Managing e-waste in Victoria

Policy Impact Assessment

VICTORIA State Government | Environment, Land, Water and Planning

ISBN 978-1-76047-678-6 (print)

ISBN 978-1-76047-678-6 (pdf)

Accessibility

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Policy Impact Assessment

In accordance with the *Victorian Guide to Regulation*, the Victorian Government seeks to ensure that any new statutory policy, or changes to a statutory policy, are well targeted, effective and appropriate, and that they impose the lowest possible burden on Victorian businesses and the community.

The policy impact assessment (PIA) process involves an assessment of regulatory proposals. A PIA provides information on the need to develop or vary statutory policy, the nature and meaning of policy proposals and their practical impacts and implications. In addition, PIAs explain the intended means of implementing new or varied policy and the likely environmental, social and economic impacts of implementation.

Under section 18A of the *Environment Protection Act 1970*, a PIA must be prepared and made available for examination before a State Environment Protection Policy or Waste Management Policy can be declared or varied.

The process allows members of the community to comment on what is being proposed before it is finalised. Such public input provides valuable information and perspectives, and improves the overall quality of statutory policies. This PIA has been prepared to facilitate public consultation on the Andrews Labor Government's proposed e-waste policy approach, which will be implemented in part via waste management policies.

A copy of each of the proposed policies is attached to this PIA, and submissions are now invited on these. Unless requested by the author, all submissions will be treated as public documents and may be made available to other parties.

Please submit comments or submissions by no later than 5pm on 25 January 2018 to:

wastepolicy@delwp.vic.gov.au

or:

Managing e-waste in Victoria

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Executive summary

Electronic and electrical waste, or 'e-waste', covers a range of items we all use and discard at work and at home. It includes, but is not limited to, televisions, computers, mobile phones, kitchen appliances and white goods. These items can contain both hazardous and/or valuable materials, many of which can be recovered when they reach the end of their working life.

It is estimated that e-waste from televisions and computers alone will grow by over 60 per cent or 85,000 tonnes over the decade to 2024. While e-waste is not one of the main waste streams generated in Australia, comprising approximately 1 per cent of the waste currently going to landfill, it is one of the fastest growing.

Some types of e-waste, such as white goods, televisions and computers are already recycled at a relatively high rate, sometimes driven by commercial imperatives in the marketplace, sometimes by non-profit organisations and sometimes by policy settings that encourage or mandate recycling (for example, product stewardship schemes). More detail on the profile of e-waste in Victoria and how it is currently managed can be read in chapter 1.

Despite this, some types of e-waste, such as small household appliances, power tools and game consoles are not recycled much, if at all. There are several reasons the demand by reprocessors for feedstock varies. They include the market value for recycled components, commodity and micro-commodity prices (including precious and rare-earth metals), the cost of reprocessing, and the regulatory framework affecting e-waste streams.

Chapter 2 focuses on the problems of e-waste and discusses why more e-waste is not recovered in Victoria and Australia. E-waste in landfill has been described as both an "urban mine", a valuable reservoir of recyclable materials, and a potential "toxic mine" of hazardous substances. Problems associated with e-waste in landfill can be summarised as the potential missed opportunity to recover valuable materials in e-waste, the harm to the environment and human health from hazardous components in landfill, and the upstream resource extraction impacts.

To address these problems, the Andrews Labor Government is developing an approach which aims to increase recovery of the resources in e-waste, reduce harm to the environment and human health from e-waste disposal, and support jobs and investment in the recycling industry. Alongside a number of other waste recovery activities, this will support the government's long-term waste and resource recovery goal for Victoria's landfills to only receive waste streams from which all materials that can be viably recovered have been extracted.

This policy impact assessment examines several options for promoting greater recycling of e-waste after the point of generation—that is, after the electronic and electrical products become unwanted. It does not examine options for reducing the generation of e-waste.

A range of interventions were considered to address the problems of e-waste in Victoria, and discussed in chapter 3. The interventions include a differentiated landfill levy, product stewardship, a legislated ban on disposal to landfill, legislated requirements for managing e-waste, improving collection and storage systems at transfer stations, e-waste collection services, market development, and an education and communication campaign.

The analysis noted complementarities between the possible interventions**.** This suggested a package of interventions would be more effective than any single intervention on its own. This is the approach that has been used to drive greater e-waste recovery in other jurisdictions, including South Australia.

The interventions determined to best complement each other were a package of both regulatory and non-regulatory measures. Regulatory components were a ban on disposal to landfill and requirements for managing e-waste. Non-regulatory components were improvements to collection and storage systems at

transfer stations, e-waste collection services, and an education and communication campaign to increase community awareness about e-waste.

A landfill ban has been an effective intervention when applied to both e-waste and other specific waste types in other jurisdictions. When paired with measures to support households with appropriate collection options and to ensure availability of e-waste at scale for the reprocessing industry, a ban has been shown to drive increased recycling rates. A ban itself only applies to landfill operators, and so needs to be supported by upstream measures (management requirements) to divert e-waste from the landfill stream, maximise availability for recyclers, and avoid unintended outcomes.

Chapter 4 discusses the impacts this preferred policy approach is expected to have on Victoria's community and industry. Section 4.2 outlines the general mechanics of the approach, in particular the new regulatory obligations, and possible changes in costs for various parties. The obligations that will likely result in the greatest costs include those that require duty-holders who are managing large amounts of e-waste (e.g. local councils) to upgrade infrastructure to be able to collect, store or move e-waste safely.

Section 4.3 discusses the major risks associated with the approach and touches on how the approach will address these risks. Risks include inappropriate disposal of e-waste such as dumping in public places and inappropriate stockpiling, unreasonable costs borne by those responsible for collecting, sorting and clearing e-waste in finding appropriate recyclers, e-waste continuing to be disposed to landfill as by-product of inadequate recycling processes and increased environmental and occupational health and safety risks due to the increased volumes and types of e-waste that will need to be reprocessed.

Chapter 4.4 then summarises the costs and benefits of the preferred approach, based on a cost-benefit analysis, and how the rates of diversion of e-waste from landfill might be affected. To explore how the costs and benefits could vary with different designs, specific variations of the preferred approach were analysed, and labelled as follows:

- Option 1a: Comprehensive landfill ban (all e-waste) with high level of access to collection services[1]
- Option 1b: Comprehensive landfill ban (all e-waste) with low level of access to collection services
- Option 1c: Comprehensive landfill ban (all e-waste) with medium level of access to collection services
- Option 2: Partial landfill ban (most hazardous e-waste only) with high level of access to collection services
- Option 3: No landfill ban with high level of access to collection services

These options differ between each other in two important elements of the preferred package—the types of e-waste that could be banned from landfill, and the level of access the e-waste collection services provide to community.

Options 1a, 1b and 1c include a comprehensive e-waste ban, in which all types of e-waste are banned from landfill. Option 2 includes a partial ban focusing on the most hazardous items and option 3 did not include a ban at all.

Options 1a, 2 and 3 include a kerbside collection service for metropolitan households, and permanent drop-off points for all towns with a population greater than 1000, representing a very high level of access to community. Option 1b includes a service that offers 'low level access' to permanent drop-off points, while 1c adds mobile collection services to the service in 1b, increasing the level of access.

In addition, all options would be supported by new regulatory requirements that specify how to manage e-waste through the supply chain from generation to reprocessing. These requirements are outlined in section

[1] Collection services are as specified in Table 5 and Table 6 in Chapter 3.

4.2.1. This would impose obligations on anyone managing e-waste within the supply chain to take preventative measures to protect human health and the environment from the risks of e-waste. For example, generators of e-waste, including householders, would be required to drop their e-waste off with an appropriate collection service, or e-waste reprocessors would need to follow specific operational standards that are designed to protect the environment and human health.

All options also include a comprehensive education campaign to inform Victorians about e-waste, their new obligations and how to comply with them, and upgrades to transfer station infrastructure to safely accommodate e-waste.

These options are compared to a base case that does not include any of these components.

On the basis of the cost benefit analysis, the preferred option is 1c. The expected benefits of this combination of interventions ($280.1 million) are expected to exceed the expected costs ($266.8 million). Although it is unlikely to drive as much diversion of e-waste from landfill as the options that include kerbside collection, it delivers significant improvement in recycling rates – with an approximately 50 per cent increase in e-waste recycled over business as usual conditions – and is a more cost-effective collection model with significantly lower public costs overall.

That is, option 1c addresses the problems of wasted, valuable resources and risks to the environment and human health, in a cost-effective and proportionate way.

There are several aspects to note about this result.

Analysis of the distribution of the costs and benefits of option 1c shows that most of the costs of implementing any of the options are expected to fall on public sources, particularly local councils or their ratepayers. The main costs are associated with building appropriate e-waste storage receptacles or areas and transporting e-waste to e-waste recyclers.

The value of the materials recovered represent most of the benefits of the policy package and it is these benefits that provide almost all the quantifiable reasons for policy intervention. Recyclers are the stakeholder group most likely to benefit from this. Although there are substantial costs associated with e-waste processing, the value of recovered materials from most of the options are likely to offset these costs. Banning a small subset of e-waste would result in a much lower benefit to recyclers.

The private benefits of reprocessing e-waste are impacted by fluctuating commodity prices and demand, and alternate sources of supply for the resources contained in e-waste. Viable volumes of recycling material and costs of recycling will vary across international markets. Victoria's volume of recycling is unlikely to directly impact the extent of extraction of virgin resources and/or commodity prices.

Assumed rates of e-waste diverted to legitimate reprocessing channels vary, depending on the type of e-waste, and are outlined in section 4.4.4. While overall recovery rates for e-waste will improve over time, some e-waste is expected to be dumped or stockpiled elsewhere in the environment (including at transfer stations, or at locations less ready for handling e-waste than landfills). It is difficult to accurately determine the volumes destined for each of these pathways as it will depend on multiple factors, including global markets.

The assumed social benefits of preventing harm to human health and the environment have been calculated using these assumed rates of diversion. Should actual diversion to legitimate reprocessing channels be less than those assumed, the harms associated with e-waste in landfill are shifted elsewhere in the environment and benefits therefore reduced.

The preferred option delivers net benefits over the 20-year horizon, with a benefit cost ratio of 1.05. The costs of the preferred option are projected to continue to grow steadily, while net social benefits are projected to peak in the early to mid-2020s, and decline thereafter. By the end of the evaluation period all options are projected to have net costs year on year. This aspect, in combination with other factors such as technological changes, fluctuations in commodity prices and uncertain information about the extent of dumping of e-waste, highlight the importance of a well-constructed evaluation strategy and review of this policy.

Chapter 5 outlines how the policy package is to be implemented, key timelines and consultation approach. Section 5.3.1 discusses the amendment to an existing waste management policy to ban e-waste disposal to landfill. Section 5.3.2 outlines the new waste management policy to regulate how e-waste should be handled. Both sections summarise the EPA’s approach to compliance. Section 5.3.3 outlines the approach to designing and implementing the education and awareness campaign. Section 5.3.4 addresses how an improved collection network will be equipped for safe e-waste storage and handling and what collection services might be needed. Importantly, it highlights the need for a comprehensive planning and assessment stage to determine how best to create an accessible network.

The evaluation strategy, chapter 6, outlines the government’s strategy to evaluate the e-waste policy package, including the outcomes to measure, how they will be measured, when and by whom. The strategy will require involvement by and collaboration between the Department of Environment, Land, Water and Planning, Environment Protection Authority, Sustainability Victoria and Victoria’s waste and resource recovery groups. Evaluation activities will commence in the first year the waste management policy’s take effect and continue periodically – from every six months to every five years, depending on the outcomes being measured.

Information gathered through the evaluation will help us to review matters such as transfer station capacity, diversions to other fates (which are currently not clear), changes to volumes of e-waste recycled, effectiveness of the collection system, and impacts on the recycling industry and generators of e-waste.

Along with the findings of a material flow analysis and the outcomes of a cost-benefit analysis, assessment of possible policy options was also complemented by information gathered by the government through a range of consultation activities and feedback provided through other channels from stakeholders. Chapter 7 summarises the consultation activities the government has had to date.

Abbreviations and acronyms

ABRI	Australian Battery Recycling Initiative
AS5377	AS/NZS *Collection, storage, transport and treatment of end-of-life electrical and electronic equipment*
BAU	Business as usual
BCR	Benefit-cost ratio
BPEM (Landfills)	Best Practice Environment Management publication for *Siting, design, operation and rehabilitation of landfills*, EPA Victoria publication 788.3
CBA	Cost-Benefit Analysis
CRT	Cathode ray tube
DELWP	Department of Environment, Land, Water and Planning
Duty-holder	A person who has a responsibility to ensure environmental and human health is protected by eliminating or minimising risks so far as is reasonably practicable.
EPA	Environment Protection Authority Victoria
EP Act	*Environment Protection Act (1970)*
E-waste	Electronic or electrical waste
Floc	By-product of e-waste reprocessing
MFA	Material flow analysis
MRR	Material recovery rates
NPV	Net present value
PIA	Policy impact assessment
PV	Photovoltaic panels
SV	Sustainability Victoria
SWRRIP	Statewide Waste and Resource Recovery Infrastructure Plan
WEEE	Waste Electrical and Electronic Equipment
WMP	Waste management policy declared under section 16A of the EP Act
WMP (Landfills)	*Waste Management Policy (Siting, Design and Management of Landfills) No. S264*

WRR	Waste and resource recovery
WRRG	Waste and resource recovery group
WTP	Willingness to pay

1 Introduction

Electronic or electrical waste, or 'e-waste', covers a range of items we all use and discard at work and at home. It includes, but is not limited to, televisions, computers, mobile phones, kitchen appliances and white goods. These items can contain both hazardous and valuable materials that can be recovered when they reach the end of their working life.

E-waste is growing up to three times faster than general municipal waste in Australia.[2] It is estimated that television and computer e-waste alone will grow by over 60 per cent or 85,000 tonnes over the decade to 2024. While e-waste is not one of the main waste streams generated in Australia, (compared with, for example, construction materials at over 4 million tonnes in 2011-12) it is one of the fastest growing.

Landfilling e-waste represents a missed opportunity to re-use or recycle valuable components and materials in a way that could provide economic benefits as well as reducing the resource footprint of Victoria's economy. Its presence in landfill can also raise risks to the environment and human health.

The Andrews Labor Government is committed to banning e-waste from landfill, and has been undertaking policy development and consultation in order to inform the design of a ban and supporting policies. A discussion paper was released in September 2015 and consultation occurred throughout 2016.

The government's e-waste policy approach aims to:

- reduce harm to the environment and human health from e-waste in landfill;
- increase recovery of the resources in e-waste; and
- support jobs and investment in the recycling industry.

The government's long-term vision is for Victoria's landfills to only receive and treat waste streams from which all materials that can be viably recovered have been extracted. The commitment to ban e-waste from landfill alongside a range of important new supporting actions will further this vision by stimulating the development of alternatives to landfill. In line with best-practice regulation and in accordance with the requirements in the *Environment Protection Act 1970*, this policy impact assessment (PIA) is made available alongside the draft waste management policy documents in order to outline the rationale for a change in policy towards e-waste, the potential options for doing so, the impacts of the proposed policy, and the issues and approach to be taken in implementing this new policy.

Section 1 of the document introduces e-waste and describes trends and current management approaches in Victoria and nationally, as well as outlining the structure and content of the remainder of the PIA.

1.1 What is e-waste?

In many countries, including Australia, the term 'e-waste' is commonly used for the waste created when we throw out our electronic and electrical equipment. Other terms used include 'electronic waste' or 'e-scrap'. It includes products that require electricity to operate, or run on batteries.

E-waste is recognised globally as a category of waste that is an emerging problem as well as a business opportunity of increasing significance, given the volumes of e-waste being generated and the content of both toxic and valuable materials in them.[3] Recognising this, it was included as a hazardous waste in the *1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal*. The Convention is designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less-developed countries. It encourages countries to keep wastes within their boundaries and as close as possible to its source of generation.

[2] Australian Bureau of Statistics (2006) Environment Snapshot: recycling up, but e-waste a looming issue accessed via http://www.abs.gov.au/ausstats/abs@.nsf/mediareleasesbytitle/FB2F33C170E4987DCA2572210077D0FA

[3] Widmer R., Oswald-Krapf H., Sinha-Khetriwal D., Schnellmann M, Boni H. (2005) *Global perspectives on e-waste*, pp 436-458 in Environmental Impact Assessment Review

Examples of e-waste are shown in Table 1, which shows the European Union categorisation of different types of e-waste for the purposes of its Waste Electrical and Electronic Equipment (WEEE) Directive[4].

Here, the table is used simply to illustrate the broad range of items that would be captured by the proposed landfill ban. E-waste is a diverse category, with items ranging from frequently-disposed consumer products to long-lived specialised business equipment, illustrating the complexity of the problems associated with disposal and the challenge in devising appropriate policy responses.

Table 1: Examples of e-waste

Large appliances	Small appliances	IT, telecommunications and TV equipment	Lighting equipment
• refrigerators • washing machines • cookers • microwaves • electric fans • air conditioners	• irons • toasters • coffee machines • hair dryer • watches	• computers • laptops • printers • mobile phones • televisions • remotes	• fluorescent lamps • high intensity • discharge lamps • compact fluorescent • lamps • LEDs
Electrical and electronic tools	**Toys, leisure and sports equipment**	**Other e-waste**	
• drills • saws • sewing machines • lawn mowers • batteries	• electric trains and • racing cars • hand-held video game • consoles • amplifiers • musical instruments • radios	• medical devices • monitoring and control • equipment (smoke • detector, thermostats) • automatic dispensers • photovoltaic (solar) • panels	

1.2 Flow of e-waste in Victoria

The movement of waste can be generally understood (and modelled) as following a series of discrete stages in a lifecycle beginning with waste 'generation' and ending with final disposal or re-use.

In the e-waste context, e-waste is first generated before being collected, stored, reprocessed (to a greater or lesser extent), and finally landfilled. Between most of these stages there may also be a 'transfer' stage where waste is moved from site to site. How these stages look in the Victorian context is described below.

1.2.1 Generation of e-waste

'Generation' in the waste context refers to the point at which an object is deemed to be unwanted or not working and it enters the waste stream, i.e. is discarded. E-waste can be generated by households, small to medium businesses, academic institutions and large corporations. It is difficult to quantify the contributions the various sources make to the overall volumes of e-waste generated, but studies in the UK suggest that e-waste generated by householders accounts for about 75 per cent of total e-waste arising in 2010.[5]

[4] Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (2012)

[5] WRAP (2011) Market flows of WEEE materials – final report into study of market flows of WEEE materials, including development of mass balance model.

It is estimated that around 109,000 tonnes of e-waste were generated in Victoria in 2015, with this projected to increase to around 256,000 tonnes by 2035. The composition of this aggregate figure is highly varied, and is changing through time. Figure 1 illustrates the range of e-waste types– according to a United Nations University categorisation of 51 e-waste types – and how the volumes of different types of e-waste are projected to change in Victoria over the next 20 years.[6]

1.2.2 Transport of e-waste

Transfer of large amounts of e-waste between sites can be undertaken by waste management services and e-waste and metal reprocessors using large vehicles such as tray or compactor trucks. Larger businesses and councils will generally have a commercial arrangement in place to transport e-waste.

Householders and small businesses may transport larger e-waste items by car, sometimes with trailer, or if not too heavy, carry items to the nearest collection point.

1.2.3 Collection and storage of e-waste

E-waste is collected via a range of ways, including hard waste kerbside pick-up services, by dropping directly at designated points, or by dropping at temporary events. Some of these collection services are free; some are offered for a fee.

E-waste is consolidated and sorted, and often stored for a period of time before it is taken to landfill or reprocessed. Storage areas can include permanent covered or uncovered areas which may have concrete, grass or dirt bases, or containers such as skip bins, steel cages, shipping containers and polypropylene bags that can be transported from the site full.

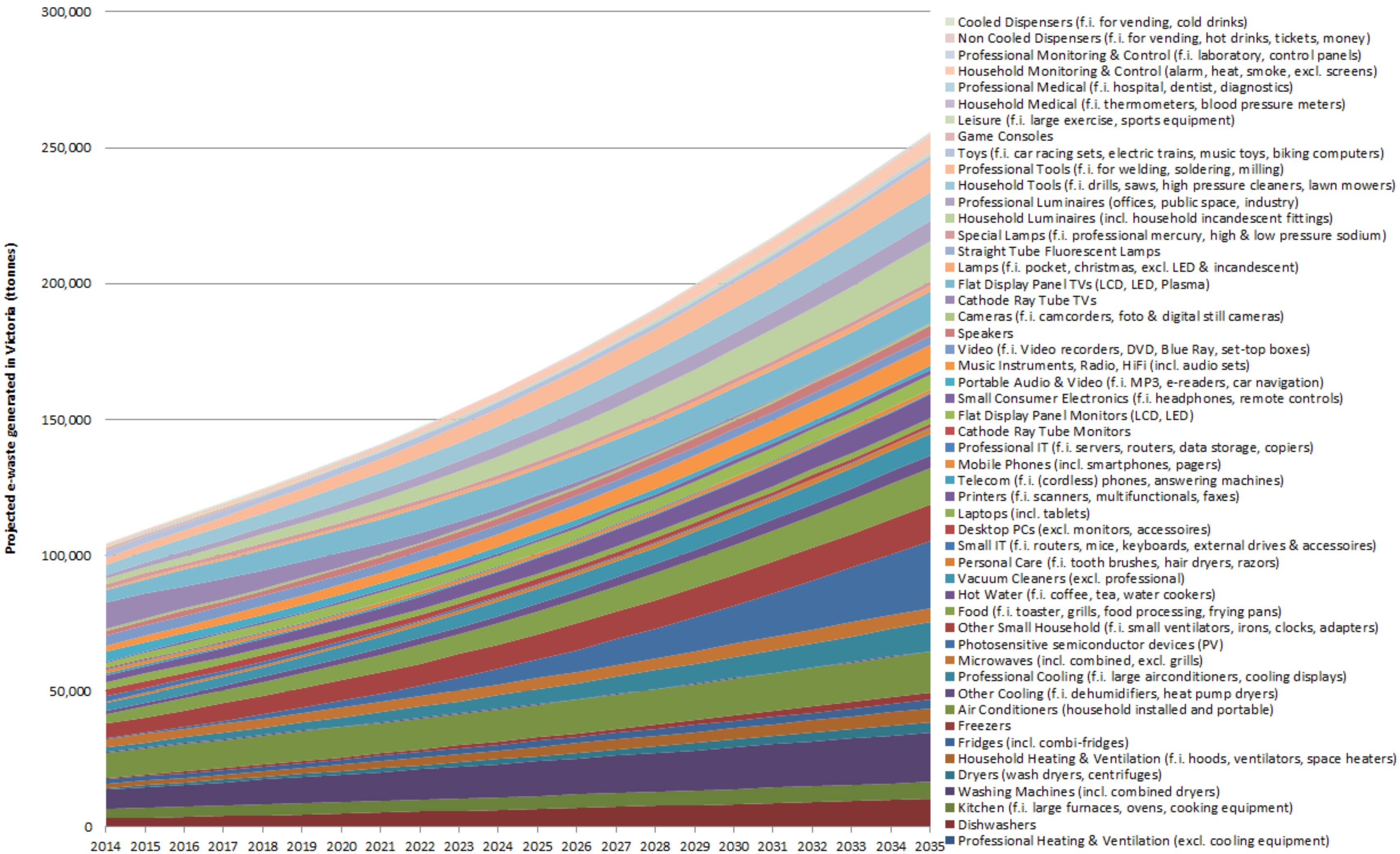
Common collection sites include:

- transfer stations and resource recovery centres;
- council civic centres and waste depots;
- retailer outlets;
- reprocessing sites;
- warehouses; and
- community hubs.

Some councils in metropolitan Melbourne are trialling the kerbside collection of e-waste. These trials are in early stages and data to understand how effective they are hasn't been released.

[6] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* accessed via http://www.sustainability.vic.gov.au/publications-and-research/research

Figure 1: Total e-waste generation by UNU-KEY product type in Victoria



1.2.4 Reprocessing of e-waste

E-waste reprocessing organisations generally follow one of the following broad business models:

- manual disassembly into intact subcomponents for sale as feedstocks for further reprocessing and or recovery;
- mechanical processing involving processes including crushing, shredding, magnetic, density, optical or x-ray sorting into sorted feedstocks for further reprocessing and or recovery.

The e-waste reprocessing industry has grown over the last decade in Australia. The number of organisations involved in the recovery of e-waste has almost doubled, and the range of programs and policies that support the collection and recycling of e-waste has increased. Of the 106,000 tonnes of e-waste generated in Victoria in 2014, 50 per cent was reprocessed by an e-waste reprocessor or a metal recycler.[7]

The Victorian reprocessing industry comprises a total of 16 facilities which represent the majority of e-waste reprocessors (manual and automated) in Victoria. They include internationally-owned companies and some privately-owned companies. Most of these companies use manual disassembly – 13 out of 16 sites exclusively use manual processing - however, there is a trend towards mechanical processing, particularly by the larger processors. One additional smaller processor has specialist technology for mercury processing and recycling from mercury containing e-waste, including fluorescent lighting and some industrial e-wastes.[8]

A small fringe of non-profit organisations employ people with disabilities to conduct manual disassembly, generally before transferring components to larger mechanical recyclers.

Metal recyclers are a separate category of businesses which employ mechanical shredders significantly larger than those used by specialist e-waste reprocessors. Metal recyclers tend to process much larger volumes of e-waste than their e-waste counterparts. Our studies suggest they account for 83 per cent of the e-waste recovered in Victoria.[9] However, these volumes are small compared with the volumes of other metal wastes they process. Most e-waste received by metal recyclers comes straight from collection (e.g. metal-rich whitegoods), although a relatively smaller flow comes from e-waste reprocessors where the more valuable components have first been removed.

The available supply of e-waste for reprocessing is driven by historical electrical goods consumption, although some portion of e-waste reprocessed in Victoria is also imported from inter-state. In 2014 approximately 2000 tonnes of e-waste were estimated to be imported into Victoria for reprocessing and this is projected to increase to approximately 3000 tonnes by 2035.[10] This represents approximately 1.8 per cent of the total e-waste reprocessed in Victoria in 2014.[11]

Determinants of demand by reprocessors for feedstock include:

- the market value for recycled components;
- commodity and micro-commodity prices (including precious and rare-earth metals);
- the cost of reprocessing;
- the regulatory framework affecting e-waste streams: e.g. landfill levy.

As a result of high demand for the metals contained in them, large white goods are at present substantially recycled and diverted from landfill despite the absence of formal recovery programs for these. Televisions, computers and computer peripherals, and mobile phones tend to be reprocessed due to the existence of recovery programs for these specific products (described further below). Other low value e-waste types, such as electrical toys and hairdryers are generally not recycled.

[7] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill,* report prepared for the Department of Environmental, Land, Water and Planning Victoria.

[8] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* http://www.sustainability.vic.gov.au/publications-and-research/research

[9] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* http://www.sustainability.vic.gov.au/publications-and-research/research

[10] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* http://www.sustainability.vic.gov.au/publications-and-research/research

[11] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* http://www.sustainability.vic.gov.au/publications-and-research/research

1.2.5 Landfilling of e-waste

Currently, it is legal to dispose most types of e-waste to Victorian landfills. Only automotive batteries, small batteries in non-domestic quantities, and radioactive substances are prohibited from landfill. While there are recovery programs for selected goods, what actually ends up in landfill can vary significantly from one landfill to another.

While it is difficult to obtain data on e-waste disposed to landfill, estimates suggest that close to 53,000 tonnes of e-waste were likely sent to landfill in Victoria in 2016 (or subjected to other fates – see below).[12]

Compared with all materials landfilled in Victoria, this accounts for approximately 1 per cent.[13] Wastes that are landfilled in greater volumes include concrete, bricks and asphalt (913,000 tonnes in 2011-12), paper and cardboard (478,000 tonnes in 2011-12) and food waste (898,000 tonnes in 2011-12).

1.2.6 Victorian e-waste flows in aggregate

A key analytical tool used to study waste flows is a 'Material Flow Analysis' (MFA) (see Box 1 for general description).

An MFA of Victorian e-waste flows was prepared in 2015, and the information in this model forms a central piece of evidence for understanding the problem of e-waste and measuring policy impacts. The estimates and projections of current and future e-waste generation and business-as-usual recycling / landfilling rates described above come from the MFA, as do the projections cited in section 2. The cost-benefit analysis in section 4 is also based on the MFA results.

Box 1. Description of Material Flow Analysis

A Material Flow Analysis is an analytical method to quantify flows and stocks of materials or substances in a well-defined system. In the waste context, it is a very useful tool for mapping out possible pathways of a particular type of waste. These pathways can then be used to inform policy and program delivery.

Preparation of an MFA involves five main steps:

1. Identification of the key (material flow related) issues.
2. System analysis (selection of the relevant matter, processes, indicator substances and system boundaries).
3. Quantification of mass flows of matter and indicator substances.
4. Identification of weak points in the system.
5. Development and evaluation of scenarios and schematic representation, interpretation of the results.

Preparation of the MFA involved extracting data on imports and exports of each type of electrical good, and then estimating historical, current and future consumption of those goods. Current and projected Australian and Victorian e-waste generation was then estimated based on lifespans of each type.

The Victorian MFA includes a number of features and details that make it useful for understanding policy impacts[14]:

[12] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill*, report prepared for the Department of Environmental, Land, Water and Planning Victoria.

