Printer Cartridge recycling by PlanetArk.

In the long term, when recycling of household batteries may become operationally feasible in Australia, it may be appropriate to explore other collection models such as kerbside; which were found to have a higher collection rate but at a higher cost. In the short term, in the absence of legislation and a wider structure for the collection of household batteries it was found that avoidance may be a more appropriate strategy to pursue. Methods of reducing battery consumption are explored in the accompanying paper *Battery Avoidance Strategies.*

Recommendations

SHORT TERM

1. That the State Government works with Regional Councils to further develop and expand the current Institutional Collection programs, providing administrative support through the WasteWise Schools program.

2. In the absence of any specific legislation or structure for the collection of household batteries, that the State Government pursues a policy of reducing the consumption of household batteries through avoidance.

3. That the State Government undertakes a lifecycle assessment of the impacts of battery recycling and disposal. This should include further research into the impacts of household batteries in landfill and justification for their removal, as well as, the potential lost resources from a failure to recycle used battery constituents.

MEDIUM TERM

4. That any battery collection model adopted in Western Australia be a part of a wider system for the collection of other wastes or build upon existing collection frameworks. This will assist in minimising the costs of collection.

5. That a working group of State and Local Government; battery retailers/manufacturers/exporters; relevant WA industries; and recycling companies; be formed to explore options for market development for recycled battery materials in Western Australia.

6. That the State Government enter into negotiations with battery retailers/manufacturers to develop a Product Stewardship Scheme for the collection of household batteries; most likely through a Retailer Take Back Scheme. And that if negotiations fail to produce a scheme or the scheme is unsuccessful in achieving its targets, that an Extended Producer Responsibility (EPR) Scheme be developed under the powers of the potential Waste Avoidance and Resource Recovery (WARR) Act.

7. That the State Government utilises a number of collection methods for household batteries. This could be done by facilitating different Regional Councils/Local Governments to establish collection methods which are suitable to their area and waste collection infrastructure.

8. That the State Government develops a state-wide, overarching promotional strategy which can be used to compliment any battery collection model. The education campaign should focus upon the environmental impacts of incorrect disposal and fit into a general education campaign on recycling.

LONG TERM

9. Depending upon the outcome of both the lifecycle analysis of collecting and recycling batteries, their impact in landfill, and negotiations in establishing a local market for household batteries, the State Government should seek to establish future legislation for the collection of batteries and their potential diversion from landfill.

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1. Introduction

1.1 Background to Study

In Australia, over 267 million primary batteries and 50 million secondary batteries (rechargeable) were imported in 2004 (ABS, 2005). It is estimated that 18 million used primary and secondary batteries are disposed of annually in Western Australia (WasteWise WA, 2005).

Batteries are identified as a problematic material in the waste stream. They contain a number of metals which have documented impacts as environmental contaminants.

Countries such as the United States, United Kingdom, Netherlands, Sweden and Japan have established legislation and regulations that target the elimination of hazardous material generated from used batteries. Thus far Australia and specifically Western Australia, has established no legislation for the collection of used batteries, and their elimination from the general waste stream.

Understanding this, the Municipal Waste Advisory Council gained funding under Strategic Waste Initiative Scheme (SWIS) from the Waste Management Board of Western Australia.

1.2 Objectives of Study

The Municipal Waste Advisory Council has undertaken this study to investigate models for reducing the disposal of consumer batteries to general household waste and for collecting consumer batteries for specialised disposal and/or recycling in Western Australia.

The key objectives of this study are:

- To minimise the disposal of untreated consumer batteries to landfill; and/or
- To minimise interference by consumer batteries with resource recovery operations; and/or
- To minimise the resource consumption associated with consumer batteries.

The study will address these key objectives using two different strategies. The first, undertaken in this paper, will research models for the collection of consumer batteries and will conclude with a set of recommendations on the best collection models. The second strategy will focus upon avoidance as a method for reduction in the consumption and hence disposal of household batteries into general household waste. The second strategy will be addressed separately in the accompanying paper *Battery Avoidance Strategies*.

1.3 Guide to Study

1. Introduction sets out the background of the study and battery recycling and gives a brief outline of the objectives and how this study will achieve these objectives.

2. Rationale for the Separate Collection of Batteries addresses why batteries should be collected and or avoided in the household waste stream.

3. Factors Affecting a Battery Collection Model outlines the context for a collection scheme such as legislation, recycling techniques, sorting processes, battery collection and recycling in Western Australia and markets for battery constituents. More information on these is available in Appendix B.

This section will also present a summary of the results of the community survey undertaken and relate the key findings to the objectives of the study. The complete survey report is attached as Appendix C.

4. Review of Used Battery Collection Models presents a summary of nine potential collection models. This will include operating examples of the models and an explanation of the criteria which will be used in Section 5 to review them.

5. Comparison of Collection Models compares the collection models according to the criteria outlined in Section 4. It will also present the results of a multi-criteria analysis which will rate the collection models using these criteria.

6. Discussion and Conclusions draws all of the information from the study together. It will explore the assumptions, factors, faults and situations under which each of the preferred collection models (from the multi-criteria analysis) would ideally operate.

7. Recommendations uses the conclusions drawn from the previous section to develop practical suggestions for the reduction of batteries in the general waste stream through a collection system.

1.4 Definitions

Consumer and household batteries are predominantly portable batteries, readily available to the public and usually of the following types – dry cell: acid and alkali, NiCad, Li-Ion, NiMH, and button batteries (HgO, AgO and Zinc-Air).

Primary and secondary are the two general types of dry cell batteries available on the market. Primary batteries provide energy which is sufficient for a single power cycle and disposed of following this. They are the Zinc Carbon/Zinc Chloride, Alkaline batteries and Silver Oxide button cells which are currently sold in retailer stores.

Secondary batteries are rechargeable batteries. They have more than one power cycle before disposal. They are rechargeable alkaline manganese (RAM), Nickel Cadmium (NiCad), Nickel Metal Hydride (NiMH) and Lithium-ion range (Duracell, 2007). A detailed list of metals used in the manufacture of batteries is attached as Appendix A.

In this study household batteries are assumed to be dry cell batteries (including button batteries).

2. Rationale for the Separate Collection of Batteries

2.1 Dry Cell Battery Consumption Trend

In Western Australia, there are 18 million primary and secondary batteries disposed of annually. This has been equated to approximately 18 units per person each year (WasteWise WA, 2007). Based on population and production data, this compares internationally to Japan: 17 units per person (Kanemaru and Matsuoka, 1995) and Germany: 12 units per person (Fricke and Knudsen, 2002; GRS-Batterien, 2005).

There is a growing demand for portable consumer electronic goods that are key users of batteries in the household. Household Electrical and Electronic Waste Survey (Katos and Hoye, 2005) reported that Australian households consumed 5.9 million units of portable goods during mid 2005 and of this, Western Australians consumed 0.7 million units. Following the growing consumption trend of portable electronic goods, the demand for dry cell batteries is also increasing.

The majority of batteries consumed in Western Australia are primary batteries. This was indicated by one of Australia's leading retailers, Coles Ltd, whose figures illustrated the top three brands of batteries being sold in their Western Australian stores are primary batteries (Coles Ltd, 2007).

2.2 Environmental Impacts of Batteries

All dry cell batteries have limited powercycles; this is particularly significant for primary dry cell batteries, which have only one powercycle. Used dry cell batteries can have a number of potential impacts when disposed of in general household waste. These have been summarised into: contamination in landfill; interference with alternative waste treatment (composting) facilities; and upstream environmental impacts associated with a failure to recycle the constituent materials from batteries.

2.2.1 Contamination in Landfill

The number of batteries disposed of into landfill in Australia is approximately 360 million used cells annually or 9,000 tonnes. Of the 9,000 tonnes, 1,750 tonnes is estimated to be rechargeable, with the majority being primary batteries (Swainston et al, 2006). Swainston et al (2006), made reference to batteries in Western Australia being classified as a hazardous waste and that they must be disposed of into a secure landfill after being secured in concrete. Whilst some metropolitan landfills have taken the initiative of concreting household batteries prior to landfilling them, the majority of batteries in Western Australia are not diverted from the general waste stream.

Batteries, as a general waste class, contain a number of metals with documented impacts as environmental contaminants. Cadmium, Lead, Cobalt, Mercury and Nickel are metals listed in the HazDat Database maintained by the Agency for Toxic Substances and Disease Registry (ATSDR). They are also listed in the ATSDR 2005 Priority List of Hazardous Substances.

Batteries disposed of into general household waste are eventually buried in landfill. In the acidic environment of a general solid waste landfill, these metals can dissolve. Over time, they could then mobilise in the leachate (Park et al, 1999).

There is uncertainty in the behaviour of metals in landfills, especially with the large number of landfills located outside the metropolitan area with basic engineering and no leachate capture (RWC, 2006). Leachate from landfill sites is a significant potential cause of local water source contamination (James, 1977).

It is widely advised in Australia and oversea's that primary batteries generally do not pose a risk to the environment and are therefore safe to be disposed of in household waste (PlanetArk, 2007).

A break down of the metals contained in household batteries is provided below.

Primary Batteries (Mercury no longer in Primary Batteries)
Alkaline
Zinc-Chloride
Carbon-Zinc
Lithium

Button Batteries
Silver Oxide (Silver component hazardous)

Secondary Batteries
Nickel Cadmium (Cadmium component hazardous)
Lithium Ion
Rechargeable Alkaline
Nickel-Metal Hydride (Semi-toxic due to electrolytes)

More information on the chemistry of household batteries is available in Appendix A

2.2.2 Interference with Alternative Waste Treatment and Secondary Resource Recovery Operations

Western Australia is home to a growing municipal waste compost industry. Whilst techniques for sorting of wastes differ within the industry, all are susceptible to contamination by hazardous wastes placed in the general household waste stream. Household batteries can potentially contaminate the final product, or prove costly or problematic to remove.

Household batteries are typically quite small and in the sorting technique, difficult to discover or remove. The potential of acute heavy metal contamination by damaged used household batteries in the waste stream is becoming more of a concern with the increased application of composting systems in municipal waste processing. A high concentration of heavy metals in the compost will place the product below legislated standards and prevent the product being applied to land (RWC, 2006).

Whilst some sources claim that the bioavailability of heavy metals in compost is low (Mamo et al, 2002), public perception of contamination risks present real challenges for the marketing of compost (RWC, 2006).

2.2.3 Upstream Environmental Impacts

The Federal Government response to the Productivity Commissions Report on Waste Management stated that resource efficiency was an important goal, fundamental to environmentally sustainable policies. It went on to say that resource conservation and upstream environmental protection have an important role to play in determining waste policy measures (Federal Government, 2007).

The metals used in battery manufacture are limited in nature. The major proportion of metals used in the manufacturing of dry cell batteries is of virgin origin (Rydh and Svard, 2003). The toxicity of a metal has an inverse relationship with their occurrence in the environment (Hakanson, 1980). For example, metals such as Cadmium and Nickel have a high toxicity and are not as highly abundant as Aluminium or Iron.

The mining, refining and manufacture of battery components come with a range of additional environmental impacts. These include energy usage, resource extraction impacts, air and water pollution and transport impacts. Recycling of batteries can in theory, reduce these impacts by replacing some of the virgin raw materials used in the manufacture of batteries.

Consultants ERM, in the UK, conducted a life cycle analysis of battery recycling and the costs and benefits of various collection and recycling options. The battery lifecycle analysis found that recycling batteries can generate between 198kg and 248kg carbon-equivalent emissions savings for every tonne of batteries recycled compared to the current situation, assuming a 35% recycling rate (ERM, 2006).

The scale of avoided upstream impacts is proportional to the size of the waste stream. The quantity of batteries discarded in WA annually is likely to be relatively small; in this context, the objective of avoiding upstream impacts may not provide convincing rational, in isolation, for battery recycling.

3. Factors Affecting a Battery Collection Model

3.1 Legislation

The establishment of legislation and regulations for recycling batteries is significant in motivating community and industry involvement in a battery collection model. Almost all nations where battery collection systems are in place have legislation which both mandates and encourages the collection of batteries.

The Basel Convention (1992) recognised the importance of treating hazardous wastes responsibly with consideration of global socio-economics and the environment. 169 countries were present at the Convention. Among these countries the United States, members of European Union: Austria, Sweden, Netherlands, United Kingdom and Japan have signed or ratified their commitment to the convention. They have also transposed the convention into their dry cell battery recycling legislation.

Australia is one of the 169 countries that attended the Basel Convention. Yet currently, the Australian government has taken no action for a sustainable solution for used dry cell batteries. There are “Low” and “No” recycling options available for Nickel Cadmium and household batteries in Australia (ABS, 2006).

It is anticipated the Waste Avoidance Resource Recovery Bill will be progressed through Parliament in the near future. This new waste legislation will enable Western Australia to actively pursue the state policy of ‘Towards Zero Waste’. If enacted in its current form, the Bill will be able to limit socially unacceptable practices through increasing financial restrictions and supporting other actions such as Extended Producer Responsibility (EPR), market development and improved infrastructure.

More information on legislation in relation to battery collection, recycling and disposal is available in Appendix B

3.2 Recycling Techniques

Understanding battery recycling techniques is useful in understanding how the various techniques could impact on the choice of collection model/s. These techniques may also be a significant consideration when assessing if avoidance is a better method of reducing consumer batteries disposed of into general household waste.

Swainston et al (2006) found that there are opportunities in Australia to partner with various companies to either close the loop in battery production or to use sorted batteries as supplementary feed materials in existing metal production routes such as Lead, Zinc, Cadmium, Nickel, Iron and Steel. Swainston et al (2006) also suggested that Australian smelters and Hydrometallurgal plants should be able to accommodate battery waste with relative ease.

More information on recycling techniques for batteries is available in Appendix B

3.3 Sorting

RWC (2006) found that industrial processes currently in use around the world to recycle consumer batteries have a general requirement for sorted feedstock.

A review of collection systems, in relation to sorting, suggested that, for household batteries, commingled collections are more the rule than source separated collections. Around the world, battery collection programs directed at household batteries appear constrained by the inability or willingness of consumers to separate their battery wastes into different types.

RWC (2006) concluded that battery sorting, manual, or automated is well developed, reasonably safe and logistically feasible exercise. Extensive battery sorting is currently carried out at the front end of almost all battery recycling operations. It is a manageable process but comes with an associated cost.

On this basis, potential for sorting at point of collection will be a factor to take into account when distinguishing between battery collection schemes, however, not a necessary feature considering the availability of both manual and automated sorting.

Transport and safe storage of used batteries is also a concern. If not properly packaged loose batteries can present a fire, corrosion or explosive risk. This is particularly significant given Western Australia's climate.

More information on sorting of batteries is available in Appendix B

3.4 Battery Collection and Recycling in Western Australia

Australia does not have a national recycling scheme for primary and secondary batteries. Historically, recycling of these batteries has been too expensive or considered commercially unviable. (PlanetArk, 2007)

Programs to divert batteries from general waste in WA have been piecemeal to date. When the disposer is willing to pay, recycling services do exist, although only a very small proportion of batteries are recovered through these services. Industry led initiatives, tasked with diverting consumer batteries from landfill, are limited. One example is the MobileMuster Program, administered by the Australian Mobile Telecommunications Association (AMTA), which collects mobile phone batteries and their accessories. The Program has a fee for disposal built into the price of the product and the costs of MobileMuster are covered by this industry managed fund. This Program has been critised in the past for its low recovery rates (RWC, 2006).

Australia does not have the technology to fully recover primary and secondary dry cell batteries. The only actual physical recovery is of secondary batteries, which are dismantled and the scraps shipped to France for recovery (Cleanaway, 2007). This is run on a 'pay as you throw' basis, where pre-paid battery recycling boxes can be purchased from waste service provider Cleanaway.

A number of Regional Councils (groupings of Local Governments) currently promote special collections of batteries with a view to disposing of the batteries with increased safeguards against environmental impacts. The batteries are encased in concrete prior to disposal in landfill. The rationale for some of the Regional Councils is that is fulfils their landfill license conditions. For other waste managers the rationale may be to minimise the impact on their resource recovery operations. The approach taken to date for collection has centered on schools. Schools are invited to encourage students to bring disposable batteries to school. Stockpiles of batteries are periodically collected from schools and removed to landfill. Small incentive programs are offered by some Councils to increase participation rates among students. The Eastern Metropolitan Regional Council is operating such a scheme (RWC, 2006).

In Australia, except for lead acid type chemistries, the only other collection of batteries for recycling overseas is done by MRI Australia, a company based in Victoria. MRI use Tredi Australia to export all batteries to a recycling facility (SNAM) in France.

A working group made of members from a number of organisations including the battery industry has been formed to investigate a national battery collection and recycling scheme for Australia. The working group has made the following recommendations:

- A collection system should 'piggyback' on an existing collection system;
- Better data on consumption and disposal trends for household batteries is needed;
- A collection scheme should encompass all battery types; and
- Issues with environmental regulations for the stockpiling of used batteries should be explored further.

The Australasian Battery Recycling Initiative (ABRI) was formed from the working group and has a strategic focus of 'no batteries to landfill'. ABRI represents the cooperation of various representatives along the battery supply chain with a focus on recycling. It believes that government support/action will be necessary to underpin a system and get the volumes of batteries collected for any battery recycling to occur in Australia. It also advocates a Product Stewardship scheme similar to and building upon other working Product Stewardship schemes on products such as mobile phones and printer cartridges (Swainston et al, 2006b).

More information on battery collection and recycling in Western Australia is available in Appendix B

3.5 Markets for Battery Constituents

Information on the market for metals recovered from consumer batteries is somewhat limited and at times, contradictory.

Current markets that do exist in Australia for battery constituents include the Silver from spent Silver Oxide button cells, which are collected by those businesses who replace them in watches or similar utilities; and lead acid car batteries. As the focus of this investigation is not upon car batteries, noting the existence of this market is sufficient.

The availability of sufficient quantities of spent batteries will depend upon the collection model utilised. In Western Australia this remains a key obstacle to any battery recycling scheme. The population density is significantly lower than other locations where battery recycling has been established.

The degree of segregation of used batteries into their chemistry types would depend upon the collection model. In this respect, the collection model does have a great bearing upon the market potential of products. As outlined, sorting of batteries for most recycling processes is a necessity.

More information on markets for battery constituents is available in Appendix B

3.6 Survey of Community Attitudes

This study also included research into community attitudes. To achieve this, a survey was carried out, with the general aim of investigating community attitudes in Western Australia to battery disposal, recycling and the different options for collection. The survey was conducted in February 2007 and is attached as Appendix C.

Some key findings from the survey include:

- 60.7% of respondents indicated they were aware that batteries could be recycled;
- less then 20% of respondents currently separately dispose of their batteries;
- kerbside, Charity Bins and vergeside recycling services were participated in by the largest proportion of respondents;
- 70.5% of respondents would take part in a battery collection service incorporated into their normal kerbside recycling;
- The majority of respondents (82.5%) indicated that they would use special battery bins located in public places; and
- The most preferred locations for special battery bins were: the workplace; local shopping centres; and large shopping centres.

A key outcome of the survey is that almost all respondents would be interested in disposing of their batteries separately to their normal household waste. Despite this, at least 80% still disposed of their batteries into their household waste. This suggests a willingness to recycle batteries but a lack of opportunity, or ease, to do so.

Almost all respondents indicated they would be willing to dispose of their household batteries into special battery bins, located in public places, highlighting the potential high participation in this type of collection model.

Kerbside, vergeside and charity bins were the recycling services participated in by the greatest number of respondents. These recycling services are characterised by their convenience to the householder. Other services such as Local Government depots or temporary collection days were indicated to be the least used by respondents. These can require significantly more effort and organisation.

Most respondents purchased their batteries from a supermarket. This has important consequences for determining potential placement of a collection bin in a retail collection scheme. This question was framed to address batteries that are purchased separately to the products that they are used for. Rechargeable batteries such as Li-Ion, NiCd and NiMH may come with the product and are purchased from a range of different outlets.

Results of the survey conducted for this study also support that primary batteries are the main type of batteries consumed in the Western Australian household and the consumption of secondary (rechargeable) batteries closely followed. When considering the separate collection of batteries, having a large quantity of rechargeable batteries is a big factor. These batteries can be recycled (internationally) and contain the most toxic substances.

Most respondents were willing to stockpile their used batteries over long periods and 45% of respondents would stockpile their used batteries for at least 6 months. This indicates that for collection schemes such as vergeside, and dedicated drop off days, that require stockpiling over long periods, respondents will stockpile batteries, as opposed to regular collections such as kerbside, drop off bins in public places etc. where residents are able to quickly dispose of their batteries

Other studies have found monthly battery consumption to be significantly and positively related to the level of organisation in battery disposal (as often indicated by the existence of a special battery bin location for the storage of used batteries) (Hannsmann et al, 2006). This implies that the more batteries consumed by the householder, the more likely the householder will aggregate the batteries for separate disposal. As batteries by their nature are a waste often produced by consumers at random intervals it is important that there are fairly regular messages about battery recycling to enforce habitual battery recycling behaviour.

The full survey report is available as Appendix C

4. Review of Used Battery Collection Models

Knowledge of the operation of various collection systems can provide an understanding of the resources needed to establish a battery collection scheme, specialised for Western Australia. The following is a study of the nine main collection models for waste and recyclables. This list was compiled primarily by listing approaches found to be operating in other parts of the world for Household Hazardous Waste. They are currently operating nationally and internationally. They are: kerbside collection; vergeside collection; institution collection programs; retail take-back; public amenity sites; periodic collection days at temporary sites; permanent collection facility; pay-as-you-throw and on demand service with mobile collection vehicle. The criteria for comparison (outlined in Section 4.1) will be the key themes highlighted throughout the review. These will then be compared between collection systems in Section 5.