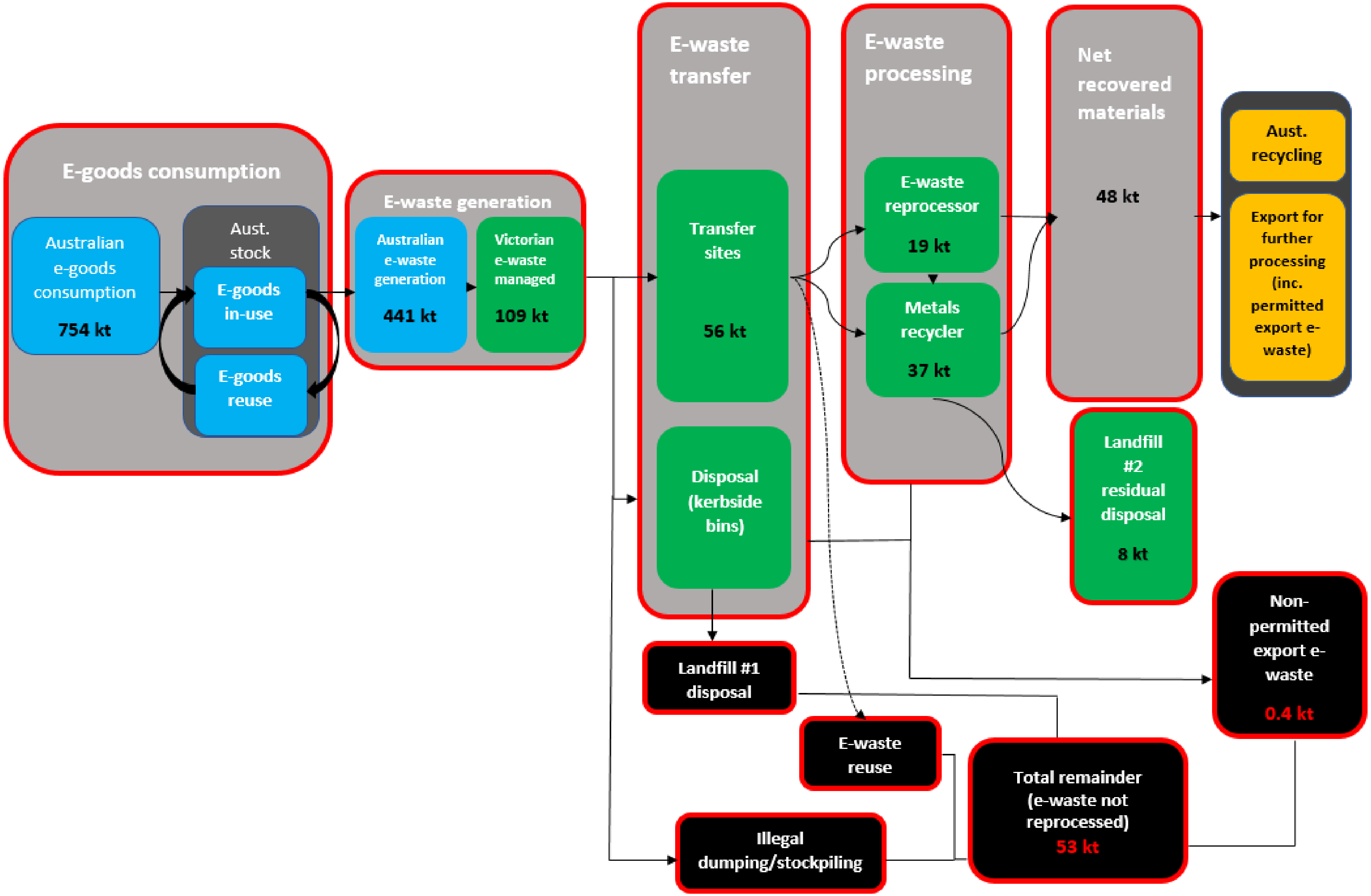
[13] Statewide Waste and Resource Recovery Infrastructure Plan 2015-44 (2015) Sustainability Victoria

[14] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* http://www.sustainability.vic.gov.au/publications-and-research/research

- a detailed and comprehensive disaggregation of e-waste by product code, according to a United Nations University categorization of e-waste types known as ‘UNU-KEYS’ (also used for EU WEEE Directive reporting) which contains 10 broad categories and a total 51 e-waste types within these;
- details for each product of the material type and hazardous waste components;
- classification of each of the 51 e-waste types into one of six categories of recycling ‘fate’ (i.e. whether and how they are recycled) as well as a broad ‘remainder’ category – due to insufficient data to estimate stockpiling, illegal dumping, or illegally export, these outcomes are grouped together with legal landfill flows;
- e-waste flows at each state of the chain – generation, transfer, processing (separately by metal recyclers and e-waste reprocessors), material recovery, post-processing disposal to landfill of ‘floc’, and the remainder – for the period 2016 to 2035, measured by weight (tonnes);
- projections of quantities of recovered materials – iron/steel, copper, lead, aluminium, precious metals and rare earths, glass, leaded glass, plastics, BFR containing plastics and other – and quantities of hazardous materials (lead, cadmium, chromium, nickel, mercury, antimony, indium, americium, POP-BDEs, other BFRs).

Figure 2 overleaf shows the structure of the MFA model, and provides a summary ‘snapshot’ of estimated material flows (tonnage) across all e-waste product types for 2014. The underlying model projects flows of e-waste out to 2035 based on various growth rate assumptions.

Figure 2: Estimated flow of e-waste in Victoria in 2015



1.2.7 Other fates

There are a range of other fates for e-waste that is not reprocessed or disposed to landfill. E-waste may also be stored in the home or onsite at a business, dumped off-site in areas not equipped to adequately manage waste, stockpiled inappropriately indoors or in open areas, or sent overseas without an export permit. Data on these fates, particularly in Australia, is difficult to obtain because these movements are not tracked at any point. One study found that in Europe, up to 40% of e-waste were subject to 'non-reported and non-compliant' fates in 2010.[15]

These fates, and their potential risks in the Victorian context, are further discussed in section 4.3.

1.3 E-waste trends

Australians are amongst the highest users of technology, and e-waste is one of the fastest growing types of waste.[16] In 2008, 106,000 tonnes of televisions, computers and computer products reached end of life in Australia.[17] By 2013, this volume had grown to 138,000 tonnes.[18]

At a state level, the e-waste MFA described above estimated that a total of about 109,000 tonnes of e-waste were generated and available for processing in 2015. This volume is projected to increase to about 256,000 by 2035.[19]

The most significant category of e-waste generated in 2015, in terms of volume, was the large appliance category. This includes refrigerators, washing machines and air conditioners. Other categories created in large quantities include information technology and telecommunications equipment, such as computers and printers, and consumer equipment such as televisions (cathode ray tube and flat screen televisions) and videos.

Information gathered on comparable countries indicates a similar pattern of increasing volumes.[20]

The underlying reasons for the global growth in e-waste volumes are a complex mixture of changing patterns of demand, such as the centralisation of digital technology to modern workplaces and consumer habits, the 'internet of things', and incentives on producers in electronic industries that also promote faster turnover from the supply side. Some of these factors include:

- **Rapid innovation** in both existing and new electronics, partly spurred by innovative features being a key differentiator and marketing strategy for consumer products, which creates a perceived need or desire in consumers to update and upgrade to a product that may be more efficient, more attractive or more up-to-date than their current model. Consumers are discarding their electronic products more frequently to ensure they have the 'latest' product.
- **A decrease in built-in lifespan of electronic products**, where products (or their parts) are failing over shorter and shorter periods, sometimes as a deliberate move by manufacturers ('planned obsolescence'). A study of planned obsolescence for the German environment department found that the proportion of electronic products bought to replace a defective appliance grew from 3.5% in 2004 to 8.3% in 2012, which

[15] Countering WEEE Illegal Trade (2015) Countering WEEE Illegal Trade Summary Report – Market analysis, Legal analysis, Crime analysis, Recommendations Roadmap

[16] Australian Bureau of Statistics (2013) Electronic and electrical waste accessed via http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4602.0.55.005Main%20Features52013?opendocument&tabname=Summary&prodno=4602.0.55.005&issue=2013&num=&view=

[17] PriceWaterhouse Coopers, report prepared for the Environment Protection and Heritage Council (2009) Decision Regulatory Impact Statement: Televisions and Computers, accessed via http://www.scew.gov.au/system/files/resources/0c513e54-d968-ac04-758b-3b7613af0d07/files/ps-tv-comp-decision-ris-televisions-and-computers-200911-0.pdf

[18] Department of the Environment (2015) National Television and Computer Recycling Scheme: Enhancements Arising from the Operational Review - Regulation Impact Statement, provided directly by the Department of the Environment

[19] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* http://www.sustainability.vic.gov.au/publications-and-research/research

[20] Baldé, C.P., Wang, F., Kuehr, R., Huisman, J. (2015) *The global e-waste monitor* – 2014, United Nations University, IAS – SCYCLE, Bonn, Germany accessed via http://i.unu.edu/media/ias.unu.edu-en/news/7916/Global-E-waste-Monitor-2014-small.pdf

was deemed “a remarkable increase”.[21] Diminishing effective lifespans are also resulting from the interplay between hardware and software manufacturers, which sees hardware capacity drive more complex software and software complexity drive demand for more powerful hardware, as software support for older models or operating systems ends or as consumers need to upgrade to maintain parity of experience.[22]

- **More affordable electronics** which mean products are becoming accessible to more people, increasing the number of items that will ultimately be discarded and prompting consumers to purchase new products rather than repair their existing products.[23]
- **More complex product design** which makes repair and recovery more difficult, and therefore more expensive. Combined with a declining price of new electronics, consumers will more likely decide that replacing their malfunctioning product will be cheaper than repairing their existing product.
- **Patterns of competition** in electronics marketing, which can see prices of new products held low or even priced as ‘loss leaders’ to attract customers to proprietary product lines. Prices of computer printers relative to proprietary ink cartridges, or e-readers relative to e-books, reflect this strategy.[24] Financially attractive packages that bundle telecommunications services to new devices, or link a range of household electrical and electronic appliances with a single control platform, can also encourage purchase.

All five factors reinforce a trend towards higher turnover of electronic products and consequently greater e-waste volumes. Lifespans vary significantly across products, however, making these trends more significant as drivers of e-waste growth for some electrical and electronic products more than others.

Figure 3 indicates how lifespans vary across common products. The figure derives from data comparing the average age of household electrical and electronic equipment, including storage time, with the average age of discarded e-waste, to show an estimated probability that e-waste of a given type will be discarded in a given year after purchase. There is around a one in ten probability that a five-year-old laptop will be discarded, for instance, and a washing machine is most likely to be discarded after around 12 years. Those products such as laptops with shorter lifespans in practice – regardless of the theoretical lifespan of the equipment – are clearly more significant contributors to e-waste problems.

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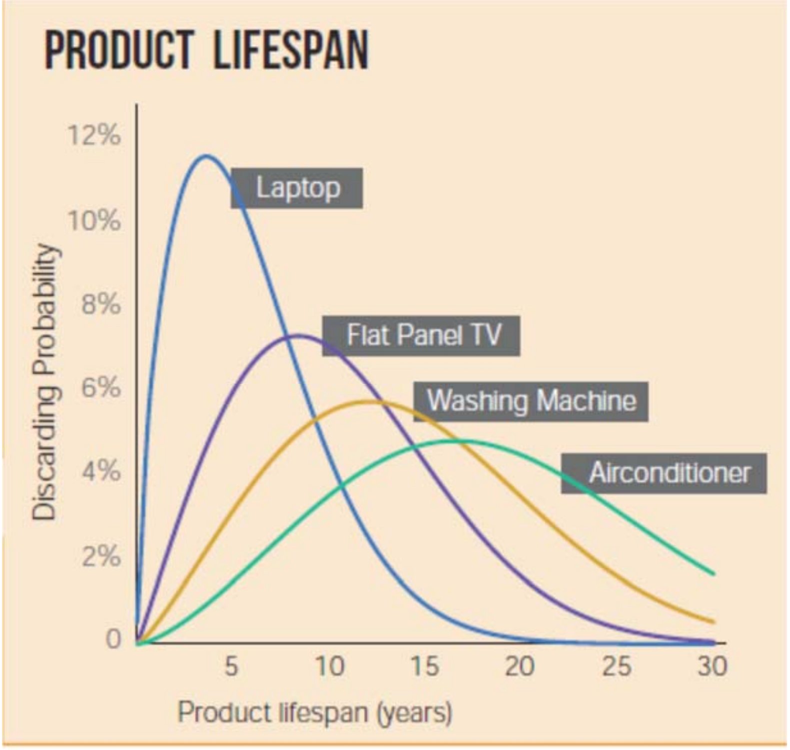
[21] ENDS Europe, Mar 2015, “Electronic goods’ life spans shrinking, study indicates”, http://www.endseurope.com/article/39711/electronic-goods-life-spans-shrinking-study-indicates

[22] The Atlantic, Sep 2016, “The Global Cost of Electronic Waste”, https://www.theatlantic.com/technology/archive/2016/09/the-global-cost-of-electronic-waste/502019/

[23] IBIS World (2015) Electronic & Computer Repair Services in the US: Market Research Report, accessed via http://www.ibisworld.com/industry/default.aspx?indid=1702

[24] The Atlantic, Sep 2016, “The Global Cost of Electronic Waste”, https://www.theatlantic.com/technology/archive/2016/09/the-global-cost-of-electronic-waste/502019/ and New Statesman, Oct 2012, “Amazon launches yet another loss-leader, but what is its plan?”, http://www.newstatesman.com/blogs/technology/2012/10/amazon-launches-yet-another-loss-leader-what-its-plan

Figure 3: Electrical product lifespan[25]



1.4 Current management of e-waste in Australia

With the exception of white goods, such as refrigerators and washing machines, and used lead acid batteries, for which there has been a fairly consistent market that keeps them out of landfill, programs to improve recovery of other e-waste are focused on just a few types.

At a national level, the **National Computer and Television Recycling Scheme** (National Scheme) is the key driver of recycling of televisions, computers and computer peripherals in Australia at present. Commencing in 2012, the National Scheme was developed by the Australian Government to increase the typically low rate of recycling of **televisions, computers and computer peripherals** (including keyboards, mice and hard drives) in Australia. It requires large television and computer manufacturers and importers to pay for the collection and recycling of a set percentage of these items each year. In their 2016 report on the outcomes from 2014-15, the Commonwealth stated that over 35 per cent of the televisions and computers that reached end-of-life in Australia were recycled.[26] In 2017-18, this percentage is set at 62 per cent. By 2025-26 it will increase to 80%.

The National Scheme is regulated by the Australian Government, under the *Product Stewardship Act 2011* and the *Product Stewardship (Televisions and Computers) Regulations 2011*, and operates through the interaction and cooperation of a range of stakeholders, including television and computer importers, the Australian Government, state and territory governments, local governments, and householders and small businesses. In practice, this means:

- manufacturers and importers (who trigger a certain threshold of volumes of televisions and computers manufactured or imported) must join and fund a 'co-regulatory arrangement';

[25] Baldé, C.P., Wang, F., Kuehr, R., Huisman, J. (2015) *The global e-waste monitor* – 2014, United Nations University, IAS – SCYCLE, Bonn, Germany accessed via http://i.unu.edu/media/ias.unu.edu-en/news/7916/Global-E-waste-Monitor-2014-small.pdf.
[26] Australian Government (2016) *National Television and Computer Recycling Scheme – Outcomes 2014-15*

- co-regulatory arrangements (there are currently four in Australia) are organisations that work on their members' (manufacturers and importers) behalf to administrate the scheme, and plan and carry out e-waste collection and recycling of televisions, computers and computer peripherals;
- e-waste reprocessors contract with co-regulatory arrangements to provide recycling services. They can also work with other businesses and government to recycle other types of e-waste not captured by the National Scheme;
- local government, retailers and other organisations can provide collection services to help co-regulatory arrangements meet the scheme outcomes They can also provide services for other types of e-waste not captured by the National Scheme;
- householders and small businesses can access collection services under the National Scheme at no charge. These services may be provided at local transfer stations, retailer outlets, or mobile drop-off events. Disposal or recycling of other types of e-waste not captured by the scheme may incur a fee.

Items provided to reprocessors under the National Scheme must be managed and recycled in accordance with the *Product Stewardship (Televisions and Computers) Regulations 2011,* which specify things such as administrative matters, recycling targets for each co-regulatory arrangement, the level of access a co-regulatory arrangement must provide to the Australian community, and the proportion of materials that must be recovered for further use (90 per cent of televisions and computer products must be recovered). Co-regulatory arrangements must report each year on how they have met their obligations.

Particularly since the introduction of the National Scheme, recovery of e-waste in Australia has increased. In 2013, the first year of operation, the scheme collected approximately 41,000 tonnes of televisions, computers and computer peripherals, more than doubling the estimated volume that was collected in the preceding year.[27] Based on the amount of e-waste estimated to be generated in Australia, however, this contribution only equates to around 10 per cent of all e-waste.[28] While televisions and computers represent a large proportion of e-waste, the targets were considered too low.[29] This created several issues including reduced collection of material, some material being collected but without industry funding for processing, closure of some council collection sites and considerable financial uncertainty and hardship for e-waste reprocessors.

To increase recovery of televisions and computers, the annual recycling targets for the scheme were increased to 50 per cent in the following year, 2015-16. Even as the recycling target rises to 80 per cent by 2027, however, the volume of e-waste in Victoria not recycled under existing programs will continue to grow.

A key finding in the MFA mentioned earlier identified **photovoltaic (PV) panels** as the most rapidly growing e-waste stream in Victoria in future years. This stream is estimated to be growing from around 550 tonnes in 2014, 0.5 per cent of all e-waste generated in Victoria, to around 25,000 tonnes by 2035, about 24 per cent. The rapid increase is largely due to the recent boom in PV system installations over the last 10 years with only two identified recycling processors in Australia.

The low volumes in the waste stream PV systems present minimal impacts to jurisdictions and local governments. However, as the PV system waste stream grows there is a concern from industry and government that there are insufficient management options to safely dispose of end-of-life PV systems across Australia presenting a potential cost burden to government, in particular local governments.

Jurisdictions across Australia are currently working alongside the PV sector to develop a national product stewardship approach for PV systems. It is anticipated that through a stewardship approach, consumers will be able to dispose of end-of-life systems in a safe and environmentally sustainable way.

[27] Economist Intelligence Unit for ANZRP (2015) Global e-waste systems: Insights for Australia from other developed countries, accessed via http://anzrp.com.au/wp-content/uploads/2015/02/Global-e-waste-systems-A-Report-for-ANZRP-by-EIU-FINAL-WEB.pdf

[28] The Global E-waste Monitor – Quantities, flows and resources (2014) United Nations University. Accessed via http://i.unu.edu/media/unu.edu/news/52624/UNU-1stGlobal-E-Waste-Monitor-2014-small.pdf

[29] Australian Government (2014) *The National Television and Computer Recycling Scheme – Operational Review*

MobileMuster, a **mobile phone** recycling program, is a not-for-profit program voluntarily funded by mobile phone industry groups. [30] It is not governed by regulation or enforced by mandatory laws, but it is accredited under the Australia's *Product Stewardship Act (2011)*. The program collects mobile phones, accessories and batteries through a comprehensive collection network, dismantles and recovers over 95% of their components for use in new products.

Mobile phones are estimated to represent a little over 1 per cent of all e-waste in Australia.[31] Since starting in 1998, MobileMuster has collected and recycled 10.9 million handsets and batteries via over 3100 public drop-off points (for example at retailer outlets, local council transfer stations and workplaces) and free post-back satchels. While amount collected is increasing, MobileMuster's market research estimates more than 25.5 million unused phones remain stored in homes.[32] This behaviour is presenting a barrier to recycling of mobile phones.

FluoroCycle is a program that seeks to increase the recycling rate of mercury-containing lamps and reduce the amount of mercury entering the environment. It is a voluntary product stewardship program, accredited by the Australian Government, in which organisations from the commercial and public lighting sectors commit to recycling their own mercury-containing lamps. It is difficult to know what proportion of these lamps are recycled through this program, but sources indicate that up to 95 per cent of mercury-containing lighting waste is still ending up in landfill.[33]

Australian Battery Recycling Initiative (ABRI), is a not-for-profit association of battery manufacturers, recyclers, retailers and government bodies that promotes safe and environmentally responsible collection and recycling of **batteries** at end of life.[34] Through state-run programs, such as BatteryBack in Victoria, it supports a range of free collection points across Australia. After collection, batteries are sorted by chemistry type and sent to appropriate recyclers in Australia and overseas.

ABRI notes that almost all batteries can be recycled to recover metals and other valuable components, however it has been estimated that only 5 per cent of the end-of-life batteries produced every year are recycled.[35] Industry, including ABRI and governments are currently working on a product stewardship scheme for the management of end-of-life handheld batteries, including rechargeable and hazardous single-use batteries.

Large storage batteries such as those used in electric vehicles and for stationary energy storage are becoming increasingly common. A significant increase is expected in the number of these batteries entering the waste stream in coming years. A recent report estimated that volumes of lithium ion batteries will grow by about 12 per cent per year over the next 20 years,[36] and result in between 100,000 and 187,000 tonnes waste per year.

At a state level, **South Australia** implemented a staged ban on the direct disposal of e-waste to landfill over a three-year period between 2010-2013. In the first stage, white goods were banned from landfill (most were already being sent to metal recyclers). Computers and televisions followed a year later to align with the introduction of the National Scheme, along with fluorescent lighting, and in the third year all remaining e-waste was banned.

While it is difficult to obtain data to evidence how effective the ban has been, it has been a key factor in the South Australian-based e-waste reprocessor Nyrstar's recent decision to expand the range of e-waste it can

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[30] Mobile Muster, accessed via http://www.mobilemuster.com.au/about-us/fast-facts/

[31] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* http://www.sustainability.vic.gov.au/publications-and-research/research

[32] MobileMuster (2016) *2015-2016 MobileMuster Annual Report*

[33] CMA Ecocycle (2016) *How Fluorocycle and CMA Ecocycle are recycling mercury lights in Australia* accessed via http://www.cmaecocycle.net/lighting-and-electrical/fluorocycle-cma-ecocycle-recycling-mercury-lights-australia/

[34] Sustainability Victoria, Batteries accessed via http://www.sustainability.vic.gov.au/services-and-advice/households/waste-and-recycling/batteries

[35] 2016-17 Product List, Australian Government accessed via https://www.environment.gov.au/protection/national-waste-policy/product-stewardship/legislation/product-list-2016-17

[36] Blue Environment, Ascend and REC (2015), *Hazardous waste infrastructure needs and capacity assessment*, Final report to Department of the Environment

process. The company expects that it will be able to process about 3000 tonnes of e-waste in 2018, increasing to 20,000 tonnes per year as the facility ramps up.[37]

Also, the **Australian Capital Territory** diverts all computers and televisions from landfill by introducing mandatory recycling for computers in 2005 and televisions in 2010. This is presently a user-pays system that works alongside the free services the National Scheme provides.

As state, territory and local governments continue to play a role in the management of all other types of e-waste (and waste more broadly) it will be important to ensure that Victoria's approach to e-waste will complement the existing schemes and any related legislation that underpins them.

1.5 Government in waste and resource recovery

Responsibilities for maintaining a healthy environment, including the management of waste, are shared across all levels of government, and in the context of e-waste there are significant roles for each.

1.5.1 Commonwealth Government

While Victoria focuses on state environmental management issues, it also contributes to and influences nationally-led programs. The Commonwealth released a national waste policy, *Less Waste, More Resources*, in 2009[38] to set direction for broad areas that are best initiated at a national level, such as product stewardship, packaging management, harmonising the definition of waste and managing international obligations.

The implementation of many of these areas are led by individual states. Victoria played an important role in the development of the National Scheme, was instrumental in the establishment of Australia's voluntary national paint product stewardship scheme, and, with Queensland, is co-leading the preparation of a national market development strategy for used tyres. Most recently, Victoria has received endorsement all states and territories in Australia to establish a working group to work with the PV sector to develop a national product stewardship approach for PV systems.

1.5.2 Victorian Government

Specific organisations within Victoria's environment portfolio collaborate closely on state waste and resource recovery issues. These organisations have a specific role to play in how waste, including e-waste, is managed in Victoria, both now and in the future.

The **Department of Environment, Land, Water and Planning** (DELWP) oversees waste and resource recovery policy development to support the Minister for Energy, Environment and Climate Change. It is also working closely with Victoria's Environment Protection Authority, Sustainability Victoria and waste and resource recovery groups to investigate options to support recovery of e-waste in Victoria.

The **Environment Protection Authority** (EPA) is responsible for regulating pollution and waste. Given e-waste can be a component of municipal waste or industrial waste, EPA's involvement with e-waste has generally been incidental to its core regulatory oversight of landfills.

Sustainability Victoria (SV) is responsible for long-term state-wide waste and resource recovery infrastructure planning and for delivery of environmental sustainability and waste programs. It also leads work in the development of markets for the recovery of priority waste streams, such as tyres, organic waste, glass fines and e-waste, and it supports innovations to increase the recovery of these waste streams. For example, in 2014, SV commissioned the e-waste material flow analysis mentioned earlier to better understand the flows of e-waste in Victoria and industry capacity. And in 2015, SV facilitated government investment in state-of-the-art, automated equipment to reprocess e-waste in Dandenong, Victoria.

Victoria's **waste and resource recovery groups** (WRRGs) are responsible for planning for waste and resource recovery infrastructure. They work with local councils to plan and coordinate waste management facilities and services in their respective areas, and provide regional-specific input into the design and

[37] *Nyrstar expands e-waste processing capabilities* (2017) Inside Waste, accessed via http://www.insidewaste.com.au/general/news/1051372/nyrstar-expands-waste-processing-capabilities

[38] National Waste Policy: Less Waste, More Resources (2009) Commonwealth Government.

development of new interventions. They supported local councils through the implementation of the National Scheme, and will be an important player in Victoria's approach to e-waste.

1.5.3 Local government

There are 79 local governments in Victoria that play an important role in addressing local environmental issues. Councils make and enforce land use planning decisions and regulate some noise and waste issues under the EP Act. Some local councils participate in the National Scheme, facilitating the collection and recycling of televisions and computers. As such, they have a great deal of experience managing these types of e-waste. Local councils are also often the operators of landfills and transfer stations, both of which form a key part of the e-waste pathway.

1.6 Victorian environmental protection framework and reforms

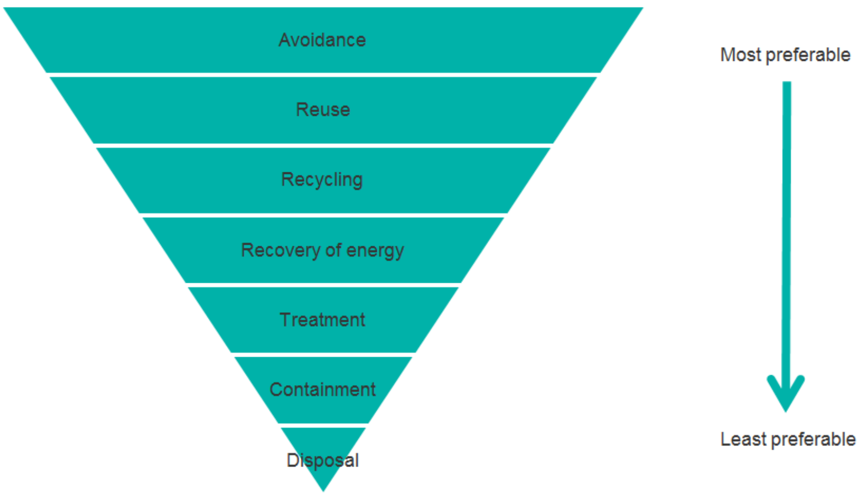
1.6.1 The Environment Protection Act

The *Environment Protection Act 1970* (EP Act) is the primary legislation that underpins the statutory framework for environment protection and waste management in Victoria. It establishes EPA's powers, duties and functions and creates a number of instruments used by EPA to prevent pollution, minimise waste and reduce risks to the environment and human health.

Central to waste management in the EP Act is the waste hierarchy for Victoria. It is one of the foundational principles in the Act and guides how options for managing waste should be preferenced. Figure 4 illustrates how the first preference would be to avoid waste altogether, followed by reuse and recycling where possible. The final preference would be to dispose of the waste.

This same principle is also embodied in the broader waste and resource recovery goal set by the Andrews Labor Government in the *Statewide Waste and Resource Recovery Infrastructure Plan* – which applies to all forms of waste including e-waste – which is that landfills should only receive and treat waste streams from which all materials that can be viably recovered have been extracted.[39]

Figure 4: Waste hierarchy of Victoria



[39] Sustainability Victoria (2015) *Statewide Waste and Resource Recovery Infrastructure Plan 2015-44*, p. 11.

The EP Act gives EPA a key role in regulating waste through a range of tools, such as licensing and works approvals for waste storage and treatment, and permits for transport. There are other tools that EPA can use under the EP Act to support its regulatory approach, such as education, remedial notices, targeted enforcement campaigns, partnerships and agreements.

Some of the EP Act's powers to regulate waste are given to other government bodies. For example, the EP Act creates a septic tank permitting system which is managed by local councils.

The EP Act also gives power to make two important types of statutory policy as subordinate legislation:

- **State environment protection policies** (SEPPs) define the uses of the environment that Victorians value (beneficial uses) and the environmental quality indicators required to protect these uses.
- **Waste management policies** (WMPs) establish state-wide standards and directions for waste management. They can cover the full waste cycle – from generation and use through to disposal, treatment and reuse. They may also allocate responsibility for industrial waste management operations and disposal, and establish the level of technology that should be applied to processes involving wastes.

1.6.2 Independent Inquiry into the EPA

One consideration for developing and implementing policy relating to the proposed e-waste landfill ban is the recent inquiry into the EPA and reforms stemming from that process.

In May 2015, the former Minister for Environment, Climate Change and Water appointed a Ministerial Advisory Committee to undertake an independent Inquiry into the EPA. The Inquiry examined the EPA's role, powers, governance and funding, and tools, and was asked to recommend how the EPA could best protect public health and the environment for future generations while considering how its environmental protection role could combine with economic sustainability and jobs growth.

On 31 March 2016, the Ministerial Advisory Committee delivered its report to the former Minister for Environment, Climate Change and Water. The government released its response to the Inquiry on 17 January 2017, initiating reforms to both the EP Act and EPA.

Particularly relevant to Victoria's approach to e-waste is the Andrews Labor Government's commitment to deliver modern, fit-for-purpose legislation. While work on this commitment continues, it is possible that some of the existing tools under the EP Act (e.g. waste management policies) will be modified under the new framework.

Also relevant is that the EP Act reforms reorient the general legal framework for environmental protection away from prohibitions on specific pollution outcomes and towards a general 'duty' to take preventative steps to reduce risks of harm. A shift toward positively-expressed obligations to take 'reasonably practicable' steps will be central to the proposed legislation, and the e-waste regulations should reflect the intent of these broader reforms.

1.6.3 Review of the Environment Protection (Scheduled Premises and Exemptions) Regulations

The *Environment Protection (Scheduled Premises and Exemptions) Regulations 2007* apply requirements to a range of industrial and commercial activities with the potential for significant environmental impacts. They prescribe premises in Victoria that are required to obtain an EPA works approval and/or licence, and/or provide a financial assurance.

DELWP and EPA have recently reviewed and amended the regulations. One of the main changes is that large e-waste reprocessors are required to obtain a works approval to set up any new e-waste reprocessing company, and/or a licence to operate. This has been considered when defining the base case for the impacts analysis.

Under the proposed revisions, which will cover all reprocessors recycling 500 tonnes/year of e-waste or greater (i.e. all but a few small manual facilities), reprocessors will face stringent environmental and OH&S controls.

1.7 Outline of the Policy Impact Assessment

A PIA, under the EP Act, is intended to lay out the objectives of a change to policy, the options for doing so, and an assessment of the impacts of each alternative – in quantitative terms where practicable – in order to ensure that the costs are not disproportionate to the benefits to be achieved.

Chapter 2 of this PIA describes in more detail the nature of the **problems** associated with trends in e-waste, and inadequacies in the way it is managed at present.

Chapter 3 describes the government's policy **objectives**, and describes the range of regulatory and non-regulatory **interventions** that could help to achieve these. A qualitative assessment of the merits of these potential interventions is then used to identify a preferred 'package' of changes to drive a new approach to e-waste management in Victoria.

Chapter 4 describes the **impacts** of this preferred package of reforms. There are three components to the analysis: a description of the regulatory requirements and costs on different parties, a discussion of policy risks, and a cost-benefit analysis (CBA) based on an underlying model of waste material flows under different policy settings.

The CBA has two key functions. First is to assess the **net social benefits** of the preferred approach against several fundamentally different alternatives (including business-as-usual). Second is to help inform several key **design choices** under the preferred approach, in particular the level of access to collection services.

Chapter 4 also includes analysis of **distributional impacts**, employment impacts, small business impacts, and a competition assessment.

Chapter 5 provides detail on how the proposed policy approach will be **implemented**, including the legislative instruments used, the roles of different parties, and staging of different interventions.

Chapter 6 describes how the policy will be **evaluated**.

Chapter 7 summarises **consultation** carried out to develop the proposed approach.

2 Problem analysis

2.1 Introduction

Only around 50 per cent of the e-waste generated in Victoria is subject to any form of recycling under current policy settings, with the remainder going directly to landfill.[40] Chapter 2 of the PIA outlines the problems associated with this outcome, describing the negative consequences of landfilling e-waste and some of the underlying behavioural, economic and policy causes.

The problem can be understood as one in which under current policy settings there is a potential missed opportunity to generate additional income streams from recovering the valuable materials in e-waste. There are also negative impacts from sending e-waste to landfill both ‘upstream’ and ‘downstream’ of Victoria’s waste management system because:

- sending non-renewable resources to landfill drives higher rates of virgin extraction, which causes environmental and social problems as well as raising problems of intergenerational inequity (upstream impacts);
- e-waste has hazardous components which create risks of harm to the environment and human health when disposed of in landfill, as well as using up limited landfill space and causing associated landfill amenity issues (downstream impacts).

E-waste has been described as both an “urban mine” – a valuable reservoir of recyclable materials, which is lost when landfilled, thereby driving further resource extraction – and a potential “toxic mine” of hazardous substances that must be managed carefully to avoid harm.[41] This framing neatly captures the key elements of the problem.

The question of why these outcomes occur under current policy settings has a range of answers, some straightforward and relating to unpriced environmental externalities, and others less obvious. The underlying reasons why more e-waste is not recycled also include behavioural, informational, and economic incentive factors which collectively act as barriers to greater recycling, including potential market failures that could hold back recycling activity even where the total social costs of doing so would be less than the value of the resources recovered.

The following sections describe these problems and their causes in more detail.

2.2 The problem

2.2.1 Lost opportunity to recover valuable resources

A major aspect of the problem relates to the permanent loss of valuable materials to landfill – the failure to exploit the “urban mine”. Around the world, governments and firms are being urged to see the opportunity in e-waste recycling to create new income streams while also improving environmental sustainability.[42] Capturing resource value is central to the Victorian Government’s *Statewide Waste and Resource Recovery Infrastructure Plan* and to policy announcements on e-waste to date.[43]

Globally, the potential wealth in e-waste is enormous. The *Global E-Waste Monitor* estimates that the gold content alone from e-waste disposed in 2014 was around 300 tonnes, or 11 per cent of global gold production. The intrinsic value of all materials contained in e-waste disposed globally in 2014 is estimated at

[40] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* http://www.sustainability.vic.gov.au/publications-and-research/research

[41] United Nations University, *Global E-Waste Monitor 2014: Quantities, Flows and Resources*, see https://unu.edu/news/news/ewaste-2014-unu-report.html

[42] United Nations University, *Global E-Waste Monitor 2014: Quantities, Flows and Resources*, see https://unu.edu/news/news/ewaste-2014-unu-report.html and World Economic Forum 2014, *Towards the Circular Economy: Accelerating the scale-up across global supply chains*

[43] DELWP (2015) Discussion Paper *Managing e-waste In Victoria: Starting the conversation*

48 billion euros, with this total dominated by gold, copper, and plastics values.[44] Australia's contribution to this wealth is relatively small, but as one of the larger generators in the world, (20 kg per person in 2014[45]), Australia is in a good position to consider how to prevent potential wealth from being trapped in landfill in future.

Landfilling e-waste could seem to some as inefficient, partly because it involves 'dispersing' valuable materials amongst low-value wastes. This action is practically irreversible – 'landfill mining' is still in its infancy.[46] Yet the costs of avoiding irreversible dispersion by collecting and sorting it at scale appear modest relative to the opportunities, or future option value, it offers for recycling (see Box 2 below for discussion of this perspective). This type of reasoning lies behind strong community support for e-waste recycling.

Elaborating on this sentiment to provide a clear statement of the policy problem associated with lost resource value that warrants new government intervention is not straightforward, however.

Recycling is costly, and so if the resources recovered can instead be acquired at lower cost through virgin extraction (i.e. mining) – that is, if the recovered materials appear to have market value insufficient to offset recovery costs – then recycling would appear to generate net social costs, not benefits. Generally allowing markets to determine which items are recycled would improve economic efficiency, it is thought, since markets will emerge in recycling where it is the least socially costly source of materials. If this does not occur, it signals that recycling would be economically inefficient.

At present only metal-rich whitegoods see market-led recycling – other activity is driven by the National Scheme or one of the other programs described in Chapter 1. To mandate reprocessing of more e-waste must therefore involve social costs greater than social benefits yielded, according to this argument.

There are several problems with this viewpoint, however, and several reasons to consider that policies allowing e-waste to be consigned to landfill, even where market incentives currently fail to stimulate recycling, could be leading to poor outcomes.

One is the presence of externalities (social impacts not fully factored into sector decision-making) in both extraction and landfilling, as discussed in subsequent sections.

A separate issue, covered here, is that there may be avoidable barriers to recycling, including market failures – particularly in the collection part of the recycling process – that prevent the private sector undertaking some activities as cost-effectively as government could. This could justify a role for government in facilitating material recovery on economic efficiency grounds. If the total social costs involved in recycling – the costs of collecting e-waste and getting it to recyclers, as well as the reprocessing costs – are less than the potential value of materials that could be recovered by a recycling industry operating at scale, then action by government could potentially lead to economic gains in the present, as well as helping to reduce the harm from extractive industries and landfilling and to protect the interests of future generations.

[44] United Nations University, *Global E-Waste Monitor 2014: Quantities, Flows and Resources*, see https://unu.edu/news/news/ewaste-2014-unu-report.html

[45] United Nations University, *Global E-Waste Monitor 2014: Quantities, Flows and Resources*, see https://unu.edu/news/news/ewaste-2014-unu-report.html

[46] For background see Krook J, Svensson N, and Eklund M (2012), "Landfill mining: a critical review of two decades of research", *Waste Management* 32(3). It is worth noting that the factors that would make landfill mining less cost prohibitive would also tend to improve the economics of recycling.

Box 2. The 'entropy of materials': an alternative perspective on the policy rationale

An unusual but useful tool for understanding the impacts of different e-waste disposal choices, and for explaining the potential role for government, is the concept from physics of '**entropy**'.[47]

Entropy refers to how far energy is dispersed and therefore how available that energy is. For example, a low-entropy state (such as oil contained in an underground reservoir) has more accessible and useful energy than a high-entropy state (such as carbon dioxide in the atmosphere). High-entropy energy needs more energy to make it more useful.

The theory of entropy can also be applied to the flow of valuable materials in the lifecycle of an electrical or electronic product. Mining requires energy to convert raw materials from nature (e.g. copper ore) into a more useful form (e.g. copper wire which could have many uses). Using copper wire in a product disperses the copper somewhat (e.g. the copper in a mobile phone is now difficult to redeploy in another product), and product distribution disperses the materials (geographically) further.

What happens to the product next can further affect how useful the materials in the product continue to be. Sending the product to landfill is relatively cheap but increases dispersion of its materials significantly so that extracting them for reprocessing requires much more energy and is extremely costly. On the other hand, collecting, sorting and consolidating materials into a 'low entropy' form can make them much more useful to reprocessors than when products are dispersed across numerous households or in landfill. Government could play a role in reducing the entropy of e-waste materials by preventing their dispersion. Markets may be unable to do it as cheaply, or less inclined to in the face of uncertainty.

Preserving materials in a low-entropy state could already be occurring intuitively in households, as many people store their e-waste at home.[48] Maintaining those materials in a low-entropy state seems logical and most efficient. The key question is whether it is actually more efficient to use a 'closed-loop' approach (i.e. collection, sorting, consolidation then recycling), than an 'open loop' approach (i.e. acquiring the same materials via virgin extraction, then disposing them post-use to landfill).

The following sections consider whether the private sector might be unable to conduct collection at efficient cost, and whether market prices in extraction and disposal might not reflect efficient social costs, and therefore why market outcomes might not be efficient outcomes. Chapter 4 then considers the overall empirical question by assessing the costs and benefits of policy initiatives that result in more e-waste recycling.

Barriers to recycling: why is more e-waste not recycled?

A superficial explanation for why more e-waste recycling does not take place under current policy settings is that reprocessors perceive the revenue potential to be insufficient to cover the costs they would incur. A

[47] See Lienig J and Bruemmer H (2017), *Fundamentals of electronic systems design,* section 7.1 "Motivation and the circular economy"

[48] Australia's Mobile Decade – 10 years of consumer insights into mobile use and recycling 2005-2015 (2015) Australian Mobile Telecommunications Association.

deeper explanation for why it is proving uneconomic for the private sector to engage in more recycling involves a number of economic, policy and behavioural factors, existing at various points in the chain from waste generation to reprocessing:

- **Missing information**: households, whose decisions about e-waste disposal determine the volumes available for recycling, are not aware either of the hazards associated with e-waste in landfill or of the potential value of the components and the existence of firms willing to recycle it. Lack of trust that items dropped at collection points will actually be recycled may also encourage home stockpiling. Both factors reduce volumes arriving at existing collection points and reduce potential scale economies for recyclers.
- **Distribution of incentives**: in Victoria, the costs of collecting, sorting and transporting e-waste are borne by households and local government, and collection systems are currently fragmented and difficult for households to understand and access (i.e. costly). The financial benefits of recycling, however, accrue to e-waste processers who sell recovered materials in the market. The mismatch of incentives reduces recycling rates.
- **Illegal pathways**, such as dumping, mixing, stockpiling or illegal export, undermine the financial viability of legitimate recycling operations by reducing the volume available as feedstock from the local recycling market.
- **Instability in e-waste volumes** and/or a lack of sufficient volume to achieve scale economies creates uncertainty in the recycling industry and deters investment. The projections discussed earlier in this PIA indicate growing volumes of e-waste generation, but recyclers claim they are not seeing higher volumes in practice. This may be linked to illegal disposal or to generators simply lacking reasons to direct e-waste out of general waste streams and towards recycling (see first two points).
- **The cost of recycling** some e-waste can be greater than the revenues from recovered materials, making disposal to landfill cheaper. In part this reflects trends in product design towards more complex and less easily recycled products, as discussed in section 1.3. As the mix of e-waste shifts towards lower value products, processing costs relative to value extracted may even increase over time.[49]
- **Global market prices** for materials recovered from e-waste can fluctuate, causing uncertainty in the recycling industry and deterring investment.

Despite these barriers, consultation with the recycling industry suggests there is latent demand for additional e-waste to recycle. Recyclers report having capacity to process greater volumes, and willingness to do so if more feedstock can be provided. This indicates that the reprocessing activity per se is profitable, but the private sector cannot undertake the necessary pre-processing activities (collection, sorting, storage, transport) at sufficiently low cost to make recycling profitable overall.

If more processing does not take place it is therefore either because the social costs of these activities are inherently too high to ever generate net profits from collection and recycling, or because there are barriers to the private sector providing these pre-processing services at their efficient cost, implying a possible role for government.

Market failures in e-waste collection?

A useful way to analyse these barriers is to consider whether there could exist market failures in pre-processing that explain why private markets are unable to profitably supply e-waste feedstock to re-processors. In other words – are there reasons why markets would fail to recycle more e-waste even if the aggregate costs along the whole recycling chain, from collection to processing, were less than the values of materials recovered?

From this perspective, a number of potential market failures include:[50]

[49] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill,* report prepared for the Department of Environmental, Land, Water and Planning Victoria.

[50] This set of market failures relates only to pre-processing recycling activities in the Victorian context. Other market failures 'downstream' and 'upstream' of the Victorian waste management system are discussed in sections 2.2.2 and 2.2.3.

- **Promotion of recycling is a public good** – as discussed later in Chapter 3, education of households and businesses about how and why to recycle is a critical part of driving greater diversion of e-waste from landfill. However, no private sector participant could profitably undertake this sort of campaign, since the costs would be privately borne but the benefits of additional available feedstock would be shared amongst all recyclers.
- **Regulatory powers are a necessary complement to recycling systems** – there are several other critical enablers of an effective recycling system that require the levers of government, and are thus beyond the powers of private sector participants. Yet without these levers the chain of supply of e-waste from generation to reprocessor will not function well:
  - **Co-ordination with local government** - local government plays a key role in waste management by providing waste collection services and operating transfer stations, which are a key intermediary between waste generators and recyclers. In both roles, local government can influence the volumes of e-waste available for recycling: hard rubbish collection, for instance, can transport large items from households to transfer stations, and transfer station capacity and sorting can influence the reliability of supply to industry. The state can influence local government capacity and policy in order to boost recycling to an economic scale, but private firms cannot.
  - **Regulation of individuals** – regulatory actions (e.g. a ban on sending e-waste to landfill) can complement efforts to encourage and provide access to recycling, as explained in Chapter 3. The private sector lacks the regulatory levers that would help a recycling system maximise volumes diverted from landfill and available for processing.

Some of these barriers are within the power of the state to influence. Given this, and given the potential for market failures to prevent recycling occurring at a socially efficient level, there is a potential role for government to support policies that increase recovery of the valuable components of e-waste.

The question of whether a policy intervention could generate sufficient benefits to the processing industries to result in net social benefits from recycling overall will be examined in Chapter 4.

2.2.2 Upstream (resource extraction) impacts

Landfilling e-waste also has indirect upstream impacts: further virgin extraction (i.e. mining) is required to serve resource needs. This often causes environmental, health, and social harm (externalities) and/or competes at an advantage to recycling by virtue of other preferential treatment (e.g. subsidies). These factors lead to over-extraction and to lower market demand and prices for recycled materials than is socially efficient.

Another upstream impact is the problem of intergenerational inequity. Further virgin extraction as a consequence of our failure to recycle valuable materials contributes to this global problem. Just as market prices for commodities fail to incorporate all social costs of extraction in the present, so too do they fail to reflect the interests of future people in having accessible commodity supplies to serve future needs.

These issues do not arise from state policy failures. However, state (waste management) policy settings can have some influence on the degree to which they occur.

These issues are expanded upon in the discussion below.

Materials in e-waste

The range of non-renewable materials in electrical and electronic products is extremely broad. It includes plastics, metals such as gold and copper, and rare earths. Up to 60 elements from the periodic table can be found in complex electronics, many of which are technically recoverable.[51] A sample of these materials is shown in Table 2.

Table 2: Non-renewable materials in electrical and electronic products[52]

Metals	Rare earths	Other
Iron	Neodymium	Plastics
Steel	Praseodymium	Glass
Aluminium	Dysprosium	
Copper		
Gold		
Silver		
Palladium		

At current rates of consumption many of these non-renewable materials have very limited reserves. Although there is general uncertainty around how long resource reserves will last, some studies estimate that virgin supplies of many materials, such as gold and copper, will be exhausted within the next century.[53] When e-waste is disposed to landfill, permanently stockpiled or dumped, these non-renewable materials are effectively removed from circulation.

Socially inefficient market responses to depletion

As reserves are depleted, these resources are likely to become increasingly valuable and expectations of future prices will rise. This can drive innovation and exploration to exploit previously undiscovered or unviable reserves, and can incentivise manufacturers to change product designs to economise on material costs.

Price signals can also incentivise resource recovery. Metal-rich whitegoods are predominantly kept from landfill at present by the profitability of recycling, and market forces may similarly drive recovery of more types of e-waste in future. The technology required for recovery of many materials is already available: at least 95 per cent of a computer, 75 per cent of a washing machine and 84 per cent of an air conditioner are recycled under some current best-practice recycling operations, for instance.[54] [55]

That markets are able to respond to resource depletion, including by stimulating recycling when it is privately profitable to do so, suggests that humanity should not literally 'run out' of resources. But that does necessarily mean that market incentives for resource extraction and recycling are strong enough to generate the best outcomes.

For one, markets may lack sufficient information today to correctly predict future shifts in technologies and material demands to recover the right resources in the right quantities before resources are irretrievably consigned to landfill. Technologically feasible alternatives to materials being discarded today will not always be developed, or they may turn out to be more costly than recycling would have been.

Neodymium, one of the most critically-scarce rare earth metals, can illustrate this point. It is now increasingly in demand for magnets in wind turbines and electric vehicles as a lighter substitute for iron-based magnets. Recent research indicates that recycling of computer hard disk drives is likely the most feasible pathway toward large-scale production of neodymium, illustrating how the legacy of sending computer hard disk

[51] United Nations University, *Global E-Waste Monitor 2014: Quantities, Flows and Resources*, see https://unu.edu/news/news/ewaste-2014-unu-report.html

[52] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill* – report prepared for the Department of Environment, Land, Water and Planning Victoria.

[53] Cohen. D. (2007) *Earth's natural wealth: an audit,* New Scientist, May 26, pp 38-9.

[54] Robinson (2009) *E-waste: An assessment of global production and environmental impacts*, Science of the Total Environment, 408, pp 183-191.

[55] Menikpura, S.N.M., Santo, A. and Hotta, Y. (2014) *Assessing the climate co-benefits from Waste Electrical and Electronic Equipment (WEEE) recycling in Japan*, Journal of Cleaner Production, 74, pp183-190.

drives to landfill in the past has locked up increasingly valuable resources.[56] In this instance, shortages of neodymium due to past failures to recycle also disrupts a key pathway to sustainable technologies.

Another reason virgin extraction is prioritised over recovery is that many of the key decision-makers, for example mining companies, commodities traders, etc, are likely to apply private 'discount rates' (weightings on future outcomes relative to present-day outcomes) that are higher than the discount rates appropriate for social decision-making. This leads to a bias in decision-making, with non-renewable resource extraction occurring faster when private interests drive decision-making than if extraction was managed like a social investment decision. Faster extraction means commodities prices and incentives for recycling are commensurately lower.

While the main causes lie beyond state policy, the problem of extraction occurring faster than is socially optimal because market decisions are not always well-informed or future-focused is one that state recycling policy can indirectly help to address.

Intergenerational equity

A related issue is that, as is well understood, market prices generally fail to put due weight on intergenerational equity (amongst other ethical considerations).[57] Extraction and landfilling of non-renewable resources means future generations will be endowed with fewer and less accessible resources than we have today, an apparent equity problem.

While it is sometimes argued that depleting natural capital today is justified since it endows future generations with greater productive capital (e.g. infrastructure) and higher material living standards, this only holds true to the extent that resource use acts overall like investment (by raising future productivity), rather than like consumption (which does not). Even if today's resource use in aggregate raises tomorrow's material wealth, it is unclear that future generations' preferences over natural capital versus material wealth are best known and served by the way that markets allocate resources today. Preferences for environmental quality tend to rise with income, not fall, so the trade-offs society deems acceptable today may not be seen that way by future generations. Extraction of less-accessible resources generally also causes greater environmental damage which wealthier future generations are likely to find less acceptable than today.

Unsustainable resource extraction is thus, on the face of it, an intergenerational equity problem. While it evidently has many drivers beyond state policy, it is a problem exacerbated by policy settings that leave recycling rates to be determined by markets and result in e-waste being consigned to landfill.

Social costs of landfilling – externalities in upstream extraction

Another well-understood market failure is that mineral extraction can generate serious negative environmental and social externalities that are generally not incorporated into the cost of extraction or into market prices for commodities. In some cases, virgin extraction also attracts financial subsidies or exemptions from taxes and regulations, leading to an uneven playing field between mining and recycling.[58] For both reasons market activity drives more extraction and less recycling than is socially optimal.

The upstream environmental and social impacts of mining can include erosion, pollution of ground and surface waters, release of airborne heavy metals, damming natural rivers, dam collapses, harm to fisheries and destruction of ecosystems, impacts on indigenous communities, etc.[59] Gold mining, for example, uses mercury and cyanide for extraction which can leak from tailings into the wider environment, as well as

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[56] Sprecher, B., Kleijn, R., Kramer, G.J. (2014) Recycling Potential of neodymium: the case of computer hard disk drives. Environmental Science & Technology, 48 (9506-9513)

[57] In looking at this issue in terms of appropriate discount rates for social decision making, the Stern Review of climate change policy has been the most prominent argument that where intergenerational interests are involved the appropriate discount rate should be extremely low – far lower than is usually applied to government investment decisions, let alone private sector decisions.

[58] See Productivity Commissions (2006), "Waste management", p119 for discussion.

[59] See, for instance, UN Environment Program "Mining and sustainable development II: Challenges and perspectives", http://www.uneptie.org/media/review/vol23si/unep23.pdf , World Resources Institute "Mining and critical ecosystems: managing the risks", http://pdf.wri.org/mining_critical_ecosystems_full.pdf Greenpeace "Coal mining impacts", http://www.greenpeace.org/international/en/campaigns/climate-change/coal/Coal-mining-impacts/

dislodging large quantities of rock and soil – 20 tonnes per single gold ring is one estimate – and resulting in erosion that affects waterways and ecosystems.[60]

This is a problem that is not necessarily best addressed by state waste management policy as these externalities occur prior to the point at which waste is generated. As the Productivity Commission's report on waste management notes, "waste management policy should not be used to indirectly address upstream environmental and social issues".[61] However, it is a problem that must be acknowledged.

Community willingness-to-pay to avoid landfilling

Another piece of evidence of the problem of landfilling e-waste, and an alternative method of considering the social costs of this, is to consider what the community would be willing to pay for additional recycling of e-waste.

In principle, willingness-to-pay may reflect some environmental and ethical considerations that matter to people – such as intergenerational equity, the perceived value of living sustainably, and the desire to reduce harms from extractive industries (or from landfilling waste) – which may not be well reflected in market prices.

However, willingness-to-pay based valuations can also reflect community misunderstandings of certain social costs (e.g. the risks to human health from landfilled material), and therefore not be a good measure of the true costs and benefits of outcomes from recycling versus landfilling. They can also be unreliable because they reflect what people say they will do, which may not end up being what they actually do. For these reasons, market prices are usually favoured over non-market valuation studies (e.g. surveys) by economists when valuing costs and benefits.

On willingness-to-pay grounds the community's preferences for recycling over landfill in fact reveal a slightly higher valuation of some forms of recycling than the use of market prices for recovered materials does (see Box 3 and later discussion in Chapter 4). That the community is collectively willing to pay this much for recycling supports a role for government in driving recycling to reflect community preferences about the environmental benefits of avoiding virgin extraction and landfilling, even if the potential economic gains from material recovery are small.

Box 3. Non-market valuation

Non-market valuation studies have been used to estimate the benefits of increasing recycling rates. In 2009 a choice modelling study commissioned by the Environmental Protection and Heritage Council estimated the amount that households would be willing to pay for government intervention to increase the percentage of televisions and computers that are recycled rather than disposed to landfill.62 The estimated amount – $963-$1,430 per tonne of recycling – was used to assess the benefits of the National Television and Computer Recycling Scheme.[63]

In the cost-benefit analysis discussed in Chapter 4, Marsden Jacob Associates used a benefit transfer approach with several adjustments to these figures to estimate a willingness to pay of

[60] Smithsonian Magazine "The environmental disaster that is the gold industry", February 2014, http://www.smithsonianmag.com/science-nature/environmental-disaster-gold-industry-180949762

[61] See Productivity Commissions (2006), "Waste management", pXL

[62] URS (2009) *Willingness to pay for e-waste recycling*, report prepared for the Environment Protection and Heritage Council.

[63] PricewaterhouseCoopers (2009) *Decision regulatory impact statement: Televisions and* computers, report prepared for the Environment Protection and Heritage Council.

$884 per tonne for recycling across the broader category of e-waste items under consideration here, plus a premium of $128 per tonne for a kerbside collection system.[64]

However non-market valuation studies have drawn criticism for flawed methodologies. In 2014 the Productivity Commission noted that non-market valuation for waste policy tended to focus on increasing recycling as an endpoint, rather than the environmental or social benefits from reducing waste disposal. Households are often asked to value a process (recycling) rather than the environmental or social endpoint. This may invalidate the estimated value of benefits because households' willingness to pay to increase recycling rates may be based on a poor understanding of the likely environmental and other benefits.[65]

Non-market valuation studies may provide an insight into the level of community support for recycling, and can be used to benchmark other valuation methods. However, care should be taken when using non-market values to understand whether they accurately reflect the likely environmental and social benefits of a policy.

2.2.3 Harm to the environment and human health from hazardous components in landfill

Hazardous materials in e-waste

Electrical and electronic products contain hazardous materials that can cause harm to the environment and human health. Hazardous materials found in e-waste include mercury, lead, cadmium, chromium, nickel, antimony and brominated flame retardants. E-waste is the source of 40 per cent of the lead and 75 per cent of the heavy metals found in landfills, and once e-waste is disposed to landfill, crushed and broken, the acidic conditions cause lead and other heavy metals to dissolve and collect as *leachate* (see Box 4). Other pollutants can be released into the air. [66,67]

Box 4. What is leachate?

Leachate, a mixture of water and dissolved solids, is produced as water passes through waste and collects at the bottom of a landfill. While the exact composition of the leachate depends on the type of waste and its stage of decomposition, leachate may contain a variety of toxic and polluting components, in large or trace amounts. If managed inappropriately, leachate can contaminate ground and surface water.

While most modern urban landfills are lined with impervious membrane layers, the quality of leachate collection and treatment systems varies and leachate may escape and pose an environmental risk. Unlined rural landfills allow leachate to migrate directly into either surface or ground water.

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[64] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill – Draft*, report prepared for the Department of Environmental, Land, Water and Planning Victoria.

[65] Productivity Commission (2014) *Environmental policy analysis: A guide to non-market valuation*, p 60; pp 89-93.

[66] Kahhat, R. (2012) *Electronic waste, environment and society* in Hieronymi et al (eds) *E-waste management, from waste to resource,* Earthscan, Oxon, UK, pp 5-23.

[67] Huisman, J. (2013) *Too big to fail, too academic to function: Producer responsibility in the global financial and e-waste crises* accessed via http://onlinelibrary.wiley.com/doi/10.1111/jiec.12012/pdf

E-wastes containing particularly significant amounts of hazardous materials include cathode ray tube televisions, batteries, photovoltaic (PV) systems and fluorescent lighting, although many other e-waste products ranging from toasters to game consoles also contain small quantities of hazardous materials.[68,69]

Examples of the e-waste types most often containing hazardous materials, and of health and environmental effects associated with these, are given in Table 3.[70,71,72]

Table 3: Examples of hazardous materials in e-waste and health consequences

Element / pollutant	Found in	Potential effects on human health
Brominated flame retardants: • polybrominated diphenyl ethers (PBDEs) • polybrominated biphenyls (PBBs)	Printed circuit boards (including capacitors, semi-conductors, resistors and inductors	Carcinogenic potential [73,74,75] Neurodevelopmental toxicity, weight loss, toxicity to the kidneys, thyroid and liver and dermal disorders[76] PBDEs and PBBs have been banned or voluntarily withdrawn from use in manufacture in many countries including Australia, Europe and North America
Cadmium	Cathode ray tubes Flat panel monitors Televisions	Carcinogenic potential, classified as a Group B1 carcinogen[77] Exposure of cadmium can result in a range of health impacts, including bronchial and pulmonary irritation, lung dysfunction, kidney disease and increased frequency of kidney stone formation.
Lead	Printed circuit boards Batteries Light bulbs Photovoltaic panels	Lead can affect almost every organ and system in the human body. Children six years old and younger are most susceptible to the effects of lead[78] and exposure can result in behaviour and learning problems, lower IQ and hyperactivity, slowed growth, hearing problems; and anaemia. In pregnant women, can cause reduced growth of the foetus and premature birth. General potential health effects include cardiovascular effects, increased blood pressure and incidence of hypertension, decreased kidney function, and reproductive problems.
Mercury	Fluorescent lighting	Can adversely affect the cellular, cardiovascular, haematological, pulmonary, renal, immunological, neurological,

[68] *How products are made: toaster* (2017), accessed at http://www.madehow.com/Volume-7/Toaster.html

[69] Brigden, K., Santillo, D., Johnston, P. (2008) *Playing dirty*, report prepared for Greenpeace International

[70] Grossman, E, 2006. *High Tech Trash: Digital Devices, Hidden Toxics and Human Health*, Island Press, Washington D.C.

[71] Townsend, T, Vann, K, Mutha, S, Pearson, B, Jang, Y, Musson, S and Jordan, J, 2004. *RCRA Toxicity Characterization of Computer CPUs and Other Discarded Electronic Devices*, Department of Environmental Engineering Sciences, University of Florida, US EPA.

[72] *E-waste: the hidden side of IT equipment's manufacturing and use* (2005) UNEP *Environmental Alert Bulletin. 5:4.*

[73] *DecaBDE phase-out initiative*, existing chemicals factsheet (2010) US EPA.

[74] World Health Organization. International Agency for Research on Cancer, Agents Classified by the IARC Monographs (2013) Volumes 1-107, http://monographs.iarc.fr/ENG/Classification/index.php

[75] National Toxicology Program, Report on Carcinogens, Thirteenth Edition. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, 2014, substance profiles PBBs.

[76] Agency for Toxic Substances and Disease Registry, Toxicological Profile for Polybrominated Biphenyls and Polybrominated Diphenyl Ethers, 2004.L.S. Birnbaum and D. F. Staskal, 'Brominated Flame Retardants: Cause for Concern?' Environmental Health Perspectives. Volume 112(1). 2004, pp. 9-14.

[77] *Cadmium Compounds* (2000) US EPA, accessed via https://www3.epa.gov/airtoxics/hlthef/cadmium.html#ref6

[78] US EPA, *Learn and Lead*, https://www.epa.gov/lead/learn-about-lead#effects

Element / pollutant	Found in	Potential effects on human health
	Printed circuit boards	endocrine, reproductive, and embryonic development of humans.[79] Methyl mercury is associated with nervous system damage in adults and impaired neurological development in infants and children.[80]
Nickel	Batteries	Chronic exposure to nickel can lead to dermatitis and compromise lung function[81], with soluble nickel compounds more toxic to the respiratory tract than less soluble compounds. Increased risk of lung and nasal cancers among nickel refinery workers exposed to nickel refinery dust (noting that e-waste dismantling does not result in emissions of nickel refinery dust).

These health impacts are most likely to affect nearby residents, landfill employees and landfill users.[82] However contaminated soil and groundwater may also affect residents who consume water and food grown in the area, as well as contributing to overall higher rates of contamination of water catchments and air-sheds – a cumulative problem with multiple contributors.

Leachate loss from landfill

Landfills in Victoria are mostly well-engineered facilities regulated by EPA. As required by EPA's Best Practice Environment Management (BPEM) publication for *Siting, design, operation and rehabilitation of landfills,*[83] they include a liner system and a leachate collection system to contain and collect leachate for treatment, as well as other required design elements, operational controls and monitoring systems.

However, in Victoria many landfill operators struggle to comply with the regulations, and there are risks even under the best management practices. An intact landfill liner will contain most leachate, but in many cases liners will fail over time, and some older landfills will not have been appropriately lined.[84,85]

A 2014 audit by VAGO of landfill management practices of EPA and four councils (with five landfill sites) found that while the four councils all met EPA's required standards for landfills, audits of gas and leachate risks identified moderate to high risks at four of the five sites. The report noted that "rehabilitation was also inadequate at these councils' licensed landfills, even though it is fundamental to managing leachate and gas risks".[86]

EPA's Landfills Improvement Program was initiated in 2015-16 specifically to address landfill environmental issues, with a large focus on leachate management.[87]

Estimates generated for the cost-benefit analysis in Chapter 4 suggest that approximately 7 per cent of all leachate generated within landfills in Victoria is lost to the environment through leakage, a figure calculated based on maximum leakage levels outlined in Victoria's BPEM and indicative values from literature.[88] At this point, pollution of land and groundwater is very difficult to remediate.

[79] KM Rice, 'Environmental Mercury and Its Toxic Effects' *Journal of Preventative Medicine and Public Health* 47.2, 2014 p 83.

[80] KM Rice, 'Environmental Mercury and Its Toxic Effects' *Journal of Preventative Medicine and Public Health* 47.2, 2014 p 74.

[81] US EPA, *Nickle Compounds – hazard summary* https://www3.epa.gov/airtoxics/hlthef/nickel.html

[82] *Living near a landfill could damage your health* (2016) Science Daily, accessed via https://www.sciencedaily.com/releases/2016/05/160524211817.htm

[83] EPA Victoria (2015) *Best Practice Environment Management - Siting design, operation and rehabilitation of landfills.* EPA Publication 788.3.

[84] Iowa's Department of Natural Resources, accessed at http://www.iowadnr.gov/Environmental-Protection/Land-Quality/Waste-Planning-Recycling/Recycling/E-waste/Hazards-of-E-waste

[85] United State Environmental Protection Agency (1988), Federal Register, volume 53, number 168, p. 33345.

[86] VAGO (2014), *Managing Landfills*

[87] *Owning the past, working with you today, shaping our future* (2016) Environment Protection Authority Victoria – 2015-2016 Annual Report

[88] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill – Draft*, report prepared for the Department of Environmental, Land, Water and Planning Victoria, section 6.4.4

Health consequences

While only a small proportion of hazardous material from e-waste may ever enter the broader environment, the consequences from exposure can potentially be severe, as Table 2 above indicates. Human health risks range from relatively minor health problems, such as allergic reactions and hypersensitivity, to serious health problems, such as cancer, respiratory illness, reproductive problems and birth defects. The risks depend on the contaminant and its concentration, the exposure pathway, the level of exposure, and the vulnerability of the exposed population.