This section will provide a summary of each model's operation system, the stakeholders, cost and examples of operating programs.

4.1 Criteria for Assessment of Collection Models

The collection models will be assessed against the following criteria; efficiency; equity; education; practicality; cost; participation; convenience; and sorting;. An explanation and justification for the use of these specific criteria is provided below. A summary of the results of comparing the collection models against these criteria is provided in Table 5.1. All assumptions are based upon the information in Section 4.

Efficiency – of a system is based upon the cost of collection for each spent household battery that is collected. Efficiency was rated as the most significant criteria as it represents a combination of both cost and yield (likely participation rates). The ideal collection model would be low cost with maximum collection rates.

Equity – relates to the accessibility of the collection model to all households in WA. Equity was rated as the second most significant criteria when assessing a collection model. The geography of Western Australia often translates into an unequitable availability of services between metropolitan and non-metropolitan areas. The ideal collection model would be available in both non-metropolitan and metropolitan areas and should be easily accessible by all residents.

Education – the opportunity for education was rated as the ability of the collection model to also be a source of information about the waste management of spent batteries and to raise awareness of waste management issues generally. Opportunity for education was rated as significant criterion when assessing a collection model. Giving householder's information on environmental impacts of batteries and correct disposal options will increase their likely participation in a scheme.

Practicality – relates to the physical feasibility of the collection system and reflects the ease with which it could be incorporated into the existing collection framework in Western Australia. Practicality was rated as significant when assessing a collection model. The practicality of meshing the collection model with an existing system will have great bearing upon the efficiency of a scheme and its success. The ideal model will require very little adjustment of current infrastructure and operations with as little upkeep and maintenance as possible.

Cost – When assessing the case for used battery collection models, cost is a key component. How costs are distributed and who bears the cost is an important consideration. In this instance the cost assessed was of the collection model as a whole. Cost was rated fairly low when assessing the collection models, as to some extent this was already addressed in the efficiency criterion. However, as cost will always be a key component limiting any system, cost was also included as a separate criterion. One consideration is that costs should be distributed fairly amongst stakeholders.

Participation – rates are based upon the likely participation in the collection model of those who currently have access to that method of collection. Participation, like cost, was rated fairly low when assessing the collection model, as this was already addressed in the efficiency criterion. Likely participation will have the highest impact on potential yields, and consequently recovery rates of used household batteries.

Convenience – to the householder relates to the ease with which the householder can utilise the collection system. Convenience to householder differs to participation rates when a collection model may be highly convenient for the householder but have low participation rates. Convenience is fairly significant when

assessing the collection model, however high convenience does not necessarily translate into high participation rates or low convenience does not presume low participation rates. Therefore, convenience should remain a consideration but below issues such as cost or participation.

Sorting – refers to the ability of a system to provide opportunity for onsite sorting. Collection systems with on site sorting would have a low contamination rate and could feed into a battery recycling system with the most ease (RWC, 2006). Sorting was rated as the least significant criterion in assessing a collection model. Whilst sorted feedstock would be ideal, sorting is not completely necessary. In the current situation, where batteries are disposed of in a Class III landfill, limited sorting is required.

4.2 Kerbside Collection

Collection system: Containers are placed at the kerbside for collection on a prearranged day. It coincides with the kerbside collection for general solid waste. In Australia, kerbside collection implies a regular collection, usually weekly or fortnightly. Some municipalities collect monthly. With respect to household hazardous wastes, this collection would involve placing the hazardous wastes in a separate container to general waste. Because of batteries' physical robustness, they could be placed in the recycling bin, either loose or within a special box or bag.

Collection channel: Pick up from outside every residential address.

Cost: Specialised equipment, container, staff, sorting, education (administration) for regular operation.

Stakeholders: Local Government, contracted waste and/or recycling collectors and householder.

Operation examples: The Bristol City Council has operated a kerbside collection of batteries since 2002 (Bristol City Council, 2004). The scheme involves the householder leaving out the batteries in an open recycling crate (Bristol City Council, 2006). The batteries are housed in a bag and the truck crew immediately removes the batteries to a separate storage unit on the recycling truck (Bristol City Council, 2004). A detailed account of the operation of Bristol system can be found in the Bristol City Council's 2004 final report on the scheme trial.

Currently, the British non-profit recycling organisation Waste & Resources Action Programme (WRAP) is conducting a two year national pilot study of a kerbside battery collection program. They provided residents of the participating municipalities with a sealable bag or box to place their used or unwanted batteries in. This was then put out with their ordinary kerbside recycling crate/box. 350,000 residents are involved in the trials due to end in March 2008. Some initial concerns of the trials were that residents may not use the bags provided and loose batteries would contaminate the recyclables. A lot of residents also failed to seal the bag they were given for the batteries, so that the batteries became loose anyway.

In the WRAP trials, the distribution of specialised bags was an administrative burden. The Councils were originally providing a collection point for the bags or posting them out; however, residents requested that the bags be available from other premises. Loose batteries were the most significant problem with this, as when obtaining a new bag was difficult residents tended to place their batteries loose in the kerbside recycling crate. The majority of Councils involved in the trials have a crate recycling system. This is similar to several Local Governments in the Perth metropolitan area. For details of the program, refer to WRAP's website (www.wrap.org.uk).

Details on other kerbside recycling systems collecting batteries, such as those operating in Sweden, were not available (Anon, 2003).

Table 4.1 Advantages vs. disadvantages of the use of kerbside collection as a collection model

Advantages	Disadvantages
• Convenient for residents (high participation) • Re-enforces habitual behaviour • Accessible for most residents • Potentially high recovery rates • Potential education tool	• High cost • Contamination risks from poor sorting • Specialised equipment may be needed • Predominantly only available for residents in metropolitan area • Regular operation

Discussion
The kerbside collection of used batteries is characterised by its convenience to the householder and incorporation into an existing and well understood system. However, whilst kerbside recycling has the potential for the greatest recovery of batteries, its weekly/fortnightly yield would be quite low. This makes the system inefficient as it would incur a cost for sorting, whilst not producing enough regular quantities of batteries to make it cost-effective. Approximately 83% of households in Western Australia are provided with a kerbside recycling service; however 84% of these households are in the metropolitan area (RRRS, Period 16, 2006). This makes kerbside collections inequitable to non-metropolitan residents.

ERM conducted a lifecycle analysis report which favoured the use of kerbside collection systems for the collection of household batteries (WRAP, 2007). WRAP has further stated that their kerbside collection trials have been a success thus far. However, WRAP has placed a large amount of time, energy and resources into the trials. This makes kerbside one of the most effective methods, but requiring the most resources to implement. A key conclusion of the ERM report was that whilst kerbside collections would be the most environmentally beneficial collection method, this would be at a substantial cost.

A review of Swiss waste administration found that with the consideration of the large efforts associated with kerbside collection and the fact that batteries only make a small amount of the waste stream, kerbside collection is not a viable option for used batteries (Hannsmann et al, 2006).

The feasibility of a kerbside collection system is also largely dependent upon whether Material Recovery Facilities (MRF) could be easily modified to separate out batteries. One example of this is the Southern Metropolitan Regional Council MRF. Batteries are extracted by a magnet with other contaminants. To recover the batteries from this small ferrous metal stream they would need to put in additional conveyers, screens and a manual sort station (SMRC, 2007).

4.3 Vergeside Collection Service

Collection system: Specified materials are placed at the vergeside for collection on a prearranged day or number of days. In Australia, vergeside collection implies a special collection for a large volume of household waste. For example: whitegoods and/or greenwaste. Various Local Governments offer quarterly, biannual or annual collections. Some Local Governments will also provide the service to householders on a 'demand' basis. Householders are given a notice to inform them about the details of time and treatment of their waste before collection. For batteries, because of their small size, it may be necessary to provide a special box or bag. Stockpiled waste batteries in a container provide greater visibility for collectors.

Collection channel: Pick up from outside every residential address.

Cost: Specialised equipment (containers), contractors, sorting and education for semi-regular collection.

Stakeholders: Local Government, contracted waste and/or recycling collectors and householder.

Operation examples: Many Local Governments in Australia already offer a vergeside collection service, however they generally exclude the collection of household hazardous wastes. In Austria, a national collection scheme is run every 6 months. Every household is provided with a paper collection bag and batteries are collected from residents (Bristol City Council, 2004; IET, 2006)

Table 4.2 Advantages vs. disadvantages of vergeside collection as a collection model

Advantages	Disadvantages
• Convenient for residents • Re-enforces habitual behaviour • Accessible to most residents • Potentially high yields • Can be meshed with existing collection scheme • Periodic and already heavily promoted	• Fairly high cost • Contamination risks with other wastes (i.e. Greenwaste) • Only available to certain residents in Metropolitan area and feasibility in inner city centres limited • Requires stockpiling of batteries • Safety Risks

Discussion
Vergeside collections have the advantage over kerbside recycling of offering the same convenience, but with pickups occurring much less frequently, making the system as a whole much more cost-efficient. Approximately 66% of households in Western Australia are provided with a vergeside recycling service. However, 90% of these are in the metropolitan area (MWAC, 2006). Pick-ups usually occur 1-2 times every year. This would require residents to stockpile their batteries for 6-12 month periods. In the community survey conducted, almost half of respondents would be willing to stockpile their spent batteries for 6 months.

It is assumed that in a vergeside collection system there would be little opportunity for sorting. In a practical sense the batteries would need to be placed in a box or bag, which is another administrative and cost burden. The feasibility of meshing it with current vergeside collections, especially those that are automated, is questionable. Material is often placed on the verge several days prior to collection; therefore, the safety of placing used batteries, as a household hazardous waste, on the verge is a factor.

4.4 Institution Collection Programs

Collection system: Batteries are collected at an institution such as a school or an enterprise. The institution promotes recycling and establishes a collection station at the institution for its members to return their used batteries. It is anticipated that the model would typically involve some kind of collection incentive, perhaps a competition between institutions, to encourage higher rates of participation. The system would be designed to be both an awareness raising exercise and a practical system for the collection of batteries.

Collection channels: Collection centre at institutions- schools, universities, colleges, community centres, Local Government buildings or workplaces.

Costs: Contractor/waste collector/disposer, promotional materials and administrative support.

Stakeholders: Community groups, schools, universities, colleges, Local Government, contracted waste and/or recycling collector and householder.

Operation examples: The Eastern Metropolitan Regional Council (EMRC) operates an institutional collection system and uses a competition as a collection incentive for schools within its boundaries. Prizes are awarded to schools and individual students within schools for collecting the most batteries, as a means of encouraging those schools to promote the separate disposal of batteries. Batteries received by the EMRC are encased in concrete prior to landfilling (EMRC, 2006). In 2006, the scheme collected 1.7 tonnes of batteries, with minimal promotion and administration work from the EMRC. In 2007, the scheme has averaged 30kg from each school per term. 16 Primary Schools are currently involved.

The Australian Mobile Telecommunications Association (AMTA)'s MobileMuster Program also encourages institutional recycling collections, for mobile phones and their accessories. (MobileMuster, 2006).

Taiwan's most frequented collection sites for batteries are schools: elementary; junior; and high school. Each school has at least one bin, "the combined weight of these bins accounts for roughly 10 tonnes of monthly collection rate for Taipei City" (Phipps, 2004). This is despite spent battery bins being located in nearly all of the nation's convenience stores, camera stores, and supermarkets and as well as affixed to garbage trucks.

In Poland, school collections account for 72 % of the total batteries collected, compared to retail and wholesale service points, companies that collect and segregate municipal solid waste (11%) and end users (17%) (IET, 2006).

Table 4.3 Advantages vs. disadvantages of use of institutions as a collection model

Advantages	Disadvantages
• Convenient (no special trip required) • Potential for education • Potentially high participation • Positive and wide community engagement in introduction stage of program.	• High maintenance and can be costly in the long term • Potential health and safety risks • Effort required for high yields • Suitability and cooperation of institutions

Discussion
The EMRC battery collection scheme is reasonably inexpensive, with the greatest costs incurred for contractor pick up and processing, promotional materials and the administration associated with running the program. The participation of 16 primary schools does cover a large proportion of residents; with a targeted and low cost approach. However, this does exclude specific parts of society who do not have children or any association with children. Congregating batteries, as a household hazardous waste, does raise certain safety issues. There is also a reliance on the institutions willingness to participate in and promote the scheme.

The main advantage of this type of scheme is its ability to act as an education tool for the correct disposal of batteries and other wastes. It builds responsible recycling behaviour into the habits of school children which can then filter back through the entire household.

4.5 Retailer Take-Back Scheme

Collection system: Retailers of batteries receive and stockpile used batteries returned by customers. Arrangements can vary depending on whether the retailer accepts only the batteries which it has sold to consumers. A proof of purchase may be required. Forwarding of the collected batteries may be either by prepaid freight or a dedicated collection vehicle.

Collection channels: Collection centre in retailer stores selling batteries.

Costs: Collection box or container, contractor pick up, promotional and advertising materials.

Stakeholders: Retail stores selling batteries, program organiser (Government or non-government organisation), collection service provider and householders.

Operation examples: The Bristol City Council scheme initially used retailers to collect batteries for recycling (Bristol City Council, 2004). In 2004, Austria had 7,000 collection points based in stores that sell batteries and at hazardous waste collections sites, this amounts to one collection point per 1,100 inhabitants (Bristol City Council, 2004).

The Rechargeable Battery Recycling Corporation (RBRC) operates a scheme which relies entirely on retail outlets for the collection of batteries; only rechargeable batteries and batteries under 1 kg in weight. The scheme is free for retailers and promoted on the basis of a range of competitive advantage and ethical grounds (RBRC, 2006). In this Scheme rechargeable battery manufacturers sign up to the RBRC and in return are allowed to place the RBRC symbol on their batteries, allowing them to be recycled through the RBRC network of collection centres.

Planet Ark operates a printer cartridge recycling service which relies on retailers to receive the cartridges (Planet Ark, 2006). The retail businesses listed as receiving the cartridges for Planet Ark are Dick Smith Electronics, Tandy, Australian Post, Harvey Norman and Officeworks (Planet Ark, 2006).

The Australian Mobile Telecommunication Association (ATMA) operates some of its Mobile Muster Collection points from retail outlets (AMTA, 2006). From 1999 to 2006, 402 tonnes of mobile phones and mobile phone accessories were collected. This collection program was revamped in 2005, in response to criticism regarding the recovery rates (Victorian Government, 2005). In 2007, the Mobile Muster suffered

further criticism for low retailer participation and participating stores not properly displaying the Mobile Muster collection point promotional material (Martinez, 2007).

In July 2007, Sustainability Victoria began trialling Batteryback, a joint initiative of Sustainability Victoria, UniRoss and Cleanaway. Retail partners Harvey Norman and Michaels Camera Video have special containers located in store to collect householder's unwanted batteries. It is a free service available to any Victorian household. It collects rechargeable batteries only, including Nickel Cadmium (Ni-Cd), Nickel Metal Hydride (Ni-MH) and Lithium Ion (Li-Ion). Cleanaway collects and manages the recycling of all the batteries collected. As in Western Australia, they are processed overseas by a French company that specialises in the recovery of Nickel and Cadmium. The recovered metals are sold for reuse, while the Cadmium can be returned to battery manufacturers to create a fully closed loop recycling system. (Sustainability Victoria, 2007)

Table 4.4 Advantages vs. disadvantages of use of retailer take back scheme collection model

Advantages	Disadvantages
• Convenient (no special trip required) • Opportunity for habit formation • Potentially low cost • Extended Producer Responsibility (EPR)	• Problems with distinguishing which batteries were purchased where (orphans in the system) • Limited opportunity for source sorting • Difficult in non-metropolitan areas • Requires cooperation of retailers

Discussion

This type of collection scheme uses the principles of Extended Producer Responsibility (EPR) and places the responsibility of disposing of waste materials back upon the manufacturer/ retailer of the product. The largest problem with the scheme is gaining the cooperation of retail outlets, as well as, assistance in the ongoing promotion of the collection points. The advantage of this type of model is its availability to all consumers of batteries, assuming that the consumers purchasing the batteries are those disposing of them. This assumption becomes problematic when the battery is purchased within another product (e.g. camera). Whether retail outlets selling products that contain batteries would be included, or just retail outlets selling individuals batteries only, be required to participate, would need to be investigated further.

4.6 Public Amenity Sites

Collection system: A box or bin is located at public amenity site such as shopping centres, libraries, government buildings and other places convenient to people's every-day business. These would primarily be un-staffed but secure (i.e. lockable) and regularly emptied by the company/authority tasked with recycling or disposing of the batteries. This system is distinct from the retailer take-back approach by no affiliation between the entity and the batteries being collected. It is also different from the institutional collection program by the lack of particular focus on a specified community. It encourages the community to take their used or unwanted batteries to a drop off station. Whereas the institutional collection program model is based on a more proactive targeted approach promoted within a school or workplace for example.

Collection channels: Collection box or bin located in small and large shopping centres, libraries, train and bus stations and government buildings.

Costs: Upkeep of container, contractor/collector, promotion of service.

Stakeholders: Site host (eg shopping centre), authority responsible for scheme; collection service provider; and householders.

Operation examples: A common example of this type of collection model is the collection of used Christmas cards in shopping centres. Usually this type of model is run by the actual shopping centre or an environmental organisation such as Planet Ark.

Currently the Eastern Metropolitan Regional Council (EMRC) has drop off points in libraries, TAFE and Council buildings in the Eastern Region of Perth. In the future, they are looking to expand the drop off points to all Council buildings of their member Councils. In this instance the EMRC are responsible for establishing a box which is emptied quarterly by a contractor who also services their schools program. The batteries are then encapsulated in concrete and taken to their Red Hill Facility where they are landfilled (EMRC, 2007).

Table 4.5 Advantages vs. disadvantages of use of public amenity sites as a collection model

Advantages	Disadvantages
• Can be meshed with existing collection framework in Australia • Fixed and established location • Opportunity for habit formation • Can be accessible for non-metropolitan and metropolitan areas • Low cost for reasonable participation • Relatively convenient	• Vandalism of collection container, cost and safety issues • Requires cooperation of site host • Questions of responsibility for container • No opportunities for sorting and potential for contamination

Discussion
This type of collection system is moderately expensive for moderate participation rates. Often the location, visibility and promotion of the drop off points will have a great bearing upon participation. They are advantageous as they are often located in places accessible by public transport, and usually require no special trip by the householder. However, as they are located in a public site vandalism and maintenance costs can become costly.

4.7 Periodic Collection Days at Temporary Sites

Collection system: A drop off point is erected at a temporary site. It is a community level event which lasts from one to several days and usually collects several different types of waste, but usually within a grouping (e.g. e-waste, or household hazardous waste). The site for such collections may be selected on the basis of a high degree of convenience for householders (e.g. a shopping centre car park) or on the basis of a high degree of safety or convenience for the responsible authorities (e.g. Local Government depot).

Collection channels: Temporary drop off point located at a wide variety of places: shopping centres, car parks, fates, festivals etc.

Costs: Site host fee (if applicable), administration, promotion, staffing and collection service provider.

Stakeholders: Site host, Local Government and/or event organiser, collection service provider and householder.

Operation examples: The NSW RecycleIT collection of computer wastes used this method and trialled their collections in shopping centre carparks (DCITA, 2003). Pesticides and agricultural chemicals across Australia have been collected through the ChemClear and ChemCollect programs using a system of prearranged collected sites and a fairly intensive system for booking individual consignments in for collection at those sites (ChemClear, 2006). In Victoria, the collection of non-specific household hazardous wastes is facilitated through Sustainability Victoria's 'Detox Your Home' program (Sustainability Victoria, 2006b). The Detox Your Home program is essentially a schedule of days for communities throughout Victoria to bring their unwanted household hazardous wastes into specified Councils depots. The terms on which these collections operate is not disclosed in their publicity, although no fee is charged to the public (Sustainability Victoria, 2006b). An Australian company which sells Lead-Acid batteries holds a 'Great Battery Round-up' over a short period of time, using a network of participating small businesses (EcoRecycle, 2004). This arrangement is partly designed to overcome the difficulties for small businesses associated with storing automotive batteries for long periods.

The South East Metropolitan Regional Council (SEMRC) and City of South Perth have started what could potentially become a regular IT drop off day at the City of South Perth Collier Park transfer station. The trial day was held on a Saturday and two waste officers staffed the day. The computers were collected in a large container (SEMRC, 2007). This may be different for batteries and several large drums may be utilised to allow for onsite sorting into battery types. The greatest cost incurred was for recycling the collected material and administration (including promotions through advertisements in the local paper).

Table 4.6 Advantages vs. disadvantages of use of periodic collection days at temporary sites as a collection model

Advantages	Disadvantages
• Opportunity for source sorting • Can be meshed with other waste collections (i.e. e-waste, HHW) • Potentially low cost • Flexible in collection size and day • Potential for educating public and source of information	• Requires cooperation of site host • Requires substantial promotion for success • May require substantial stockpiling on householders behalf • Potentially inconvenient (requires special trip) • Low participation

Discussion
This type of collection method is becoming popular for the collection of problematic wastes, particularly e-waste. It works well for this type of waste as usually households are interested in disposing of a large volume. Because of their small size batteries are easily disposed of into household waste and do not create the same incentive to take them to a temporary disposal day. In the community survey less than a third of respondents indicated they would be willing to take part in this type of collection service.

When coupled with other wastes, which it is assumed the day would be, this form of collection is very low cost and offers many other benefits such as an education source and potential for onsite sorting.