The main environmental concerns with modern landfills are gases (particularly methane), and leachate containing heavy metals, pesticides, oils and paints. E-waste (particularly batteries) is a key contributor of heavy metals and flame retardants to leachates. Identifying the extent of the specific risks associated with landfilled e-waste is difficult, however, with little available data (particularly in the Victorian context) to assess the size of the problem.

Although a substantial number of studies have been conducted, the risks to health from landfill sites in general are hard to quantify and the risks specifically from e-waste even more so. Adverse health effects (low birth weight, birth defects, certain types of cancers) have been reported near individual landfill sites and in some multisite studies, however there is insufficient exposure information and effects of low-level environmental exposure in the general population are difficult to establish.[89]

Despite scientific uncertainty, a precautionary approach suggests that these health risks should be addressed if possible, particularly since technologically-viable recycling alternatives to landfilling are available (which is not always the case for other hazardous wastes such as asbestos).

Future trends of hazardous components of e-waste in landfill

Projections from the material flow analysis introduced in Chapter 1 suggest that, in the absence of further government intervention, the aggregate volume of hazardous e-waste components entering Victorian landfills is actually expected to *decline* in the near future, from the current levels of around 177 tonnes per annum to 124 tonnes by 2026. The primary driver of this is the reduction in disposal of cathode ray tubes (CRT) televisions, which can contain up to 3kg of lead each.[90] Manufacturer trends, cost-saving incentives, market competition and corporate responsibility initiatives may also contribute to reducing volumes over time.

However continued growth of other e-waste going to landfill, particularly photovoltaic panels, will likely reverse this decline, with volumes expected to increase to 148 tonnes per annum by 2035 (see Figure 5).

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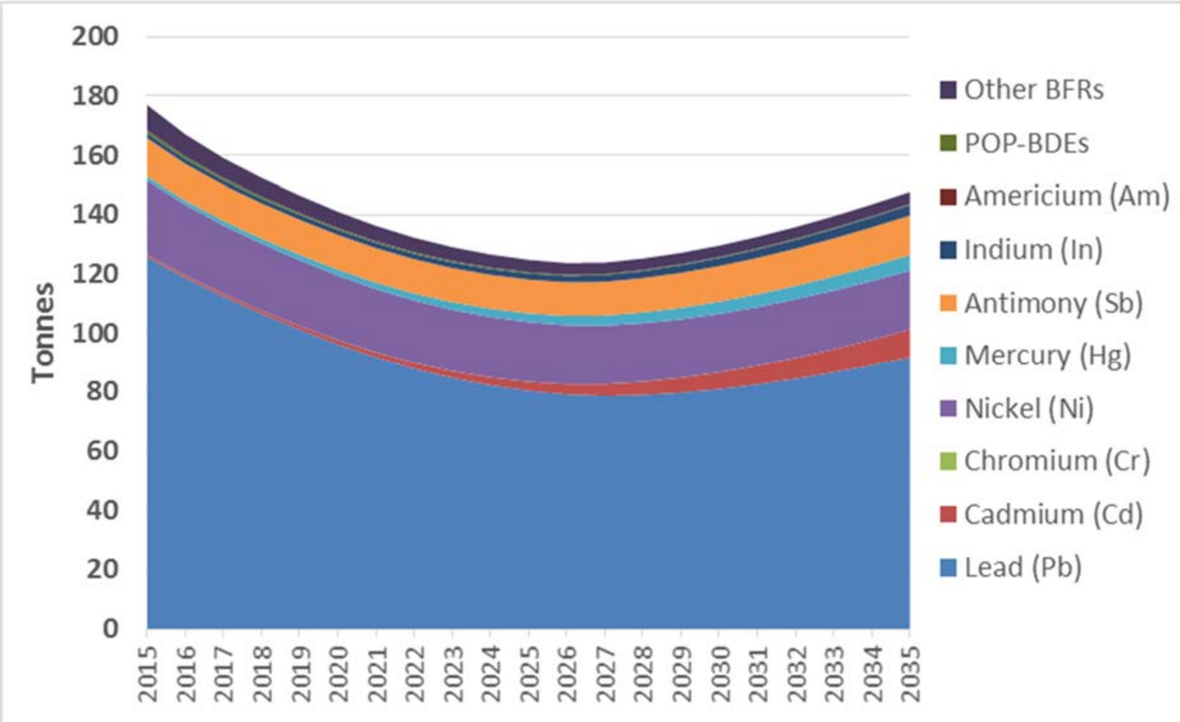
[89] Vrijheid M. (2000) Health effects of residences near hazardous waste landfill sites: a review of epidemiologic literature. Environmental Health Perspectives, Vol 108, pp101-112.

[90] Herat, S. (2008), "Recycling of Cathode Ray Tubes (CRTs) in Electronic Waste", Griffith University Research Repository, https://research-repository.griffith.edu.au/handle/10072/22550

Figure 5: Volumes of hazardous components of e-waste predicted to be disposed to landfill[91]



Landfill airspace and amenity impacts

While environmental health hazards are the major downstream impact of concern, an additional issue worth noting is that, like other wastes, e-waste occupies limited and valuable landfill 'airspace' (the volume of space available for filling) and contributes to the general amenity issues associated with landfills. While the quantitative significance of e-waste is small – only around 1% of landfilled waste by weight – it is one contributor to a larger problem.

Victoria's population is growing fast, and the amount of waste being generated and landfilled is also increasing. At current rates, the total waste generated in Victoria will grow from 12.5 million tonnes in 2015 – around a third of which ended up in landfill – to more than 20 million tonnes per annum by 2043.[92]

Historically, landfills have provided a cheap, readily available option for managing residual wastes. However, if not managed properly they can impact communities and the environment. The potential for these impacts, and growing community expectations of environmental protection, have led to more stringent regulation of landfills and growth in landfill costs over time.[93]

The amenity impacts of landfills can include noise, dust, litter, odour and pests. In 2006, as part of its inquiry into waste management, the Productivity Commission valued the loss in amenity of nearby households and businesses, concluding it was less than $1 per tonne of waste for best practice landfills but up to $3.70 per tonne for poorly managed landfills located in built-up areas.[94] These estimates are much lower than in comparable international studies, however. A European Commission study values the loss in amenity at

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[91] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill,* report prepared for the Department of Environmental, Land, Water and Planning.

[92] *Statewide Waste and Resource Recovery Infrastructure Plan 2015-44* (2015) Sustainability Victoria

[93] *Review of the application of landfill standards* (2010), report prepared for the Department of the Environment, Water, Heritage and the Arts

[94] Productivity Commission (2006) *Waste Management,* p75

$22 per tonne of waste[95], while studies from the UK and New Zealand have estimated a range of values up to $9 per tonne of waste.[96] The lower values in Australia potentially reflect small populations and lower population density which reduce the number of households impacted by landfills.

In 2009, BDA Group recommended using the Productivity Commission values for loss in amenity from best practice landfills but applying higher values for landfills not operating at best practice – $10 per tonne for urban landfills and $5 per tonne for rural landfills.[97] These higher values broadly align with estimates from other jurisdictions, but are not based on local studies.

In sum, these studies suggest that amenity impacts from landfills in Australia are a relatively small problem in quantitative terms. Community acceptance of new landfills is generally low, however, as the 2005 example of the proposed landfill in the rural area of Nowingee, Victoria, illustrates. Public opposition to this was strong enough to prevent further development despite the relative remoteness of the site. The experience has prompted greater efforts to reduce the volumes of waste sent to landfill in recognition that airspace in existing landfills is a limited resource and community preferences against new landfills are strong.

2.3 Summary

As the above discussion indicates, there are multiple aspects to the view that current rates of loss of valuable materials in e-waste to landfill are undesirable.

The discarding of valuable material resources contained in e-waste suggests a potential lost opportunity for the state to recover non-renewable materials that have market value.

Private enterprises are evidently unwilling to pursue collection and processing for many e-waste materials at present. There are many reasons – including national or global forces beyond the control of state government – for why repair, re-use, and recycling are more difficult and expensive than they might be; some were discussed in section 1.3.

However, it is not a given that the aggregate social costs of collection and processing necessarily exceed the potential value of materials that could be recovered, either in Victoria or generally. There may be market failures that are currently preventing recycling industries from being able to undertake collection and even where it would be socially efficient to do so – problems that suggest a potential economic efficiency-improving role for government. Section 2.2.1 discussed these.

There are also well-established market failures both ‘upstream’ and ‘downstream’ of Victoria’s waste management system that distort market decisions and cause market prices to not reflect all social impacts, resulting in more extraction and landfilling and less recycling than is socially optimal.

As discussed in section 2.2.2, by driving further resource extraction, landfilling e-waste contributes to environmental harms upstream and adds to global problems of unsustainable resource use and intergenerational inequity. It also fails to reflect community preferences for greater recycling (likely driven in part by these resource extraction issues).

Section 2.2.3 also described the potential environmental harms from landfilling e-waste, and the economic and social costs of using up limited landfill space and causing landfill amenity issues.

Market failures do not automatically imply a role for government. However, they prompt the question of whether government intervening to encourage more recycling could generate sufficient surplus in the recycling industries to result in net social benefits overall.

[95] European Commission (2000) *A study on the economic valuation of environmental externalities from landfill disposal and incineration of waste*, Brussels.

[96] DEFRA (2004) *Valuation of the external costs and benefits to health and environment of waste management options, final report* for DEFRA by Enviros Consulting Limited in Association with EFTEC; Covec (2007) *Recycling: Cost-benefit analysis*, prepared for the New Zealand Ministry for the Environment.

[97] BDA Group (2009) *The full cost of landfill disposal in Australia*, report prepared for the Department of the Environment, Water, Heritage and the Arts.

3 Policy objectives and interventions

3.1 Objectives

The Andrews Labor Government's e-waste policy approach aims to:

- increase recovery of the resources in e-waste;
- reduce harm to the environment and human health from e-waste disposal; and
- support jobs and investment in the recycling industry.

It is clear that achieving these policy objectives goes hand-in-hand with improving the viability and scale of the industry. Industry benefiting from the recovery of materials from e-waste will increase demand for e-waste materials for processing, supporting the policy objectives. Growth in the industry is therefore an important intermediate objective in achieving the ultimate policy goals.

These key policy objectives are consistent with Victoria's existing waste policy, planning, and` regulatory arrangements. They reflect the principles of waste recovery in the EP Act (including the waste hierarchy) and the goals in the existing government strategy for waste and resource recovery discussed in Chapter 1.

3.2 Interventions to achieve the objectives

To achieve these policy objectives more e-waste must be diverted from landfill and channelled to recovery processes.

A threshold question is whether a regulatory intervention such as a landfill ban is required in addition to the existing programs – such as the National Scheme, MobileMuster, and other product stewardship programs in development.

If so, then what sort of regulatory intervention is possible, and what is likely to be most effective – are there regulatory tools other than a ban that might achieve similar outcomes? And as an alternative (or a complement) to regulatory intervention, which non-regulatory interventions, e.g. service delivery programs or private sector approaches encouraged by government, might be effective?

Chapter 3 is the first stage in the PIA options analysis – a 'strategic options' analysis. Section 3.2 explains the interventions that were considered, and the merits of each. Section 3.3 summarises this analysis, identifies a preferred package of interventions and outlines the key design choices for this.

The second stage in the options analysis considers whether this proposed policy change is likely to yield overall social benefits greater than costs, and how these vary according to the design of the package.

3.2.1 Regulatory vs non-regulatory interventions

There are many regulatory and non-regulatory approaches that are used around the world to divert e-waste from landfill or reduce the harms caused by e-waste.

Examples of **regulatory** approaches include:

- mandating recycling of e-waste;
- setting minimum standards for production of electrical goods;
- prohibiting use of certain hazardous materials in electrical goods;
- mandating manufacturers to take back and recycle used electrical goods;
- prohibiting disposal of e-waste to landfill; and
- requiring consumers to pay a recycling fee at point of purchase.

These approaches use legal frameworks to define responsibilities and require actions and penalties.

Non-regulatory approaches are those that are not written into legislation or subordinate instruments. Rather, they are driven by individual corporate responsibilities, sector agreements, community pressure, and general marketing incentives, or by government grants or service delivery programs that aim to drive behavioural change and support alternatives to landfill. Examples include:

- voluntary codes of practice for manufacture of electrical goods;
- voluntary minimum recycled content standards;
- improving technology to increase recycling capacity;
- community education to increase awareness of the hazards of e-waste and benefits of recycling;
- funding for improved collection infrastructure or services; and
- grants to support community recycling initiatives.

Jurisdictions that operate a well-functioning e-waste management system have typically used a mix of regulatory and non-regulatory tools.

For example, the South Australian Government implemented a legislated ban on e-waste to landfill which began in 2011. Recognising the needs of community and industry, the government supported the ban with a comprehensive education campaign (to increase awareness of e-waste and of the new obligations), and a funding program to upgrade e-waste storage and processing infrastructure.

South Australia is the only state with a comprehensive e-waste landfill ban at present, although the ACT has a ban on computers and televisions (as well as on various non-electronic wastes). Other states, like Victoria, have existing bans on a range of specific waste types: tyres are banned (or pre-approval is required) in Victoria, ACT, Tasmania, and parts of NSW and WA, and clinical wastes are banned in NSW and Tasmania for instance. Some local councils (e.g. Pittwater, Mosman, Manly and Warringah in northern Sydney) have banned certain types of e-waste from being placed in kerbside disposal or accepted at their local landfill.[98] Instead, these councils accept various types of e-wastes for recycling, offer 'clean up collections' for metal recycling, and encourage the householder or business operator to contact a local reprocessor.

Another example of how a combination of regulatory measures has been applied is demonstrated in Oregon, in the United States of America. In 2007, Oregon's *Electronics Recycling Law 2007* established a product stewardship program for e-waste recycling, 'Oregon E-Cycles'. The law requires electronics manufacturers and importers to provide free recycling for computers, monitors and televisions – i.e. broadly the same scope of e-waste as in Australia's National Scheme. In 2010, a landfill ban for the same limited scope of items came into effect. Since operations began in 2009, the combination of the two policies has led to benefits such as:

- a 36 per cent increase in tonnes of e-waste recycling;
- reductions in recovery costs through efficiencies of scale;
- an additional 61 jobs created in the refurbishment and recycling of televisions, computers and monitors.[99]

In the United Kingdom, those involved in the sale, purchase and disposal of electrical and electronic equipment have obligations under the UK's *Waste Electrical and Electronic Equipment Regulations 2013*, developed to implement the European Union's 2012 WEEE Directive. To support the regulations, the UK

[98] Hyder Consulting (2010), Landfill ban investigation: final report, Report to Department of Sustainability, Environment, Water, Population and Communities South Australia.

[99] Oregon Department of Environmental Quality (2014) *Oregon E-Cycles Biennial Report – January 2014*, accessed via http://www.deq.state.or.us/lq/pubs/docs/ORECyclesBiennialReportLeg2014.pdf

Government developed a non-statutory code of practice that provides specific advice and guidance on how to comply with the regulations.[100]

3.2.2 Is another regulatory intervention required?

Victoria's experiences to date with e-waste recycling via the National Scheme and MobileMuster show that, while recovery of e-waste has increased over time[101], large volumes are still being sent to landfill, limiting the recovery of non-renewables, creating environmental health hazards, and taking up landfill airspace.

As Chapter 2 discussed, there are a range of informational issues and misaligned incentives that mean encouraging recycling through non-regulatory means alone is unlikely to drive substantially increased rates of recovery. Victoria has committed to take a stronger stance to achieve better diversion of e-waste, and based on the experiences of other jurisdictions the combination of a regulatory component with effective non-regulatory supporting measures appears most effective in achieving this goal. Possible interventions and a preferred package are discussed below. Chapter 4 also aims to test further the need for regulation, by modelling the impact of the proposed non-regulatory interventions alone.

3.2.3 What kind/s of regulatory intervention are suitable?

Four regulatory interventions that are commonly used and have potential to achieve the objectives in 3.1 are discussed below.

Differential landfill levy

One option is to use an economic instrument. An additional legislated levy on each tonne of e-waste disposed to landfill would provide an additional economic incentive to reduce e-waste disposal and stimulate investment and innovation in resource recovery technologies.

In Victoria, a levy must be paid for every tonne of municipal and industrial waste deposited in a landfill. E-waste generated domestically is currently subject to the same levy as all other municipal wastes, while e-waste generated from commercial or industrial premises falls in the industrial waste category. While landfill levies increase recovery of resources, and indeed will be supporting Victoria's current levels of recovery to some extent, the current levy is evidently not high enough to drive higher rates of recovery of e-waste. As discussed earlier, the National Scheme is the main driver for current levels of e-waste recovery.

A higher levy on e-waste could in theory create a greater financial driver to separate e-waste from other waste types and seek alternative, cheaper recovery pathways. It could also assist the e-waste recycling industry to be a more financially competitive alternative to landfill disposal.

Differential levies are used in many jurisdictions, mostly to differentiate municipal and industrial wastes. Research into the relationship between levies implemented in European Union member states and their effectiveness at reducing waste sent to landfill shows that there is a correlation between the total landfill charge and the amount of municipal waste recycled and composted.[102]

It can, however, be difficult to link a reduction in waste to landfill directly or exclusively to a levy. In Western Australia, a report on the effectiveness of the state's levy indicates it is likely that redistribution of levy funds to other programs which support waste reduction have made greater contributions to reductions in municipal waste going to landfill than the price signal from the levy itself.[103]

More significantly, levies as currently applied provide a weak price signal to waste generators. Household decisions about waste disposal are in aggregate a major influence on overall outcomes, yet most householders currently pay a flat annual waste disposal fee and hence face effectively no price signals relating to their waste disposal activities. Landfill levies are paid directly by local councils who pass these

[100] WEEE Regulations 2013 – Government Guidance Notes (2014) Department for Business Innovation and Skills.

[101] Economist Intelligence Unit for ANZRP (2015) *Global e-waste systems: Insights for Australia from other developed countries*, accessed via http://anzrp.com.au/wp-content/uploads/2015/02/Global-e-waste-systems-A-Report-for-ANZRP-by-EIU-FINAL-WEB.pdf

[102] Bio Intelligence Service. Use of Economic Instruments and Waste Management Performances, 2012. Available at http://ec.europa.eu/environment/waste/pdf/final_report_10042012.pdf

[103] *Landfill levy review* (2007) report prepared by Four Scenes Pty Ltd for the Waste Management Board of Western Australia

costs on to households and small businesses as a component of rates. A differential levy would provide no financial incentive to households to separate e-waste, since they will pay the same fee regardless of any behaviour modifications they may make.

If a higher, differential levy was applied to e-waste, the added expense to councils of landfilling e-waste may prompt councils to encourage households to separate e-waste from general waste, or it may encourage councils to reach agreements with recyclers to remove sorted e-waste from transfer stations. However, these effects would be indirect and contingent on councils taking action. More likely is that higher landfill expenses from a differential levy alone would be built into higher rates bills without encouraging much diversion of e-waste from landfill.

Differential levies can also impose substantial administrative costs and create confusion and complexity for both waste generators and landfill operators. Variable charging can provide perverse incentives to waste collectors to misrepresent waste types, or to mix waste types to pay the lower levy rate. As e-waste is a comparatively small waste stream, the administrative effort to manage a different levy may influence managers of e-waste to avoid handling it in the first place, or to seek other options that will not necessarily result in better outcomes. Higher landfill levies also provide greater economic incentives to dump waste illegally or move it interstate or overseas or into less environmentally-friendly treatments, such as incineration.[104]

There is no known precedent for a jurisdiction to manage e-waste through a differential levy. This may be because e-waste volumes are small compared with other waste streams, and the risk of perverse outcomes is considered too great to justify the limited effects of the price signal it provides.

In Victoria, the inquiry by the independent ministerial advisory committee into the EPA concluded that broadly-based levies on waste 'are failing in their primary regulatory objective of reducing disposal to landfill. The widespread incidence of illegal dumping of wastes, to avoid landfill costs, is undermining both the regulatory and the revenue objectives of landfill levies'.[105] The Andrews Labor Government, in its response to the inquiry recommendations, supported in principle the recommendation to redesign the municipal and industrial landfill levy so that it better meets its regulatory objectives and to reduce incentives for illegal dumping.[106]

Establishing a differential landfill levy specifically for e-waste would require a broader review of the state's landfill levy because changing the current levy arrangements could have substantial impacts on other sectors.

Product stewardship

Enacting the principles of 'product stewardship' into regulation by some means was considered as an alternate regulatory option to form the basis of the new policy. Some of the more successful policy approaches to e-waste in other jurisdictions require producers of electronic and electrical goods to be responsible for their product at end-of-life. This is globally referred to as product stewardship (or 'extended producer responsibility') and can be enacted via both regulatory and non-regulatory approaches.

Product stewardship approaches ask manufacturers and importers to adopt greater responsibility for their products throughout their lifecycle, including at the end of their life. Japan, a leader in the management of e-waste, adopts a product stewardship approach through two laws: one that requires consumers to dispose of e-waste at designated collection points and another to require manufacturers to take care of the recycling.[107] A third, non-mandatory law encourages manufacturers to design products that can be recycled or reused easily. The examples of Oregon and the UK cited above incorporate elements of product stewardship as well.

[104] *Landfill levy review* (2007) report prepared by Four Scenes Pty Ltd for the Waste Management Board of Western Australia

[105] Independent Inquiry into the Environment Protection Authority (2016) accessed at http://www.epa-inquiry.vic.gov.au/epa-inquiry-report

[106] Andrews Labor Government Response to the Independent Inquiry into the Environment Protection Authority (2017) accessed at https://www.environment.vic.gov.au/sustainability/independent-inquiry-into-the-epa

[107] Economist Intelligence Unit for ANZRP (2015) *Global e-waste systems: Insights for Australia from other developed countries*, accessed via http://anzrp.com.au/wp-content/uploads/2015/02/Global-e-waste-systems-A-Report-for-ANZRP-by-EIU-FINAL-WEB.pdf

Product stewardship approaches to waste management have several attractive aspects. Inherent to the concept is that the greatest responsibility for minimising environmental impacts lie with the party with the greatest ability to affect the full lifecycle impacts of the product. Costs of disposal are shifted from taxpayers to producers (and indirectly to product consumers), a more equitable distribution of the burden. Depending on the design of the stewardship approach, the incentives on manufacturers for environmentally responsible product design are also correspondingly stronger, offsetting some of the forces leading to rapid disposal of products outlined in section 1.3 above. Internalising the costs of recycling or disposal with the manufacturer can create cost advantages for producers of longer-lasting, more easily repairable products, providing price signals to consumers to purchase environmentally preferable alternatives.

Depending on the application of the approach, industry-led recycling programs can have some downsides in terms of simplicity for consumers and overall social costs of e-waste collection activity. As Chapter 1 described, collection programs for various types of e-waste are currently fragmented and can be confusing to waste generators who wish to dispose of their products responsibly. Piecemeal or duplicated collection networks designed by industry to meet either their own targets or to meet regulated recovery targets or access requirements may not necessarily offer the lowest-cost form of access to collection services, and can tend to shift the costs of disposal to consumers which reduces the likelihood of products being recycled. A regulatory approach to product stewardship requires careful design and monitoring to ensure requirements on industry are well specified without being overly burdensome.

As noted, Australia currently adopts a co-regulatory product stewardship model for televisions, computers and computer peripherals through the *Product Stewardship Act 2011*. The National Scheme has achieved some success at diverting e-waste from landfill and channelling it through recovery processes. Expanding the products covered by product stewardship could encourage greater efficiency in the recycling and material recovery process, such as via investment in advanced technologies for dismantling e-waste, thus reducing costs per unit recycled.

It is therefore worth considering if there are ways to complement the existing approach under the National Scheme in the design of Victoria's e-waste approach, or even to incorporate elements of product stewardship for other items into the Victorian policy to drive better recovery. Ensuring that the approach adopted in Victoria is not inconsistent with future developments in federally-driven product stewardship is also important.

The major difficulty in developing state policy that shifts more responsibility onto producers is that only the Commonwealth Government has the power to regulate companies under the Product Stewardship Act: there are no provisions for state-specific requirements. While Victoria can, and will, continue to advocate to expand existing product stewardship programs, particularly the National Scheme, to place more responsibility for recycling end-of-life electrical goods on producers or importers, it is unclear whether there are any elements of a product stewardship approach that can be progressed by the state independently. Pragmatic reasons – i.e. the costs of policy administration and the likely effects on Victoria's competitiveness as a location for business within a federation in which goods trade is unrestricted – also limit the state's ability to act alone.

Landfill ban

A ban on e-waste in landfill in contrast is clearly within the scope of the state's powers and, as noted, has precedent as a tool used (in combination with other interventions) to drive greater resource recovery here and in other jurisdictions.

Under the EP Act a waste item may be prohibited from disposal to landfill where a significant environmental risk exists, or where a practicable waste management option higher on the waste hierarchy exists. Items currently prohibited from landfill in Victoria include whole tyres, automotive batteries, small batteries in non-domestic quantities and radioactive substances.

The items that are currently prohibited from landfill in Victoria are generally managed by discrete sectors of Victoria – e.g. businesses dealing with automotive batteries or waste tyres. As e-waste is generated and handled by a range of different individuals and organisations, an e-waste ban would impact more than discrete sectors, including households and many types of small to medium businesses.

A key merit of a ban is that it can send as a strong and clear message that better outcomes can be achieved by completely diverting something from landfill than by simply reducing the volumes disposed. Relative to a price signal (e.g. a differentiated levy), a complete prohibition also expresses a stronger social sanction and can in some situations therefore encourage more significant adjustments in norms and social attitudes and thus greater behavioural change.[108] If enacted successfully, with demonstrable results that helped people understand the positive impact of their recycling choices, a ban could help move households towards greater recycling and increase the prospect of success in future recycling initiatives.

However, in isolation, a landfill ban is an end-of-the-line solution that does not place obligations on those involved in the management of e-waste upstream from a landfill. Without other complementary mechanisms, this would place a disproportionate responsibility on a landfill operator to prevent e-waste from ending up in landfill, with neither incentives nor alternative pathways for upstream parties to support this. Clearly a ban must therefore be accompanied by other supporting measures, which result in others further up the supply chain – households, businesses, councils, waste management companies – supporting the goal of avoiding e-waste reaching the landfill gate. These complementary interventions are discussed in subsequent sections.

Precedent from elsewhere suggests a ban accompanied by upstream guidance and requirements and other supporting policies could be an effective driver of higher rates of e-waste material recovery.

A review and cost-benefit analysis of the effects of landfill bans prepared for the Queensland Government in 2014 identifies that a number of jurisdictions that have had landfill bans in place (for various waste types, not just e-waste) have experienced significant reductions in landfill volumes and corresponding increases in the volumes of waste materials recovered. The Netherlands, for example, saw a reduction of 19 per cent of waste disposed to landfill and a 27 per cent increase in material recovery over the six years it has had its landfill ban in place.[109]

Another useful comparison is between the experiences of the US and UK in relation to mobile devices. In 2009, the US disposed 92 per cent of end-of-life mobile devices to landfill. At around the same time the UK, which had banned these items from landfill in response to the European Union's WEEE Directive, recovered 25 per cent of end-of-life mobile devices – almost three times as many mobiles as in the US. By 2020, the UK is expected to recover around 80 per cent of mobiles discarded, resulting in about 13 million pounds of material value kept in the economy.[110]

As in the various European jurisdictions cited in the report to the Queensland Government, a sensible approach to implementing a landfill ban is to package it with other supporting policies – such as collection infrastructure and support for development of recycling industries – to provide practical alternatives to landfill for households, other waste generators, and waste management authorities. These supporting measures can complement the ban by maximising volumes available and allowing for economies of scale, while the ban itself functions as a credible commitment to keeping e-waste from landfill over the long term, thus providing greater certainty for investment in the recycling industry. For individuals, the ban can also engender a level of trust that their own personal efforts in disposing of e-waste items responsibly will not be in vain, since it is clear that other downstream handlers are bound to act in certain ways to avoid the items going to landfill.

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[108] The Haifa daycare experiment, in which introduction of late fees for parents collecting children late from daycare led to an *increase* in lateness rather than the predicted decrease, is often cited as a classic illustration of the phenomenon whereby price incentives can be less effective than prohibitions, or even counterproductive. While prohibitions carry attached social norms, prices (such as the Haifa late fees) signify a market transaction that carries different norms and prompts different behaviour (Levitt and Dubner (2005), *Freakonomics: A rogue economist explores the hidden side of everything*).

[109] Cost-benefit analysis of the implementation of landfill disposal bans in Queensland (2014) Report prepared by Synergies Economic Consulting Pty Ltd for Queensland Department of Environment and Heritage Protection.

[110] Green Alliance (2014) *Why we need landfill bans*

As with any policy measure that increases the cost associated with disposal of waste material, a ban could have perverse outcomes such as illegal dumping and inappropriate stockpiling. Clearly the degree to which these outcomes occur will be highly contingent on the types of waste involved and the nature of other regulations and supporting policies; section 4.3 discusses this risk further.

A 2013 study on landfill bans in the US also affirms the importance of other supporting measures (such as education and communications), suggesting that providing more information to women and older people in particular could increase the effectiveness of existing bans.[111] Studies on landfill bans used in the UK similarly conclude that gains are likely to be greatest where the landfill bans are coupled with other measures, such as a requirement to sort materials.112

Other critical supporting elements are that there is a demand for the materials recovered as a result of the ban, and that recovery infrastructure has sufficient capacity to manage the increased quantity of materials arising from the ban.[113]

Victoria's 2014 ban on tyres in landfill is illustrative. Tyres were seen as a significant fire hazard in landfill, and the Victorian Government sought to mitigate this risk. At the time, however, with little market demand for used tyres or their products the prevalence of large tyre storage lots not adequately prepared to manage fire risk increased. Other measures were required to prevent this problem exacerbating.

In the case of e-waste, Victoria's analysis and consultation with reprocessors suggests that there is latent demand for e-waste if it can be provided in sufficient volumes with sufficient reliability to make recycling viable. Industry capacity also appears adequate for expansion of processing volumes. The MFA report estimated capacity based on a survey of reprocessors, finding that current annual e-waste processing capacity (excluding metal recycling) was around 42,000 tonnes as of 2014, with another 18,000 tonnes capacity to be installed in the 'near future' (assumed to be 2020). Under business as usual projections, that is, no change to current policy and management of e-waste, that capacity is not reached at Victorian reprocessor sites until after 2030.[114]

Critical to the success of a landfill ban, therefore, will be policies to support alternative collection pathways, to improve understanding of appropriate disposal methods, to develop markets for recycling, and to place proportionate requirements upon all participants in the waste supply chain to act in practical ways that avoid e-waste mixing with other waste streams destined for landfill.

Legislated requirements for improving management of e-waste

A 'management standard' for anyone involved in the generation, collection, transport, storage, treatment and disposal of e-waste is an important tool to support the intent of a ban. Regulatory requirements upstream from landfill are one way to share responsibility for preventing e-waste ending up in landfill, ensuring better handling and treatment, and facilitating greater recovery.

This instrument would specify the controls needed to protect the environment and human health in the management of e-waste from its generation through to its recovery. It would explain how households and businesses should discard e-waste, and what other parties involved in waste management should act to reduce environmental and health risks and maximise material recovery.

Focusing on how e-waste is managed earlier in its life would avoid it reaching the landfill gate, and could help mitigate some of the human health and environmental risks inherent in the reprocessing activity itself.

The requirements would include, for example, generators of e-waste being obliged to take their e-waste to a collection point established to safely store e-waste. A transporter of e-waste would need to ensure appropriate fire suppression and spillage equipment is readily available on the vehicle. An organisation that

[111] State e-waste disposal bans have been largely ineffective (2013) Science Daily

[112] WRAP (2012) Landfill Bans: Feasibility Research

[113] ACIL Tasman and GHD (2006). Landfill ban. An investigation into the environmental, social and economic impacts of a potential ban on disposal of household recyclable packaging, recyclable building products and organic waste to landfill. Report to the Department of Environment, 26 October.

[114] Randell Environmental Consulting (2016), *Victorian E-waste Market Flow Analysis (MFA) – part 1 report*, section 5.5, accessed via http://www.sustainability.vic.gov.au/publications-and-research/research

collects e-waste must be able to store it so that it is not damaged during handling and storage, and so that contamination to land or groundwater is avoided.

Similar regulatory requirements exist for other waste types, such as the *Environment Protection (Industrial Waste Resource) Regulations 2009*, which regulate the handling, management and disposal of hazardous waste in Victoria. Waste classifications under the EP Act also allow EPA to specify how certain waste streams must be managed, such as the *Classification for end-of-life industrial transformers containing PCB-free oil*.

These tools can be very effective because waste classifications, in particular, are targeted at a small sector and can be very clearly written. However, since a wide range of entities may be involved in the chain of custody of e-waste, a standard such as this has potential to be long and complex. It may also be difficult to enforce for entities that are not already captured through existing tools (e.g. households). One possible approach which aligns with the broader reforms to the EP Act is to develop a generic requirement based on the 'reasonably practicable' standard. This means that a person would be required to do what they are reasonably able to do to protect the environment and human health from the risks of e-waste. This would apply to a wider range of people than those currently regulated by the existing environment protection framework. Non-regulatory guidelines or codes of practice would be provided to assist interpretation of this requirement for particular groups.

3.2.4 Which non-regulatory interventions are suitable?

Common non-regulatory approaches that might help to prevent e-waste from being disposed to landfill and increase recovery of e-waste are discussed below.

Improving e-waste storage at transfer stations

One way to increase diversion of e-waste from landfill is to ensure more transfer stations in Victoria are better prepared to accept e-waste and to store it safely until it is moved off-site.

Transfer stations, generally operated by local councils, are a crucial part of the public waste recovery system. They actively consolidate waste to enable more cost-effective transfer to landfill or to alternative recovery options. In the case of e-waste, they have designated containers, sometimes cover for protection from weather, and clear signage to segregate e-waste from other wastes. Transfer station operators are in a good position to support diversion of e-waste from landfill and to increase collection and recovery rates.

Transfer stations not yet equipped to manage e-waste safely can limit collection potential. This may lead to dumping of e-waste or inappropriate storage at home. If transfer stations not well equipped to handle e-waste do so regardless, this may also create local environment, human health and occupational risks. Transfer stations lacking a covered area might see e-wastes deteriorate through weather damage, for example, and breakage during handling makes dust pollution or escape of hazardous compounds more likely, poor storage practices may cause fire risks, etc. Either way, not having the infrastructure to safely manage e-waste works against the policy objectives.

The e-waste collection network in Victoria is at present mostly driven by the needs of the co-regulatory bodies serving the National Scheme. While this network appears to adequately meet the collection requirements of co-regulatory bodies (and has helped them to achieve their annual recycling targets), it is unlikely to facilitate greater rates of collection of e-waste types not covered by the National Scheme. Initial studies indicate that only about 80 of the 260 regional transfer stations in Victoria have adequate infrastructure to safely manage e-waste onsite.[115] Subsequent assessments (yet to be completed) suggest the number may be even lower.

A valuable non-regulatory intervention to support greater recycling rates would involve upgrading enough transfer stations to encourage resident and commercial e-waste generators to use the sites. Upgrades could include a designated area for e-waste that is contained and protected from the weather, such as a covered skip bin or a shed with an impermeable floor. The number of transfer stations that need upgrades would be

[115] Randell Environmental Consulting (2016), *Victorian E-waste Market Flow Analysis (MFA) – part 1 report,* accessed via http://www.sustainability.vic.gov.au/publications-and-research/research

determined based on achieving an acceptable or reasonable level of access and sufficient overall storage capacity to handle increased volumes.

An example of how appropriate facilities at a transfer station can improve recycling rates is the upgrade recently performed at the Mount Scobie Transfer Station in Kyabram. The upgrade included construction of a large shed in which to separate and store recyclable material. The shed also includes a large area for the drop-off of resalable materials and items, which are sold back to the community. Before the upgrade, approximately 1,100 tonnes of waste were sent to landfill each year. After the upgrade, the transfer station has recorded approximately 900 tonnes sent to landfill (18 per cent reduction) and about 200 tonnes recycled.[116]

E-waste collection service

A critical part of increasing diversion from e-waste to landfill will be establishing better access to e-waste collection facilities. As noted earlier, options for households in particular to responsibly dispose of e-waste are difficult to find and are piecemeal in their coverage of geographical areas and of types of e-waste. The difficulties – the transactions costs (e.g. search and transport) – faced by households are a major barrier to recycling.

Consultation with local councils and others makes clear that collection sites must be easy for the community to access to be useful.[117] The experience of MobileMuster illustrates this; the program has expanded its network of drop-off points five-fold since it started, which has been key to the observed increase in volumes of mobile phones collected.[118] Whether waste generators take the required steps to avoid directing e-waste to landfill will depend in large part on the convenience with which appropriate disposal options are provided.

If sites are perceived as too distant or difficult to find, waste generators will be reluctant to make the effort and will seek easier options. In the case of e-waste, 'easier' options include disposing items with other household waste (which ends up in landfill), accumulating items in the house or dumping larger items in remote areas. Environmental risks can be exacerbated, and potentially valuable materials remain unavailable for recovery.

A state-funded collection network to support the overall policy goal could have several different elements, such as kerbside collection (using a separate bin or as part of hard rubbish collection for large items), permanent drop-off points (e.g. transfer stations, public libraries, retailer outlets), and mobile/temporary collection events. The type and scale of collection systems provided are an important design choice, and options for this are discussed below and modelled in Chapter 4.

One possible model for a publicly-funded system is the Household Chemical Collection program, which is administered by SV in partnership with local councils.[119] The program provides 30 permanent drop-off sites and 31 mobile collection events around the state. Victorian residents can drop specific waste household materials at any of these points or events. Collected materials are consolidated by a third party and sent for recovery. In over 22 years of operation, the service has collected close to 6,500 tonnes of toxic materials and serviced over 150,000 householders at mobile collection events, and it is a successful program in many ways.

There are clear advantages to establishing state-administered e-waste collection arrangements over leaving this as a matter for waste management authorities and participants in current recovery schemes. One is that it can provide a baseline of access, ensuring areas poorly served at present are offered easier access to collection services rather than putting the onus and costs of responsible disposal on individuals.

[116] Sustainability Victoria (2017) *Case Study – Improving resource recovery centres; Mount Scobie (Kyabram) Transfer Station*, <not yet published>

[117] E-waste landfill ban – Stakeholder workshop findings (2016) report by Resource Advisory for Department of Environment, Land, Water and Planning.

[118] Australia's Mobile Decade – 10 years of consumer insights into mobile use and recycling 2005-2015 (2015) Australian Mobile Telecommunications Association.

[119] Toxic household chemicals ('Detox your Home'), Sustainability Victoria. Accessed via http://www.sustainability.vic.gov.au/services-and-advice/households/waste-and-recycling/detox-your-home

A second advantage is that a state-funded system can provide greater clarity and consistency about disposal points. Many people will dispose of e-waste only infrequently and some level of permanency in the collection service will lower the information costs of appropriate disposal.

Third is that relative to collection networks developed by industry as part of recovery programs, a state-administered service offers the prospect of less duplication and potentially lower aggregate social costs of collection. 'One-stop shop' collection is likely less costly both for people disposing of e-waste and for the overall administration of the system, although this will depend on how the services are structured.

Education and communication campaign

Another non-regulatory option is to invest in an education and communication campaign aimed at preventing e-waste ending up in landfill and encouraging recycling.

In many jurisdictions, this is core to the delivery of any new regulatory intervention, but there are also examples where it has been used in isolation of other policies. One example is the 'Love Food, Hate Waste' awareness campaign aimed at reducing the amount of food waste generated in households. Modelled on the original program created by the Waste and Resources Action Program, United Kingdom, the program has gained a significant following, particularly through social media.

MobileMuster relies heavily on its communication campaign and has found that effective advertising and promotion have a direct impact on awareness and engagement. More people are aware of how, why and where to recycle mobiles than ten years ago, and MobileMuster reports that this has seen recycling grow from 42 tonnes in 2005 to 74 tonnes in 2015. As promotional activity reduces, however, awareness and collection rates tend to drop.[120]

For e-waste, an effective campaign would need to educate people about what constitutes e-waste, why it should be kept from landfill, where to recycle it, what the legal obligations are under any new regulations and any costs. While the campaign would need to be adaptable to each local council area, it would also need to ensure the core messaging is consistent across the state.

An ongoing element to any campaign is also critical, as available evidence from waste and other environmental programs and policies indicates that while information and education can play a significant complementary role to regulatory measures and incentives in facilitating behavioural change, a campaign needs to be ongoing to ensure that behavioural change is not short lived.[121]

Market development for resources in e-waste

Another non-regulatory supporting measure is to invest more heavily in developing the market and supply chains for the products of e-waste recycling.

Market development is about creating and expanding appropriate and sustainable markets for the use of recovered materials and products. Expanding the profitable uses of recovered materials is critical to meeting the policy goals. Even with a community that wants to support recycling, achieving these goals requires adequate market demand for products using recovered resources.

As with the other non-regulatory interventions discussed here, 'demand side' development is not a standalone solution but a complementary approach to 'supply-side' actions. Without markets and marketable products, there is no commercial incentive to reprocess e-waste, creating new problems of stockpiling and safe storage capacity at transfer stations. Equally, without collection and storage of adequate quantities of e-waste ready for reprocessing, the industry will lack the scale and certainty of supply to invest in plant and process and seeking customers or to scale up production. There is therefore a fine balance between

[120] Australia's Mobile Decade – 10 years of consumer insights into mobile use and recycling 2005-2015 (2015) Australian Mobile Telecommunications Association.

[121] OECD (2008), Household Behaviour and the Environment: Reviewing the Evidence, & OECD (2011) Greening Household Behaviour: The Role of Public Policy.

expediting the market and providing an appropriate level of feedstock. Other interventions must go hand-in-hand with developing markets for e-waste products.

Recognising the importance of this, the Andrews Labor Government has already committed to supporting product manufacturing through the Market Development Strategy for Recovered Resources.[122] This strategy focuses its first five years on statewide priority materials, which include e-waste, and supports research and development, development of product specifications, facilitation of product procurement and other actions.

3.3 Preferred strategic level approach

3.3.1 Analysis of interventions – summary

Table 4 summarises the key points relating to each policy intervention from the discussion above.

Table 4: Regulatory and non-regulatory interventions – summary

Intervention	Key points
Differentiated landfill levy	Price signals not transferred to households; likely minimal impact on disposal practices Illegal alternatives (e.g. mixing wastes) become attractive for waste management contractors, and are relatively easy with the small volumes of e-waste Expensive to administer for small volumes
Product stewardship	Generally attractive as a means of improving producer incentives and consumer price signals Implementing new or expanding existing schemes is a Commonwealth power, but Victoria can continue to advocate nationally and lead development of programs Potential for duplication and piecemeal, higher-cost approach to e-waste collection Unclear how state could progress meaningful product stewardship initiatives given trade possibilities between states; pragmatic barriers to 'going it alone'
Legislated ban	A clear message against landfilling e-waste, and a stronger social sanction against inappropriate disposal of e-waste than a price signal can Would be the first time in Victoria a ban demanded widespread individual action, and could help increase appetite for future recycling initiatives Provides a credible commitment to the reprocessing industry of sustained volumes, which provides a better environment for investment/market development Engenders trust that individual efforts to recycle will not be futile Ban itself only applies to landfill operators; requires complementary upstream actions to have the intended effect Illegal alternatives become attractive; essentially unenforceable at household level and for small items Expected to improve recovery, but increase in volumes may result in issues in collection / storage that need to be managed with complementary actions Economic costs: recycling overall more costly than landfill disposal – although benefits of resource recovery will offset these (as explored in Chapter 4)

[122] Victorian Market Development Strategy for Recovered Resources (2016) Sustainability Victoria

Legislated requirements for managing e-waste	Can complement a landfill ban by providing direction as to upstream actions to prevent e-waste entering the landfill waste stream More evenly shares responsibilities for increasing diversion and better management of e-waste Can reduce risks (e.g. health hazards) associated with higher volumes of e-waste stored, transported and processed Creates compliance costs for regulated parties. Poorly designed or disproportionate requirements can limit flexibility and innovation in e-waste management practices.
Improving collection and storage systems at transfer stations	Important to accommodate expanded volumes of e-waste collected, to ensure quality sorted feedstock for industry, and to protect human health
E-waste collection service	Key to providing feasible alternatives to landfill for waste generators (especially households) Potential to provide more widespread access and be a long-run lower cost approach than overlapping industry collection systems Several key choices of methods and access levels need to be made
Market development	Won't achieve rapid change alone Relies on complementary mechanisms (collection, education, storage infrastructure, regulatory restrictions) to ensure certainty of supply Actions already underway to promote this via the *Victorian Market Development Strategy for Recovered Resources*
Education and communication campaign	Critical to explaining practical implications of a ban and driving behavioural change towards responsible disposal Limited impact on its own if collection services, storage infrastructure, and markets for recovered materials are not in place

3.3.2 Preferred package of interventions

The analysis above has noted a number of complementarities between the various interventions**.** These complementarities suggest that a package of interventions will be generally more effective than any single intervention on its own. This is the approach that has been used to drive greater e-waste recovery in other jurisdictions, including South Australia.

A landfill ban, the centrepiece of the Andrews Labor Government's proposed policy approach, has been an effective intervention when applied to both e-waste and other specific waste types in other jurisdictions. When paired with measures to support households with appropriate disposal options and to ensure availability of e-waste at scale for the reprocessing industry, this option has been shown to drive increased recycling rates. A ban itself only applies to landfill operators, and so needs to be supported by upstream measures (management requirements) to divert e-waste from the landfill stream, maximise availability for recyclers, and avoid unintended outcomes.

In terms of the other regulatory interventions considered, a landfill levy specifically for e-waste would be an unusual approach and potentially less cost-effective than a ban. It would likely be less powerful in driving behavioural change, particularly since most households would continue to face no price signal, and it would be expensive to administer. The government has indicated it will review the statewide levy structure following the EPA inquiry, so imposing a new levy at this stage could also be premature and disruptive.

Product stewardship programs have attractive features relative to an outright ban, and can be effective drivers of e-waste recovery, as the early years of the National Scheme have demonstrated. The existing scheme only captures some e-waste items, but the state's standalone options for developing new product stewardship arrangements appear unfortunately limited. However, continued involvement in developing other national programs and in advocacy for expanding the reach of the National Scheme will complement a landfill ban and the development of the local recycling industry.

The non-regulatory interventions discussed will be critical to providing practical alternatives for e-waste disposal and addressing specific risks and constraints in concert with a ban. To enact any or all of these interventions as a standalone option without a ban could also feasibly drive more recycling, but would likely be less effective without the regulatory element providing the strong imperative for behavioural change.

For these reasons, the proposed approach to achieving the policy objectives is a package of interventions:

1. A legislated landfill ban on e-waste;
2. Legislated requirements for management of e-waste;
3. An education and communication campaign;
4. Improved e-waste storage infrastructure at transfer stations; and
5. A new publicly-administered e-waste collection service.

3.3.3 Key design choices

There are a range of options for how the design and implementation of this broad policy package could proceed. Two key design questions are whether a comprehensive e-waste ban or a partial ban focusing on the most hazardous items is preferable, and what type and coverage of collection service is most appropriate. These two choices are discussed here and taken up again in the quantitative analysis in Chapter 4. Other design and implementation questions are discussed in Chapter 5.

Scope of the ban

While the available precedents from other jurisdictions examined (SA, Oregon, the UK and various European countries) all involve comprehensive bans, a possible alternative is to consider a partial ban focusing either on the most environmentally hazardous items or on some other subset of items such as those already covered under the National Scheme or other recovery programs (which would potentially allow for easier adaptation to the ban).

Although there are reasons of precedent and principle and pragmatism (in terms of logistical difficulties) for favouring a comprehensive ban, the CBA in Chapter 4 also assesses two alternative policies:

- A partial ban – on the most hazardous items, with all other elements of the policy package in place
- No ban – but with all other elements of the policy package in place

(While the second alternative is not strictly a 'design choice' within the scope of the package outlined above, it is included to assess the value of the ban itself, by estimating how outcomes may vary without the legal imperative).

Collection service

A second design choice that is less clear-cut in the absence of quantified evidence is the question of appropriate levels of access by households to collection services.

Householder access to e-waste collection will be a key driver of how much e-waste is diverted from the general waste stream. Convenience will be an important factor driving e-waste disposal behaviour in households. More comprehensive and convenient collection services clearly offer greater potential to divert more e-waste from landfill, and to achieve the policy objectives and associated benefits to a greater extent. However, a more comprehensive collection regime also has higher costs.

In considering design choices for collection services, of central importance was the concept of 'reasonable access' to recycling services for all Victorians.

‘Reasonable access’ is a concept promoted in relation to a range of government services, although there is no single or universal definition. In the waste management context, different definitions of reasonable access have been applied to designing collection systems for the National Scheme and Victoria’s Household Chemicals Collection Program. However, for any collection program designed through even the most collaborative of processes, it is generally very difficult to achieve an access level that meets every person’s needs. The design choices considered here have taken into account feedback on these and other similar programs.

Access to collection can be provided in different ways, including through permanent drop-off points (such as transfer stations or collection boxes for smaller items), collection events, or kerbside collection.

Three different design options for household collection services are outlined in Table 5 – labelled the ‘High’, ‘Low’ and ‘Medium’ access models – and Table 6 shows what these options imply in terms of rates of access by percentage of population. All options would offer significant improvements in access to collection services over current arrangements.

While the reasonable access concept is a useful starting point to guide the policy choice, and more detailed assessments would be needed to carefully map the existing network, another important consideration is how the relative costs and benefits of these access models differ. To answer this question, waste flows and the associated costs and benefits under these options have been modelled as part of the cost-benefit analysis in Chapter 4.

Table 5: Access models analysed

Region	High	Low	Medium
Metropolitan	Kerbside collection service for every municipality (domestic) .	One permanent drop-off point for every 250,000 people	One permanent drop-off point for every 250,000 people plus, mobile collection events in municipalities that don’t have permanent points or are large in area
	Commercial collection services used for commercial e-waste	Commercial collection services used for commercial e-waste.	Commercial collection services used for commercial e-waste.
Regional	One permanent drop-off point for every municipality plus one for every other town of 1000 people	One permanent drop-off point for every municipality plus, one for every other town of 4000 people.	One permanent drop-off point for every municipality plus, one for every other town of 4000 people plus, mobile collection events for every other town of 2000

Table 6: Levels of access to e-waste collection services

Region	Estimated level of access[123]		
	High	Low	Medium
Metropolitan	>99%	95%	99%
Regional	93%	78%	88%

[123] The estimated level of access is based on a travel distance of less than 10 kilometres each way in metropolitan areas, which requires less than 20 minutes of driving time each way in non-peak hour traffic. In regional areas the estimated level of access is based on the proportion of the population living in or in the immediate vicinity of towns providing an e-waste service.

4 Impact analysis

4.1 Introduction

The previous chapter outlined the various interventions that could be implemented to achieve the Andrews Labor Government's policy objectives, and based on a qualitative assessment of their applicability and merit identified a preferred package of reforms centred on a ban on e-waste in landfill.

Chapter 3 also identified two key design choices: whether the landfill ban should be comprehensive or limited only to the most hazardous e-waste, and what level of access to e-waste collection should be provided by publicly-funded collection services.

The purpose of Chapter 4 is to describe the policy impacts both of the general reform package and of each of these design choices.

There are three parts to the analysis.

Section 4.2 first provides a general description of the 'mechanics' of the ban – how it will be enacted and how waste flows will change – and outlines the new regulatory obligations and potential regulatory costs applying to various parties.

Section 4.3 discusses the major risks associated with the new policy. The focus is on the complex residual risks not able to be fully addressed through the design of the proposed policy package.[124]

Section 4.4 summarises a cost-benefit analysis (CBA) of various policy options conducted by Marsden Jacob Associates (MJA), Blue Environment and Ascend Waste & Environment. The CBA model uses the outputs from a material flows analysis (MFA) model, since the physical flow of e-waste ultimately drives many of the costs, benefits and distributional impacts of the policy options.

The CBA here serves two main functions: to assess whether the proposed policy package generates positive net benefits – that is, whether the new e-waste policy approach as a whole is worthwhile on cost/benefit grounds – and also to help inform policy choices in relation to the two design choices noted in Chapter 3. The CBA model also permits estimation of impacts on some specific groups, e.g. small business.

Section 4.4 first describes the options modelled, then reports the results including material recovery rates, costs and benefits, results and sensitivity analysis, distributional impacts, and small business and competition impacts. The full report is provided at Appendix 1.

4.2 Regulatory requirements and costs

4.2.1 Regulatory requirements

A landfill ban would be enacted by varying the existing waste management policy[125] which lists items prohibited from landfill. The prohibition itself only applies to landfill operators, and so to prescribe required actions for management of e-waste upstream of landfill, a new waste management policy would be developed to specify how e-waste should be managed. The EPA would be responsible for administering these policies and enforcing compliance.[126]

The new e-waste policy frames the broad obligation on all persons as being to take 'reasonably practicable' measures to prevent or minimise risk of harm to human health and the environment associated with e-waste. It also requires more specifically that all persons take reasonably practicable steps to prevent e-waste entering landfill, to maximise e-waste material recovery, to limit the duration of storage of e-waste and e-waste materials, and to ensure that other e-waste services used also comply with the policy. E-waste

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[124] The risk that, for instance, low recycling rates result in inadequate supply of e-waste which inhibits investment and recycling was discussed in section 3 and is directly addressed through the design of the policy package (via a collection service and education campaign), hence is not re-examined here.

[125] *Waste Management Policy (Siting, Design and Management of Landfills) No. S264*

[126] The naming and nature of the regulatory instruments provided for under the EP Act may change as part of the overhaul of the EPA's legislative framework, in which case the new regulatory requirements will be enacted under the relevant replacement instrument.

services face an additional specific requirement that they keep records of e-waste movements. As such, there may be some duty-holders that face obligations additional to what they are already doing.

The reasonably practicable test as applied to these new obligations allows for flexibility both in interpreting the obligations as they apply to different parties (e.g. households, reprocessors) and in interpreting the obligations over time as the state of knowledge and technology and standard practices evolve. To provide more clarity for some situations, guidance outlining acceptable (but not exclusive) means of achieving compliance with the new policy would also be provided.

For small waste generators – households and small businesses – reasonably practicable steps will generally include appropriate handling to avoid breakage, separating e-waste from general waste and existing co-mingled recycling, appropriate storage (e.g. to avoid rain damage) and disposing of e-waste only at designated collection points.

For larger commercial businesses (including waste management contractors), reasonably practicable requirements might additionally include conducting a risk assessment of e-waste risks, training staff in appropriate practices, and keeping records of e-waste handled.

In accordance with the greater risks they present and their position of greater influence in the e-waste disposal chain, reprocessors may be required to keep more extensive records of waste sources, conduct due diligence on downstream purchasers, achieve certain minimum recovery of materials from e-waste received, provide support to upstream providers to aid compliance, etc. For reprocessors who reprocess less than 500 tonnes of e-waste each year, these requirements may be additional to what they are currently required to do under Victorian legislation. However, under the revised *Environment Protection (Scheduled Premises and Exemptions) Regulations* (refer to section 1.6.3 for background), many reprocessors will be required to have implemented these changes already.

Table 7 summarises the type of requirements likely to be necessary and which would be laid out in either the policy or in guidance developed in future, and also provides examples of the types of practical actions that would achieve compliance. Table 7 is ordered around the activities in the e-waste disposal chain – generation, collection, transport etc – but in practice a single party may undertake multiple activities. Households, for instance, will both generate e-waste and transport it to drop-off points, which will be an additional obligation, and reprocessors may be involved in storage, transport, and treatment.

Table 7: What type of compliance actions might be required under the new e-waste policy?

You are responsible for…	You are a…	You would be required to…	To comply you might need to…
• Small amounts of e-waste you have generated	• Residential household • Small or medium-sized organisation	• Eliminate or minimise risk of harm to human health and the environment associated with e-waste. • Prevent e-waste disposal to landfill • Provide e-waste to an appropriate e-waste service	• Handle e-waste to prevent breakage • Separate e-waste from other wastes as per collector's instructions • Provide e-waste to appropriate collector or reprocessor
• Any volume of e-waste generated by others; or • Large amounts of your own e-waste	• Large organisation generating e-waste • Any organisation operating an e-waste collection or take-back service • E-waste transporter • Resource recovery center or transfer station accepting e-waste • Local government drop-off and collection point • E-waste storage site	• Eliminate or minimise risk of harm to human health and the environment associated with e-waste • Prevent e-waste disposal to landfill • Provide e-waste to an appropriate e-waste service • Minimise the duration of storage of e-waste under their control or in their possession • Only store e-waste for the purposes of transfer, reuse, repair, recycling or reprocessing • Record specific information for each movement of specified e-waste • Record certain information each financial year • Meet certain processing standards	• Understand risks of harm to human health and the environment posed by e-waste and communicate them to staff • Store, transport and handle e-waste to minimise risk of harm • Separate and store e-waste from other wastes. • Provide e-waste to an appropriate collector or reprocessor • Store, transport and handle e-waste to minimise risk of harm • Keep records for the movements of e-waste • Document your assessment of downstream processors or vendors of e-waste, process materials and residual waste • Support upstream providers to ensure e-waste is received in a way that minimises risk of harm to human health and the environment • Achieve material recovery rates in line with the AS5377 or existing Australian product stewardship programs, depending on the type of e-waste
• Altering the physical state of e-waste, including manual dismantling, shredding, crushing or compacting, thermal treatment, hydrometallurgy and other forms of e-waste treatment	• Repair and refurbishment workshop • Metal recycler • Research organisation treating, reprocessing or recycling e-waste • E-waste reprocessor or recycler • E-waste dismantler • E-waste treater		
• Operation of a landfill	• Municipal landfill • Privately-operated landfill	• Prevent e-waste going to landfill	• Treating e-waste as a waste prohibited from landfill • Implementing waste acceptance measures to prevent e-waste disposal to landfill in accordance with Victoria's BPEM for landfills[127], e.g. signage, procedures, training

[127] Best Practice Environment Management (BPEM) publication for *Siting, design, operation and rehabilitation of landfills*

4.2.2 Behavioural and process changes

In practice, diversion of e-waste from the landfill waste stream will start with householders and businesses being asked (via an education and communications campaign) to ensure e-waste items are not mixed with general waste and are instead dropped off at a collection depot, such as a council transfer station or collection box in store or in municipal buildings, or at a collection event.[128] This information would be provided in conjunction with councils so that where additional collection options are available (e.g. if councils offer to collect and separate large e-waste items left in hard rubbish) households are informed of this.

Businesses using commercial waste management contractors will need to ensure e-waste is source separated and a specialist e-waste removal service is used. Typically, e-waste removal contractors will drop e-waste at transfer stations, although some may make arrangements for drop-off directly with reprocessors.

These actions will lead to increased volumes of e-waste ultimately arriving at transfer stations for sorting and storage by transfer station operators. Transfer station operators will need to make arrangements for this e-waste to then be transported to a reprocessor for disassembly and further processing.

The particular reprocessing involved will vary depending on the item and the economics of recovery. Some items might go through multiple stages of reprocessing and be handled and transported by different parties, such as where a not-for-profit organisation undertakes manual disassembly before a larger reprocessor mechanically processes particular components. In some instances, recovered components or materials may be exported, in others sold locally, and in others landfilled where no further processing or sale is viable.

Victoria's new requirements would work in parallel with the National Scheme and other e-waste recovery schemes, and potentially support the operation of these. National Scheme co-regulatory bodies would continue to face obligations under the scheme to meet certain recycling targets, and higher rates of diversion by households and businesses of e-waste from the general waste stream to consolidation at transfer stations may make it easier for these organisations to acquire sufficient volume to meet their targets.

4.2.3 Regulatory costs

The new policy will impose various regulatory requirements on different parties.

Some of these, such as storing e-waste undercover to avoid weather damage that would reduce recoverable materials or risk leaching of hazardous substances, amount to sensible habits or 'good housekeeping' for some parties and will have low cost, or they may impose a significant cost on others. Similarly, the requirement for households to transport e-waste to drop-off points may create new obligations with substantive costs, or require only little additional effort or cost.

Table 8 catalogues the key regulatory requirements in the draft policy that apply to different regulated parties, and indicates the likely significance of the regulatory cost associated with each. Where these additional regulatory costs are included in the CBA cost estimates in some way, they are marked with an asterix.[129] The requirements that will likely result in the greatest costs include those that require duty-holders who are managing large amounts of e-waste (e.g. local councils) to upgrade infrastructure to be able to collect, store or move e-waste safely.

Regulatory costs have not been separately itemised in the CBA. For example, the additional costs associated with requiring risk assessment, appropriate handling, record-keeping etc by e-waste processors are not calculated one by one, but rather are taken into account when estimating overall processing costs. Other additional costs associated with such requirements as adequate storage and segregation of e-waste from other wastes would be considered a proportion of the costs of collecting and sorting e-waste. Over 20 years, the maximum total additional costs associated with meeting new regulatory requirements could be estimated by summing the costs associated with collection, sorting and processing, which is approximately $215 million. Section 4.4.5 discusses these costs in more detail.

[128] Under a 'high access' collection service model metro households would also be able to use a kerbside bin service.

[129] Note that these regulatory costs are generally not separately itemised in the CBA. For example, the additional costs associated with requiring risk assessment, appropriate handling, record-keeping etc by e-waste processors are not calculated one by one, but rather are taken into account when estimating overall processing costs.

The economic incidence of these regulatory costs – i.e. who ultimately bears the cost – might differ from the legal incidence (as shown here). For example, the requirement for e-waste transporters to take appropriate care in handling e-waste is likely to be borne by businesses utilising commercial waste collection services when it arises in that context. In some cases, it is not yet clear who will bear the costs – e.g. while transfer station operators will be legally responsible for providing e-waste to an appropriate reprocessor, the transport costs associated with this might be borne by the reprocessor or by others (e.g. co-regulatory organisations under the National Scheme), depending on the type of e-waste.