4.8 Permanent Collection Facility

Collection system: A permanent facility or site that accepts recyclables. It is located in publicly assessable areas such as shopping centre car parks, churches, Local Government depots and landfills. It is usually opened for limited hours during the week staffed or open all the time unstaffed. Some examples include drink bottle, paper container recycle bins and charity clothing bins.

Collection channels: Shopping center car parks, churches etc, Local Government depots and landfill sites.

Cost: Rent of site, maintenance, collection service provider.

Stakeholders: Local Government, site host, charity organisation, collection service provider and householder.

Operation examples: In Netherlands, battery collection points are integrated into a bottle bank which is located in supermarket car parks (IET, 2006).

Australian charity bin systems are one example of this model. The collection bins are located in service stations, churches and shopping centre car parks; places where there is easy assess for the donator by public transport or private vehicle. Collection is by a charity organisation such as St Vincent de Paul. This type of collection service is relatively inexpensive as it is conducted by volunteers. The major cost comes from illegal dumping around the bins, which can become such a problem that some Local Governments have limited the amount of charity bins in their area (Ferrante, 2006).

Another example is recycling at landfill sites and transfer stations. These sites will usually have an area dedicated to bins collecting different types of recyclables. The cost of collecting batteries at these would be minimal as it is already set up to collect most types of waste. The largest cost would be for the safe disposal of the batteries, which is not being taken into account at this stage.

Table 4.7 Advantages vs. disadvantages of use of permanent collection facility collection model

Advantages	Disadvantages
• Easily meshed with existing system • Low cost • Some potential for onsite sorting • Accessible in metropolitan and non-metropolitan areas.	• Illegal dumping • Potential high maintenance costs • Special trip required (inconvenient) • Requires cooperation of site host • Potentially low participation rates

Discussion
Permanent collection facilities at landfill sites and transfer stations are one of the most easily established collection models. The infrastructure is usually already in place and little initial investment would be needed. However, as indicated in the community survey, few households actually visit these facilities on a regular basis, if at all. It is assumed that this type of collection method would occur simultaneously with any other collection model adopted.

Civic amenity sites (household recycling centres) in the UK were one of the favoured collection systems for household batteries in the ERM battery recycling lifecycle analysis (ERM, 2006) and are also a common current collection model for local authorities in the UK. This is because batteries can be aggregated at these facilities, making collection and transportation more efficient.

4.9 On Demand Collection Service with Mobile Collection Vehicle

Collection system: On demand collection service with a mobile collection vehicle involves door-to-door service whereby resident's advice the service that they have waste to be collected and a vehicle is dispatched to collect it. Collection may occur from many houses in a given area.

Collection channels: Collection vehicle collecting from homes on demand.

Cost: Collection service provider fee, pick up, disposal (built into collection fee in some instances).

Stakeholders: Collection service provider, householders.

Operation Examples: There are a couple of examples of this type of collection model in relation to the collection of used furniture. Many private second hand retailers of furniture will pick up used furniture, usually for free, or depending upon the value of the used furniture, at a profit to the disposer. In this example, there is a profit to be made for resale of the material, which makes it worthwhile for the collection service. Charity shops will also often offer a free pick up service for second hand furniture. In this case the collections are conducted by volunteers but the furniture is sold on for a profit. Like the above service, this is feasible because of the positive resale value for the furniture.

Table 4.8 Advantages vs. disadvantages of an on demand collection service with mobile collection vehicle, collection model

Advantages	Disadvantages
• Convenient • Opportunities for sorting	• High cost • Low likely participation rates • Only available in certain areas • Inefficient

Discussion
Even though the collection vehicle could potentially collect from many houses in a given area and that there are opportunities to increase the efficiency through route and timing planning this method was found to be expensive as well as suffering from other difficulties by Teague's (2003) review of household hazardous waste collections. It is impractical and the working examples of this type of model are all for wastes which have a positive market value for resale, which makes pick-up commercially viable for the operator, alleviating costs for the disposer. It is assumed that the quantity of batteries in a household could not feasibly justify this sort of system, even if coupled with other wastes

4.10 Pay-as-You-Throw

Collection system: A collection container is purchased from a battery collection service provider. The service requires the user to send back the container after it has been filled with used batteries. Postal and service fees are included in the purchase price. The service may be provided by a waste treatment company that has a treatment plant.

Collection channels: Container or box through the post.

Cost: Container, postage, sorting and safe disposal, administration.

Stakeholders: Householders/groups and collection service provider.

Operation examples: Cleanaway waste service company is currently conducting a national Dry Cell Battery Collection Program (Cleanaway, 2007). The consumer/group purchases a pre-paid box from Cleanaway which is then posted to them. The fee for the box includes the postage and service cost. After the container is filled with spent batteries, the box is posted back to Cleanaway who then sort the batteries. Only rechargeable batteries are recycled in this process. Spent disposable batteries are 'safely disposed' of by encasing in concrete and landfilling.

Table 4.9 Advantages vs. disadvantages of use of pay-as-you throw collection model

Advantages	Disadvantages
• Accessible anywhere • Sorting included in service	• High cost for the consumer • Low participation rates • Inequitable distribution of costs

Discussion

This type of collection system is only feasible for certain groups or individuals. The high costs make it inequitable which in turn would give it very low likely participation rates. The inability of this type of service to properly recycle all household batteries would inhibit its ability to promote itself as a battery recycling service. Justification for consumers to pay such a large fee for 'safe disposal' for disposable batteries would be difficult.

5. Comparison of Collection Models

5.1 Comparison of Collection Models

In Section 4 the main collection models for used batteries were outlined. Based on that information Section 5 will compare each of the collection models based on the criteria: efficiency; equity; education; practicality; costs; participation; convenience; and sorting. A summary of the results of comparison of the collection models against these criteria is provided in Table 5.1

5.1.1 Efficiency

In kerbside collections the efficiency is very low because the cost of providing a fortnightly collection and sorting would be very high compared to the amount of batteries collected. Similarly pay-as-you-throw and on demand mobile collection services would incur a high cost compared to the amount of batteries collected.

Vergeside collections would be more cost effective, as they only occur 1-2 times a year and would involve a stockpiling of batteries which would make the cost per battery collected lower. Similarly institutional, retailer take-back, public amenity sites and permanent collection facilities are medium to low-cost to operate with medium to low participation rates.

No collection model was found to be particularly efficient in the current WA situation. The low density of the population coupled with high transportation costs mean that any truly successful scheme is likely to be expensive.

5.1.2 Equity

Kerbside and vergeside cover the largest proportion of residents in Western Australia and have the advantage of being available to residents with low mobility or lack of transport. However, kerbside and vergeside are predominantly only available to metropolitan areas and regional centres. Hence, they present an inequity to people located in rural areas. Furthermore, vergeside is not available to inner metropolitan residents due to impracticalities of pick-up. The most accessible collection method is retailer take-back, as theoretically all consumers who are purchasing batteries have access to this method of disposal. This assumes that all retailers of batteries would offer the service and the consumer purchasing the battery is the one disposing of it.

Pay-as-you throw was deemed to be unequitable because of issues with the cost. On demand service with a mobile collection vehicle was assumed to be only practical or successful in more populated areas. Periodic days at temporary sites and permanent collection facilities may require use of a private vehicle for transportation and hence are inequitable for those without private transport. Public amenity sites should theoretically be accessible to all residents, as they would be located near public transport, however they may not be as feasible in non-metropolitan areas. Institutional collection schemes are potentially accessible to most residents; however usually target certain groups, such as schools, which may only represent certain households.

5.1.3 Education

It was assumed that a scheme in an institutional establishment, specifically a school, would provide the most opportunity to be a source of information about the waste management of spent batteries and to raise awareness of waste management issues generally. Vergeside and kerbside collection systems would provide some opportunity for information to be placed on the bins, or enter the household through information booklets and calendars. Periodic drop-off days provide face-face contact which could also be used as a mechanism for feeding information back into the community.

5.1.4 Practicality

The collection models with the highest practicality are institutional, retailer take-back, public amenity sites and pay-as-you throw. These are all systems which are currently in use in WA, for batteries or other problematic wastes, and would not require significant modification for the collection of batteries. On demand

service with a mobile collection vehicle was deemed not to be practical for other feasibility reasons. Kerbside and vergeside are both established services but the practicality of collecting batteries in these methods remains questionable. Specialised containers may be needed and many different systems for collecting and sorting waste material are in place in Western Australia, all of which would be impacted differently. Periodic collection days at temporary sites are more practical because it is assumed they will be combined with other types of waste.

5.1.5 Costs

Regular pickup through kerbside collections remains what is perceived to be the most expensive option. The cost would be directly to Local Government and passed on to the community via rates. A vergeside collection model, whilst not as expensive or frequent as kerbside collections, would also distribute costs in a similar fashion. Institutional collection programs, depending upon their parameters, were assumed to be moderately costly. They raise questions as to who is responsible for maintenance, collection, recycling/safe disposal and depending upon model, where costs will lie. Retailer take back schemes are a relatively cheap option. The costs are borne by the retailer/battery manufacturer. Who will in turn charge a small fee on the sale of the product to recover these costs. Hence, the cost would eventually be borne by the consumer. Public amenity sites are a relatively inexpensive option but would require regular maintenance and upkeep which may in the long term prove costly. Periodic collection days at temporary sites, whilst appearing expensive for their initial investment, incur only one off costs, compared to other systems which require regular input. This sort of collection day is already occurring and is increasing in frequency.

Permanent collection facilities were assumed to be low cost as they would occur at an existing site, with other wastes. It was assumed that this would be the most low cost system. On demand service with mobile collection vehicle and pay-as-you throw services would be expensive to the consumer as it would likely require a commercial enterprise to run the collections.

5.1.6 Participation Rates

From Survey results (Section 3) it was assumed that kerbside collections would have the highest participation rates. Vergeside collections of batteries were assumed to have a slightly lower participation rates due to the irregularity of pick-ups and knowledge of dates needed. Institutional drop off models would be moderately participated in; this was based on the school model, with appropriate promotion. Public amenity sites, periodic collection days pay-as-you throw and on demand services with mobile collection vehicle were assumed to have the lowest participation rates. The reason for these participation rates is a combination of cost (pay-as you throw and mobile collection vehicle) and convenience (public amenity sites, periodic collection days at temporary sites). These collection models would only attract certain groups of the public, even though they could potentially target all groups.

5.1.7 Convenience to Householder

Convenience to the householder relates to the ease with which the householder can utilise the collection system. Convenience to householder differs to participation rates when a collection model may be highly convenient for the householder but have low participation rates. On demand service with a mobile collection vehicle is one such model. Collection systems which do not require the householder to take extra-trips; retailer take-back, public amenity, Institutional; or do not require the householder to leave their place of residence; kerbside; vergeside; will be the most convenient. Whilst periodic collection days or permanent collection facilities (such as landfills) may require the householder to take a special trip and remain less convenient.

5.1.8 Sorting

Most of the collection systems had very little opportunity for onsite sorting and contamination in these cases could be a problem. On demand service and pay-as-you throw would have the best opportunity for onsite sorting, as it is assumed trained professionals would be doing the collecting. There is some opportunity for onsite sorting in institutional collection models, periodic collection days at temporary sites and permanent collection facilities. This would depend upon how the system was set up and the commitment of the host organisation.

Table 5.1 Assessment of Used Battery Collection Models

Models	Cost	Participation	Convenience	Efficiency	Practicality	Sorting	Education	Equity
Kerbside collection	High	High	High	Low	Low	Low	Medium	Medium
Vergeside Collection Service	High-Medium	Medium	High-Medium	Medium	Medium	Low	Medium	Medium
Institution	Medium	Medium	High-Medium	Medium	High	High-Medium	High	Medium
Retailer Take Back	Low	Medium	High-Medium	Medium	High	Low	Low	High
Public Amenity Sites	Medium	Low	Medium-Low	Medium	High-Medium	Low	Low	Medium
Periodic Collection Days at Temporary Sites	Low	Low	Low	Medium-Low	Medium	High	Medium	Medium-Low
Permanent Collection Facility	Low	Medium	Medium-Low	Medium	High	Medium	Low	Medium
On Demand Service	High	Low	High	Low	Low	High	Low	Low
Pay-as You Throw	High	Low	Low	Low	High	High	Low	Low

5.2 Multi-Criteria Analysis

A multi-criteria analysis is useful in providing a set of values for the criteria on which the collection models have been compared. However, the criteria selected and the values assigned to them will represent different priorities and assumptions in each assessment. The assumptions and an explanation for the scoring system was given in Section 4.1

The multi-criteria analysis worked on the following scoring (5 being the most important and 1 being the least):

Efficiency	5
Equity	4
Education	3
Practicality	2
Cost	2
Participation	2
Convenience	2
Sorting	1

Based on the above comparisons a multi-criteria analysis was conducted.

Table 5.2 Multi-Criteria Analysis of Used Battery Collection Models

Models	Cost	Participation	Convenience	Efficiency	Practicality	Sorting	Education	Equity	Total
Kerbside collection	2	10	10	5	2	1	9	12	**51**
Vergeside Collection Service	4	6	8	15	6	1	9	12	**61**
Institution	6	6	8	15	10	4	15	12	**76**
Retailer Take Back	10	6	8	15	10	1	3	20	**73**
Public Amenity Sites	6	2	4	15	8	1	3	12	**51**
Periodic Collection Days at Temporary Sites	10	2	2	10	6	5	9	8	**52**
Permanent Collection Facility	10	6	4	15	10	3	3	12	**63**
On demand service	2	2	10	5	2	5	3	4	**33**
Pay-as You Throw	2	2	2	5	10	5	3	4	**33**

5.2.1 Summary of Findings: Ranking of Collection Models

From the multi-criteria analysis the battery collection models were ranked (with 1 being the most favoured and 9 being the least favoured).

1. **Institutional Collection Programs**
2. **Retailer Take Back Scheme**
3. **Permanent Collection Facility**
4. **Vergeside Collection**
5. **Periodic Days at Temporary Sites**
6. **Public Amenity Sites**
7. **Kerbside Collection**
8. **Pay-as-you Throw**
9. **On Demand Service with a Mobile Collection Vehicle.**

6. Further Discussion and Conclusions

6.1 Analysis of Preferred Models - 3 Tiers of System

Based on the multi-criteria analysis conducted in Section 5 the proposed collection models have been categorised into three different tiers. The tiers are ordered 1-3 (1 being the highest scoring models and 3, the least). This section will explore the circumstances under which each system will best operate and the assumptions of each model. Due to their low score, Pay-as-you throw and On demand service with a mobile collection vehicle have been discarded.

6.2 Tier One

Institutional Collection Programs

Institutional collection programs were the highest scoring collection model in this analysis for a number of reasons. In the absence of extensive waste collection/drop off infrastructure in Western Australia it is envisioned that this could be the most practical to implement and administer through the Regional Councils. Already, several of the Regional Councils have implemented similar schemes in the metropolitan area.

Some limitations that would need to be overcome include cooperation of schools and involvement of individual teachers, (scheme may rely on a 'champion' for that school). Given the current lack of recycling processes for household batteries the collected material could be sorted into rechargeable and disposable. Other obstacles may involve the liability or public perception of a state push for the collection of what may be considered a household hazardous waste, by children through schools. To date this has not been a significant concern.

Areas that the State could facilitate in initiating this program are administrative support, provision of promotional/educational materials which could be used by Regional Councils for distribution to participating schools. The State could also develop a centralised collection mode/contractor for the collection of the batteries from schools/thereby alleviating the main cost of the program/ and one main barrier to its implementation. The State could also look to expanding the network further by establishing collection points in universities/TAFE etc, which could be promoted internally as a part of sustainability courses.

Retailer Take-Back Schemes

In this instance it is assumed Retailer take-back schemes place the responsibility for collection/disposal of batteries on producers/retailers of the product. The Victorian BatteryBack is one example of this in a Product Stewardship approach. The Australasian Battery Recycling Initiative ABRI illustrates that there is willingness for stakeholders in the battery supply chain to participate in the diversion of batteries from general waste. If this type of scheme was unsuccessful Extended Producer Responsibility for batteries at the end of their life could be explored. The Statutory Waste Authority will also have extensive head powers to bring the manufacturers/retailers into a scheme. It will also have the ability to establish an overall framework for the collection of wastes (i.e shared collection centres etc)

Some key parameters that would need to be established is whether all types of batteries would be collected, or if only rechargeables would be collected. Whether there is a pre-disposal fee (as with MobileMuster) or if it will be a partnership of retailers running the scheme (BatteryBack), with the State picking up the cost for orphans. Due to the variety of places that batteries are purchased, it is recommended that the Scheme have a wide coverage, however, the feasibility of having collection points at places such as supermarkets is limited due to their number. Whether retailers who sell products with a battery included are responsible would be another consideration. Labelling is one option for illustrating that the batteries can be recycled with their retailer, however, the feasibility of achieving this for Western Australia is limited and would best be accomplished on a National scale (e.g. The Rechargeable Battery Recycling Corporation in the US). The European battery recycling model indicates that government help is required to develop a collection levy to pay recycling costs.

6.3 Tier Two

Permanent Collection Facility

It would be relatively easy to incorporate collection facilities at landfills and transfer stations. It is expected that permanent collection facilities at landfills and transfer stations is likely to occur as part of ordinary operating practice.

Vergeside Collections

Vergeside collections offer the convenience of a kerbside collection, without the costs of such a regular pick up. As different Local Governments collect and implement their vergeside collections in a variety of ways, this may work well for some areas and not so well for others (e.g. Local Governments who offer a skip bin such as the City of Bayswater).

It is envisioned that vergeside collections would occur with the hardwaste collection, with a bag or box distributed prior to the collection for residents to place their used batteries into. For it to be feasible, the Local Government would likely need to be operating a manual pickup of the hardwaste and have a box or bag secured to the truck for collectors to empty or place the boxes/bags of batteries (similar to WRAP trials of kerbside pick ups).

One way that the State could assist in facilitating this type of collection is through the provision of funds or administrative support for the boxes or bags that would be needed. It is assumed that these would be printed with educational material on the effects of batteries in landfill. If this type of collection was combined with other collection models, the bags could also contain information on other places that it could be dropped off.

6.4 Tier Three

Periodic Days at Temporary Sites

This method scored relatively low because few survey respondents indicated that they would participate in this type of collection day. To be cost effective, this type of collection would be coupled with other wastes such as e-waste or household hazardous waste, which are already collected in some areas WA via this model. As batteries are much smaller and easier to dispose of into normal household rubbish, there would need to be substantial promotion of the day, to collect sufficient quantities. These days would likely occur only every few months so it would take time to build up the habit of stockpiling for special disposal on these days.

Methods that the State can use to facilitate periodic collection days is assistance in the promotion and advertising (providing template promotional materials) and provision of a centralised collection service for the recycling of these batteries (for shipment of rechargeable batteries overseas and a contractor to appropriately dispose of primary batteries).

Public Amenity Sites

Public amenity sites scored relatively low in this analysis. These would be most effective if combined with other types of collection methods such as retailer take back schemes and institutional collection programs, in a network of drop off points, all serviced by the one collector.

Kerbside Collection

The community survey results show that kerbside collection could have the highest participation rates and ERM found kerbside collection to be the most effective collection method. However, without legislation to underpin collection targets, there is little motivation to undertake kerbside collection, which is one of the most costly collection schemes.

7. Recommendations

SHORT TERM

1. That the State Government works with Regional Councils to further develop and expand the current Institutional Collection programs, providing administrative support through the WasteWise Schools program.

Funding could be provided for a centralised contractor to collect/ sort/ export or prepare batteries for safe disposal. This collection model was found to be the most appropriate for current context in Western Australia. It also has several successful working examples in other countries. This is a model already in use in WA, which can be expanded and formalised with the assistance of the State Government through the Regional Councils. Opportunities also exist for this type of scheme to expand out to high schools, universities and TAFE's.

2. In the absence of any specific legislation or structure for the collection of household batteries, that the State Government pursues a policy of reducing the consumption of household batteries through avoidance.

Models of consumption avoidance and hence the disposal of household batteries are explored in the accompanying paper 'Battery Avoidance Strategies'. Given that there are currently few options for recycling batteries, and that these options are international and only for rechargeable batteries, a State policy of avoidance may be more practical and appropriate. The current quantities of batteries disposed of in Western Australia make economies of scale difficult and any truly successful collection scheme could come at significant costs which may be inappropriately distributed.

3. That the State Government undertakes a lifecycle assessment of the impacts of battery recycling and disposal. This should include further research into the impacts of household batteries in landfill and justification for their removal, as well as, the potential lost resources from a failure to recycle used battery constituents.

Little information was available on the specific impacts of household batteries in landfill. ERM has done a lifecycle analysis on battery collection and recycling in the UK and found it environmentally beneficial to collect and recycle batteries. A similar analysis could be conducted on the Western Australian situation, with due consideration of population density, transport distance to battery recycling facilities and collection systems in place.

MEDIUM TERM

4. That any battery collection model adopted in Western Australia be a part of a wider system for the collection of other wastes or build upon existing collection frameworks. This will assist in minimising the costs of collection.

Some examples of how to achieve this include the collection of batteries at household hazardous waste days, Container Deposit System (CDS) drop off points, or e-waste collection days. In the multi-criteria analysis it was found that collection systems which could be combined with other wastes such as permanent collection facilities, periodic collection days at temporary sites and retailer take-back schemes, were the cheapest to implement.

5. That a working group of State and Local Government; battery retailers/manufacturers/exporters; relevant WA industries; and recycling companies; be formed to explore options for market development for recycled battery materials in Western Australia.

Further assistance and motivation in developing this working group can be gained from the Australasian Battery Recycling Initiative which has already done a lot of ground work to this end. Their research has found that battery recycling could be feasible in Australia and several industrial processes could be easily modified to use sorted batteries. Finding a local market for battery constituents to be recycled could greatly increase the viability of a collection scheme.

6. That the State Government enter into negotiations with battery retailers/manufacturers to develop a Product Stewardship Scheme for the collection of household batteries; most likely through a Retailer Take Back Scheme. And that if negotiations fail to produce a scheme or the scheme is unsuccessful in achieving its targets, that an Extended Producer Responsibility (EPR) Scheme be developed under the powers of the potential Waste Avoidance and Resource Recovery (WARR) Act.

A retailer take back scheme was the second highest scoring model. This model is consistent with making the producers responsible for the collection of their own product post-life. Depending upon the set-up of the scheme, the price of disposal could be built into the purchase price of the product, giving this scheme a more equitable distribution of costs. As with the MobileMuster Program, a Product Stewardship or EPR retailer take back scheme could be combined with institutional and public amenity collection models (e.g. potential Container Deposit Scheme collection points). Compulsory labelling of batteries is one possible way of making this scheme more successful.

7. That the State Government utilises a number of collection methods for household batteries. This could be done by facilitating different Regional Councils/Local Governments to establish collection methods which are suitable to their area and waste collection infrastructure.

Various collection methods will suit different households and areas. Depending upon the collection model, there is usually reliance upon the collection model being compatible with the Local Government infrastructure already in place in that area. Non-metropolitan areas would particularly need a unique approach. Whilst there is a lower population density and hence consumption of batteries in these areas, the rural landfills tend to be designed at a much lower safety standard, often without leachate capture or liners.

8. That the State Government develops a state-wide, overarching promotional strategy which can be used to compliment any battery collection model. The education campaign should focus upon the environmental impacts of incorrect disposal and fit into a general education campaign on recycling.

The success of any battery collection model will be largely underpinned by an understanding in the community that batteries can have adverse impacts on the environment when disposed of into normal household waste. Given the current lack of recycling options, it is difficult to focus upon the upstream impacts of resource efficiency, but this could be a direction that an education campaign could take in the future when, and if, other recycling options emerge.

LONG TERM

9. Depending upon the outcome of both the lifecycle analysis of collecting and recycling batteries, their impact in landfill, and negotiations in establishing a local market for household batteries, the State Government should seek to establish future legislation for the collection of batteries and their potential diversion from landfill.

Given that almost all countries with established battery collection systems have implemented strong legislative underpinnings it has been assumed that to fully divert batteries from landfill government intervention is needed. This could tie in with an Extended Producer Responsibility scheme and give incentive for more complicated and costly, but high yielding collection models such as kerbside and vergeside collections.

References

Anon, 2003, *Battery collection in Sweden*, from Hem till Holken website, Available Online: https://wwwhemtillkoken.nu/, <click on English>, [Accessed 20.07.06]

Australian Bureau of Statistics, 2005, *Australian Yearbook*, Available Online: http://www.abs.gov.au [Accessed on 23.02.07].

Australian Bureau of Statistics, 2006, *Australia's Environment: Issues and Trends*. Available Online: http://www.abs.gov.au [Accessed on 24.02.07].

Australia Mobile Telecommunications Association (AMTA), 2006, *Businesses join Mobile Muster and help recycle old mobiles*, AMTA Website. Available Online: http://www.amta.org.au/?Page=807, [Accessed 20.07.06]

Bristol City Council, 2004, *Recycling- your black box,* Bristol City Council website. Available Online: http://www.bristol-city.gov.uk/ [Accessed 20.07.06]

Bristol City Council, 2004, *Battery Recycling Campaign in Bristol: Final Report on Pilot Campaign in Preparation for Forthcoming European Directive* (September 2002-September 2003) Available Online: http://www.bristol-city.gov.uk/ [Accessed 20.07.06]

ChemClear, 2006, *Questions and Answers*, Chemclear Website Available Online: http://www.chemclear.com.au/qa.php [Accessed 20.07.2006]

Cleanaway, 2007, Pers. Comm. Technical Support Manager. More information available online www.cleanway.com.au/batteryrecyling

Coled Ltd, 2007, Pers. Comm. Manager Regulatory Affairs.

Department of Communications, Information Technology and the Arts (DCITA), 2003, *RecycleIT: Computer Collection Pilot*, Data, October 2003, p21 Available Online: http://www.dcita.gov.au.

Duracell, 2007, Duracell Learning Centre website. Available Online:
http://www.duracell.com.au/pages/learning-centre-gen-purpose-batteries.asp
http://www.duracell.com.au/pages/learning-centre-rechargeable-batteries.asp
[Accessed on 25.01.07]

Eastern Metropolitan Regional Council (EMRC) 2007, Pers. Comm. Waste Education Officer. More information available online: www.emrc.org.au

EcoRecycle Victoria, 2005, *Towards Zero Waste: Annual Survey of Victorian Recycling Industries 2003-04*, Melbourne. Available Online:
http://www.ecorecycle.sustainability.vic.gov.au/resources/documments/Annual_Survey_of_Victorian_Recycling_Industries_2003-04.pdf

Environmental Resources Management (ERM), 2006, *Battery Waste Management Lifecycle Assessment* Available Online: http://www.defra.gov.uk/environment/waste/topics/batteries/pdf/erm-lcareport0610.pdf)

Federal Government, 2007, *Response to the Productivities Commission's Final Report on the Inquiry into Waste Generation and Resource Efficiency in Western Australia*. Available Online:
http://www.wmaa.asn.au/director/newsreleases/news.cfm?itemID=2A60E38997FFC2C96918445D067E72C3 [Accessed 10.10.07]

Ferrante, M., 2006, 'Agreement on Bins' *Stirling Times,* 14 November 2006.

Fricke, J L, and Knudsen, N, 2002, *Disposal of Portable Batteries*, GRS Batterien, Hamburg. In: Swaiston J., Wright S. and Bruckard W., 2006, Opportunities for used consumer battery recycling in the Australia/Pacific region, *Green Processing*.

Hakanson, L .,1980, 'An Ecological risk index for aquatic pollution control- A sedimentological approach'. *Water Research*. 14: 975-1001

Hansmann, R., Bernasconi, P., Smieszek, T., Loukopoulos, P., Scholz, R. W,. 2006 'Justifications and self-organisation as determinants of recycling behaviour: The case of used batteries', *Resources, Conservation and Recycling* 47:133-159.

HazDat Database, 1995, Agency for Toxic Substances and Disease Registry (ATSDR), 1995, Available Online: http://www.atsdr.cdc.gov/hazdat.html [Accessed on 26.01.07]

Australian Productivity Commission, 2006, *Productivity Commission Inquiry Report: Waste Management*, No.38, Available Online: http://www.pc.gov.au/inquiry/waste/finalreport/waste.pdf [Accessed on 3.02.07].

The Institute of Engineering and Technology (IET), 2006, *Recycling of Batteries.* Available Online: www.theiet.org/factfiles [Accessed on 25.01.07].

James, S.C., 1977, 'Metals in municipal landfill leachate and their health effects'. *American Journal of Public Health*, 67 (5):429-432.

Kanemaru, T., and Matsuoka, T., 1995, 'General overview of battery waste management in Japan', *Journal of Power Sources*, 57, (1-2): 23-26.

Katos, G & Hoye J, 2005, *Household Electrical & Electronic Waste Survey- Report of Findings*, ISOP

Mamo, M., Halbach, T. R., and Rosen C. J., 2002, 'Utilization of Municipal Solid Waste Compost for Crop Production, University of Minnesota Extension Service' Available Online: http://www.extension.umn.edu/distribution/naturalresources/DD7083.html [Accessed on 26.01.07]

Martinez, C., 2007, 'Gloves off over Mobile Recycling Scheme Credibility' *Environmental Management News*, 31 July 2007

Panasonic, 2007, Panasonic Website, Available Online: www.panasonic.com.au/ [Accessed 19.07.07].

Park, S., Joe, K .S., Han, S. H., Eom, T. Y., and Kim, H. S., 1999, 'Characteristics and Distribution of Metallic Elements in Landfill Leachate', *Environmental Technology*, Vol 20(4):443-448.

Phipps, G., 2004, 'Battery recycling in need of a recharge', *Taipei Times.* Available Online: www.taipeitimes.com/News/feat/archives/2004/08/22/2003199806 [Accessed on 2.02.07]

Planet Ark, 2006, *Cartridge for Planet Ark*, Planet Ark website. Available Online: http://www.planetark.com [Accessed on 10.02.07].

Planet Ark, 2007, *Recycling Near You* website. Available Online: http:// www.recyclingnearyou.com.au [Accessed on 10.07.07].

Rechargeable Battery Recycling Corporation, 2007, *RBRC* Website, Available Online: www.rbrc.org [Accessed 10.10.07]

Reid Waste Consulting, 2006, *Sublet Tasks Undertaken by Reid Waste Consulting on behalf of the Municipal Waste Advisory Council* (Available on request from the Municipal Waste Advisory Council)

Municipal Waste Advisory Council (MWAC), 2006, *Resource Recovery Rebate Scheme, Period 16 Administration Report.*

Rydh, C. J., and Savard, B., 2003, 'Impact on global metal flows arising from the use of portable rechargeable batteries', *The Science of the Total Environment*, 302:167-184.

Southern Metropolitan Regional Council (SMRC), 2007, Pers. Comm. Manger Engineering Works. For more information visit www.smrc.com.au

South East Metropolitan Regional Council (SEMRC), 2007, Pers. Comm. Waste Officer. For more information visit www.semrc.wa.gov.au

Sustainability Victoria, 2007, *BatteryBack* website. Available Online: http://www.sustainability.vic.gov.au/www/html/2406-batteryback.asp [Accessed: 7.07.07]

Swaiston, J., Wright, S., and Bruckard, W., 2006a 'Opportunities for used consumer battery recycling in the Australia/Pacific region' in *Green Processing*

Swainston, J., Wright, S., and Herbertson, J., 2006b *No Batteries to Landfill: Committed to Maximise Value and Minismise Waste*, Australasian Battery Recycling Institutive (ABRI) May 2006.

Teague, C., 2003, *Household Hazardous Waste Collection –What is best practic*e? Environmental Science, Division of Science and Engineering, Murdoch University, Perth

Victorian Government, 2005, *Thwaites warns mobile phone companies on recycling*, Media Release, 29 March 2005. Available Online: http://wwwdpc.vic.gov.au/domino/Web_Notes/newmedia.nsf/798c8b072d117a01ca256c8c0019bb01/273042a74e080a87ca256fd300830990!OpenDocument, [Accessed 24.07.2006]

The Waste and Resources Action Programme, 2007, *WRAP* Website. Available Online: http://www.wrap.org.au [Accessed on 9.02.07].

WasteWise WA, 2005, Available Online: http://www.wastewise.wa.gov.au/ [Accessed on 26.02.07]

Wiauz, J.P. and Waefler J.P., 1995, 'Recycling zinc batteries: an economical challenge in consumer waste management', *Journal of Power Source*, 57: 61-65.

Appendix A

Tables of Battery Chemistry

Table 1 Chemistry of Manganese Primary Batteries

Component (wt %)	Battery type	
	Zinc-carbon	Alkaline
Li	-	-
Fe	20	20
Mn	25	30
Zn	20	20
NH_4Cl, ZnCl	5	-
KOH	-	5
H_2O	10	10
Plastic, paper, carbon	20	15

Table 2: Metal Content of Rechargeable Batteries

Component (wt %)	Battery Type			
	NiCd	NiMH (AB5)	NiMH (AB2)	Li-based#
Al	0.02	-	-	4.6-24
Cd	15-20	-	-	-
Ce, La, Nd, Pr	-	8-10	-	-
Co (Mn, Ni)	0.6	3-4	1.0-2.0	12-20
Cr, Ti, V, Zr	0.02	0.08	13-14	-
Cu	-	-	-	5-10
Fe	29-40	22-25	23-25	5-25
K	1-2	-	-	-
Li	-	-	-	1.5-5.5
Mn	0.08	0.8-3.0	-	-
Ni	15-20	25-46	37-39	-
V	-	-	2.2-4.7	15*
Zn	0.06	0.1-1.6	20	-
Zr	-	-	3.9-8.7	-
Plastic, paper, carbon	5	5-7	15	-

#Lithium Ion and Lithium-polymer
*Lithium-polymer

References

Fricke, J. L., and Knudsen, N., 2002, *Disposal of Portable Batteries*, GRS Batterien, Hamburg. In: Swaiston J., Wright S. and Bruckard W., 2006, 'Opportunities for used consumer battery recycling in the Australia/Pacific region', *Green Processing*

Rydh, C.J., and Savard, B., 2003, 'Impact on global metal flows arising from the use of portable rechargeable batteries', *The Science of the Total Environment*, 302:167-184.

Appendix B

Additional Information on Factors Affecting a Battery Collection Model

1. Legislation

The establishment of legislation and regulation for recycling of batteries is significant in motivating community and industry involvement in any battery collection model. Almost all nations where battery collection systems are in place have established legislation which both motivates and regulates battery collection and recycling.

The Basel Convention (1992) recognised the importance of treating hazardous wastes responsibly with consideration of global socio-economics and the environment. 169 countries were present at the Convention. Among these countries the United States, members of European Union: Austria, Sweden, Netherland, United Kingdom and Japan have signed or ratified their commitment to the convention. They have also transposed the Convention into their dry cell battery recycling legislation.

Australia is one of the 169 countries that attended the Basel Convention. Yet currently, the Australian government has taken no action for a sustainable solution for used dry cell batteries. There are “Low” and “No” recycling options available for Nickel Cadmium and household batteries in Australia (ABS, 2006).

Examples of legislation in place internationally are:

- United States of America:
    - Mercury-Containing and Rechargeable Battery Management Act (“Battery Act”) 1996: aims to phase out the use of the mercury in batteries and administrate the treatment of used NiCad, small sealed lead battery (SSLA) and rechargeable batteries.
    - Universal Waste Regulations (40 CFR Part 273) (US EPA): used to regulate a stream-lined collection requirement for hazardous wastes, including mercury-containing batteries.
- Japan:
    - Law for the Promotion of Effective Utilisation of Resources (2001) (MIE) mandates that batteries manufacturers take responsibility for the establishment community education programs and battery recycling schemes. A Recycled volume target is set for the members of association.
- European Union:
    - EC Framework Directive on waste 91/157/EEC (Revised as 2006/12/EC: its aim is to restrict and ban batteries containing mercury. Also set long term targets to recycle waste batteries.

The European Union Batteries Directive and has recently been transposed into United Kingdom law. The Batteries Directive defines the operation cost, Product Stewardship and regulations for treating the collected waste in household batteries. It emphasised the importance of providing

waste education to the community, retailers and industries on battery recycling. Any net costs from the collection, treatment and recycling of spent batteries is to be met by producers or organisations on their behalf. The legislation also restricted the use of hazardous substances such as Cadmium in batteries. (Waste Resources Action Program, 2007)

The UK is in the process of compiling data from a National Pilot Household Dry Cell Waste Battery Recycling Program. The current battery collection program is organised and conducted by Waste and Resources Action Program (WRAP). The results will be used to inform the Government of the capital required for a collection and recycling model to suit the United Kingdom to achieve targets set by European Union Batteries Directive (Batteries Project Officer, WRAP, per comm. 2007).The WRAP program will conducting a number of different collection trials to attempt to reach the 25% of batteries target set by the EU Batteries Directive.

In the USA and Canada, legislation has been developed to prohibit the disposal of rechargeable batteries into normal household rubbish. The US Battery Act establishes national, uniform labeling requirements for Ni-Cd batteries and requires them to be easily removable from products. It mandates the collection, storage; and transportation of rechargeable batteries. The legislation also required the EPA to establish a public education program on battery recycling and proper handling and disposal (RBRC, 2007). This was developed in the form of the Rechargeable Battery Recycling Corporation (RBRC) which promotes rechargeable battery recycling and the use of rechargeable batteries over disposable batteries (RBRC, 2007).

One area that legislation has assisted in the success of collection models internationally is mandatory requirements for the labelling of batteries. Labelling can provide information to the consumer on battery chemistry type, toxicity and whether it can be recycled. One example of this is the Battery Recycling Association of Japan (BAJ) which has developed guidelines for batteries to make it easier for consumers to identify that batteries are recyclable and rechargeable, to ensure consumers would know to hold the batteries for special collections. The design guidelines also made it easier for recyclers to distinguish the different chemistry types for each rechargeable battery (Fuijimoto, 1997).

A draft of the Waste Avoidance Resource Recovery Bill has been developed. This new waste legislation is envisioned to be the enabling legislation to allow Western Australia to actively pursue the state policy of ‘Towards Zero Waste’. In addition the Bill will be able to limit socially unacceptable practices through increasing financial restrictions and supporting other actions such as Extended Producer Responsibility (EPR), market development and improved infrastructure. (Teague, 2003)

2. Recycling Techniques

The three general recycling processes in practice are (Espinosa et al, 2004):

- **A. Separation of components through unity operations of mining treatment**

Phase 1: Manual treatment (dismantle, removal of paper, plastic cover) of collected waste batteries.

Phase 2: Metal scraps go through pyrometallurgic treatment (Heat treatment).

Phase 3: Molten metal goes through distillation and is recovered as a solid form.

- **B. Pyrometallurgy**

*Phase 1: Manual treatment of waste batteries (dismantle, remove paper and plastic cover)

Phase 2: Heat treatment: distillation of Zinc or Cadmium in furnace.

Phase 3: Metals recovered in powder form.

(*Note-requires removing mercury before extraction process- mercury can vaporise.)

- **C. Hydrometallurgy**

Phase 1: Manual treatment of waste battery (Dismantle, remove paper and plastic covers etc.)

Phase 2: Chemical treatment- leaching of metal scrap by using acid/base solvent.

Phase 3: Metals are extracted by precipitation/electrolysis

Table:1 Espinosa et al, (2004) has summarised the main processes used around the world for battery recycling.

Country	Process	Description
Japan	*Sumitomo*	Totally based on pyrometallurgy. Expensive but used to recycle all types of portable batteries. Unknown if used for NiCd batteries.
Switzerland	*Recytec*	Combines pyrometallurgical, hydrometallurgical and physical treatments. It is used for recycling all types of portable batteries and also fluorescent lamps and Hg-containing tubes. Does not recycle NiCd batteries. The investment for this process is smaller than that for the Sumitomo process, but operating costs are higher.
France	*Snam–Savam*	Totally based on a pyrometallurgical method. Process for rechargeable NiCd battery recycling. Also claims to process NiMH and is developing capacity to process Li-Ion batteries.
Sweden	*Sab Nife*	Totally based on a pyrometallurgical method. Process for rechargeable NiCd battery recycling. Reclaims cadmium and sends reclaimed or separated nickel and steel onwards to steel smelters.
North America	*Inmetco*	Initially developed with the objective of recovering dusts from electric arc furnaces. It can also be used to recover metallic wastes from other processes, and NiCd batteries can be included as one of such wastes.
Netherlands	*TNO*	Hydrometallurgical process for battery recycling. This process developed two recycling alternatives, one for Zn–C and alkaline household batteries and the other for NiCd batteries. The alternative for household batteries was not commercially implemented
Germany	*Accurec*	Pyrometallurgical process to recycle batteries, where NiCd batteries are treated separately

3. Sorting

WRAP (2006) claims that sorting processes only become economic once quantities reach in excess of 5,000 tonnes per annum. Usually automated systems can only sort types AAA, AA, C and D battery types. Manual sorting involves sorting on a conveyer belt into the different chemistry types. Experienced sorters are able to roughly sort one tonne of batteries a day.

RWC (2006) concluded that battery sorting, manual, or automated is well developed and a reasonably safe and logistically feasible exercise. Extensive battery sorting is currently carried out at the front end of almost all battery recycling operations. It is a manageable process but comes with an associated cost.

A review of collection systems in relation to sorting suggested that, for household batteries, commingled collections are more the rule than source separated collections. Around the world, battery collection programs directed at household batteries appear constrained by the inability or willingness of consumers to separate their battery wastes into different types.

In a 1997 Report, the secretary of the OECD Battery Working Group cited research showing that consumers strongly distinguished batteries from general waste but demonstrated very little awareness of the differences between battery types (Beaurepaire, 1997). The battery working group recommended a ‘global collection of batteries’. The Report also provided a summary of the experience of a number of private enterprises which established battery take-back or collection schemes in the 1990’s. Unwillingness or inability of consumers to distinguish between battery types and adhere to the acceptance guidelines was a problem common to four separate retail chains studied (Beaurepaire, 1997).

On this basis, potential for sorting at point of collection will be a factor to take into account when distinguishing between battery collection schemes, however, not a necessary feature considering that there are options available for both manual and automated sorting of batteries.

Large quantity of used batteries in collection containers creates a safety risk if they are not completely discharged and are in electrical contact with each other. Consequently, large quantities of waste batteries to be stored should be packed with inert cushioning material in a fibreboard box, wooden box or wooden slatted crate. Note that if stored waste batteries are allowed to get wet they may become very corrosive. In the unlikely event that a cracked lithium cell was exposed to water at any point in the storage and transporting process, an explosion may result. (PlanetArk, 2007)

4. Battery Collection and Recycling in Western Australia

Australia does not have a national recycling scheme for primary batteries. Historically, recycling of these batteries has been too expensive or considered commercially unviable. A working group made of members from the battery industry has been formed to investigate a national battery collection and recycling scheme for Australia (Swainston et al, 2006)

Programs to divert batteries from general garbage in WA have been piecemeal to date. When the disposer is willing to pay, recycling services do exist, although only a very small proportion of batteries are recovered through these services. Industry led initiatives tasked with diverting consumer batteries from landfill are very limited. One example is the Mobile Muster, administered by the Australian Mobile Telecommunications Association (AMTA), collecting mobile phone batteries. This scheme has suffered much criticism in the past for its low recovery rates (RWC, 2006).