Table 8: Key regulatory requirements and potential changes to costs

Who	What	Comment on regulatory costs
Residential households and small/medium sized organisations	Handling to prevent breakage, separation from other wastes and appropriate storage	Commonsense practices, likely already occurring, minimal cost.
	Provide to appropriate collector (i.e. drop off at collection point or use kerbside option if available)	Costs of transport to collection points will be significant under some access models*
Large organisations generating e-waste	Risk assessment – understand risks and communicate to staff	Complexity of assessment can be proportionate to size and risk profile; minimal burden for most businesses
	Handling to prevent breakage, separation from other wastes and appropriate storage	Commonsense practices, likely already occurring, minimal cost
	Provide to appropriate collector (i.e. use a commercial e-waste collector in place of a general waste collector in metro areas, or a drop-off point in non-metro areas)	Costs of commercial e-waste collection are likely to be higher than for general waste collection, hence imposing some cost on business*
E-waste transporters (e.g. commercial collection services, transfer from drop-off points to reprocessors, transport to landfill)	Risk assessment – understand risks and communicate to staff	Risk assessment and training are likely already standard practice, so additional costs are likely to be minor*
	Keeping records of e-waste movements	Some form of record-keeping likely to be undertaken already; additional burden may not be significant*
	Store, transport and handle appropriately	Likely some cost premium associated with transport/handling requirements (using a covered vehicle, avoiding breakage, etc)*
Non-government organisations offering a take-back service (e.g. retailer drop-off box)	Handling to prevent breakage, separation from other wastes and appropriate storage	Commonsense practices, likely already occurring, minimal extra cost*
	Keeping records of e-waste movements	Systems are in place with some but not all services to record this information. Further assessment required
	Provide e-waste to appropriate collector or reprocessor	An inherent cost of providing a take-back service, not a new regulatory cost. Transport costs will often be borne by another party (e.g. co-regulatory organisations, recyclers)*

Who	What	Comment on regulatory costs
Other collection service providers (e.g. councils as delivery partners in state-administered collection system providing events, permanent drop-off points, or kerbside collection)	Risk assessment – understand risks and communicate to staff	Complexity of assessment can be proportionate to size and risk profile; minimal burden for most providers*
	Keeping records of e-waste movements	Systems are in place with some but not all services to record this information. Further assessment required
	Handling to prevent breakage, separation from other wastes and appropriate storage	These costs will be significant in some instances (e.g. sorting at collection sites)*
Transfer station operators (e.g. councils)	Risk assessment – understand risks and communicate to staff	Transfer station administrative costs will be higher than at present*
	Keeping records of e-waste movements	Systems are in place with some but not all services to record this information. Further assessment required
	Handling to prevent breakage, separation from other wastes and appropriate storage (i.e. higher transfer station operating costs, and need for upgraded transfer station storage infrastructure to meet AS5377)	Transfer station upgrades will be required, and ongoing handling and sorting costs at transfer stations are likely to be significantly higher than at present*
	Provide e-waste to appropriate collector or reprocessor	May be more costly than sending to landfill, although transport costs will sometimes be borne by another party (e.g. co-regulatory organisations, recyclers)*
	Minimise the duration of storage of e-waste under their control or in their possession. Only store e-waste for the purposes of transfer, reuse, repair, recycling or reprocessing	Should not be significant additional cost where market for e-waste recovery products continue to exist. Further assessment required
E-waste processors – including small not-for-profits, larger firms, and metal-only recyclers	Risk assessment – understand risks and communicate to staff	Larger reprocessors now operate as scheduled premises and so are subject to strict oversight and licence conditions, meaning this requirement is likely not to pose an additional burden[130]* Small reprocessors may need to perform a risk assessment. Therefore, administrative costs will be higher than at present*
	Handling to prevent breakage, separation from other wastes and appropriate storage	An inherent part of the reprocessing activity; the regulatory requirement itself is not likely to add significant cost*

[130] Under Victoria's *Environment Protection (Scheduled Premises) Regulations 2017*, any premise processing more than 500 tonnes of e-waste per annum is required to obtain a licence and/or works approval and is now subject to a higher degree of EPA oversight. See section 4.3 'Policy risks'.

Who	What	Comment on regulatory costs
	Minimise the duration of storage of e-waste under their control or in their possession. Only store e-waste for the purposes of transfer, reuse, repair, recycling or reprocessing	Should not be significant additional cost where markets for e-waste recovery products continue to exist. Further assessment required
	Keeping records of e-waste movements (including for recovery rate calculations)	Some form of record-keeping likely to be undertaken already for larger e-waste processors so additional costs may not be significant. * Costs may be greater for small not-for-profits and metal-only recyclers
	Achieving certain minimum recovery of e-waste materials	Required recoveries will be based on percentages set by established programs, and/or using recovery processes as specified in AS5377. Costs will not change for those meeting the requirements of AS5377 and existing product stewardship programs. Additional costs for those not
	Due diligence on downstream receivers, support for compliance by upstream providers	Assessing downstream providers and documenting this will involve some cost*
Landfill operators	Treat e-waste as a waste prohibited from landfill Implement waste acceptance measures to prevent e-waste disposal to landfill in accordance with landfill BPEM	Monitoring waste deliveries to ensure compliance with this requirement is likely to impose additional costs on landfill operators*

***Costs included in CBA**

4.3 Policy risks

Several key risks associated with the new policy approach have been identified. An assessment of these is provided below, and the implementation section of the PIA discusses actions planned to mitigate these.

4.3.1 Inappropriate disposal (dumping, mixing, stockpiling, illegal export)

A key risk of the new policy approach, emphasised by some stakeholders, is the prospect of an increase in illegal and harmful disposal of e-waste. There are several possible 'fates' of concern:

- dumping (or 'flytipping') of e-waste in public places;
- mixing or hiding e-waste in with general waste bound for landfill;
- stockpiling intended to subvert the recycling requirements, e.g. where e-waste is collected on a large scale under the guise of consolidation or temporary storage and then abandoned;
- illegal export – where e-waste sent abroad nominally for re-use or repair ends up recycled under poor environmental and OHS conditions.

Many of the incentives and regulatory difficulties prompting these concerns apply similarly to other waste streams, and there is now a substantial body of evidence from waste in general suggesting that inappropriate disposal in breach of the regulatory requirements may be a significant risk in the e-waste context.

For the first time, the policy will create both a prohibition on allowing e-waste in the general (landfill) waste stream, and an elevated cost for legal disposal relative to the previous costs of sending waste to landfill. For households, this cost stems from the inconvenience of using drop-off points. For larger businesses, the price of commercial e-waste removal is likely to exceed the price of general waste removal, prompting some illegal disposal or stockpiling by businesses, but also driving profit incentives for waste contractors to illegally dispose of e-waste and thereby undercut responsible operators. For reprocessors, meeting material recovery rates may appear more costly or less profitable than partial recycling, providing incentives to subvert the regulations in various ways – e.g. dumping wastes or illegal export.

The ban may also provide opportunities for 'informal' recyclers, from backyard operations to factories failing to obtain the required licences, to grow and to undercut legitimate operators. Informal operations are likely to illegally dispose of leftover e-waste components as well as to ignore OHS and environmental health regulations (discussed as a separate risk below).

In all of these cases, material is lost to the legitimate reprocessing sector, reducing supply for compliant processors and putting them at a competitive advantage with non-compliant processors (domestic and overseas). The human health and environmental hazards arising from openly dumped e-wastes are also greater than when it is contained in landfill, and the health impacts of unregulated recycling of exported e-waste in developing countries are well known and can be severe.[131]

The costs associated with cleaning up illegally dumped waste are difficult to quantify and would differ depending on location and types of waste dumped. But in most cases, these costs will be borne by taxpayers or ratepayers. To illustrate the variability, the EPA Inquiry found that illegally dumped construction and demolition material, which accounts for approximately half of illegally disposed waste in Victoria, cost the state around $10m in clean-up costs in 2015.[132] In Queensland, a report on the impact of landfill bans estimated that councils face average clean-up costs in the order of $800 per tonne.

Introduction of landfill bans or collection targets overseas has been accompanied by an increase in inappropriate disposal of banned wastes, although piecing together data to establish the extent of these impacts has also proven challenging. In the UK, for instance, there was no observed increase in instances of public dumping following a 2004 landfill ban on hazardous wastes. However, reconciliation of waste records pointed towards significant volumes of hazardous waste remaining unaccounted for following introduction of the policy, with no clear explanation other than widespread mixing of hazardous wastes with other wastes.[133]

The EPA Inquiry examined problems of dumping, mixing and permanent stockpiling of wastes in Victoria, particularly in relation to asbestos and other prescribed industrial wastes, concluding that financial incentives to avoid landfill costs (including the landfill levy) were a major driver behind growing rates of illegal dumping, in particular for construction and demolition waste.[134] Similar cost and profit incentives for non-compliance may apply in the context of e-waste recycling, with similar potential for industry practices to deteriorate if poorly-behaved operators gain market share and illegal behaviour becomes normalised. Price signals designed to drive waste reduction and recovery also inherently incentivise illegal disposal, a problem noted by the Inquiry, which recommended weakening price signals by cutting landfill levies particularly where recycling alternatives to landfill are not viable.

Off-shoring of e-waste recycling in the absence of strong export controls has become a significant policy issue in Europe in recent years, following EU-wide adoption of collection targets under the WEEE Directive.

[131] Informal recycling can involve, for example, melting circuit boards over open fires to remove components or recover lead solder, and burning parts to separate plastic from scrap metal, resulting in widespread lead poisoning and other health conditions and extreme environmental damage. See Greenpeace "Guiyu: an e-waste nightmare", http://www.greenpeace.org/eastasia/campaigns/toxics/problems/e-waste/guiyu/, and UN Environment Program, "Waste from Electrical and Electronic Equipment", http://www.unep.org/ietc/what-we-do/e-waste

[132] EPA Inquiry, Chapter 21.

[133] Waste Resources and Action Program (WRAP), 2010, "Landfill bans – feasibility report", section 9.6.2

[134] EPA Inquiry, Chapter 21.

The Countering WEEE Illegal Trade (CWIT) project, a collaboration of various UN agencies, Interpol and other parties, mapped out the extent of the problem of illegal e-waste disposal in a 2015 report which found that only 35% of e-waste disposed in Europe in 2012 ended up in officially reported collection and recycling systems, with a significant portion of the remainder either illegally exported from the EU or wrongfully mismanaged or illegally traded within Europe itself.

According to Interpol, "much [exported e-waste] is falsely classified as 'used goods' although in reality it is non-functional. It is often diverted to the black market and disguised as used goods to avoid the costs associated with legitimate recycling.... A substantial proportion of e-waste exports go to countries outside Europe, including west African countries. Treatment in these countries usually occurs in the informal sector, causing significant environmental pollution and health risks for local populations".[135]

Australia is a signatory to the Basel Convention prohibiting export of hazardous waste (including e-waste), and has enacted these prohibitions domestically via the *Hazardous Waste (Regulation of Exports and Imports) Act 1989*. As in Europe, however, there is evidence that border controls are at present inadequate to prevent illegal export occurring via declarations that containers of e-waste are used goods in working order.[136] No permit is required for export of equipment in working order from Australia, and although the legislation requires testing of equipment before export, enforcement is lacking. As of late 2014, despite 21 containers of illegal e-waste exports having been intercepted at the Australian border no prosecutions of exporters had occurred. Evidence of the extent of the problem is less clear than in Europe, as well – there have been no tracing exercises equivalent to the CWIT project in Europe, and there has been far less public scrutiny and debate around the issue in Australia.

In summary, the risks of illegal disposal undermining the intent of the policy in various ways – by inhibiting the development of the legitimate industry, and by worsening environmental and health risks via disposal outside landfill – appear significant.

The extent to which these risks materialise as a result of the ban will depend on a number of variables.

The primary driver of recycling rates by households in particular will be the convenience of access to collection services, and as discussed in Chapter 3 this will be a key determinant of how much e-waste is mixed with general waste.

All the illegal disposal cases discussed above will clearly be in breach of the new regulatory requirements (and potentially in breach of federal export law or the pollution prohibitions in the EP Act more generally), so the approach taken by the EPA towards compliance – i.e. towards detecting and punishing breaches and encouraging the right behaviour in the first place (e.g. for household disposal where breaches are not motivated by profit) – will also be critical. A recent assessment of the effectiveness of e-waste management policies in Australia concluded that auditing and compliance measures generally need to be enhanced, noting that "recycling targets are pointless without measures to ensure that e-waste is properly handled and audited".[137]

Increased demand for e-waste feedstock from a more developed recycling industry can also re-enforce the diversion of e-waste from landfills. It could create stronger incentives for the recycling industry to enter into arrangements that make recycling a more attractive proposition than other means of disposal for upstream parties. Profitable recycling opportunities (such as for whitegoods at present) can provide incentives on industry to support upstream arrangements, to the extent possible, to avoid valuable items leaving the recycling stream. For example, e-waste reprocessors may be willing to support collection arrangements (such as drop-off boxes at retailers, or direct arrangements with waste management contractors), or they may bear the costs of transporting e-waste from transfer stations, which could reduce the likelihood of transfer station owners seeking to recover costs via gate fees and hence deterring legal disposal. Actions the state can take to encourage low gate fees and ensure the policy intent is not being undermined at the local level will also be important. This is discussed further immediately below.

[135] United Nations University, https://ourworld.unu.edu/en/toxic-e-waste-dumped-in-poor-nations-says-united-nations

[136] An ABC investigation in March 2017 estimated around 3 container loads of e-waste from Australia arrive monthly at Agbogbloshie dump in Ghana, considered the worst dump in the world for informal e-waste recycling; see http://www.abc.net.au/news/2017-03-10/australian-e-waste-ending-up-in-toxic-african-dump/8339760 . See also SBS Dateline 2 October 2011, http://www.sbs.com.au/news/dateline/story/e-waste-hell

[137] Morris A. and Metternicht G. (2016), "Assessing effectiveness of WEEE management policy in Australia", *Journal of Environmental Management*, Vol. 181; see also https://theconversation.com/does-not-compute-australia-is-still-miles-behind-in-recycling-electronic-products-63381

4.3.2 Unreasonable financial burden on e-waste collectors

The increased volume and different storage and handling requirements for e-waste are likely to impose some new burden on collectors of e-waste, such as transfer stations, predominantly local councils. Under the new policy approach, transfer stations in particular will effectively function as a critical 'intermediary' or 'clearing house' between the supply of e-waste from households and other waste generators, which is uncontrollable in terms of volume and composition, and the demand for e-waste items from the recycling industry, which may have certain requirements or require certain standards in terms of consistency of composition and volume. Negotiating this role will pose some challenges.

While state-funded upgrades to transfer stations and other possible collection points will assist with infrastructure requirements, responsibility for sorting and clearing e-waste stockpiles before reaching capacity will ultimately fall on the collector. Operators will in practice need to reach arrangements with reprocessors to transfer e-waste before the capacity of the transfer station is reached.

The difficulty or ease of doing so will depend on factors such:

- the state of development and production capacity of the reprocessing industry;
- whether items are subject to the National Scheme or another recovery program which makes recycling the responsibility of the relevant industry; and
- the profitability of reprocessing the items involved.

Where industry bears responsibility for ensuring recycling as in the National Scheme, or where material values are high such as for whitegoods metals recycling, councils or other transfer station operators will have less difficulty arranging removal. In situations where the e-waste has low material value, or firms lack the technology to recycle it, it may be difficult for e-waste collectors to find downstream takers for some items or may need to incur transport costs to transfer items to recyclers. If this is not possible or costs are prohibitive, collectors may be left with e-waste for which the only viable option is landfill.

There are several different aspects to this risk.

One is that if transfer stations incur significant costs in sorting or transport, they may elect to use gate fees on commercial e-waste or even residential e-waste drop-off for cost recovery purposes, which carries a risk of undermining recycling rates or leading to illegal disposal (as discussed above).

Another issue is that industry may face incentives to 'cherry pick' the most profitable items, leaving transfer station owners with growing volumes of e-waste that are economically unviable to recycle.

To avoid escalating burdens to either ratepayers or firms handling e-waste, an exemption process will be important to ensure that obligations imposed by the e-waste policy on transfer station operators are not unlimited. A 'hardship' type provision already exists under section 30A of the EP Act allowing prohibited items to be disposed to landfill in certain situations. The government is in the process of determining how this would be applied in practice. Interpretation of the 'reasonably practicable' policy wording could also in principle account for situations imposing undue burdens on councils or recyclers, allowing disposal to landfill under some conditions. Clarity over this in the policy or guidance to ensure a consistent and appropriate exemption system is in place will be important.

4.3.3 Inadequate recovery of e-waste

Another risk of the policy is that a significant amount of e-waste continues to be disposed to landfill as by-product of inadequate recycling processes. This may occur because disposal of certain types of e-waste to landfill is cheaper than recovery, or because a reprocessor lacks appropriate equipment and processes to recover certain types of e-waste.

To help avoid this, the policy requires adherence to 'material recovery rates' (MRRs) and minimal processing standards to e-waste reprocessors.

For e-waste types captured by schemes under the Commonwealth's *Product Stewardship Act 2011*, a reprocessor must meet recovery requirements in the Act, which specify the minimum percentage of e-waste by weight which must be recovered (equivalently, the maximum percentage allowed to landfill). For e-waste types that are not captured by existing schemes, the minimum processing standards in the Australian standard AS/NZS *Collection, storage, transport and treatment of end-of-life electrical and electronic equipment* must be followed.

In a manner that helps to alleviate potential financial burden associated with collection of e-waste (detailed in the section above), these standards are also means by which economically viable forms of disassembly and recycling can be achieved without reprocessors who collect e-waste effectively taking on unlimited responsibility for recycling – which could deter many forms of reprocessing for which partial material recovery is possible. MRRs and minimum processing standards are thus important tools in encouraging recovery of materials wherever it is viable, while avoiding perverse consequences where it is not, and they will support the policy intent of all materials that can be *viably* recovered being extracted.

4.3.4 Environmental and OHS risks during reprocessing

E-waste reprocessing is itself an activity raising significant environmental health and OHS risks, even in jurisdictions with modern OHS laws and technological practices. The primary risks arise from fugitive air emissions and dust associated with processing techniques such as mechanical shredding or spinning and smashing, which can damage components and expose hazardous elements. In addition, on-site storage can potentially result in soil contamination, and increase the likelihood of fires which release various pollutants. Emissions and contaminated dust as well as handling risks also raise OHS issues for recycling workers.

While these risks all exist at present, expansion of the number and scale of organisations in the reprocessing industry and growth in the volume of e-waste processed can be expected to increase the overall magnitude of risk and expected number of instances of poor outcomes (e.g. worker injuries).

On the other hand, increasing professionalisation of the industry and the possibility that greater scale encourages investment in safer reprocessing technologies also suggests the relative risk of reprocessing may decline. One Victorian reprocessor already uses 'Blu Box' technology, for example, which crushes LCD, LED, plasma and OLED screens as well as some other wastes in a negative pressure, contained environment, and the feasibility of using this and similar technologies will likely improve with higher processing volumes.[138]

The e-waste management requirements written into the new policy and codes include a number of obligations which will act to mitigate these reprocessing risks. These include safe handling requirements, risk assessments, and training staff as practical measures to limit OHS risk. These will generally mirror or reinforce practices already undertaken by firms to comply with OHS law. The storage requirements, handling to avoid breakage, and requirements on some parties to perform due diligence on downstream recipients and support good practices by upstream suppliers will act not only to maximise materials recovery and minimise landfilling of e-waste, but also to reduce the environmental health risks associated with reprocessing.

In addition, in a process separate to the development of the Andrews Labor Government's e-waste policy, the review of the *Environment Protection (Scheduled Premises and Exemptions) Regulations* has resulted in the inclusion of e-waste reprocessors recycling more than 500 tonnes/year (i.e. all but a few manual processors) as 'scheduled premises' in the regulations remade earlier in 2017.

These e-waste reprocessors will now be required to obtain a works approval to set up any new facility, and/or a licence to operate, allowing the EPA to prescribe minimum standards for plant and equipment and to impose conditions on ongoing operations to mitigate these risks. The licensing and works approval regime

[138] Regulatory Impact Statement (RIS) for the Environment Protection (Scheduled Premises) Regulations 2017, p59

allows for a far higher level of EPA oversight than is normally applied to premises outside the regime, and this will help mitigate the reprocessing risks described above.

4.4 Cost-benefit analysis

4.4.1 Introduction

The assessment of social costs and benefits of the proposed policy package is the central analytical component of this PIA. Its purpose is to help to identify whether the policy in some form provides net benefits to the Victorian community, and if so which policy option is likely to provide the greatest net benefits.

CBA can provide a range of information about costs and benefits, including indicating which are quantitatively most significant, which key parameters drive overall results, how net benefits vary across groups, etc. Typically, a CBA also involves reporting several key metrics – i.e. the Net Present Value (NPV) and the Benefit-Cost Ratio (BCR) – which can be used as a decision tool for policy.

These metrics have several distinctive features and limitations as a tool for informing policy.

- only *quantifiable* costs and benefits are included – significant unquantifiable benefits as well as matters of principle or ethics are outside the scope of analysis;
- only *incremental* costs and benefits over and above business as usual (BAU) are reflected in the key CBA metrics – even though sometimes the absolute levels of some variable (like a recycling rate) might be considered important policy objectives in their own right; and
- NPV and BCR figures show aggregate outcomes across society as a whole – redistributive impacts (e.g. whether costs of some activity are borne by taxpayers or households, or whether benefits accrue to businesses or more broadly) do not matter for these metrics.

For these reasons, CBA results alone are rarely a sufficient input for policy decisions. Rather, they are typically read alongside other information relating to achievement of the policy objectives, distributional impacts, taxpayer costs, and unquantifiable benefits.

4.4.2 Policy options

The five policy options modelled are as follows:

- Option 1a: Comprehensive landfill ban (all e-waste) with high level of access to collection services[139]
- Option 1b: Comprehensive landfill ban (all e-waste) with low level of access to collection services
- Option 1c: Comprehensive landfill ban (all e-waste) with medium level of access to collection services
- Option 2: Partial landfill ban (most hazardous e-waste only) with high level of access to collection services
- Option 3: No landfill ban (all e-waste) with high level of access to collection services

These options are variations on the preferred package identified in Chapter 3. All options include the new management requirements for e-waste, an education and communication campaign, transfer station storage infrastructure upgrades, and a state-administered collection service.

The comparison of Options 1a, 1b, and 1c informs the design question of which level of access to collection services yields the greatest social return.

The comparison of Options 1a, 2, and 3 informs the question of whether, with the other supporting elements in place, the ban itself is worthwhile in terms of quantifiable net benefits – or whether a partial ban or no ban would be equally valuable on CBA grounds.

[139] Collection services are as specified in Table 5 and Table 6 in section 3.

Across Options 1a, 1b, and 1c the landfill ban is defined as applying to 'any end-of-life 'equipment which is dependent on electrical currents or electromagnetic fields in order to work properly'.

Under Option 2, the ban is modelled as applying only to e-waste types with high concentrations of hazardous components, including:

- Information technology equipment such as mobile phones
- Televisions
- Computers and computer peripherals
- Photovoltaic systems
- Fluorescent lighting
- Batteries

The ban is assumed to take effect in July 2018 across the whole of Victoria. Specific technical assumptions (e.g. maximum contamination rates allowed at landfill) are outlined in the CBA report (Appendix 1).

4.4.3 Base case

The five options above are compared with a 'base case' – a hypothetical 'do nothing' scenario reflecting likely outcomes if other activities continue on a BAU basis.

The base case assumes:

- No regulatory landfill ban on e-waste;
- No additional investment in collection, storage and processing infrastructure;
- No additional investment in specific education campaigns;
- The National Television and Computer Recycling Scheme (NTCRS) continues: The National Scheme has set annual recycling targets until 2026 (the 2018 target is 62%). By 2026 the target will reach 80% and is assumed for the analysis to remain at this thereafter.
- MobileMuster continues: There are no forward estimates of the volumes the program expects to recover. The analysis assumes that volumes collected remain small and will not significantly impact overall costs and benefits.

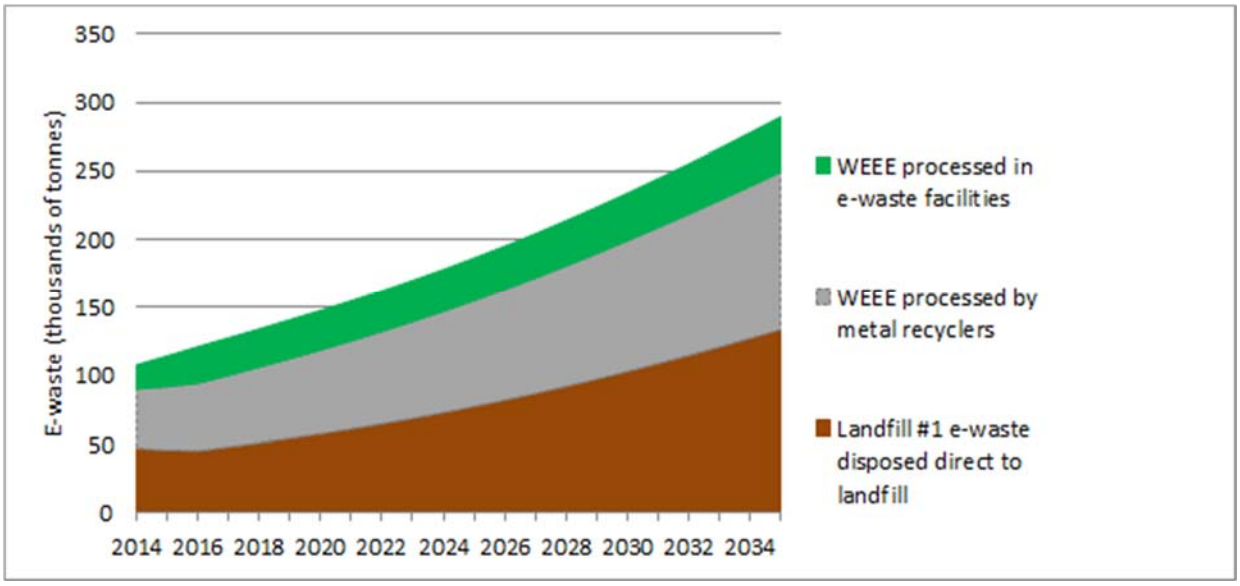
4.4.4 Material flows and recovery rates

Behind the CBA costs and benefits lie a material flow analysis model projecting the volumes and types of e-waste generated, processed, landfilled and exported out to 2035. The MFA was discussed in section 1.2.

The base case (BAU) projections in the MFA are associated with continued absolute growth in e-waste generation, recycling and disposal to landfill, as shown in Figure 6. In the BAU projections, processing rates for most of the 51 e-waste product types are assumed to remain at current rates. Products covered by the National Scheme are assumed to see processing rates consistent with the scheme targets.[140]

[140] Randell Environmental Consulting (2016), *Victorian E-waste Market Flow Analysis (MFA) – part 1 report*, Sections 2.2 (for assumptions) and 5.4.1 (for BAU results) accessed via http://www.sustainability.vic.gov.au/publications-and-research/research

Figure 6: Projections of e-waste processed and landfilled in Victoria



The assumed rates of diversion of e-waste from landfill for each of the 51 product types under each of the policy options draw on various sources, including discussions with stakeholders. These were based on the following considerations:

- BAU diversion rates (including the targets under the National Scheme);
- diversion rates achieved with other currently recyclable wastes;
- ease of compliance with the ban, which is influenced by the services available to the waste generator;
- the ease of non-compliance with the ban, and in particular whether a waste item fits in household bins;
- the likely effectiveness of the education campaign, which is assumed to be partly dependent on the breadth of the proposed ban;
- whether the waste is generated by households (which are strongly influenced by cultural norms) or a commercial entity (which are more influenced by cost); and
- an assumption that compliance will improve over time as infrastructure is developed, knowledge of the management rules improves and cultural norms develop.

Assumed diversion rates vary widely, from a low of 10 per cent for small items from commercial sources in year 1 under Option 3, to 100 per cent for large items from domestic sources often sought by metal recyclers.[141]

The calculation of CBA costs and benefits uses this information at the product level – since each e-waste type differs in hazardous material content and material recovery potential value.

To indicate in overall terms across all products how effective each option is expected, overall percentages for e-waste recovery and ongoing landfilling can be calculated. Figure 7, Figure 9, Figure 8 and Figure 10

[141] Assumptions about diversion rates are presented in section 6.4.3 of the CBA report at Appendix 1.

overleaf illustrate these aggregate recovery rates under BAU each policy option, as well as residual volumes not recycled.

As section 1.2.7 noted, the MFA model is not capable of distinguishing between volumes going to landfill or being illegally disposed – the information base to calibrate the model is not available, so these ‘fates’ are grouped into a broad remainder category. Neither is there reliable information on which to estimate for each policy option in the CBA the volumes that might be mixed with general wastes, stockpiled, illegally exported, or dumped. The extent of the illegal disposal policy risk is not something the CBA calculations can shed light on. The estimates in Figure 8 and Figure 10 thus effectively group all these potential (illegal disposal) fates together with post-processing ‘floc’ assumed to be allowed to landfill legally.

Figure 7 shows the overall e-waste recovery percentages under different types of regulatory ban, assuming high level of access to collection services. A comprehensive ban (Option 1a) is expected to drive significantly higher overall recovery rates than either a partial ban (Option 2) or no ban (Option 3). Figure 9 then compares overall recovery rates, with a comprehensive ban in place, under different access models. Options 1b and 1c without a kerbside collection service in metro areas are expected to see significantly lower recovery rates. The combination of the full ban and most extensive access (Option 1a) drives the highest rates of diversion from landfill – from the current 43 per cent to 72 per cent by 2035.

Modelled recovery rates under all options rise to 2024 as assumed compliance rates rise over the first five years, then decline slightly to 2035 as the composition of items in e-waste tends towards those for which recycling rates are lower. Table 9 summarises the projected overall recovery and disposal outcomes under the five options and BAU.