Australia does not have the technology to fully recover primary (Zinc and alkaline) and secondary (nickel cadmium based) dry cell batteries. The only actual physical recovery is of secondary batteries, which are dismantled and the scraps shipped to France for recovery (Environmental and Technical Support Manager, Cleanaway, 2007). This is run on a 'pay as you throw' basis, where boxes can be purchased from Cleanaway, who then sort, dismantle and export the batteries collected.

A number of Regional Councils currently promote special collections of batteries with a view to disposing of the batteries with increased safeguards against environmental impacts. The batteries are encased in concrete prior to disposal in landfill. The rationale for some of the Regional Councils is that is fulfils their landfill license conditions. For other waste managers the rationale may be to minimise the impact on their resource recovery operations. The approach taken to date for disposal has centered on schools. Schools are invited to encourage students to bring disposable batteries to school. Stockpiles of batteries are periodically collected from schools and removed to landfill. Small incentive programs are offered by some Councils to increase participation rates among students. The Eastern Metropolitan Regional Council is one Regional Council operating such a scheme (RWC, 2006).

A number of scrap metal merchants report that they are happy to take automotive and industrial batteries, mainly lead acid. For these types of batteries a range of handling economies emerge from the large quantities of metals available from the batteries. However, the economies for small consumer batteries are much different and hence the market is very limited.

In Australia, except for lead acid type chemistries, all other battery disposal collection for recycling overseas is done by MRI Australia, a company based in Victoria. MRI use Tredi Australia to export all batteries to a recycling facility (SNAM) in France. Tredi currently have an export permit issued by Environment Australia for Ni-Cad and Ni-MH batteries and Tredi expect (or may have already obtained) a permit for Li-Ion batteries. (PlanetArk, 2007)

MRI currently has a contract with the Australian Mobile Telephone Association (AMTA) for recycling mobile phones, handsets and accessories collected through the MobileMuster Program. (PlanetArk, 2007)

A working group made of members from a number of organisations including the battery industry has been formed to investigate a national battery collection and recycling scheme for Australia. The working group has made the following recommendations(Swainston et al, 2006):

- A collection system should 'piggyback' on an existing collection system;
- Better data on consumption and disposal trends for household batteries is needed;
- A collection scheme should encompass all battery types; and
- Issues with environmental regulations for the stockpiling of used batteries should be explored further.

5. Markets for Battery Constituents

Information on the market for metals recovered from consumer batteries is somewhat limited and at times, contradictory.

Panasonic (2006) claim that there is a positive market value for Cadmium and Nickel recovered from NiCd/NiMH, Cobalt recovered from Lithium-Ion batteries, Lead from Lead-Acid batteries and Silver and Mercury from Silveroxide button batteries. Panasonic does not specify if there is particular locations or conditions under which these markets operate, but it is assumed they would differ with the place and type of process used to recycle batteries.

Current markets that do exist in Australia for battery constituents include spent silver oxide button cells, which are collected by those business that replace them in watches or similar; and lead acid

car batteries. As the focus of this investigation is not upon car batteries, noting the existence of this market is sufficient.

The recovery and recycling of lead-acid and silver oxide button cell batteries is cost effective. The market value of the extracted silver or lead is greater than the cost of recovering the spent battery waste. Despite the metal content, this in not he case for other types of battery waste (WRAP, 2006).

The viability of any battery recycling model will always be underpinned by the market demand for the materials. If the market value of the recovered products does not cover the costs of recovering it, then long and short term markets for this product will not be viable. *The Stakeholders Guide to Sustainable Waste Management* (2006) has identified the following factors as influencing the financial viability of recovery and recycling:

- value of the recovered products, e.g. metals, metal oxides;
- availability of sufficient quantities of spent batteries (economy of scale);
- degree of segregation of the waste stream into different battery type;
- cost of sorting the spent batteries into type;
- cost of transporting the batteries to the reprocessing plant; and
- cost of reprocessing the batteries to extract the recoverable fraction.

In applying the above criteria to the Western Australian situation a hypothetical understanding of the current market situation or market potential can be attained.

As illustrated above, many of the metals contained in the common household battery do have a net positive value. However, these batteries are typically rechargeable types such as Li-Ion, NiCd and NiMH. This may be a key strength when assessing the case for the promotion of rechargeable batteries, compared to a collection system for disposable batteries.

A main target for the study was the removal of used household batteries from Resource Recovery operations. The current process of sorting materials for Resource Recovery in Western Australia does already include sorting techniques which remove the batteries from the final compost product. Whilst damaged batteries may still release heavy metals into the product, in large part batteries are already removed from the material. Theoretically the weakness in this would have been the smaller button cells, which may not be picked up in the sorting process. In this study, the smaller button cells have been identified as perhaps not as problematic to Resource Recovery then first thought. These batteries are usually present in devices, such as watches, which require specialised knowledge or equipment to replace. Hence, inadvertently, spent button cells are returned to place of purchase. As these button cells have a positive market value for their constituents, they are often then aggregated and resold.

References

Australian Bureau of Statistics, 2006, *Australia's Environment: Issues and Trends*. Available Online: http://www.abs.gov.au [Accessed on 24/2/07]

Basel Convention, 1992, *The Basel Convention on the control of transboundary movements of Hazardous Waste and their disposal.* Available Online: http://www.basel.int/ [Accessed 10.07.07]

Beaurepaire, E., 1997, 'How to Collect Portable Ni-Cd Secondary Batteries Efficiently: A Consumers Point of View', representing the Battery Working Group, France, in *Proceedings of the OECD Workshop of the Effective Collection and Recycling of Nickel-Cadmium Batteries*, Lyon France, 23-25 September 1997, OECD Environmental Directorate, Series on Risk Management No. 8. Available Online: http://www.olis.oecd.org/olis/1999doc.nsf/LinkTo/env-jm-mono(99)17 [Accessed 19.07.06]

Cleanaway, 2007, Comments from Technical Support Manager. More information available online www.cleanway.com.au/batteryrecyling

Espinosa, D. C. R., Bernardes A.M., Tenorio, J.A.S. , 2004, 'An Overview on the current processes for the recycling of batteries', *Journal of Power Sources*, 311-319

Fujimoto, K, 1997, 'Collection and Recycling Activity for Small Rechargeable Batteries in Japan', representing (Sanyo Electric Co. Ltd), Battery Association of Japan, in *Proceedings of the OECD Workshop on the Effective Collection and Recycling of Nickel-Cadmium Batteries*, Lyon, France, 23-25 September 1997, OECD environment Directorate, Series on Risk Management No. 8 Available Online http://www.lis.oecd.org.olis/1999doc.nsf/LinkTo/env-jm-mono(99)17 [Accessed 19.07.06]

Panasonic 2007, 'Panasonic' Website. Available Online: www.**panasonic**.com.au/ [Accessed: 10.07.07]

Planet Ark, 2007, 'Recycling Near You' Website. Available Online: www.recyclingnearyou.com.au [Accessed on 10/7/07].

RBRC, 2007, 'Rechargeable Battery Recycling Corporation' Website. Available Online: www.rbrc.org [Accessed 4.5.07]

Reid Waste Consulting, 2006 'Sublet Tasks Undertaken by Reid Waste Consulting' on behalf of the Municipal Waste Advisory Council. (Available on request from the Municipal Waste Advisory Council)

Swainston, J., Wright, S., and Bruckard, W., 2006 'Opportunities for used consumer battery recycling in the Australia/Pacific region' *Green Processing*

Teague C, 2003, *Household Hazardous Waste Collection –What is best practice?* Environmental Science, Division of Science and Engineering, Murdoch University, Perth

'wasteguide', 2006, *The Stakeholder Guide to Sustainable Waste Management*. Available Online http://www.wasteonline.org.uk/ [Accessed 10.10.07]

WRAP, 2007, 'The Waste and Resources Action Programme' Website. Available Online: http://www.wrap.org.au [Accessed on 9/2/07].

WRAP, 2007, Comments from WRAP Batteries Project Officer. More information available www.wrap.org.au [9.2.07]

Appendix C

Municipal Waste Advisory Council Survey Report

February 2007

Assessment of Behaviours and Attitudes of Western Australians to Used Household Battery Collection and Recycling

Table of contents

1 EXECUTIVE SUMMARY

In Australia, over 267 million primary batteries (alkaline) and 50 million secondary batteries (rechargeable) were imported in 2004 (ABS, 2005). It is estimated that of these, 18 million used primary and secondary batteries are disposed of annually in Western Australia (WasteWise WA, 2005).

Batteries have been identified as a problematic waste in the waste stream. They contain a number of metals which have documented impacts in landfill as environmental contaminants (Park et al, 1999).

The Municipal Waste Advisory Council has been granted Strategic Waste Initiative Scheme (SWIS) funding, from the Waste Management and Recycling Fund of Western Australia, to investigate models for reducing the disposal of consumer batteries to general waste and for collecting consumer batteries for specialised disposal and/or recycling. A key feature of this study is researching community attitudes. To achieve this, a survey was carried out, with the general aim of finding out community attitudes in Western Australia to battery disposal, recycling and the different options for collection.

The specific aims and objectives of the survey are:

1. To gather information on battery consumption and recycling (gauge how members of the community perceive batteries as a waste; gauge people's willingness to separately dispose of household batteries; gather data on peoples' behaviour and habits);
2. Establish community views about recycling and environmental values (gather attitudinal data surrounding recycling and environmental values; gauge the significance of recycling as a motivator for separate disposal of batteries);
3. Establish community preference for a separate battery collection method (identify preferences for different recycling options given different constraints and trade-offs);
4. To gain a representative sample of the population (gather information on demographic and attitudinal characteristics of the community members surveyed); and
5. Produce results which are comparable to other surveys in the field.

The survey was designed using Survey Monkey, a web based program. Survey Monkey allows the user to design, collect, collate and analyse results through the same program. A link to the survey was distributed randomly through various email networks and via the Municipal Waste Advisory Councils Wastenet website and Information Bulletin.

Some key findings from the survey include:

- 60.7% of respondents indicated they were aware that batteries could be recycled;
- less then 20% of respondents currently separately dispose of their batteries;
- Kerbside, Charity Bins and Vergeside recycling services were participated in by the largest proportion of respondents;
- 70.5% of respondents would take part in a battery collection service incorporated into their normal Kerbside recycling;
- The majority of respondents (82.5%) indicated that they would use special battery bins located in public places; and
- The most preferred locations for special battery bins were: the workplace; local shopping centres; and large shopping centres.

Despite almost all respondents indicating willingness to dispose of their batteries separately, less then one fifth currently separately dispose of their batteries. This indicates that there is willingness in the community to participate in battery collection schemes, but perhaps a lack of opportunity, or ease, to do so.

Environmental awareness was reported by most respondents, with only a minority participating in no recycling services, and the majority of respondents aware of the potential hazards of disposing of batteries into normal household garbage.

Almost all respondents indicated they would be willing to dispose of their household batteries into special battery bins, located in public places, which highlights this option as potentially one of the most feasible for battery collection.

2 LITERATURE REVIEW

To establish the behaviour and attitudes of those in the community on battery consumption; disposal; and recycling; a survey has been undertaken. This section examines definitions and relevant information from both international and national battery surveys. The majority of the literature review was conducted at the time of the 2007 survey.

2.1 International and National Battery Recycling / Collection Surveys

2.1.1 International Battery Recycling / Collection Surveys

Waste & Resources Action Programme (WRAP)
The Waste & Resources Action Programme (WRAP) in the UK published a report titled C*onsumer Battery Collection Trials - Market Research* in May 2006.

The aim of their survey was to:

- identify hoarding and disposal practices for household batteries;
- consumer views on advantages and disadvantages of different recycling schemes; and
- consumer knowledge, understanding and use of existing collection facilities.

The survey was conducted via telephone interview combined with an interview questionnaire carried out in the street.

Key findings of the survey included:

- More than nine out of ten respondents indicated that recycling is important to them;
- Nearly three quarters of those interviewed throw their batteries away immediately;
- More than 80% of respondents put their used household batteries in the normal rubbish bin, 7% take them to a recycling centre and 5% put them outside their home for collection by a recycling collection service;
- Seven out of ten people have never thought about recycling their household batteries;
- More than nine out of ten people said they would recycle their batteries if they had a collection service from their home; and
- Three quarters of respondents would prefer to recycle their batteries by using a special container to put them in for collection from outside their home. A small minority would prefer to take them back to a shop or send them back in the post.

Rechargeable Battery Recycling Corporation (RBRP)
The Rechargeable Battery Recycling Corporation (RBRP) in Belgium conducted a telephone survey on Rechargeable Battery Recycling Programme in January 2006. The objectives of the survey were to assess the awareness of and participation in their programme.

Some key findings of the Survey included:

- Only 36% of respondents were aware of collection points for batteries;
- Almost 50% of collection points utilised were at housing estates, schools or commercial buildings;
- 86% of respondents use Rechargeable batteries instead of Single-use batteries; and
- Inconvenience of collection points (40%) and not knowing what can be recycled (31%) were the reasons most listed for not recycling.

Switzerland Battery Recycling Survey
Another survey used battery recycling in Switzerland as a 'case in point' to analyse the relationship between self-reported recycling behaviour and socio-demographic variables, attitudes towards ecologically positive waste disposal, trust in waste disposal authorities, specific knowledge concerning recycling, justifications for not participating in the recycling scheme, self-organisation of recycling behaviour, and level of battery consumption (Hansmann et al, 2006).

The survey was in the format of a standard questionnaire.

Some key findings, which are relevant to the current survey, were:

- The effect of self-selection, in the sense that people choosing not to participate in the survey may be non-recyclers, together with a social desirability bias influencing the responses of people choosing to participate, are possible explanations for high reporting of recycling behaviour;
- No significant relationship was observed either between appropriate disposal and monthly battery usage, or between appropriate disposal and age;
- Both the number of batteries used per month and attitudes towards ecological waste disposal had no influence on battery disposal behaviour; and
- Recycling knowledge, self-organisation of recycling, and disagreement with justifications for non-recycling were positively related to recycling behaviour.

The survey emphasised the significance of self organisation in recycling, in whether a person will dispose of their batteries separately or not. A person may have very positive attitudes to ecological waste disposal but without self-organisation in the collection, stockpiling and transport of batteries to collection points', recycling of batteries was unlikely to occur.

2.1.2 Australian Battery Recycling / Collection Surveys

No Australian surveys on attitudes to battery collection and recycling were identified. However, general information on recycling is available.

Australian Bureau of Statistics (ABS)
The Australian Bureau of Statistics, *Environmental Issues: Peoples views and Practices* (2004), surveyed public concern for environmental issues in Australia compared over the last 10 years. This survey shows that concern for the environment has declined in Australia; as well as in Western Australia since 2001. In 2004, 62.4% of Western Australians over 18 years of age indicated they were concerned by environmental issues. This is higher then the National average of 57.1%. People aged between 45-54 years expressed the most concern and those aged 65 years and over, the least.

Southern Metropolitan Regional Council (SMRC) Studies
The Southern Metropolitan Regional Council (SMRC) conducted a study *One Region, One Waste Strategy, One Communication Campaign? The Value of "Segmenting" and "Targeting* (Raphaely, 2004). The study aimed to research and evaluate the effectiveness of, and thus further refine and focus, its Regional Communication and Education Campaign.

Both quantitative and qualitative methods were used. Quantitative work included a telephone survey of 354 residents and qualitative work involved the completion of 4 focus groups with male and female residents from each of the municipalities in the study area.

Some key findings included:

- Information was felt to be a key tool in changing recycling behaviours and was ranked above any other options such as fines;
- There was some support for “cause and effect” messages that stress the importance of recycling, explain what happens if people don’t recycle, and, descriptions of stages in the recycling process after waste has left the home; and
- Councils or Local Government were perceived as the most credible or believable source of information regarding recycling.

The most unexpected result of the research was the identification and description of 7 different “segments” within the regional community. These “segments” showed, that, whilst being part of the same regional community, and thus participants in the same Regional Waste Management Project, the regional community comprised 7 different groupings of individuals, with each grouping having discrete and specific attitudes, and thus behaviours, regarding recycling.

These different attitudes, when subjected to a cluster analysis, revealed the existence of the 7 “segments” or groups of “like” respondents across the study area:

- The habitual recyclers (21.8%);
- The passionate recyclers (16.4%);
- The habit formers (26.6%);
- The worriers (11.3%);
- The reluctant recyclers (9.9%);
- The “my kids made me do it” recyclers (9.0%); and
- The non recyclers (5.1%).

This “segmentation”, based on attitudes and thus domestic behaviours regarding recycling, is significant in the development and operation of smaller education campaigns, which then falls under the umbrella of broader campaigns.

Another study conducted on behalf of the Southern Metropolitan Regional Council, *Hazardous Household Waste – A Study of Household Attitudes and Behaviours* (Market Equity, 1999) researched the attitudes and behaviours of households in relation to disposal of Hazardous Household Waste (HHW).

Two focus groups were used to develop and carry out a telephone questionnaire.

Main findings, related to this survey, included:

- Batteries were the most common item that households would like to dispose of at the time of the survey (16%);
- Batteries (59%) are an HHW item that households are currently disposing of in the green bins provided by councils;
- Awareness of what constitutes a Household Hazardous Waste Item is low with 27% of respondents indicating no HHW items in the home;
- The majority of households would not use a HHW facility more than once a year. The majority of Households would not travel more than 20 minutes to use a HHW facility; and
- Attitudes to disposal of HHW suggest that an education campaign is required to change the current behaviour of households.

3 METHODOLOGY

The methodology for the survey included a review of the previous surveys conducted, additional literature search, survey formulation, quality control, survey distribution, survey analysis and reporting.

3.1 Research Method

3.1.1 Survey Formulation

The survey was formulated to address the specific aims and objectives of the program. These aims and objectives flow specifically from the Battery Collection Model Study. The literature reviewed had some influence on the survey questions and provided possible comparisons. Work done by Reid Waste Consulting (2006) provided the framework for the final survey format and content.

Given the resource and time constraints an online survey was identified as the most appropriate medium for distribution. Whilst this form of survey may be biased towards certain demographics, its features allow for fast and widespread distribution, with ease in the collection, collation and analysis of results. In order to increase the response rate, a monetary incentive was offered. This was in the form of two cash prizes of $50. A monetary incentive has been shown to more than double the response rate for some surveys (Edwards et al, 2002).

The survey was designed using Survey Monkey, a web based program. Survey Monkey allows the user to design, collect, collate and analyse results through the same program.

For the purposes of analysis, the survey was divided into the following four sections:

- Section A Consumer / Householder Profile;
- Section B Consumer / Householder Lifestyle;
- Section C Views on Battery Recycling;
- Section D Collection Methods.

3.1.2 Quality Control

The quality of survey data can be rendered less useful when respondents answer questions by “saying what is socially desirable, rather than what might be the actual case” (Nancarrow & Brace, 2000). This is termed ‘social desirability bias’. In order to reduce this form of bias, questions were designed to allow cross verification. For example: Respondents were asked if they separately dispose of their batteries, then were asked the specific method used.

3.1.3 Survey Distribution

The surveys were distributed through Survey Monkey, the online survey program. Survey Monkey provides a web link for the survey which can then be distributed via email, and provides a link directly to the survey. The survey was open for two weeks in February 2007. Networks of the Western Australian Local Government Association, the Information Bulletin, and WasteNet website were used to promote the survey. 84 responses were received in the two weeks the survey was open. This was considered a good response rate.

The use of an online survey can present a number of issues when evaluating the surveys validity. Online surveys are a relatively new form of distribution and may present novel challenges not normally present in traditional survey format. However, online surveys may also overcome many shortcomings of traditional survey methods. For instance, data is entered directly into the database by respondents eliminating error in

data entry of surveys or miscommunication by respondents (Pawloski and Topp, 2002). The privacy of the internet also allows for more honest and therefore potentially more consistent answers (Moskowtiz et al, 2002).

Web based surveys do face a threat in the area of predicative validity in that populations are usually biased towards those that have access to the Internet, and/or the inclination to respond to online surveys (Pawloskia and Topp, 2002). The sample in a Web survey isn't really a random sample, and there is no method for selecting random samples from general e-mail addresses. There is also a great variation in Internet access between some rural and urban areas and with different ethnic groups.

One way to validate the data is to compare the results to external demographic data and other quantitative information. In this survey, this has been achieved via comparisons to the ABS Census data for a snapshot of how representative the respondents are, in addition comparisons to other similar surveys in the field have been used.

4 RESULTS

4.1 Overall Responses

- The response rate for the survey was 84.

Section A Consumer / Householder Profile

4.1.1 Age

Q1. Which age group do you belong to?

- 15 – 24 years
  - 8.4% of respondents
  - 18.1% ABS 2001
- 35 – 44 years
  - 9.7% of respondents
  - 19.8% ABS 2001
- 55 – 64 years
  - 16.9% of respondents
  - 11.6% ABS 2001
- 25 – 34 years
  - 34.9% of respondents
  - 18.4% ABS 2001
- 45 – 54 years
  - 27.7% of respondents
  - 17.9% ABS 2001
- 65+
  - 2.4% of respondents
  - 14.2% ABS 2001

4.1.2 Gender

Q2. Gender?

- Of the Overall Respondents, 45.2% were Female and 54.8% were Male.
- The population of Western Australia is 49.98% Female and 50.02% Male (ABS, 2001).

4.1.3 Location

Q3. Which of the following best describes the area where you live?

Refer to Figure 4.1.1

- 9.5% of respondents live in Central Perth (5km from Central Business District (CBD));
- 32.1% of respondents live in Metropolitan Perth (5-15km from CBD);
- 45.2% of respondents live in Outer Metropolitan Perth (15-30 km from CBD);
- 6.0% of respondents live in Regional Centres (e.g. Albany);
- 6.0% of respondents live in Regional Towns (45-90 km from Regional Central Business District (RCBD)); and
- 1.2% of respondents live in Remote Towns (100+ km from RCBD).

4.1.4 Income

Q4. Which income range best describes your households annual income (before tax)?

- < $25,000
  - 2.4% of respondents
- $40,000 - $54,000
  - 22.6% of respondents
- $70,000 - $84,000
  - 19.0% of respondents
- $25,000 - $39,000
  - 3.6% of respondents
- $55,000 - $69,000
  - 11.9% of respondents
- $85,000 +
  - 40.5% of respondents

4.1.5 Number of People in Household

Q5. How many people live in your household? (Including you)

- 0-3 people:
  - 67.9% of respondents
  - 74% ABS 2001
- 7-10 people:
  - No respondents in this section
  - 1.5% ABS 2001
- 4-6 people:
  - 32.2% of respondents
  - 23% ABS 2001
- 10+ people
  - No respondents in this section
  - 1.5% ABS 2001

4.1.6 Attitude to Environment and Environmental Issues

Q6. Which of the following statements describes how you feel about the environment and environmental issues?

- 25.0% of respondents indicated they were 'an environmental defender, committed to protecting the environment';
- 72.6% of respondents indicated they were 'environmentally responsible and try not to unnecessarily harm the environment';
- 2.4% of respondents indicated they were 'aware of environmental issues but not concerned about the environment'; and
- No respondents indicated they were 'indifferent to environmental issues and have more important things to think about'.

4.1.7 Appliances Using Batteries in the Home

Q7. The following are types of appliances that require batteries. Which of them do you use in the home?

Refer to Figure 4.1.2

Table 4.1 Breakdown of respondent's use of Batteries in home.

Area	Appliances	Response(%)*
Bathroom	Electric toothbrush, Shaver	43.4%
Bedroom	Alarm Clock	33.7%
Garage	Door Remote	30.1%
Home Entertainment	Television & VCR Remote, Portable Electric Toys	94.0%
House	Clock	67.5%
Kitchen	Other Small Kitchen Electrical Goods	28.9%
Office	Laptop Computer, Mouse, Calculator	73.5%
Personal	Watch, Camera, Electric Portable Music Player, Radio	95.2%
Safety/ Assistance	Torch, Hearing Aide, Smoke Detector	85.5%
Workshop	Power Tools	43.4%
Other	Electric Fence, Wireless Microphones, Car Key, Reticulation Timer, Garden Water Timer	10.8%

Summary
Most respondents used batteries for personal use (95.2%) and for home entertainment (94.0%). Batteries are used least by respondents, in the garage (30.1%) and the bedroom (33.7%). (*The percentages show how many respondents nominated each option)

4.1.8 Buying Batteries

Q8. Do you buy batteries?

- 77.4% of respondents indicated that they bought batteries; and
- 22.6% of respondents indicated that they did not buy batteries.

4.1.9 Types of Batteries Used

Q9. Which types of Batteries do you use?

Refer to Figure 4.1.3

Table 4.2 Types of Batteries Used by Respondents

Battery Type	Battery Use	Response (%)*
Zinc Carbon / Zinc Chloride	General purpose/ extra heavy duty batteries	15.7%
Alkaline Batteries	New generation of long life batteries	25.4%
Lithium	Digital camera use	19.3%
Speciality Alkaline	Uses for car lock remotes, Medical devices, Toys	8.5%
Silver / Zinc Oxide	Button battery use in calculator, Hearing aid and Pager	8.5%
Rechargeable	General purpose	21.8%
Other	Lead Acid/ Sealed Lead Acid	0.8%

Summary

A quarter of respondents indicated they used Alkaline Batteries. 21.8% of respondents used Rechargeable and 19.3% Lithium. (*Percentages are based on total number of responses to this question.)

Section B Consumer / Householder Lifestyle

4.1.10 Usage of Recycling Services

Q10. Do you currently use any recycling Services?

Refer to Figure 4.1.4

Table 4.3 Percentage of respondents using different types of recycling services

Recycling Service	Response (%)*
Recycling Collection Campaign	34.9%
Kerbside Recycling	83.1%
Vergeside Recycling	71.1%
Charity Bins	74.7%
Salvage Stores	36.1%
Retail Take Back System	21.7%
Institutional Collection Programs	8.4%
None	3.6%
Other (Workplace, Drop off at Local Government)	8.4%

Summary

Most respondents used Kerbside (83.1%), Charity Bins (75.7%) and Vergeside (71.1%) recycling services. Institutional Collection Programs were used by the least amount of respondents (8.4%). Only 3.6% of respondents used no recycling service. (*The percentages show how many respondents nominated each option.)

4.1.11 Reasons for Recycling

Q11. If you recycle, what the most important reasons for doing it? Please rate the following statements level of importance to you: (1=Most important, 5=Least important)

Refer to Figure 4.1.5

The 3 reasons most nominated for recycling were:

- To avoid waste to landfill;
- To conserve resources; and
- Reduce pollution;

The 3 reasons least nominated for recycling were:

- It saves me money;
- It saves space in my main bin; and
- It saves space around my home.

4.1.12 Frequency of Visit

Q12. How often do you visit your Local Government Depot, Transfer Station or Landfill to dispose of your household waste?

Refer to Figure 4.1.6

- Weekly
  - 3.7% of respondents
- Monthly
  - 3.7% of respondents
- Every 6 months
  - 9.8% of respondents
- Yearly
  - 28.0% of respondents
- Other (Never)
  - 31.7% of respondents
- Fortnightly
  - 2.4% of respondents
- Every 3 months
  - 7.3% of respondents
- Every 9 months
  - 1.2% of respondents
- Other (Rarely)
  - 12.2% of respondents

4.1.13 Facilities Visited Throughout Year

Q13. Which of the following facilities do you visit throughout the year? Please rate these amenities/facilities from highest to lowest frequency. (1= Most Frequent, 5= Least Frequent)

Refer to Figure 4.1.7

Facilities most often visited by respondents:

- Workplace;
- Local shopping centre; and
- Large shopping centre.

Facilities least often visited by respondents:

- Recreation centre;
- Library; and
- Post office.

4.1.14 Battery Purchase

Q14. Where do you usually buy your batteries from?

Refer to Figure 4.1.8

- Supermarkets
  - 59.8% of respondents
- Home Electrical
  - 6.3% of respondents
- Battery Specialists
  - 3.9% of respondents
- Electronics Specialists
  - 15.8% of respondents
- Home Hardware
  - 14.2% of respondents

Section C Views on Battery Recycling

4.1.15 Battery Recycling

Q15. Are you aware that batteries can be recycled?

- 60.7% of respondents indicated that they were aware that batteries could be recycled; and
- 39.3% of respondents indicated that they were unaware that batteries could be recycled.

4.1.16 Separation of Batteries

Q16. Do you currently dispose of your used batteries separately from your other household waste?

- 19.3% of respondents currently dispose of batteries separately from their other household waste; and
- 80.7% of respondents do not currently dispose of batteries separately from their other household waste.

4.1.17 Separate Disposal of Batteries

Q17. If you answered yes to the previous question, please indicate how you separately dispose of your batteries?

- 26.7% of respondents indicated that they stockpile used batteries in the home;
- 20.0% of respondents indicated that they dispose of their used batteries through school collection programs;
- 20.0% of respondents indicated that they dispose of their used batteries at Local Government recycling centres;
- 13.3% of respondents indicated that they placed their used batteries in their recycle bin; and
- 13.3% of respondents indicated that they disposed of their used batteries at a drop off at their workplace; and
- 6.7% of respondents indicated that they disposed of their used batteries at drop off point at a shopping centre.

4.1.18 Battery Awareness

Q18. Are you aware that batteries…

Table 4.4 Respondents awareness of issues around battery disposal.

Battery Issue	Yes (%)	No (%)
Contain harmful elements	91.6%	8.4%
Required Special Treatments to avoid the harmful elements from causing harm to the environment and your health.	68.3%	31.7%
Contain valuable resources which are lost when buried with other wastes	58%	42%
Consumption is increasing rapidly, but currently the vast majority of household batteries are being stockpiled in households or are simply disposed of into landfill	66.7%	33.3%

Summary
The majority of respondents (91.6%) were aware that batteries contained harmful elements. Only just over half of respondents were aware that batteries contained valuable resources which are lost when buried.

4.1.19 Separate Disposal of Batteries

Q19. Would you be interested in disposing of your batteries separately, rather than putting them into the general rubbish to be landfilled?

- 98.8% of respondents would be interested in disposing of their batteries separately, rather than putting them into the general rubbish to be landfilled; and
- 1.2% of respondents would not be interested in disposing of their batteries separately, rather than putting them into the general rubbish to be landfilled.

4.1.20 Programs for Recycling Batteries

Q20. Given the information on the cost of recycling batteries, which of the following programs would you be willing to participate in:

- 7.3% of respondents indicated that they would be more interested in a program to collect batteries separately so that they could be specially treated to make landfilling those batteries safer; and
- 92.7% of respondents indicated that they would be more interested in a program to collect batteries separately so that they could be recycled.

Section D Collection Methods

4.1.21 Battery Stockpiling

Q21. How long would you be willing to stockpile your used batteries for, so that they could be separately collected?

Refer to Figure 4.1.9

- One Week:
  - 3.8% of respondents
- Six Months
  - 44.3% of respondents
- Indefinitely
  - 21.5% of respondents
- One Month
  - 12.7% of respondents
- One Year
  - 17.7% of respondents

4.1.22 Special Battery Bins

Q22. Would you use special battery bins to deposit your used batteries in public places?

- 82.5% of respondents indicated that they would use special battery bins to deposit their used batteries in public places; and
- 17.5% of respondents indicated that they would not use special battery bins to deposit their used batteries in public places.

4.1.23 Locations for Battery Bins

Q23. If you answered yes to the previous question, which of the following locations would be most convenient for you to take your used batteries to? Please rank in order from most convenient to least convenient. (1=Most Convenient, 8=Least Convenient)

Refer to Figure 4.1.10

Most convenient locations:

- Workplace;
- Local shopping centre; and
- Large shopping centre.

Least convenient locations:

- Recreation centre;
- Library; and
- Post office.

Q24. Which of the following collection methods would you like to take part in for recycling your batteries? (You can select more then one of the following options.)

Refer to Figure 4.1.11

Table 4.5 Respondents preferred collection method for the recycling of batteries

Collection Method	Respondents (%)*
A nominated place on an advertised day, to return your used batteries.	32.1%
A battery collection service which required you to put your used batteries on the verge at the same time as your bulkwaste/greenwaste collection.	55.1%
Separately dispose of your batteries through a battery collection event organised through your local school; workplace; sporting club; social group etc in order to assist that organisation/ group win a prize for collecting the most batteries;	41.0%
Use a battery collection service which required you to put your used batteries into a special bag sent to you by your local Council and placed in your recycling bin for collection every fortnight.	70.5%

Summary
The most respondents (70.5%) indicated they would take part in a collection service incorporated into their fortnightly recycling service. The majority of respondents (55%) would also take part in a collection service which occurred as part of bulkwaste/vergeside collection. The lease amount of respondents (32.1%) would take part in a nominated drop off day. (*The percentages show how many respondents nominated each option)

4.1.25 Kerbside Battery Collection

Q25. Collecting Batteries through existing recycling collection system is feasible but would be more expensive than some of the alternatives. The main advantage of this system would be additional convenience to the householder. Which of the following statements do you most agree with?

- 68.8% of respondents indicated that they agree 'batteries should be collected through existing kerbside recycling system, because if separating batteries isn't made easier for the householder, it just won't happen'; and
- 31.2% of respondents indicated that they agree 'Local and State Governments need to balance convenience against cost, so they should try to use the cheaper alternatives first.

Figure 4.1.1 Distribution of Respondents

Summary

The majority of respondents were located in Outer Metropolitan Perth and Metropolitan Perth. The least amount of respondents was located in Remote Towns and Regional Centres.

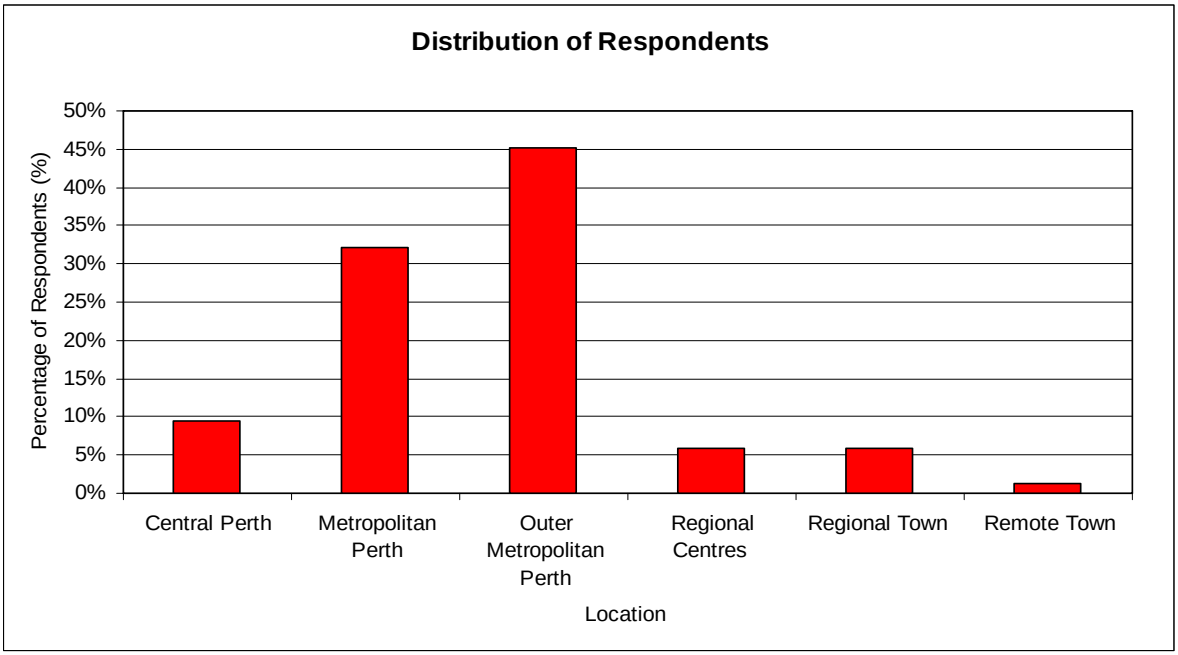


Figure 4.1.2 Appliances Using Batteries in the Home

Summary

Household batteries are used most for home entertainment and personal use. These include TV/DVD/Stereo remotes, personal portable music players, etc.

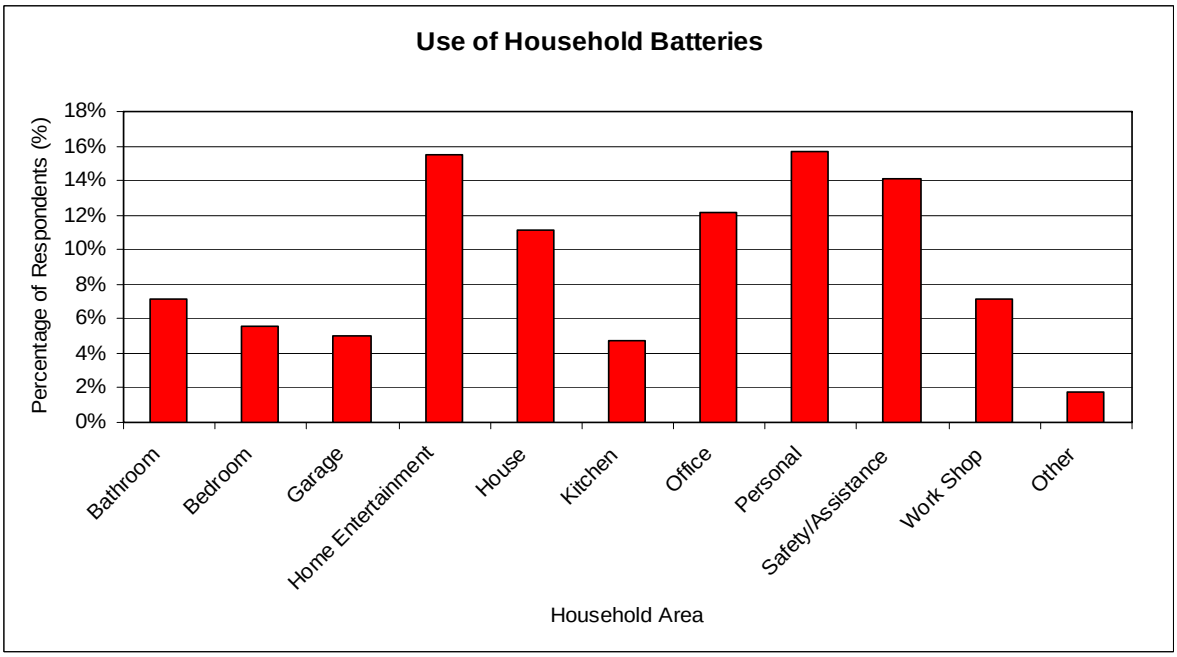


Figure 4.1.3 Types of Batteries Used

Summary

Alkaline batteries are the most used. Rechargeable and Lithium batteries are also used frequently.

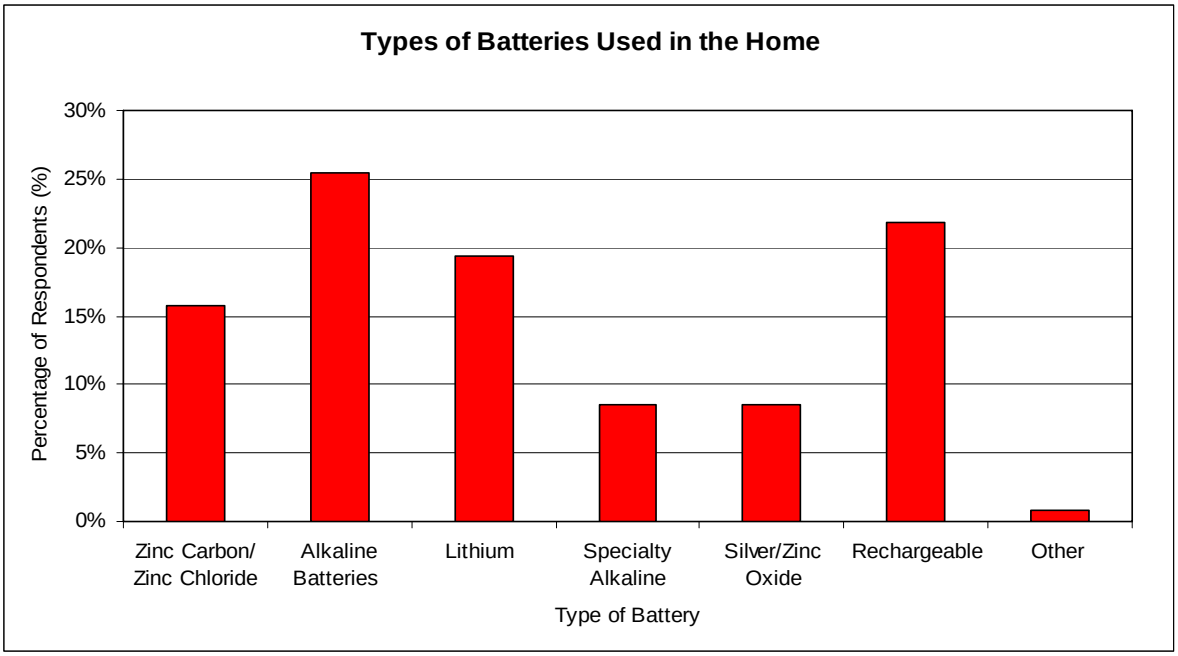


Figure 4.1.4 Usage of Recycling Services

Summary

Over 80% of respondents used Kerbside recycling services. Charity Bins and Vergeside Recycling were used by over 70% of respondents.

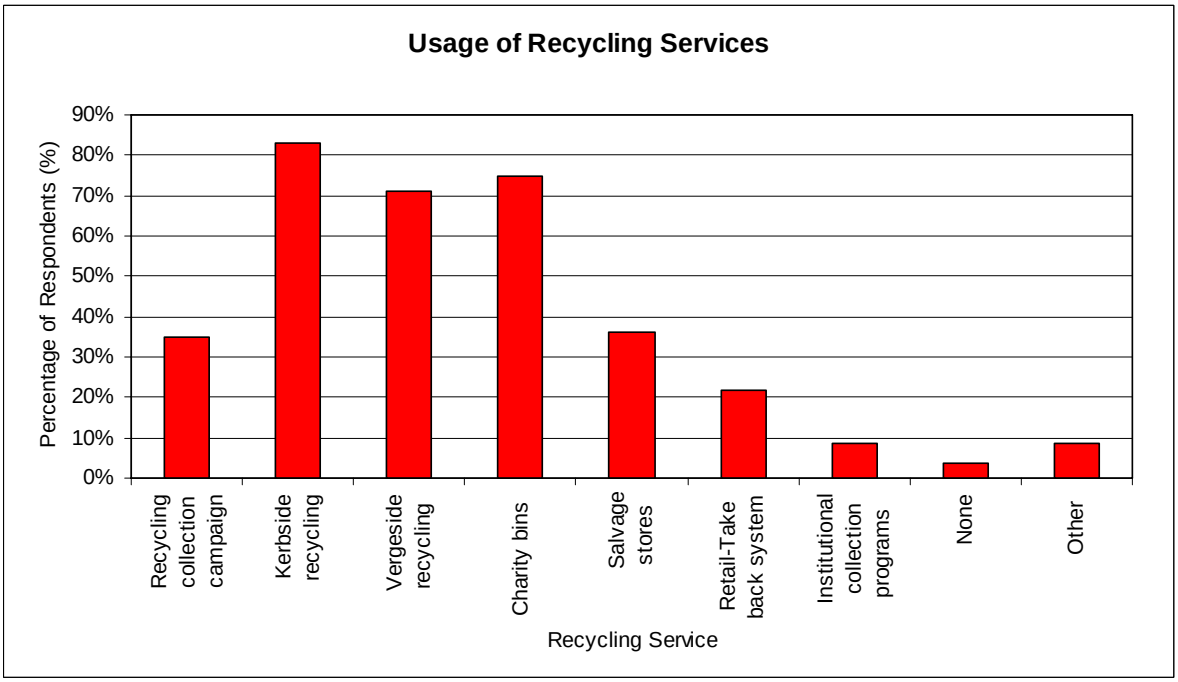


Figure 4.1.5 Respondents Most Listed Reasons for Recycling

Summary

The reasons respondents listed most for recycling were: To avoid waste to landfill; reduce pollution; good for community and to conserve resources.