Figure 7: E-waste recovery, BAU and Options 1a, 2 and 3 (%)

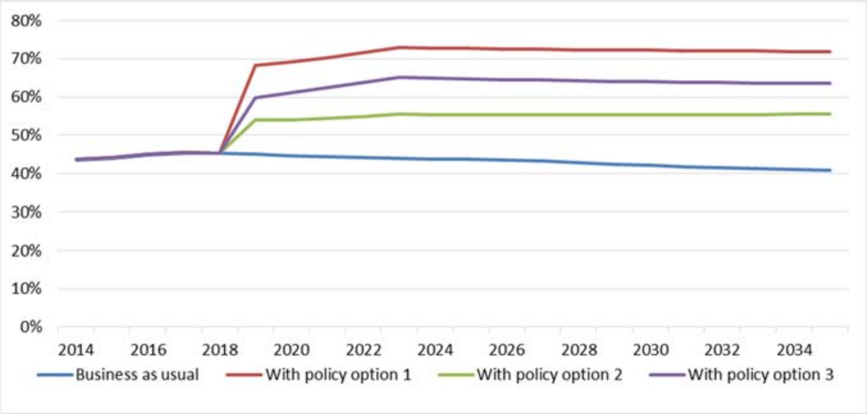


Figure 8: E-waste disposed to landfill, BAU and Options 1a, 2 and 3

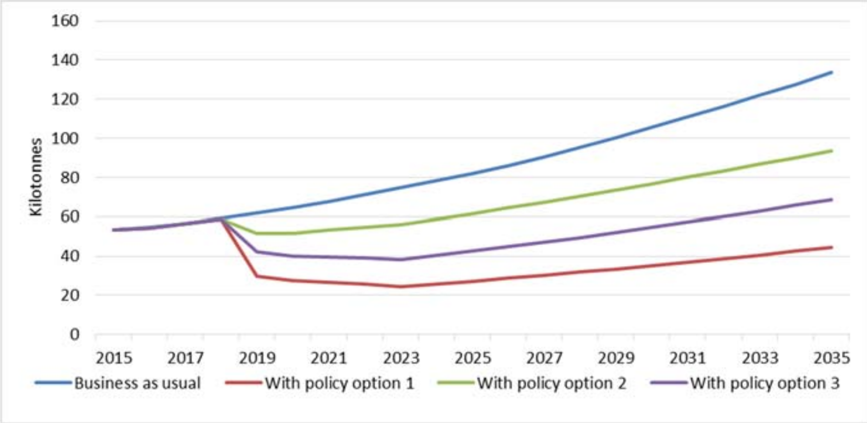


Figure 9: E-waste recovery, BAU and Options 1a, 1b and 1c (%)

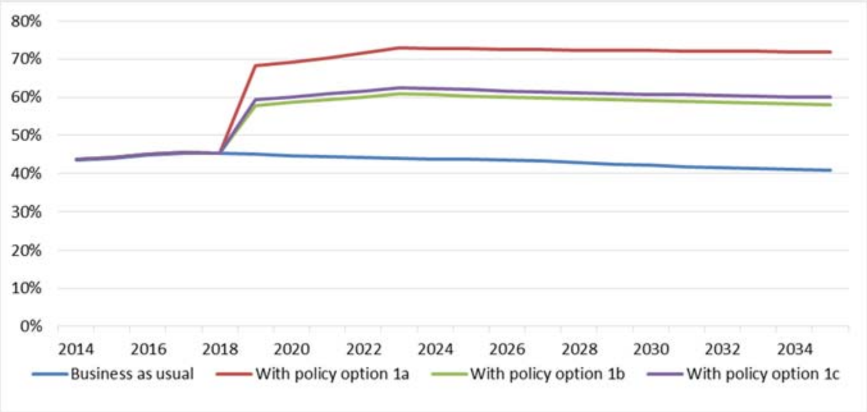


Figure 10: E-waste disposed to landfill, BAU and Options 1a, 1b and 1c

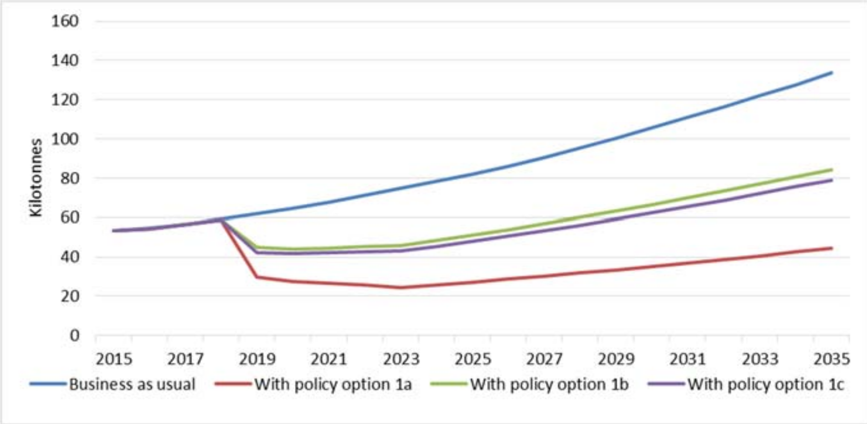


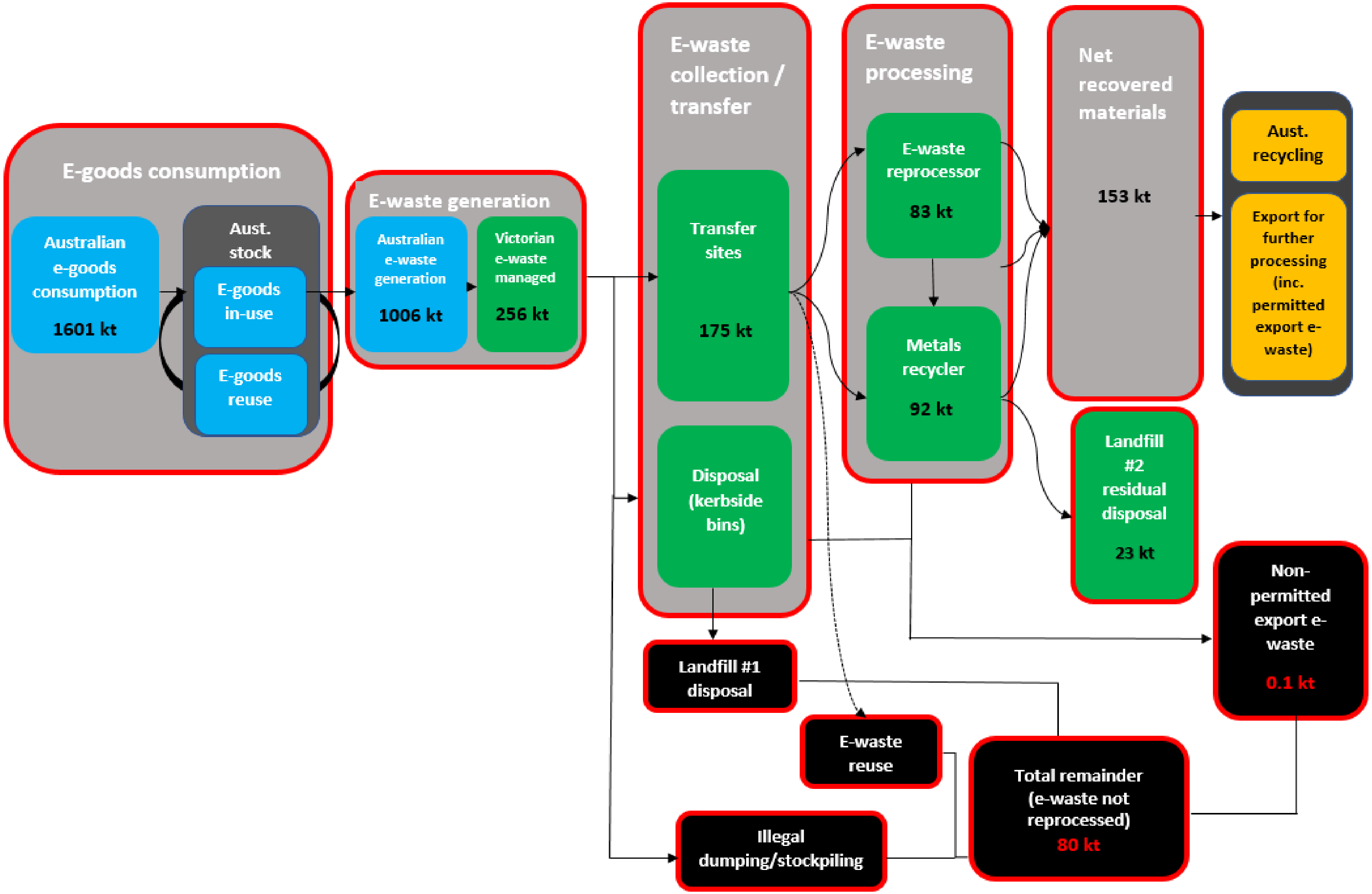
Table 9: E-waste recovery outcomes under BAU and policy options[142]

	Net recovery of e-waste 2035 (tonnes)	E-waste recovery rate 2035 (%)	Total e-waste diverted from landfill relative to BAU 2019-2035 (tonnes)
BAU	104,000 (from 45,000 in 2015)	41% (from 43% in 2015)	-
Option 1a	184,000	72%	922,000
Option 1b	149,000	58%	520,000
Option 1c	153,000	60%	573,000
Option 2	142,000	56%	393,000
Option 3	162,000	64%	664,000

Figure 11 illustrates how the volumes of e-waste are projected to flow in 2035, after the preferred option has been implemented.

[142] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill,* report prepared for the Department of Environmental, Land, Water and Planning Victoria, sections 5.2.2 and 5.2.3

Figure 11: Victorian e-waste flow projections, after implementation of policy package (2035)



4.4.5 Costs

The incremental costs quantified in the CBA are discussed below.

Policy, regulation and administration costs

Additional regulatory and administrative costs are associated with policy development and implementing the preferred option, and with ongoing regulation including monitoring and enforcement costs (for the Victorian Government) and compliance costs (local councils and contractors). Cost assumptions are based on DELWP estimates and stakeholder consultation.

Key costs include:

- an estimated $22,750 per council associated with updating and ongoing administration of their waste management plans, plus ongoing costs to councils associated with administration of the plans;
- costs to Victorian Government associated with policy development under any option, and with ongoing monitoring of compliance with a ban under all options other than Option 3; and
- ongoing costs to transfer stations and landfill operators associated with monitoring compliance with a ban under all options other than Option 3.

Table 10: Policy, regulation, administration and compliance costs

Start-up regulation and administration costs ($)	Options 1a, 1b, 1c	Option 2	Option 3
Victorian Government policy development	300,500	300,500	179,500
Local councils development of e-waste management plan	1,979,250	1,979,250	791,700
Annual regulation and administration costs ($/year)	**Options 1a, 1b, 1c**	**Option 2**	**Option 3**
Victorian Government – annual	206,500	206,500	
Local council / contractors (incl. transfer stations, landfill) – annual	506,800	506,800	

Education and information costs

A comprehensive information and education campaign accompanying implementation of each option will need to include an intensive period upon introduction of the policy and ongoing education thereafter. An ongoing element is critical: evidence from other environmental programs indicates this is needed to ensure behavioural change is not temporary.[143]

Cost estimates were benchmarked against similar waste- and environment-related education campaigns in Victoria and elsewhere in Australia, including water efficiency education programs implemented in the 2000s in Victoria and litter and recycling education programs in Victoria and NSW.

The initial cost of the campaign is assumed to be greater for Option 2 because of the complexities of communicating a ban only involving certain types of e-waste.

[143] Gardner & Stern 2002, OECD 2008, 2011

Table 11: Education and information costs[144]

E-waste education and information costs ($)	Year 1	Year 2	Year 3	Years 4 to 20
Options 1a, 1b, 1c, and 3				
Education and information campaign	1,000,000	1,000,000	1,000,000	500,000
Option 2				
Education and information campaign	2,000,000	1,000,000	1,000,000	500,000

Collection, transport, sorting and disposal costs

Costs incurred between waste generation and reprocessing – i.e. for collection, transport, sorting and disposal – vary significantly between options, and the nature of the collection service influences the distribution of these costs between taxpayers, ratepayers, and households.

Options 1a, 2, and 3 include a kerbside collection system in metro areas (with recycling bins for small e-waste and hard rubbish collection for large e-waste), which involves significantly greater public costs than in Options 1b and 1c but with lower transport costs for households. Under Options 1b and 1c, permanent drop-off points and/or events are used in place of kerbside collection, with some additional staffing costs assumed but with lower overall cost to councils or the state. Higher transport costs borne by households in taking items to drop-off points, however, offset much of this lower public cost.

In the CBA all of these costs are calculated using $/tonne cost parameters multiplied by the volumes of waste projected from the material flow analysis. Total costs therefore vary across options for two reasons: because different collection methods have different unit costs per tonne diverted from landfill, and because different collection methods drive differences in overall volumes recycled.

Table 12 provides an overview of the $/tonne cost parameters used. They were derived from recent data on costs currently incurred by waste management services and from discussions with stakeholders, especially regarding recent experience with pilot e-waste collection and drop-off schemes.

Table 12: Collection, transport, sorting and disposal costs ($/tonne)

Cost item	Waste type	Region	Cost $/tonne
Residential & commercial garbage collection	General waste	Metro	165
		Non-metro	168
Residential kerbside collection	Small e-waste	Metro	295
Residential hard waste collection	General waste & whitegoods	Metro	201
Residential hard waste collection (e-waste)	Large e-waste	Metro	302
Commercial e-waste collection	All e-waste	Metro	312

[144] Marsden Jacob & Associates

Residential e-waste drop-off (participation)	All e-waste	Metro	168
		Non-metro	178
Commercial e-waste drop-off (participation)	All e-waste	Non-metro	154
Handling costs	All e-waste	All	10
Handling & sorting, permanent drop-off sites	All e-waste other than whitegoods	Metro (Options 1b & 1c only)	81
		Non-metro	81
Events handling, sorting & organising (Option 1c)	All e-waste	Metro	179
		Non-metro	217
Transport to processors	All e-waste	Metro	80
		Non-metro	342
Landfill operating costs	All e-waste	Metro	46
		Non-metro	60

Transfer station upgrades

There are an estimated 296 transfer stations in Victoria, 55 in metropolitan areas and 241 in regional areas. It is estimated that only 65 of these are both able to collect e-waste and are currently compliant with the Australian Standard for the *Collection, Storage, Transport and Treatment of End-of-life Electrical and Electronic Equipment* (AS5377).[145]

Under Options 1a, 2 and 3 transfer stations in metro areas will need capacity to accept e-waste from kerbside collection, and transfer stations accepting drop-off will be provided in non-metro areas for every town of over 1000 people. Under these options 181 transfer stations will need to be able to accept e-waste, requiring upgrades to 116 transfer stations.

These upgrades will mean establishing a fully enclosed storage area with a concrete floor and contained storage areas or bins, at an estimated total cost of approximately $9.3 million, made up of:

- 108 smaller regional transfer stations at $75,000 per upgrade; and
- 8 larger metropolitan transfer stations at $150,000 per upgrade.

Under Options 1b and 1c, the requirement for access to a fully compliant transfer station is less stringent – only non-metro areas with population >4000 will be provided a permanent drop-off point. As a result, only 39 transfer stations require major upgrades.

However, it is also assumed that the 65 transfer stations currently meeting AS5377 will need minor upgrades to establish them as permanent collection points capable of accepting significantly increased volumes. These minor upgrades have been estimated at $20,000 per metropolitan site and $10,000 per regional site.

The total cost of transfer station upgrades under Options 1b and 1c is $4.3m.

[145] Randell, Pickin and Latimer, 2015. This includes 30 that have undergone upgrades in the past 12 months

Processing costs

E-waste processing costs are modelled as being of three different types, with different $/tonne unit costs across these types:

- manual processing, which is often associated with dismantling e-waste products and recovering higher value materials (e.g. circuit boards) before lower value items are sent for shredding via a mechanical process, is estimated to cost $660 /tonne;
- mechanical processing, generally entailing significantly larger volumes than manual processing, is estimated to be 20% lower at $550 /tonne; and
- metal recycling, which is also a mechanical process, exhibits very low costs ($71 /tonne) reflecting the straightforward nature of the process and relatively large volumes.

As with collection, storage, transport and disposal costs, processing costs are calculated based on a single per-tonne figure multiplied by volumes processed. Although processing costs in reality include capital (fixed) costs and operating costs, for the analysis all processing costs are modelled on a $/tonne basis noting that the MFA report as well as discussions with recyclers indicate that for the foreseeable future there are no significant infrastructure constraints on substantially increasing volumes processed.

4.4.6 Benefits

Two of the three policy objectives outlined in Chapter 3 have a closely associated quantifiable benefit.

The benefit of reducing harm to the environment and human health from e-waste in landfill can be valued by estimating avoided environmental and health impacts, particularly from pollutants entering the environment via landfill leachate. The value of reducing the use of landfill airspace by e-waste is represented by avoided landfill fees.

The benefits of increasing recovery of the resources in e-waste are here valued by estimating the material values of incremental resources recovered over and above base case levels under each policy option. As discussed in chapter 2, materials prices are not a complete representation of the global social costs of consigning valuable resources to landfill, since they do not incorporate the environmental harms of virgin extraction nor reflect the costs to future generations of using up non-renewable resources. Using materials values here therefore reflects only the financial benefit generated in Victoria from greater materials recovery. A sensitivity test of whether net benefits are positive based on household willingness-to-pay for e-waste recycling – a metric which potentially incorporates environmental and intergenerational inequity concerns – was also conducted (see section 4.4.11)

Employment impacts and additional investment are not typically suitable for inclusion as a CBA benefit. This is because CBA measures *net* social benefits including offsetting resource costs. Additional wages have an opportunity cost, namely other productive uses of labour time. The dollar value of industry investments similarly reflects foregone investment or spending opportunities elsewhere in the economy. Only where additional employment or productive capacity are truly incremental from a macroeconomic viewpoint are their inclusion in CBA appropriate, and so standard practices do not include valuing these as additional benefits.

Several other potential benefits are not quantified here. These include the potential precedent value of a ban in driving support for recycling initiatives more generally, and the avoided amenity impacts of landfills on nearby residents (dollar values are negligible relative to the other benefits quantified here, and e-waste is a very small portion of landfill overall).

Avoided health and environmental impacts

The approach to valuing the reduction in downstream externalities (health and environmental impacts) from including hazardous e-waste in landfill begins by quantifying the levels of hazardous pollutants expected to leach into the environment under BAU and each of the policy options. The pollutants estimated include mercury, lead, cadmium, chromium, nickel, antimony, americium, indium, brominated flame retardants (BFRs) and persistent organic pollutant brominated diphenyl ethers (POP DPE).

To enable comparison of impacts the quantities of these pollutants were normalised to mercury (Hg) equivalents based on their hazard levels relative to mercury, since much work has been undertaken internationally to assess the economic costs of mercury pollution. The approach used takes damage cost estimates from Spadaro and Rabl (2008) in which the principal cost is due to IQ loss in children, and the cost in an Australian context (which is adjusted from the US values according to relative GDP per capita) is $11,093 per kilogram of mercury.[146]

The avoided quantities of all the hazardous pollutants (Hg equivalent) were in turn used to estimate the value of total avoided health and environmental impacts.

The process of normalising all hazardous pollutants to mercury equivalents and the general uncertainty attached to the economic cost of mercury pollution mean there is significant uncertainty attached to these figures, which is addressed to some extent by applying a wide range of values in the sensitivity analysis (from 28% to 124% of the central value), as well as by the application of willingness to pay (WTP) as an alternative approach to testing whether the policy options yield net benefits.

Recovery of valuable materials

Despite there being a great deal of data available on market value of materials, reinforced by information from recyclers on prices for recovered materials, there remains uncertainty about the future value of materials recovered through increased recycling of e-waste, reflecting:

- prices, which are largely driven by global factors, fluctuating significantly from year to year;
- the wide range of materials recovered from e-waste having very different values.

The analysis uses prices that could reasonably be expected to be received for the materials over the next few years considering medium term trends. Given this uncertainty, a wide range of prices were applied in the sensitivity analysis.

Recovery rates for precious metals and rare earths (e.g. gold, palladium), which although representing a small proportion of e-waste by weight form a significant proportion of total material value, are assumed to be the same as for e-waste processing generally – around a 7% level of wastage. This is broadly consistent with recovery rates of approximately 93-97% for precious metals stipulated in the literature[147].

Leaded glass, contained principally in cathode ray tube (CRT) televisions, is costly to reprocess with little or no material value. The CBA treats it as an e-waste type with negative material value. As a 'prescribed industrial waste' already banned from most landfills, leaded glass must be transported to the only facility in Australia that can process it (the Nyrstar lead smelter in Port Pirie). Although this represents a significant cost even under BAU, the cost of recycling leaded glass under each option is higher still since it is assumed that more CRT TVs will be diverted from landfill under the new policy.

4.4.7 Results

CBA results are summarised in Table 13 overleaf. They show the net costs and benefits of options relative to BAU assessed over the total period of the analysis, 2017-2035 (the period covered by the MFA).

The NPVs of costs and benefits and the BCRs associated with these options answer the question of whether the overall policy package in each of these forms is worthwhile in quantifiable cost/benefit terms. An NPV greater than zero (or equivalently a BCR>1) indicates the policy yields measurable benefits greater than costs.

[146] Spadaro, J. and Rabl, A. (2008): "Global health impacts and costs due to mercury emissions". Risk Analysis, Vol.28, No. 3, 2008.

[147] Khaliq, A., Rhamdhani, M., Brooks, G. and Masood, S. 2014. "Metal Extraction Processes for Electronic Waste and Existing Industrial Routes: A Review and Australian Perspective", pp. 152-179 in Resources, Vol 3, 2014.

There are several notable features of the CBA results.

First, material values recovered represent the vast majority of the quantifiable policy benefits – 90 to 94 per cent of the total – and processing costs are the most significant category of costs. From a social cost-benefit point of view, it is the economic value of material recovered from e-waste that provides the strongest of the quantifiable rationales for policy intervention.

Two, under all options the material values exceed processing costs in aggregate, which is both a useful sense-check on the analysis (since recyclers would not engage in reprocessing were this not the case) and also indicates that – since there is surplus in the processing activity – there is potential for society-wide net benefits from additional recycling.[148] This potential will be realised if the upstream activities to get items to recyclers can be undertaken at sufficiently low cost (to taxpayers and waste generators) relative to the surplus it allows the recycling industry to generate.

Three, the total benefits and total costs vary significantly and predictably across options in line with the variation in recycling rates and hence the volume collection, transport, storage and processing activity noted in section 4.4.4 above. The breakdown of collection and sorting costs across options with kerbside recycling also differs to the breakdown where this collection option is not available. Kerbside collection is more costly, but a drop-off based collection system imposes transport costs on households which partly offset the collection service cost savings.

Four, despite the wide variation in total costs and benefits across Options 1a, 1b, and 1c, all three options produce a small positive net benefit and BCR>1. This indicates with a landfill ban in place the potential value of material recovered net of reprocessing costs (in other words the potential surplus at the processing end of the waste chain) is sufficiently high to offset the public expense of a collection system, education campaign, transfer station investments and regulatory and administration costs and to generate in aggregate a net benefit.

While the largest net benefit is associated with the option with the highest diversion rate (Option 1a), the positive NPVs across these three options suggest that implementation of any of these options carries a reasonable prospect of delivering net benefits – and that some decision criteria other than the NPV and BCR must be used to select a preferred policy option.

Fifth, despite not including a regulatory ban, Option 3 generates a BCR around 1. This illustrates the centrality of the collection system to driving recovery rates. Although on a basic reading it also suggests a ban is unnecessary, there are other outcomes not captured in the BCR that are important. In particular, Option 1a drives significantly more recycling than Option 3: for the approximately $8 million in additional regulatory costs incurred to 2035 (present value), the ban is expected to divert around 250,000 more tonnes of e-waste from landfill, and to recover around $130 million in additional material value. While this monetary gain is largely offset by higher collection, transport and processing costs, so that the net benefit of Option 1 is only $15 million higher, it is clear that Option 1 better meets the policy objectives of diversion from landfill and material recovery.

Finally, when the landfill ban is restricted to hazardous items as in Option 2, the value of material recovered is inadequate to offset the social costs of diversion from landfill – Option 2 has a negative NPV with a BCR of 0.7. The implication of this result is that as the economic rationale for diversion from landfill ban largely centres on recovering valuable materials, the design of a ban and collection system must be oriented around collecting the highest-value e-waste types.

[148] Note that the aggregate figures obscure potential differences between items that are highly profitable and others for which no economically viable reprocessing is possible; item-by-item feasibility calculations were not possible in the CBA. These differences point towards potential upsides – i.e. net social benefits of processing which may be higher than reported here – but also potential risks and public costs associated with storage and disposal of low-value items, as discussed in section 4.3 above.

4.4.8 Benefits and costs over the evaluation period

The present value figures in Table 13 obscure some important trends in how costs and benefits change over time. Over the evaluation period, the mix of e-waste items changes notably – and the trend is towards items with relatively lower resource value.

Most of the average 4 per cent per annum growth in e-waste generation is expected to be in large appliances, small household tools and appliances, and solar PV panels. These three categories contribute 118,000 of the 149,000-tonne growth in overall e-waste generation projected between 2015 and 2035.[149] By contrast, waste generation of higher-value National Scheme products (TVs, computers, and computer peripherals) is expected to grow by only around 3,000 tonnes over the period – with the share of these products in overall e-waste falling from 25 per cent to less than 12 per cent over the period.

The consequence of this is that as costs continue to grow steadily over the period, net social benefits peak in the early to mid-2020s and decline thereafter so that by the end of the evaluation period all options have net costs year on year. Option 2 even sees materials revenues fall slightly below processing costs at this point – indicating processing of collected wastes may (on average) no longer be commercially feasible.

[149] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill,* report prepared for the Department of Environmental, Land, Water and Planning Victoria, section 5.2

Table 13: Cost benefit analysis results summary

	Present value of costs and benefits relative to BaU over 2017-2035 – $million in 2016 present value				
	Option 1a (comprehensive ban, high level access)	Option 1b (comprehensive ban, low level access)	Option 1c (comprehensive ban, medium level access)	Option 2 (ban on hazardous items, high access)	Option 3 (no ban, high access)
Collection costs	-$65.1	-$2.3	-$8.4	-$32.9	-$51.4
Metro	-$65.8	-$3.0	-$7.6	-$33.2	-$51.7
Non-metro	$0.7	$0.6	-$0.8	$0.4	$0.3
Sorting costs	-$13.4	-$33.6	-$33.9	-$10.6	-$12.1
Metro	-$4.7	-$15.1	-$15.3	-$2.3	-$3.7
Non-metro	-$8.8	-$18.5	-$18.6	-$8.2	-$8.4
Transport to recyclers	-$59.6	-$33.2	-$36.9	-$22.4	-$40.5
Metro	-$27.9	-$15.9	-$17.5	-$9.4	-$20.5
Non-metro	-$31.7	-$17.3	-$19.4	-$13.0	-$20.0
Processing costs	-$280.4	-$157.9	-$172.7	-$116.1	-$200.2
E-waste	-$279.2	-$157.1	-$171.7	-$116.1	-$199.2
Metal	-$1.2	-$0.8	-$1.1	$0.0	-$0.9
Regulatory costs	-$8.6	-$8.6	-$8.6	-$6.8	-$0.9
Education costs	-$6.3	-$6.3	-$6.3	-$6.3	-$9.0
Total costs	**-$433.6**	**-$242.0**	**-$266.8**	**-$195.0**	**-$314.1**
Value of material recovered	$426.0	$235.7	$262.0	$123.9	$298.1
Avoided landfill costs	$13.7	$8.6	$9.2	$8.3	$10.5
Avoided impacts of landfills	$13.9	$8.2	$8.9	$6.2	$10.1

Total benefits	$453.7	$252.4	$280.1	$138.5	$318.7
NPV	$20.1	$10.4	$13.3	-$56.5	$4.7
BCR	1.05	1.04	1.05	0.71	1.01
WTP threshold	$931 / tonne	$915 / tonne	$915 / tonne	$995 / tonne	$942 / tonne

4.4.9 Drivers of CBA results

Table 14 provides an overview of the key variables driving the CBA results above. It shows the average material values, costs and net benefits per tonne of waste diverted.

Several figures in Table 14 can help explain the aggregate results above:

- For Options 1a, 1b, 1c and 3 the value of materials recovered is generally around $300 / tonne higher than processing costs – but collection, sorting, transport and disposal costs at around $250-300 per tonne offset almost all of this;
- A kerbside collection service (as in Option 1a) vis-à-vis a drop-off system (as in Options 1b and 1c) has total collection, sorting, transport and disposal costs only around $30-40 per tonne higher;
- Although processing costs vary negligibly between options, the average material values in Option 2 are significantly lower than in other options, and this drives the negative net benefit for this option;
- Collection and sorting costs under Option 2 are slightly higher than in other options, since the volume of e-waste diverted is lower but there are fixed costs associated with upgrades to transfer stations.

Table 14: Key variables influencing CBA results

	Total tonnes e-waste diverted from landfill 2019-2035 relative to BAU ('000)	Net benefit (cost) per tonne diverted (PV$/ PV tonne)	Collection, sorting, transport & disposal costs (PV$/ PV tonne)	Processing costs (PV$/ PV tonne)	Value of materials recovered (PV$/ PV tonne)
Option 1a	922	$44	($276)	($621)	$944
Option 1b	520	$41	($237)	($619)	$924
Option 1c	573	$47	($248)	($614)	$931
Option 2	393	($301)	($306)	($618)	$660
Option 3	664	$14	($290)	($621)	$925

4.4.10 Sensitivity Analysis

A sensitivity analysis was undertaken as part of the CBA, involving changes to five cost and benefit categories:[150]

- collection, sorting and transport costs;
- processing costs;
- disposal costs;
- value of recovered materials; and
- avoided health impacts associated with the disposal of e-waste to landfill.

[150] Discount rate sensitivities were calculated but had marginal impact since few costs are upfront and future cost and benefit profiles grow at similar rates.

Three sets of parameters were used for each: low, high, and central case. Wider ranges were applied to benefit parameters – i.e. materials prices and health damage costs – in recognition that these are generally less certain than the cost parameters. Uncertainty in materials values arises because commodity prices are volatile, and in health damage costs because of the significant uncertainty around both the relative hazards of compounds in e-waste other than mercury (which has been most extensively studied) and around mercury health costs and their applicability in the context of Victorian landfills.

Alternative BCRs were prepared by adjusting all cost parameters simultaneously, by adjusting all benefit parameters simultaneously, and by adjusting all cost and benefit parameters simultaneously. While sensitivities to individual cost or benefit parameters were not calculated, a sense of the most significant individual drivers of the CBA results can be gained from Table 14 above. Material values are 90 to 94 per cent of total benefits, so commodity prices are overwhelmingly the key driver on the benefit side. On the cost side, processing costs are around 2-3 times as significant as collection, transport, and sorting costs, and so a given percentage change in the former will drive a much larger change in NPV / BCR than in the latter.

Since the BCRs of Options 1a, 1b, 1c and 3 are close to one in the central case, adjusting either all costs or all benefits while holding the other fixed tips the BCR above one or below one in a predictable way.

A notable result from the sensitivity analysis is that in any alternative with higher-than-expected benefits (i.e. commodity prices at the high end of the range) the policy yields a BCR>1 under Options 1a, 1b, 1c, or 3 regardless of the cost parameters:

- upside benefit estimates with central case costs increase the BCRs under these four policy options from 1.01-1.05 to 1.34-1.38;
- upside benefit estimates with lower-than-expected costs result in BCRs for Options 1a, 1b, 1c, and 3 as high as 1.73-1.80;
- upside benefit estimates with higher-than-expected costs leave the BCRs for Options 1a, 1b, 1c, and 3 between 1.08 and 1.12.

Interpreting the sensitivity figures under lower-than-expected commodity prices and/or higher-than-expected processing costs is more conceptually difficult. This is because the sensitivity analysis takes processing volumes as a given for each option – but in a future scenario where processing became unprofitable, the volumes recycled in reality would diminish. On the one hand, this would mean the true policy NPV would be 'less negative' – the overall social disbenefit would be less than estimated here as unprofitable reprocessing would not occur – but on the other hand the BCR may be even lower than modelled here, since the 'fixed' elements of the overall cost (e.g. kerbside collection, household transport costs, administration costs, transfer station upgrades) would remain constant even as recycling benefits fell away.[151]

Overall, the sensitivity analysis supports the conclusion that there is a reasonable prospect of the proposed policy approach yielding net benefits, so long as a comprehensive ban is complemented with a high-access collection system in place.

4.4.11 Willingness to pay (WTP) valuations

Given uncertainties with the values attached to key benefit items, Marsden Jacobs' report also estimates the community's WTP for the increased e-waste recycling that could be expected to occur with the implementation of the policy.[152]

As section 2.2.2 describes, WTP estimates might capture some outcomes important to the community that are unable to be represented in the quantified CBA benefits (resource value and landfill health impacts), such as intergenerational equity or concern with living more sustainably. However, WTP estimates can also reflect broad misunderstandings about the true magnitudes of costs (e.g. collection and recycling) or risks

[151] The CBA calculates some of these costs – collection, household transport to drop-off – on a per-tonne basis. But in reality, were volumes processed to shrink under a low-commodity-price future, these activities and costs would need to continue at similar levels (e.g. households would continue dropping off e-waste even if transfer stations were unable to find willing reprocessors to take it). Hence while these are estimated as variable costs here they have a fixed element in practice.

[152] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill,* report prepared for the Department of Environmental, Land, Water and Planning Victoria.

(e.g. health risks from landfills). Non-market – i.e. survey a.k.a. 'expressed preference' – measures of social welfare are generally treated with caution and market valuations – 'revealed preferences' – used where available instead (see Box 3 in chapter 2).

Here the results of a previous study into WTP for e-waste recycling (Rolls, Brulliard & Bennett, 2009) have been used to derive a WTP estimate applicable to the proposed policy. The result of this interpolation exercise is a WTP estimate of $884 per tonne of additional e-waste recycled, plus a premium of $128 for each tonne recycled via kerbside collection. Under Options 1a, 2 or 3 (with kerbside collection) the estimated benefit on a WTP basis is therefore $1,012 per tonne, and under Options 1b and 1c, the community's WTP for additional e-waste recycling is estimated to be $884/ tonne.

As an alternative 'sensitivity' test these estimates can be compared to the average costs (of all types) per tonne recycled under each option. A WTP higher than the average cost, which are labelled the WTP "threshold values" in Table 13 above, indicates a positive NPV (a BCR>1).