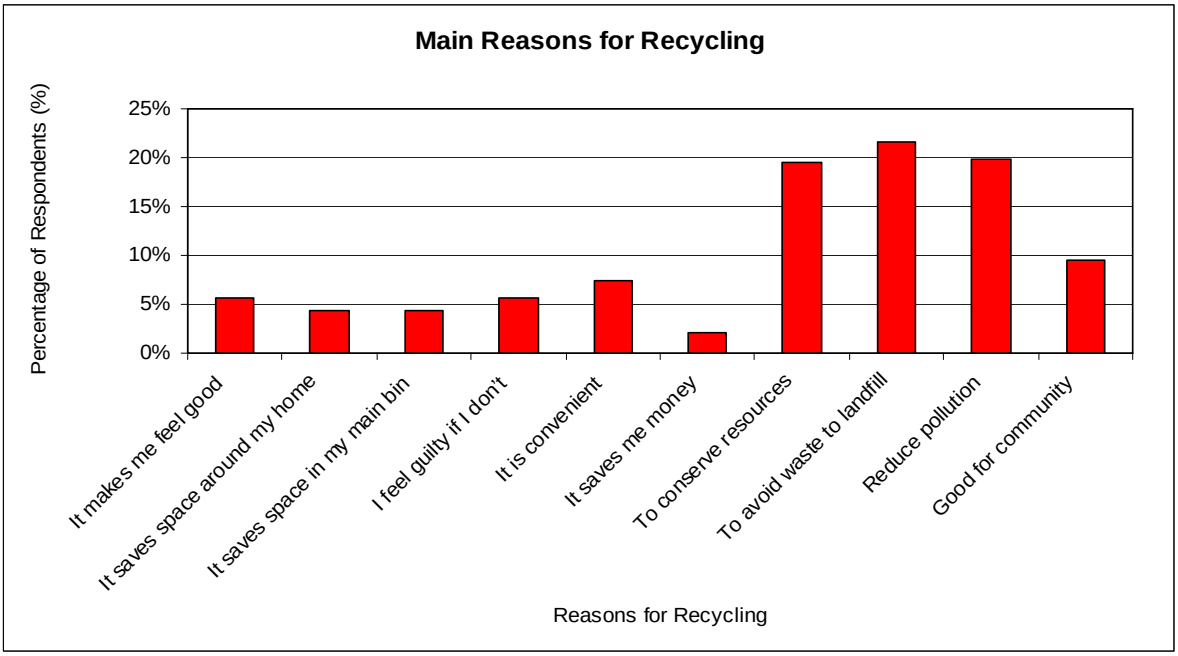


Figure 4.1.6 Frequency of Usage of Local Government Depot/ Waste Management Facility

Summary

The greatest percentage of respondents have never visited their Local Government Depot/ Waste Management Facility. Over a quarter visit it yearly but fewer than 5% would visit it weekly or fortnightly.

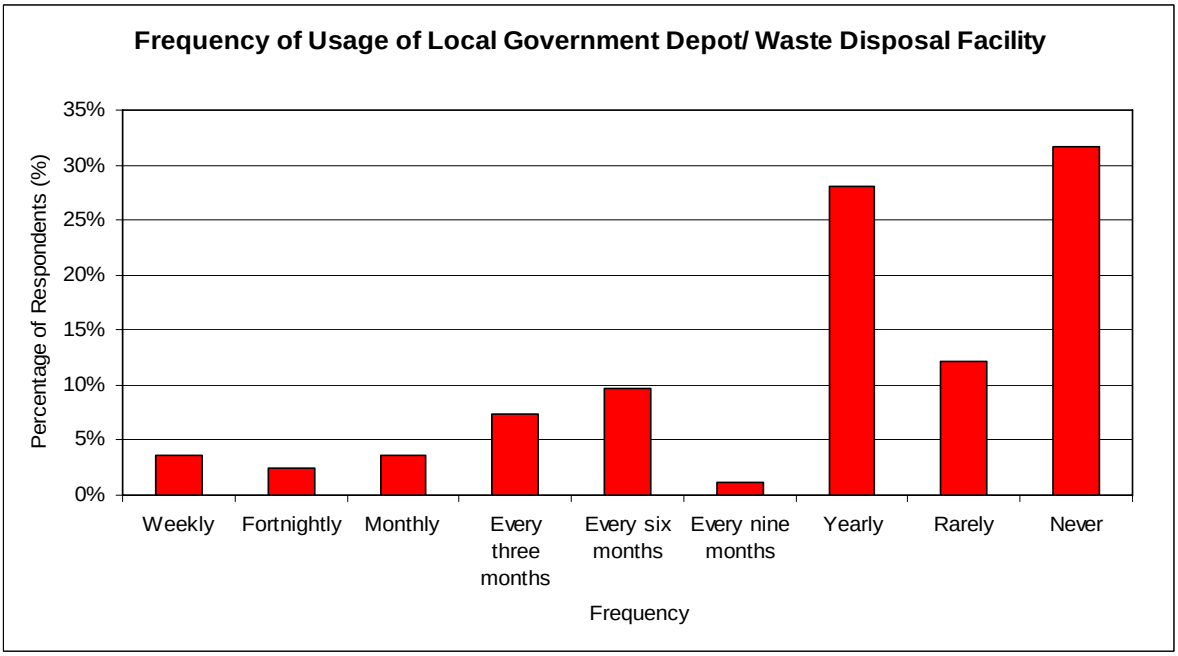


Figure 4.1.7 Facilities Most Frequently Visited by Respondents

Summary

The majority of respondents visited their workplace the most frequently. Recreation centres and libraries were visited the least frequently.

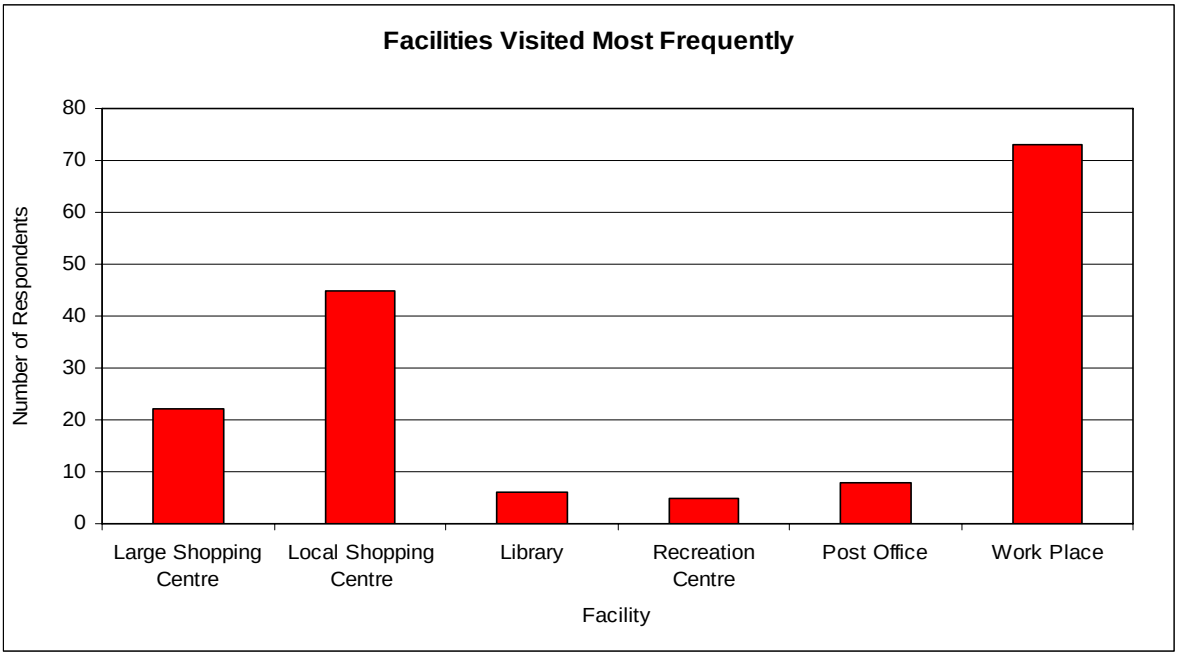


Figure 4.1.8 Place of Battery Purchase

Summary

The majority of respondents purchased their batteries from Supermarkets. The least amount of respondents indicated that they purchased batteries from Battery Specialists.

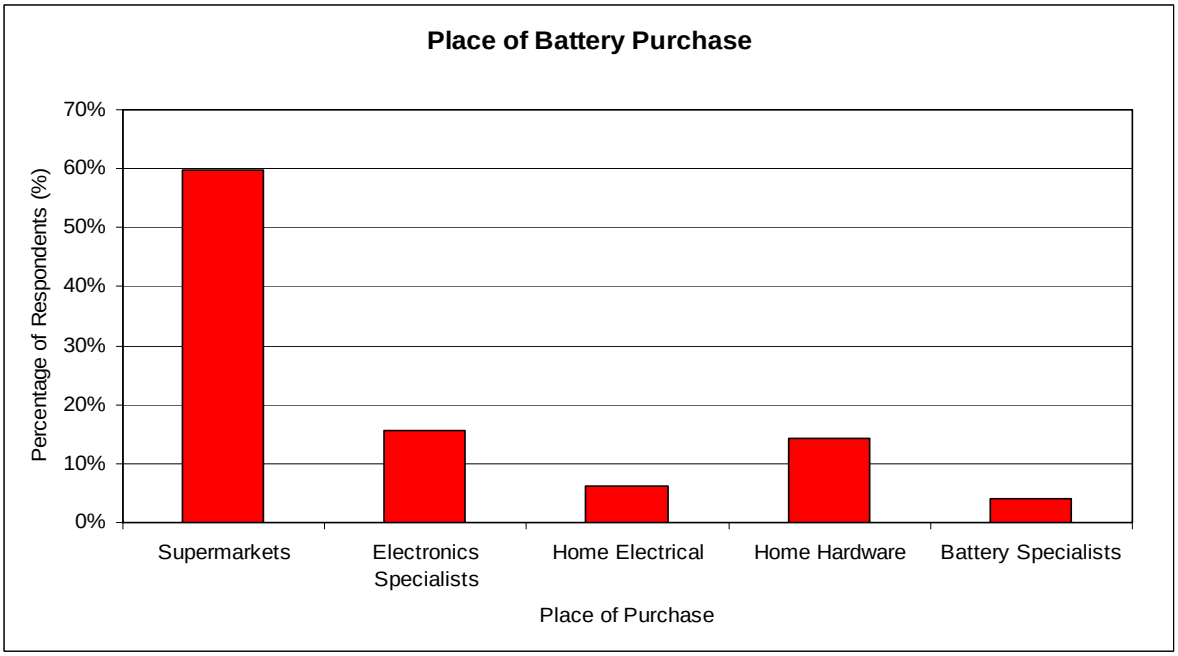


Figure 4.1.9 Length of Time Respondents would be willing to Stockpile Batteries for

Summary

Over 40% of respondents would be willing to stockpile their batteries for six months. Only just over 20% of respondents would be willing to stockpile their batteries indefinitely.

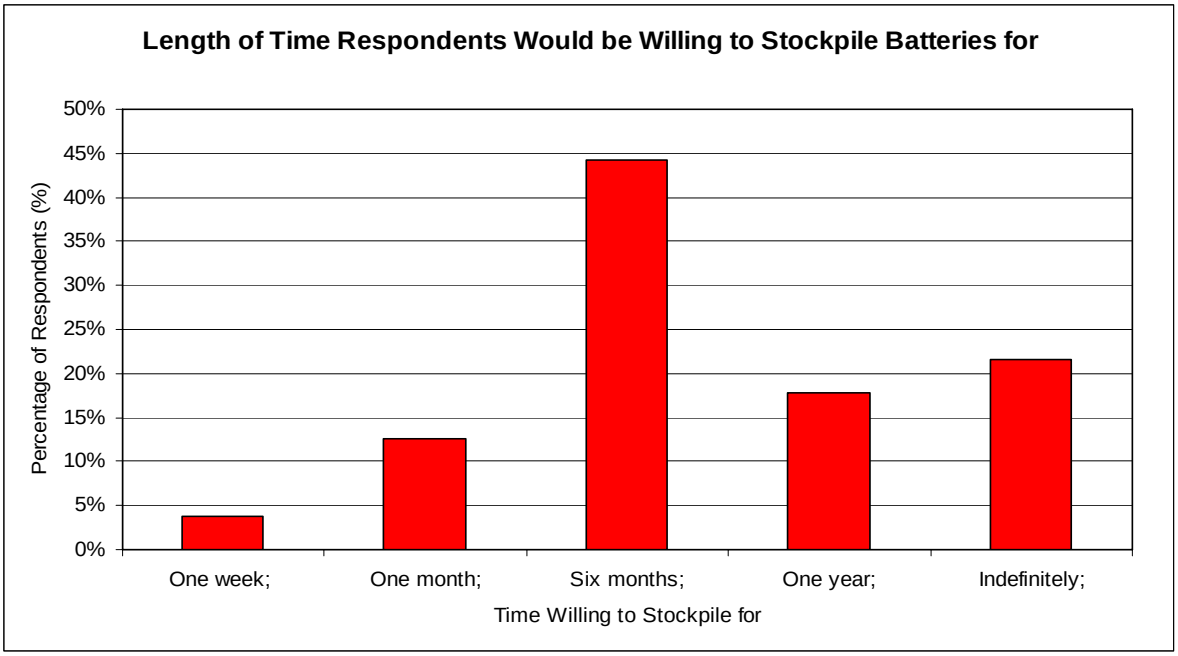


Figure 4.1.10 Facilities Most Convenient for Separate Collection of Batteries

Summary

The Workplace and Local Shopping Centre was indicated by the greatest number of respondents to be the most convenient place of for the drop off of batteries. Recreation centres was considered the least convenient.

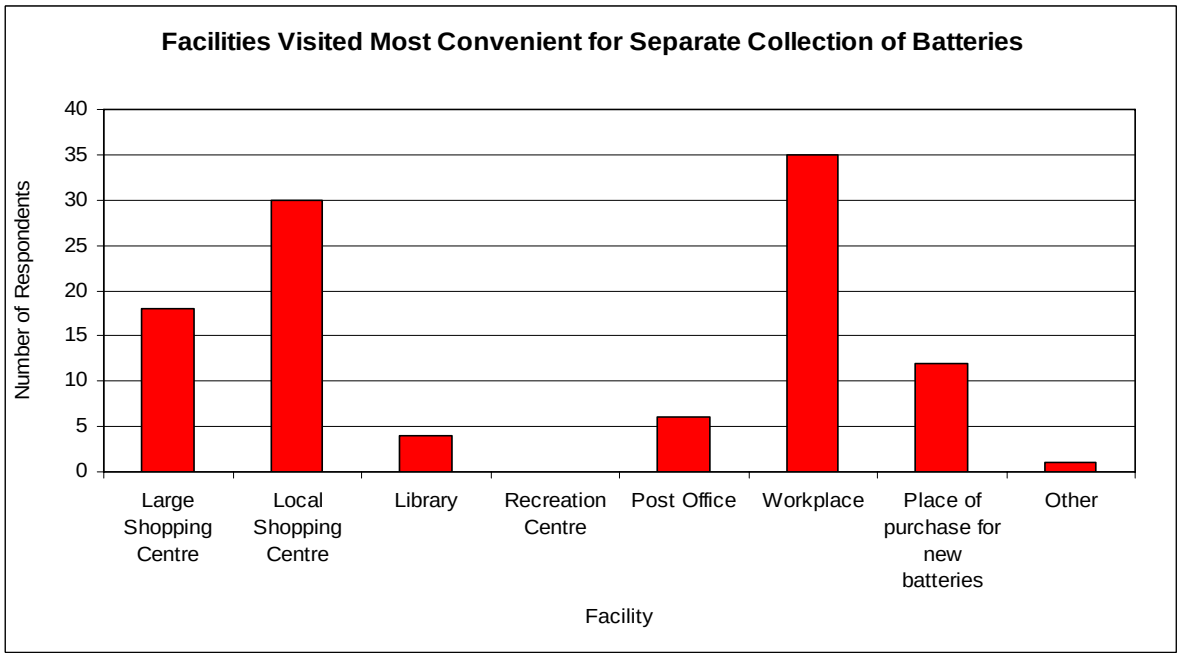
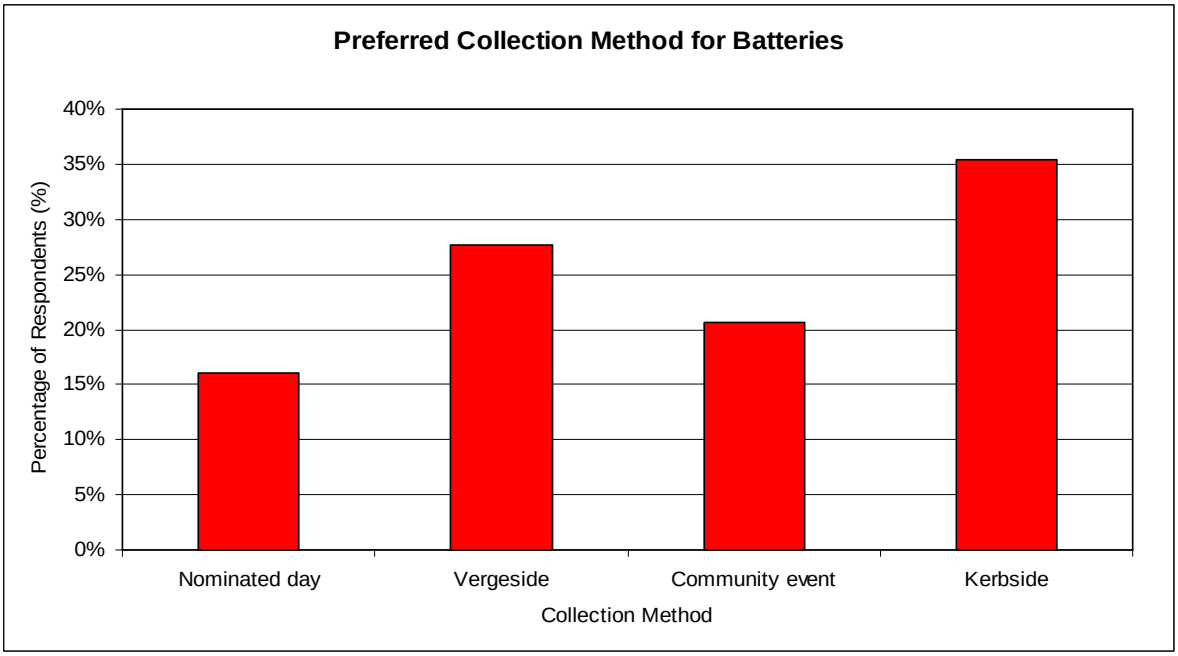


Figure 4.1.11 Preferred Collection Method for Batteries

Summary

Kerbside was indicated by the most respondents to be the preferred method for the separate collection of batteries. A nominated day at an advertised place was indicated as preferred by the least respondents.



5 DISCUSSION AND CONCLUSIONS

This section presents a discussion of the outcomes of the survey. The results are outlined and related to the survey objectives. The key findings and characteristics of respondents are compared in table format. The discussion considers factors of battery purchase, consumption, disposal, attitudinal and behavioural characteristics of respondents, as well as the how representative respondents are and comparison to other surveys.

5.1.1 Battery Consumption and Recycling

Objective One: Gather Information about Battery Consumption in the Home

Battery Purchase, Use and Type – Table 5.1
Over three quarters of respondents purchased batteries. The majority of respondents purchased their batteries from a supermarket, only a small proportion purchased their batteries from a battery specialist. Alkaline, Rechargeable and Lithium batteries were used by the most respondents. The majority of respondents identified they used batteries for personal use (95.2%) (camera, portable music player), home entertainment (94.0%) (remote control, portable electronic toys) and safety/assistance (85.5%) (torch).

Almost all respondents (91.6%) were aware that batteries contained harmful elements. Over half of respondents (68.3%) were aware batteries require special treatment to be disposed of safely. However, more than 40% of respondents were unaware that batteries contained valuable resources, which are lost when batteries are sent to landfill.

Conclusion
Supermarkets, as the leading place of purchase for batteries, offer a significant source of information on battery consumption and potential as a collection centre for used battery disposal. The large proportion of respondents purchasing batteries from these outlets indicates that place of battery purchase could potentially target the most users of batteries. Therefore, education campaigns about battery collection or awareness could use supermarkets as a focal point.

The message that batteries are a hazardous waste has been communicated to the community, indicated by over 90% of respondents aware that batteries contain harmful elements. The proportion of respondents unaware of the valuable resources in batteries that are lost when batteries are landfilled presents a possible focus area for education or awareness campaigns, which promote battery recycling.

Objective One: Gather Information about Recycling of Household Batteries

Battery Recycling and Separate Collection – Table 5.2
60.7% of respondents indicated they were aware that batteries could be recycled. However, less than 20% of respondents indicated that they currently dispose of their batteries separately from general household waste. The methods of separate disposal most listed by respondents were stockpiling, school collection programs, Local Government recycling centres, Kerbside recycling bins and drop off points at shopping centres.

Almost all respondents (98.8%) would be interested in disposing of their batteries separately rather then putting them into general rubbish to be landfilled. The most interest (by 92.7% of respondents) was shown in programs to collect batteries separately so that they could be recycled.

Conclusion
The proportion of respondents indicating that they currently dispose of their household batteries in their recycling bins (Table 5.2) illustrates the misconceptions in the community about the materials that can be placed in their Kerbside recycling bins. It also indicates that the community has some idea that batteries should not be disposed of in their general waste bin.

Despite the fact that almost all respondents would be willing to dispose of their batteries separately, less then 20% currently do so. This indicates that there is willingness in the community to participate in battery collection schemes, but perhaps a lack of opportunity, or ease, to do so.

The overwhelming support for recycling of batteries, over special treatment in disposal, reflects the community support for recycling. It is difficult to discern, from this question, if respondents would be more interested in special treatment if recycling was not possible. However, considering the high amount of awareness about the hazards of disposing of batteries (untreated) in landfill it is likely separate disposal would be supported.

5.1.2 Environmental Values and Views about Recycling

Objective Two: Establish Respondents Views about Recycling and Environmental Values

Attitude to Environmental Issues, Recycling, and Use of Recycling Services – Table 5.3
Almost three quarters of respondents considered themselves 'environmentally responsible and try not to unnecessarily harm the environment'. No respondents indicated that they were 'indifferent to environmental issues'. A very small minority of respondents participated in no recycling service. Two thirds of these respondents were located in Regional Towns and may not have had access to recycling. Kerbside (83.1%), Charity Bins (75.7%) and Vergeside (71.7%) recycling services were participated in by the largest proportion of respondents. The reasons most nominated by respondents for recycling were: avoid waste to landfill; reduce pollution; and conserve resources. The reasons nominated least by respondents for recycling were: saves money; saves space in main bin; and saves space around the home.

Just under one third of respondents have never visited a Local Government Depot or Waste Management Facility. 28% of respondents visit a Local Government Facility annually.

Conclusion

Most respondents identified themselves as 'environmentally responsible', however, this question potentially falls prey to the 'social desirability bias' (outlined in the methods section), where respondents may give responses which are seen to be socially desirable, rather then what is the actual case. As shown in Table 5.2 less than 20% of respondents indicated that they separately dispose of their batteries. However, in Table 5.3, participation in recycling services such as Kerbside, Charity Bins and Vergeside, indicates that respondents do have some sensitivity to environmental issues, at least in relation to recycling.

Most respondents indicated that they would use special battery collection bins located in public places (Table 5.2) however, the majority of respondents also indicated that they think batteries should be collected through kerbside collections, even if it is more expensive, because of the convenience it offers to the householder. Kerbside, Charity Bins and Vergeside recycling are all convenient for the householder, whilst people seem less likely to participate if the service provided requires more effort, for example: Local Government depot site visit.

The use of Kerbside recycling services by respondents potentially indicates that battery collection integrated into Kerbside collections could have a high participation rate in the community. This is not taking into account other issues of feasibility which would be related to such a scheme. For instance; Kerbside recycling is a service not usually offered outside the metropolitan area.

Whilst most respondents currently use Kerbside recycling, only 70.5% agreed that batteries should be collected through Kerbside because of the cost it would impose, and over 80% indicated that they would be willing to use special battery collection bins, located in public places (Table 5.4). Utilisation of these bins would of course depend upon their convenience for the householder and awareness of the location.

The minimal use of Local Government Depots or Waste Management Facilities by respondents suggests that collection points at these facilities would not have high participation rates. The low use of Local Government Depots may also be related to the high rate of respondents in the outer metropolitan and

metropolitan areas (Table 5.5). Kerbside waste and recycling and Vergeside collections would, in large part, cover these areas, meaning that use of Local Government Facilities would not be a necessity. In non-metropolitan areas, this may be substantially different and any design of separate battery collection methods should take this into account.

The reasons most nominated by respondents for participating in recycling services indicate a high level of environmental sensitivity. The avoidance of waste to landfill; reduction of pollution; and conservation of resources; are all issues representing benefits to the community and environment at a higher level then the individual need. Whilst, saving money, and saving space; the reasons least nominated by respondents; represent benefits which are immediate to the individual participating in the service.

5.1.3 Separate Battery Collection Methods

Objective Three: Establish Community Preference for a Separate Battery Collection Method

Preferred Methods of Battery Collection, Special Battery Bins and Kerbside Recycling – Table 5.4
The majority of respondents (70.5%) indicated that they would be interested in taking part in a collection of batteries through Kerbside recycling. Less then a third of respondents would be willing to take part in a nominated site on an advertised day, collection service.

44.3% of respondents would be willing to stockpile their batteries for six months. Only 3.8% of respondents would dispose of their batteries after only a week of stockpiling.

The vast majority of respondents (82.5%) indicated that they would use special battery collection bins located in public places. The most preferred locations for special battery collection bins were: the workplace; local shopping centres; and large shopping centres. The least preferred places for battery collection were: recreation centres; library; and post office.

When given the background feasibility issues to used battery collection programs integrated into current Kerbside recycling services, 68.8% of respondents still indicated that they think batteries should be collected through Kerbside recycling because it is easier for households. 31.2% of respondents indicated that they agree 'Local and State Governments need to balance convenience against cost, so they should try to use the cheaper alternatives first'.

Conclusion

Of the collection options listed, Kerbside, Vergeside, nominated site on a advertised day and community event, Kerbside was favoured. In a general question regarding the use of Kerbside recycling to collect batteries 70.5% supported this option, when given the additional cost implications, 68.8% of respondents still supported this option. However, in terms of actually recovering batteries, the vast majority of respondents (82.5%) preferred the use of special battery bins located in public places. Considering that 44.3% of respondents would be willing to stockpile their batteries for at least six months, the use of special battery bins remains the most feasible.

The workplace would be the ideal location for a battery bin as it would require no special trip on behalf of the householder to dispose of their collected batteries. However, workplace collection would rely upon the employer or employees organising collection points and disposal/recycling. This would be a collection on much more of a localised scale, a scale that may not be possible, or only effective in some situations. Battery collection points at local and large shopping centres are much more achievable option.

To ensure comprehensive access to battery disposal options, collection points should be in as many different types of locations as possible. Some of the multiple options available include: workplace; local and large shopping centres; library; and Government institutions (i.e. schools).

5.1.4 Representative Sample

Objective Four: To Gain a Representative Sample of the Population

Gender, Age, Income and Distribution of Respondents – Table 5.5
Of the respondents 45.2% were female and 54.8% were male. In the population of Western Australia 49.98% of citizens are female and 50.02% are male (ABS, 2001). The gender ratios in this survey did not differ significantly to that of the Western Australian population.

The majority of respondents were in the 25-34 years (34.9%) and 45-54 years (27.7%) age groups. In the 2001 ABS only 18.4% of the WA population was in the 25-34 years age group and 17.9%, in the 45-54 years age group. The age distribution of respondents did differ from that of the population, especially in the lack of representation in younger age groups 15 – 24 years and older age groups 65+ years.

The most respondents (40.5%) had a household income in the $85,000 + range. In the 2001 ABS, the annual household income indicated by the greatest proportion of respondents was $78,000-$104,000 (9.92%) and $41,600-$51,900 (9.86%) for Western Australia. Compared to the Western Australian population the current survey had a greater concentration of respondents in the higher income levels whilst the ABS had a more even distribution across income levels.

The majority of respondents live in Outer Metropolitan (45.2%) and Metropolitan (32.1%) Perth. The distribution of the Western Australian population is similarly distributed with almost three quarters in metropolitan areas of Perth.

Conclusion
When considering the quality of the data generated by the survey, how representative survey respondents are when compared to the general population is important. Some variation between the demographics of the survey respondents and the overall population was anticipated due to the online method of the survey, which would be biased towards certain groups. This does not decrease the usefulness of the results however, as the groups represented are those that may be most targeted in a battery collection program.

It is evident that survey respondents did have an average household income that is slightly higher than the general population of Western Australia. Whilst the majority of respondents in the ABS were located between income levels $41,000-$104,000, a greater spread of income levels was evident. This could be caused by the lack of respondents in under than 25 and over 65 years age groups, in the current survey, which would be less likely to be working or, for the less than 25 years group, on a lower income.

Only a small percentage of respondents were from non-metropolitan areas. This is an issue, as their needs and attitudes are often very different to those in metropolitan areas. However, the survey respondents did represent the distribution of Western Australia's population. The low population density in non-metropolitan areas also indicates that it is likely there would be a low volume of battery use and disposal. This is difficult to quantify as waste generation data for non-metropolitan areas is limited.

Note should be taken to address the special needs of non-metropolitan areas which may not have arisen in this survey. For example: Kerbside recycling was nominated as the recycling service used by the largest amount of respondents, Kerbside recycling is not a service available to all non-metropolitan areas in Western Australia, and hence a battery recycling scheme incorporated into Kerbside recycling would not be addressing the needs of those living in these areas.

5.1.5 Comparison of Surveys

Objective Five: Produce Results which are Comparable with Other Surveys in the Field

Environmental Values, Separate Collection of Batteries and Kerbside Recycling – Table 5.6
The Waste & Resources Action Programme (WRAP) research report, C*onsumer Battery Collection Trials - Market Research* (Mruk Research, 2006) surveyed consumer practices, views and knowledge of battery recycling, disposal and collection (outlined further in the literature review). This survey has been used to compare the results of the current survey.

More then 90% of respondents to the WRAP survey indicated that recycling is important to them. In the current survey, 72.6% of respondents indicated that they considered themselves 'environmentally responsible and try not to unnecessarily harm the environment'.

In both the WRAP and current survey, over 80% of respondents indicated that they do not separately dispose of their household batteries.

Of the respondents to the WRAP survey that indicated they separately dispose of their household batteries: 43% disposed of them at recycling centres; 32% placed them in their recycling bin; 18% stockpile them and a minority disposed of them at work. Of the respondents in the current survey that indicated that they separately dispose of their household batteries: 26.7% stockpile them; 20% dispose of them in school collection programs; 20% dispose of them at recycling centres; and a minority either place them in their recycle bin, dispose of them at work or take them to drop off points at their local shopping centre.

Over 90% of respondents to the WRAP survey indicated they would recycle their batteries if they had a collection service from their home. In the current survey 70.5% of respondents indicated they would take part in a collection method incorporated into the current Kerbside recycling service and over a half indicated they would take part in a collection method incorporated into the current Vergeside recycling service.

Conclusion
Like the current survey, respondents to the WRAP survey indicated they believed themselves to have a certain amount of environmental sensitivity. Despite this, and similar to the current survey, most respondents did not separately dispose of their household batteries from general household waste.

Compared to the WRAP survey, more respondents in Western Australia are currently stockpiling their batteries as a method of separate disposal.

A greater proportion of respondents to the WRAP survey would recycle batteries collected from their home than respondents to the current survey. It is unclear, from this question, if those who would not participate in a Kerbside recycling service would not participate in battery recycling at all, or see other alternatives as more effective. However, from the higher percentage of respondents to the current survey that would use special battery bins in public, it can be concluded that a significant percentage would participate in battery recycling.

The Swiss Battery Recycling Survey (Hansmann, R. et al 2006) found the amount of batteries consumed and ecological attitudes were not related to battery disposal behaviour. However, recycling knowledge and recycling self organisation were positively correlated to correct battery disposal. Under this assumption, those that already recycle, or are aware of the available recycling services are those most likely to participate in a separate battery collection scheme. It also emphasises the significance of education in the success of any collection scheme.

Table 5.1: Objective One – Gather Information about Battery Consumption in the Home

Battery Purchase	Place of Battery Purchase	Types of Batteries Used	Use of Batteries	Battery Awareness
77.4% of respondents indicated that they purchase batteries.	The majority of respondents (59.8%) purchased batteries from Supermarkets.	Alkaline (25.4%), Rechargeable (21.8%) and Lithium (19.3%) batteries were used by the most respondents.	Most respondents indicated they used batteries for personal use (95.2%)(camera, watch etc), home entertainment (94.0%)(remote, portable toys) and safety/assistance (85.5%) (torch, smoke detector)	91.6% of respondents indicated they were aware that batteries contained harmful elements. 68.3% of respondents were aware batteries required special treatment in their disposal.
22.6% of respondents indicated that they did not purchase batteries.	Only 3.9% of respondents purchased batteries from Battery Specialist.	Speciality Alkaline (8.5%) and Silver/Zinc Oxide (8.5%) batteries were used by the least respondents.	A lower proportion of respondents indicated they used batteries in the kitchen (28.9%), garage (30.1%) and bedroom (33.7%).	42% of respondents were unaware batteries contained valuable resources, which are lost when batteries are sent to landfill.

Table 5.2: Objective One – Gather Information about Recycling of Household Batteries

Battery Recycling	Separation of Batteries	Methods of Separate Disposal	Willingness to Separately Dispose of Batteries	Programs for Recycling Batteries
60.7% of respondents indicated they were aware that batteries could be recycled.	80.7% of respondents indicated that they do not currently dispose of batteries separately from other household waste.	Methods of separate disposal indicated by respondents: • stockpile used batteries in the home (26.7%); • dispose of batteries through school collection programs (20.0%); • dispose of used batteries at Local Government recycling centres (20.0%); • dispose of them in their recycle bin (13.3%) ; • dispose of them at work (13.3%); and • dispose of used batteries at drop off point at a shopping centre (6.7%).	98.8% of respondents would be interested in disposing of their batteries separately, rather than putting them into general rubbish to be landfilled.	92.7% of respondents indicated they would be interested in programs to collect batteries separately so that they could be recycled.
39.3% of respondents indicated they were unaware that batteries could be recycled.	19.3% of respondents indicated that they currently dispose of batteries separately from household waste.		Only 1.2% of respondents would not be interested in disposing of their batteries separately.	Only 7.3% of respondents indicated they would be interested in programs to collect batteries so they could be specially treated to make landfilling safer.

Table 5.3: Objective Two – Establish Respondents Views about Recycling and Environmental Values

Attitude to Environmental Issues	Use of Recycling Services	Reasons for Recycling	Use of Local Government Facility
The majority of respondents (72.6%) indicated that they considered themselves 'environmentally responsible and try not to unnecessarily harm the environment'.	Most respondents indicated that they utilised Kerbside (83.1%), Charity Bins (75.7%) and Vergeside (71.7%) recycling services.	The reasons most nominated by respondents for recycling were: • Avoid waste to landfill; • Reduce pollution; and • Conserve resources.	The most respondents (31.7%) indicated they have never visited their Local Government Depot/Waste Disposal Facility. 28% of respondents indicated they visit a Local Government Facility yearly.
No respondents indicated they were 'indifferent to environmental issues' and only 2.4% were 'aware…but not concerned'.	Institutional Collection Programs were used by the least amount of respondents (8.4%). Only 3.6% of respondents utilised no recycling services.	The reasons least nominated by respondents for recycling were: • It saves money; • It saves space in main bin; and • It saves space around the home.	Only 2.4% of respondents indicated they would visit it fortnightly and 3.7% would visit it weekly.

Table 5.4: Objective Three - Establish Community Preference for a Battery Collection Methods

Preferred Collection Method	Battery Stockpiling	Special Battery Bins	Locations for Bins	Kerbside Recycling
The majority of respondents (70.5%) indicated that they would take part in collection of batteries through kerbside recycling.	The most respondents (44.3%) indicated they would be willing to stockpile their batteries for six months.	The majority of respondents (82.5%) indicated that they would use special battery bins, located in public places.	The preferred locations for special battery bins were: • Workplace; • Local shopping centre; and • Large shopping centre.	68.8% of respondents indicated they think batteries should be collected through kerbside recycling because it is easier for households.
Only 32.1% of respondents indicated they would be willing to dispose of batteries at a nominated disposal site on an advertised day.	Only 3.8% of respondents would be willing to stockpile their batteries for only a week.	Only 17.5% of respondents indicated that they would not use special battery bins, located in public places.	The least preferred locations for special battery bins were: • Recreation centre; and • Library.	31.2% of respondents indicated that cheaper battery collection options, instead of kerbside recycling, should be explored first.

Table 5.5: Objective Four - Representative Sample

	Gender	Age	Income	Location
MWAC Survey	Of the respondents, 45.2% were female and 54.8% were male.	The majority of respondents were in the 25–34 years (34.9%) and 45–54 years (27.7%) age groups.	The most respondents (40.5%) had an annual household income in the $85,000 + range.	The majority of respondents live in Outer Metropolitan Perth (45.2%) and Metropolitan Perth (32.1%) areas.
2001 ABS	In the 2001 ABS, 49.98% of the Western Australian population was female and 50.02% was male.	In the 2001 ABS, 18.4% of the Western Australian population were in the 25-34 years age group and 17.9% in the 45-54 years group.	In the 2001 ABS, the annual household income indicated by the greatest proportion of respondents was $78,000-$104,000 (9.92%) and $41,600-$51,900 (9.86%) for Western Australia.	In the 2001 ABS, the Western Australian population was mostly located in Perth (73.4%).

Table 5.6: Produce Results Comparable to Other Surveys

	Environmental Values	Separate Disposal	Methods of Separate Disposal	Kerbside Collection
MWAC Survey	The majority of respondents (72.6%) indicated that they considered themselves 'environmentally responsible and try not to unnecessarily harm the environment'.	80.7% of respondents indicated they do not separately dispose of their household batteries.	Of respondents that do separately dispose of their household batteries: 26.7% are stockpile them; 20% dispose of them in school collection programs; 20% dispose of them at recycling centres; 13.3% put them in their recycle bin; 13.3% dispose of them at work and 6.7% dispose of them at drop off points at shopping centres.	The majority of respondents (70.5%) indicated that they would take part in collection of batteries through kerbside recycling. Over half would participate in a collection through the Vergeside recycling service.
WRAP Market Research	More than nine out of ten respondents indicated that recycling is important to them.	83% of respondents indicated they did not separately dispose of their household batteries.	Of respondents that do separately dispose of their household batteries: 43% dispose of them at recycling centres; 32% dispose of them in their recycling bin; 18% stockpiled them; and 7% dispose of them at work.	More than nine out of ten people said they would recycle their batteries if they had a collection service from their home.

6 REFERENCES

Australian Bureau of Statistics, 2001, *Basic Community Profile*. Available Online: http://www.abs.gov.au [Accessed 2.02.07]

Australian Bureau of Statistics, 2002, *A Snapshot of Western Australia*. Available Online: http://www.abs.gov.au [Accessed 2.02.07]

Australian Bureau of Statistics, 2004, *Environmental Issues: Peoples Views and Practices*. Available Online: http://www.abs.gov.au [Accessed 2.02.07]

Edwards, P., Roberts, I., Clarke, M., Duiseppi, C., Pratap, S., Wentz, R. and Kwan, I., 2002, 'Increasing response to postal questionnaire: systematic review' *British Medial Journal*, vol. 324.

Hansmann, R., Bernasconi, P., Smieszek, T., Loukopoulos, P. and Scholz, R. W. 2006, 'Justifications and self-organisation as determinants of recycling behaviour: The case of used batteries' *Resources Conservation and Recycling,* vol. 47.

Market Equity, 1999, on behalf of the Southern Metropolitan Regional Council, *Hazardous Household Waste – A Study of Household Attitudes and Behaviours.* Available Online from: www.smrc.com.au [Accessed 23.02.07]

Moskowitz, H., Beckley, J., and Keeling C., 2002, 'Establishing data validity in conjoint: experiences with Internet based 'mega-studies' *Journal of Online Research*.

Mruk Research, 2006, *WRAP Consumer Battery Collection Trials – Market Research.* Waste & Resources Action Program (WRAP). Available Online: www.wrap.org.uk [Accessed 2.02.07]

Nancarrow and Brace, 2002, 'Saying the "right thing": coping with social desirability bias in marketing research' *Bristol Business School Teaching and Research Review.* Issue 3, Summer.

Park S, Joe K S, Han S H, Eom T Y and Kim H S, 1999, Characteristics and Distribution of Metallic Elements in Landfill Leachate, *Environmental Technology*, vol. 20(4)

Pawloski, B., Topp, N.W., 2002, 'Online Data Collection' *Journal of Science Education and Technology,* vol 11.

Raphaely, T., 2004, for the Southern Metropolitan Regional Council (SMRC) 'One Region, One Waste Strategy, One Communication Campaign? The Value of "Segmenting" and "Targeting"'. , *Waste & Recycle 2004 Conference Proceedings Setting Outcomes and Measuring Performance: Benchmarks, Baselines and Bulldust*

Rechargeable Battery Recycling Programme, 2006, Annual General Meeting 2006 (Hong Kong). Available Online:http://www.rechargebatteries.org/RBRP_final.pdf [Accessed: 15.02.07].

WasteWise WA, 2005, Available Online: http://www.wastewise.wa.gov.au/ [Accessed: 26.02.07]