In all options which include a kerbside collection service, the WTP estimate of $1,012 /tonne exceeds the WTP thresholds (of $913, $995, and $942 per tonne for 1a, 2, and 3 respectively). Without kerbside collection the WTP estimate is slightly lower than the threshold of $915 /tonne for options 1b and 1c, suggesting a BCR<1.

The WTP analysis therefore appears to reinforce the central finding of the CBA calculations – that social benefits are broadly on par with costs for most of the policy options examined.

Any further inferences are probably unreliable; there are limitations to the survey figures used that make this WTP approach not well suited to comparing options. One issue is that the community is deemed to place the same value on each tonne recycled under a collection system that fails to capture non-hazardous but potentially valuable e-wastes (option 2). This seems incongruous with the premise that broader sustainability concerns (not landfill disposal risks or economic gains) likely lie behind WTP views. Another issue is that the higher WTP for kerbside recycling presumably reflects household perceptions not of environmental or economic benefits but of heightened convenience / lower costs – which is already reflected in the cost-side figures (the WTP thresholds), raising questions about double counting.

4.4.12 Distributional impacts

This section decomposes the aggregate cost and benefit figures in order to identify the impacts (net benefits) likely to be borne by different groups of stakeholders under the various policy options. The impacts on local councils, residents recycling e-waste, businesses recycling e-waste, the Victorian Government, landfill operators, e-waste processors/recyclers, and the broader community are separately estimated.

Some assumptions are required about how the burden of certain costs are distributed. It is noted that some aspects of the way the policy is implemented in practice – e.g. grants for infrastructure from the Victorian Government, gate fees at transfer stations, changes in who pays for transporting e-waste – will alter the distributional impacts from those shown here.

Table 15 summarises how benefits and costs (and transfers) are assumed to be borne by different groups. Notable assumptions are that:

- costs associated with the collection or drop-off of e-waste fall on local councils, residents and business generators of e-waste (in different ways depending on the collection service model);
- transfer station capital and operating costs fall on local councils (it is acknowledged that state infrastructure grants and gate fees could affect this in practice);

- costs associated with transporting e-waste to recyclers are assumed to fall on local councils and business consumers of e-waste (although it is acknowledged that some of these costs may end up being borne by recyclers, as is often the case with respect to metals recycling at present);
- reductions in landfill costs are received by local councils, and reductions in landfill levies act like a transfer from the Victorian Government to local councils; and
- landfill costs on e-waste residual sent to landfill after processing are borne by processors, and landfill levies on this act like a transfer from processors to the Victorian Government.

The benefit from recovery of valuable materials is assumed to go to the recyclers (no payments from the recycling industry to councils are assumed), and the benefits of avoided impacts from disposal of hazardous materials to landfill are attributed to the environment / broader community.

Table 15: Impacts (costs, benefits and transfers) of options on stakeholder groups

Costs		Benefits/ avoided costs	
Item	**Stakeholders**	**Item**	**Stakeholders**
Regulatory and administrative costs (option development, ongoing administration of the option; monitoring and enforcement)	Victorian Government	Value of recovered materials	Reprocessors/ metal recyclers
Information & education	Victorian Government	Avoided impacts associated with disposal of hazardous materials to landfill	Environment/ community
Compliance costs	Local councils, reprocessors/metal recyclers, landfill operators	Avoided transport costs to landfill (direct disposal)	Local councils/residents, business consumers of e-waste
Collection and participation costs	Local councils/residents, business consumers of e-waste	Avoided landfill operating costs (direct disposal)	Local councils/residents, business consumers of e-waste
Transfer site capital costs (including storage)	Victorian Government	**Transfers**	
Transfer site operating costs	Local councils/residents	**Item**	**Stakeholders**
Reprocessing facility capital costs	Reprocessors/metal recyclers, state government	Avoided landfill levy (direct disposal)	Local councils/residents (+)/ state government (-)
Reprocessing facility operating costs	Reprocessors/metal recyclers, state government	Increased landfill levy (indirect disposal)	Victorian Government (+)/ reprocessors/ recyclers (-)
Transport costs to reprocessing facilities	Local councils/residents, business consumers of e-waste	Transfer station gate fees	Not included

Transport costs to landfill (indirect disposal)	Reprocessors/metal recyclers	Recycler gate fees	Not included
Landfill operating costs (indirect disposal of residual waste)	Reprocessors/metal recyclers	Infrastructure grants	Not included
Onsite stockpiling impacts (environment, amenity)	Not included	Non-compliance penalties	Not included
Impacts of illegal dumping (environment, amenity)	Not included		

The results displayed in Figure 12 and Figure 13 below show that a substantial proportion of the overall costs of implementing either Options 1a, 2 or 3 fall on local councils and the state, while under Options 1b and 1c there is a substantial shift of collection and sorting costs from local councils to residents. Recyclers are the stakeholder group most likely to benefit from implementing any of the options.

The figures highlight a key point already evident from the discussion of problems, interventions, and aggregate CBA results: in a broad sense the proposed policy is one involving significant public cost and effort in e-waste collection (by households, local councils/ratepayers, and the state/taxpayers) expended primarily (in terms of quantifiable benefits) in order to generate a surplus for a growing recycling industry.

While that growth has many instrumental benefits that citizens at large are concerned with, it also raises the question for future consideration of how the policy can be made to pay for itself. For certain e-waste items, refund schemes may be one possibility, and more generally the arrangements between transfer stations and reprocessors may in time be able to be structured around cost recovery.

Figure 12: Distributional impacts of options on stakeholder groups, Options 1a, 2 and 3 (2016$)

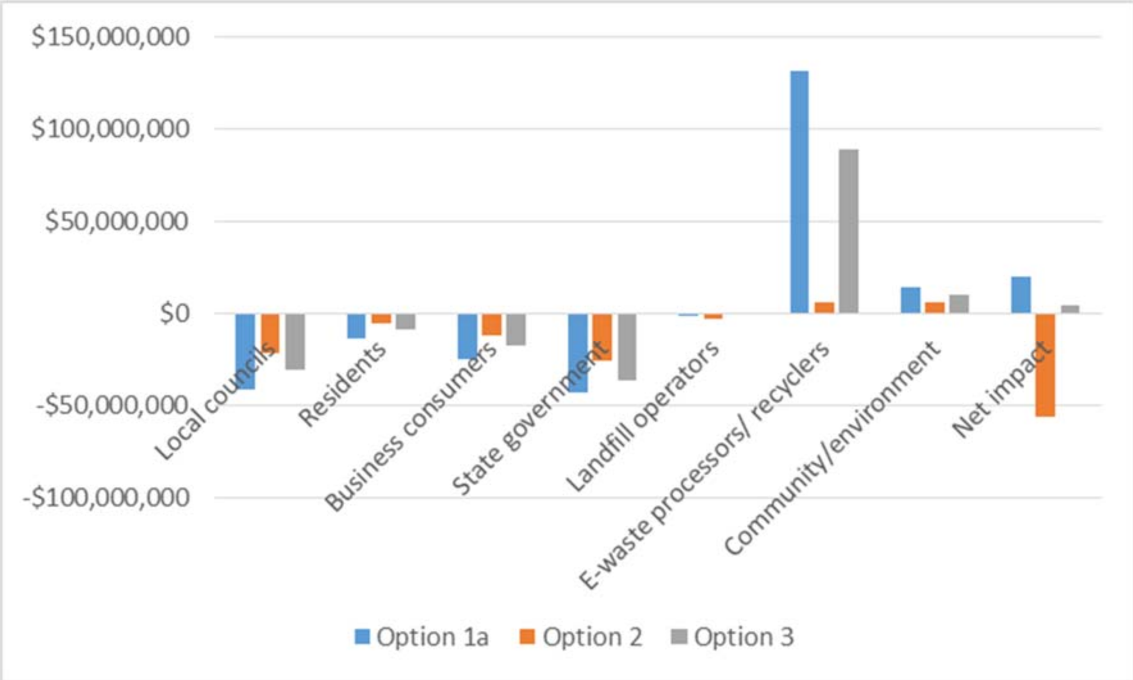
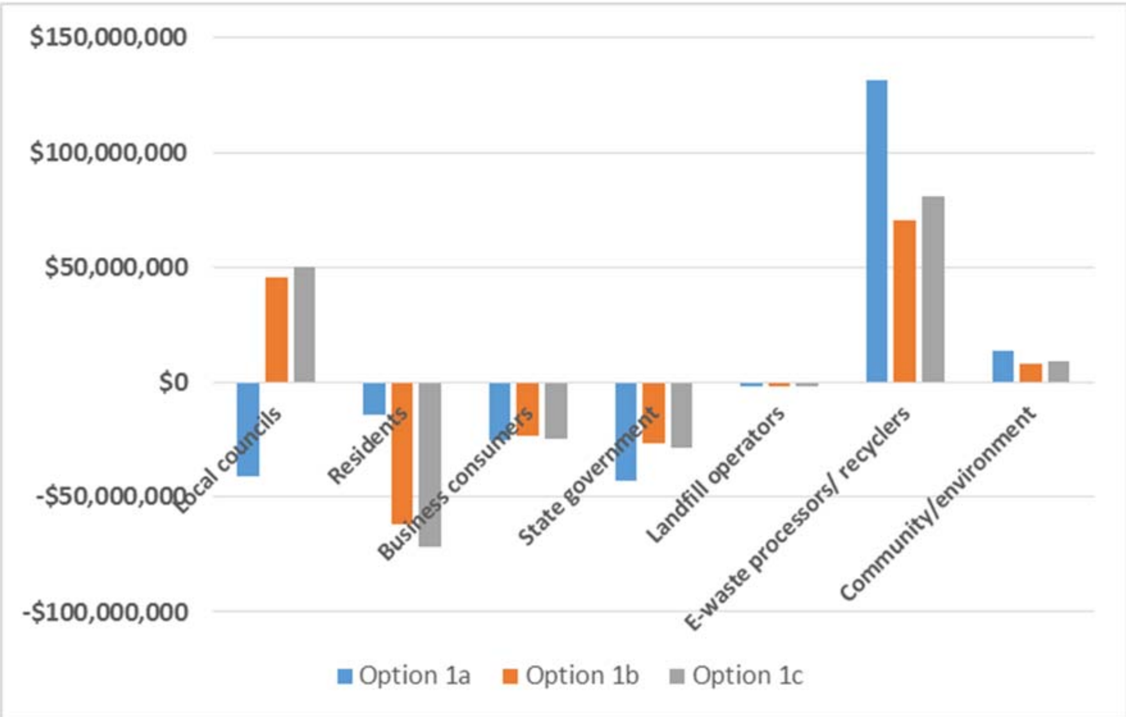


Figure 13: Distributional impacts of options on stakeholder groups, Options 1a, 1b and 1c (2016$)



4.4.13 Employment impacts

E-waste recycling is evidently a more labour intensive process than sending e-waste to landfill, and with an additional $116m to $280m in NPV terms estimated to be spent in the reprocessing industries over the period to 2035 (see Table 13 above), the proposed policy approach offers the prospect of positive employment impacts.

A preliminary assessment of the employment impacts under each option is presented in Table 16 below. The figures draw on an Access Economics (2009) study which estimated the direct full time equivalent (FTE) employment gains from greater recycling at 9.2 FTE jobs per 10,000 tonnes recycled, more than three times larger than the 2.8 FTE jobs lost per 10,000 tonnes diverted from landfill.

Under Option 1a, which generates the highest recycling rates, this equates to approximately 50 additional jobs per annum in recycling with a net increase of 35 jobs per annum. Under other options the net impacts are lower.

There may also be flow-on effects from the employment generated in the waste sector. Based on an estimated multiplier in the waste sector of 1.84 (Access Economics 2009), indirect employment impacts may amount to around 30 jobs under Option 1a, and somewhat less under other options.

As for all multiplier-based estimates of employment change, these figures should be treated as upper limits given that they do not account for offsetting impacts in other markets (e.g. reductions in employment elsewhere due to the recycling industry competing for employees or due to higher waste management costs across the economy reducing output and employment).

Table 16: Impacts of options on employment

	Increase in resource recovery	Direct employment impact (FTE)			Indirect employment
	('000s t/ yr)	Recycling	Landfill	Net impact	(FTE)
Option 1a	54,239	49.9	- 15.2	34.7	29.2
Option 1b	30,578	28.1	- 8.6	19.6	16.4
Option 1c	33,744	31.0	- 9.4	21.6	18.1
Option 2	23,116	21.3	- 6.5	14.8	12.4
Option 3	39,032	35.9	- 10.9	25.0	21.0

Source: Marsden Jacob drawing on Access Economics 2009

4.4.14 Small business impacts

When assessing the impacts of an e-waste landfill ban on small business, two groups of small business need to be considered:

- small business in the waste management sector; and
- small business more generally.

Small business in waste management sector

Noting that most waste management businesses in Victoria meet the Australian Securities and Investment Commission definition of a small business[153], it is likely that many of the jobs created in recycling industries as described above are likely to be in the small business sector.

While large businesses in the e-waste management sector may already comply with the proposed new e-waste management requirements, some small businesses in the sector will face costs to achieve compliance because they tend to operate at a standard lower than the proposed requirements. The requirements that are likely to have greatest impact will be those that require new infrastructure, such as that needed to create appropriate storage areas and new pollution controls. The requirements to keep certain records may also increase costs. However, it is expected that the increase in volumes of e-waste channelled through this sector will result in an increase in profit, and as such, it is likely that implementation of the preferred policy will result in positive impacts for this group.

Small business in general

While the broader macroeconomic implications of a landfill ban have not been explicitly quantified, it is clear from the analysis above that implementation of the proposed policy approach will increase costs for business (including small businesses) associated with e-waste disposal. This is because e-waste will now need to be managed separately to general waste. Where e-waste may currently be collected as part of existing local council services, particularly in metropolitan areas, this may not necessarily continue with the implementation of the policy.

As such, business costs have been estimated in the CBA as the costs of participating in e-waste collection (i.e. the cost of engaging commercial e-waste collectors in metropolitan areas or the time costs of drop-off in non-metro areas) less costs avoided in general waste collection. Figure 12 and Figure 13 above show these as ranging between $12 million and $25 million in NPV terms to 2035, or $0.7 million to $1.4 million per annum in 2016 dollar terms. Spread across all businesses in the economy, this is a minor impact, reflecting the fact that waste disposal is a small percentage of business total costs (<1 per cent). The cost impacts on small businesses for diverting e-waste to a recovery option are therefore likely to be minor.

4.4.15 Competition impacts

In considering the potential for competition impacts, the relevant question is whether implementation of the landfill ban and management requirements will unfairly favour some businesses at the expense of others, or will create barriers to market entry.

The businesses most relevant to this analysis are any that generate, collect, transport, store, treat or dispose of e-waste. In the generation end of the chain, this range of business types is extremely broad given most businesses today rely on electronic or electrical equipment to operate. Examples of each are shown in Table 17.

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[153] Defined as a business with an annual turnover of <$25 million

Table 17: Businesses involved in the e-waste chain of custody

Role in e-waste chain	Examples of businesses
Generation	Any type of organisation that uses electrical or electronic equipment to operate e.g. post office outlets, fitness centres, administrative offices, medical centres, commercial kitchens, retailers etc
Collection / storage	E-waste recyclers, metal recyclers, material recovery facility operators, warehouse operators, retailer outlets offering take-back services
Transport	E-waste recyclers, waste management organisations, transport companies
Treatment	E-waste reprocessors, metal recyclers, repair services
Disposal	Landfill operators

Businesses that generate e-waste will need to seek an appropriate recovery option rather than landfill disposal. Most large organisations do this already through contracted waste management services. However, many smaller businesses currently manage their own e-waste, so they would now need to send it to an e-waste processor or a transfer station. But this will apply to all businesses that manage their own waste.

Businesses in regional Victoria may need to transport e-waste further distances to appropriate recovery options, and therefore would face greater costs than their metropolitan counterparts. Businesses that compete in all other aspects, however, will be affected by the new policy in the same way.

Businesses involved in the e-waste chain downstream of generation, i.e. those that collect, store, transport and treat e-waste should also be affected proportionately. They will all have obligations to avoid disposing e-waste to landfill and to protect the environment and human health through requirements such as adequate storage and transport conditions, minimum processing standards and pollution controls. While these requirements will incur additional costs in some ways, they also aim to create a more level playing field. In the absence of these new requirements, it could be said that those who do not operate under practices that effectively manage the risks of e-waste have a competitive advantage over those who do. Without the new policies, the current framework can also encourage the entry of new businesses that have little intention of providing a long-term, safe and environmentally sound service, again impacting the financial sustainability of others.

Conversely, the policy package may advantage those who already operate under best practice environment and human health practice as they may be more ready to take advantage of the increased volumes and types of e-waste channelled through recovery options. The Andrews Labor Government has accepted that restricting competition to encourage practices that best protect environment and human health is an acceptable approach. The design of the policy package, and its implementation, monitoring and evaluation, will be critical to ensure this requirement for better reprocessing practice is not creating unnecessary barriers to entry, and therefore excessive restrictions to consumer/business choice, concentration of market power and ability of certain firms to adapt prices.

The policy package should not significantly or unequally affect the existing structure of those working across the e-waste chain.

Government procurement processes, such as in relation to delivery of the education campaign or state-administered collection service, have potential to either enhance or detract from competition depending on the structure of the procurement process, and thus must be undertaken in a way that promotes competition. However, the proposed policy in general imposes no apparent restrictions on competition.

4.5 Summary

Option 1a – comprehensive landfill ban (all e-waste) with high level of access to collection services

Option 1a is likely to result in the greatest diversion of e-waste from landfill – an average 54,000 tonnes/year – mainly because Victorians in metropolitan areas would have access to an e-waste kerbside recycling service. However, to achieve this level of household access to collection services involves a high public expense: total collection costs are $65 million in present value terms over the period to 2035, compared to $2 million or $8 million under access options without kerbside recycling. Even taking into account the lower transport costs for households and the higher volumes recycled, the average costs for collection, sorting, transport and disposal at $276 /tonne are $30-40 /tonne higher than under the access models without kerbside recycling. As in the other options (bar Option 2), margins for reprocessors are sufficiently high to generate a small net benefit and positive BCR overall, after netting off collection, sorting, transport and disposal costs as well as the costs incurred by the state in implementing and administering the new policy.

Option 1b – comprehensive landfill ban (all e-waste) with low level of access to collection services

Option 1b would achieve slightly less diversion of e-waste than Option 1c (31,000 tonnes per annum), because the main way Victorians could access collection services would be through their existing transfer stations (without additional collection events). E-waste generators would bear a greater part of the costs because further travel is required, but the per tonne costs of collection, sorting, transport and disposal are basically on par with Option 1c ($237 /tonne). With access to collection more difficult, this option is possibly also more likely to result in an increase in illegal dumping.

Option 1c – comprehensive landfill ban (all e-waste) with medium level of access to collection services (PREFERRED)

Option 1c would achieve significant diversion of e-waste from landfill, although not as much as under a kerbside collection system. Around 34,000 more tonnes of e-waste per annum are expected to be recycled, thanks to a significant improvement in access to collection services around Victoria – provided through permanent drop-off points at transfer stations and scheduled collection events – in combination with the effect of the regulatory ban. Public collection costs are significantly lower than in Option 1a but much of this saving is offset by higher sorting costs and higher costs to households associated with participating in drop-off. Total collection, sorting, transport and disposal costs at $248 /tonne are significantly lower than in the options with kerbside recycling. Options 1b and 1c are more cost effective than other options in terms of the cost in dollars and time borne by the general public per tonne of e-waste recycled.

At this point in time Option 1c is the preferred option for the Andrews Labor Government. Although it is unlikely to drive as much diversion of e-waste from landfill as the options with kerbside recycling, it still delivers significant improvement in recycling rates – with an approximately 50 per cent increase in e-waste recycled over BAU – and is a more cost-effective collection model with significantly lower public costs overall.

Option 2 – Partial landfill ban (most hazardous e-waste only) with high level of access to collection services

Option 2 results in a negative net benefit, mostly because of the expected low volume and narrow range of e-waste items collected – even with kerbside collection in place. This results in higher average costs for collection, sorting and transport of e-waste, and lower average values for the materials recovered. It would also require a more carefully structured education and communication campaign to ensure community was clear on which types of e-waste were included in the ban.

Option 3 – No landfill ban (all e-waste) with high level of access to collection services

Option 3 is expected to achieve a reasonable diversion of e-waste, similar to Options 1b and 1c, despite not including a regulatory ban. However, it is less cost-effective than Options 1b and 1c because its success relies on a high access collection model, which is expensive. These costs, as with Option 1a, would be borne mostly by local councils and their ratepayers.

5 Implementation

This chapter outlines the general approach for how the preferred option will be implemented. Note that there are certain aspects to this policy that make implementation complex and as such, some detail is yet to be further defined.

Firstly, the preferred option is not just a regulatory change: rather it is a package of interdependent measures which must be delivered in an ordered manner to prevent perverse outcomes.

Secondly, delivery of these different measures will be led by different Victorian Government agencies. Coordination between agencies will be critical to ensure communications and critical activities are complementary.

5.1 Governance

The development and analysis of the preferred option has been led by the Victorian Government's **E-waste Working Group** (EWG), which comprises representatives from DELWP, EPA, SV and Victoria's WRRGs. The role of the EWG has been to identify and develop options to implement the Andrews Labor Government's commitment to ban e-waste from landfill, and drive the delivery of the commitment.

The EWG will continue to play a core role in the implementation of the preferred option to ensure it is implemented in a timely manner, and in consultation with key stakeholders. With DELWP to coordinate, the EWG will also be critical to ensure essential data is collected that can be used to monitor and evaluate the effectiveness of the preferred option. The EWG will also be responsible for briefing the Victorian Government's environment portfolio executive team and the Minister for Energy, Environment and Climate Change.

The Victorian Government's **Waste and Resource Recovery Project Control Board** (WRR PCB), comprising executive level representatives from DELWP, EPA, SV and Victoria's WRRGs, was the governing body for the EWG. It provided clear direction and boundaries for the project and ensured project objectives were realised.

The WRR PCB will be important to address issues as they arise throughout the implementation of the preferred option and to ensure feedback on indicators and evaluation results contribute to ongoing improvements to the policy.

5.2 Consultation

Consultation, particularly over the first five years, with various stakeholder groups throughout the implementation of the preferred option will be critical to monitor the effectiveness of the ban and to ensure the risks listed in section 4.3 are managed appropriately.

The **Local Government E-waste Reference Group**, initially established to provide input into the development of the preferred option, will be key to providing insight into how the policy is working on the ground. The EWG will establish a regular format for dialogue between the two groups over the first five years.

The EWG will also seek opportunities to speak with industry representatives from e-waste recycling, waste management and resource recovery, and landfill operation through arranged meetings, industry conferences, and other relevant forums.

The Victorian Government will seek to consult with the Commonwealth Government, particularly in relation to how well the ban is working with the National Scheme, and other Australian state and territories, to understand any inter-jurisdictional impacts from the ban

A more detailed five-year consultation plan will be developed for release at the time the e-waste landfill ban takes effect in July 2018.

5.3 Delivery

This section discusses how each component of the preferred option will be implemented in detail.

5.3.1 Legislated landfill ban

To legally ban e-waste from landfill, the most appropriate approach is to amend EPA's existing *Waste Management Policy (Siting, Design and Management of Landfills) No. S264* to include e-waste as a material banned from landfill.

The *Waste Management Policy (Siting, Design and Management of Landfills) No. S264*[154] (WMP (Landfills)) states, under subclause 19(2) that EPA Victoria (the Authority) may 'prohibit the disposal of specified wastes to landfill where the Authority determines that a higher practicable waste management option exists consistent with the policy or where a significant environmental risk exists'. As such, it is proposed to add e-waste to the existing list of prohibited waste types under subclause 19(6).

'E-waste' is a very broad term that can mean different things in different states and countries. To ensure this term is clear to those using the WMP (Landfills), a new simple term will be added to subclause 19(6) in the WMP (Landfills), further information in clause 6 (Definitions), and an extra schedule that provides examples. Details are as follows.

- Under subclause 19(6), add 'E-waste'. Also, delete item (d) (small batteries) as they will be covered by the new term.
- Under clause 6, Definitions, add 'E-waste means waste equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields'.

SCHEDULE B: EXAMPLES OF ELECTRICAL OR ELECTRONIC EQUIPMENT PROHIBITED FROM LANDFILL

Large appliances	Professional tools & equipment	Small household tools & appliances	Computers, TVs, IT	Lighting & mobile phones	Leisure, PV
• refrigerators • washing machines • cookers • microwaves • electric fans • air conditioners	• welding, soldering, milling • medical devices • monitoring and control equipment • automatic dispensers	• irons • toasters • coffee machines • hair dryers • electric tools • sewing machines • musical instruments • batteries	• computers • monitors • laptops • mice, keyboards, routers • printers • CRT TVs • Flat screen TVs (LCD, LED, plasma)	• fluorescent lamps • high intensity discharge lamps • compact fluorescent lamps • LEDs • mobile phones	• toys • game consoles • cameras • portable audio & video • remote controls • photosensitive semiconductor devices

[154] *Waste Management Policy (Siting, Design and Management of Landfills) No. S264* accessed via http://www.gazette.vic.gov.au/gazette/Gazettes2004/GG2004S264.pdf

The draft amended WMP (Landfills) is included as Appendix 1 **- Cost benefit analysis report**

Appendix 2.

Timing: This amendment to WMP (Landfills) would take effect on 1 July 2018.

Roles and responsibilities:

Organisation	Roles and responsibilities
EPA	• enforcing this WMP • supporting dutyholders to comply with this WMP • managing scenarios where e-waste may be disposed to landfill i.e. exempting disposal of e-waste
SV	• ensuring Victorians have access to information relating to this amendment
DELWP	• evaluating the effectiveness of the amendment • liaising with other jurisdictions about interstate impacts of the amendment • evaluating and reporting on the effectiveness of the ban
WRRGs	• supporting Victorians to understand their obligations under this amendment
Local government	• supporting Victorians to understand their obligations under this amendment • ensuring new services procured for waste management and resource recovery are aligned with the new legislative framework

Compliance and enforcement:

The Andrews Labor Government expects that all measures used to manage prohibited wastes brought to a landfill are in place, and have been adapted to capture e-waste by 1 July 2018. Chapter 7.4 Waste acceptance, in EPA's best practice environmental management publication 788.3, *Siting, design, operation and rehabilitation of landfills* describes what these measures are for all landfills.

These measures include signs that advise of wastes that may be deposited at the landfill, signs to show where recyclable materials must be placed, random inspections, and procedures that deal with the dumping of prohibited wastes, identification of the source of the prohibited waste, isolation of the prohibited waste and notification of authorities.

The EPA will enforce this WMP (Landfills) in line with EPA's *Compliance and Enforcement Policy*, that is, by applying a risk-based approach. EPA expects that, while small volumes of e-waste are likely to filter through to landfill, every endeavour should be made to prevent large quantities of e-waste entering the landfill cell. EPA will expect landfill operators to be guided by actions outlined in the BPEM (Landfills).

As with other requirements of the WMP (Landfills), EPA will use administrative notices as first recourse against non-compliance, with the potential to take enforcement action for breach of notice if the duty holder fails to comply.

5.3.2 Legislated e-waste management requirements

To ensure appropriate management of e-waste in Victoria, we propose that the most appropriate approach is a new waste management policy that specifies how e-waste should be managed.

The draft *Waste Management Policy (E-waste)*, (WMP (E-waste)) describes the responsibilities and requirements for e-waste collection, storage, transport, and treatment to prevent e-waste going to landfill and manage the impacts on the environment and human health. The WMP (E-waste) is shown as Appendix 3.

There are three requirements under section 6 in the WMP (E-waste) that will apply to any person involved with e-waste. Section 7 specifies requirements that apply to e-waste service providers, those responsible for e-waste collection, storage, handling, transport, reuse, repair or reprocessing. Table 18 and Table 19 list these requirements.

Section 8 specifies how a person can comply with the WMP (E-waste), and refers to the Australian/New Zealand Standard, AS/NZS 5377:2013 *Collection, storage, transport and treatment of end-of-life electrical and electronic equipment*.

Table 18: General requirements in WMP (E-waste)

General requirements (section 6)
(1) This clause applies to any person involved in the following activities with respect to e-waste: a. generation; b. collection; c. storage; d. handling; e. transport; f. reuse; g. repair; h. reprocessing.
(2) A person must take all reasonable steps to eliminate or reduce the risk of harm to human health and the environment associated with e-waste.
(3) Without limiting subclause (2), a person must take all reasonable steps to: (a) prevent e-waste disposal to landfill; and (b) maximise recovery of output materials from e-waste; and (c) prevent breakage or spoilage of e-waste that might limit its suitability for reprocessing; and (d) if applicable, provide e-waste to an e-waste service provider who complies with this Policy.

Table 19: E-waste service requirements in WMP (E-waste)

Requirements for e-waste services (section 7)
(1) An e-waste service provider must only store e-waste for the purposes of transfer, reuse, repair, recycling or reprocessing.
(2) An e-waste service provider must take all reasonable steps to minimise the duration of storage of e-waste under their control or in their possession.

(1) An e-waste service provider who receives a load of specified e-waste greater than 3 cubic metres must record the following information for the load:

  (a) a description or name and address of the person responsible for the generation of the specified e-waste or the name and address of the e-waste service provider previously in possession of the specified e-waste;
  (b) the date of receipt of the incoming load;
  (c) a description of the specified e-waste;
  (d) the amount or quantity of the specified e-waste.

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(3) A person or e-waste service reprocessing e-waste must record the following information during a financial year:

  a. Description of input material.
  b. Weight of input material.
  c. Recycling process, including all stages of multi-stage recycling process.
  d. Weight of output material.
  e. Classification by type of the output material.
  f. Further reprocessing of output material.
  g. Weight of waste to landfill.
  h. End-market and end-use for useable materials.

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(4) An e-waste service provider who receives specified e-waste that is subsequently transported to another premises must record the following information for each load transported:

  a. the date the specified e-waste is transported;
  b. the name and address of the premises to which the specified e-waste is transported;
  c. a description of the specified e-waste;
  d. the amount or quantity of the specified e-waste.

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(5) An e-waste service provider responsible for reprocessing of e-waste must record the following information during a financial year:

  a. the description of incoming e-waste;
  b. the weight of incoming e-waste;
  c. the type of processes used, including all stages of a multi-stage process;
  d. the classification, weight and destination of output materials;
  e. the weight of residual waste.

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(6) An e-waste service provider responsible for reprocessing of e-waste must calculate and record material recovery rates, for each financial year, either:

  a. in accordance with the following formula, using the information recorded under subclauses 7(3) and 7(4):

$$\text{Material recovery rate (\%)} = \frac{\text{weight of output materials}}{\text{weight of incoming e-waste}} \times 100$$

or

  b. if batch processing assessment is used to assess and report material recovery rates, by calculating the rates in accordance with Appendix D in AS/NZS 5377:2013.

(7) An e-waste service provider responsible for reprocessing of e-waste must meet or exceed the minimum material recovery rate provided by:

a. an accredited voluntary or an approved co-regulatory arrangement under the Product Stewardship Act 2011 of the Commonwealth; or
b. the minimum acceptable processing, end-use and method of disposal requirements in Table 1 of AS/NZS 5377: 2013.

(8) An e-waste service provider must retain records required under this clause for at least 5 years.

Timing: This WMP (E-waste) would take effect on 1 July 2018.

Roles and responsibilities:

Organisation	Roles and responsibilities
EPA	• enforcing this WMP • supporting industry to comply with this WMP
SV	• ensuring Victorians have access to information on the options for safe management of e-waste
DELWP	• evaluating the effectiveness of the WMP
WRRGs	• ensuring Victorians are aware of this WMP and understand their legal obligations
Local councils	• ensuring waste management and resource recovery services used are aware of this WMP and understand their legal obligations • ensuring Victorians have access to information on the options for safe management of e-waste

Compliance and enforcement:

Achieving compliance with this WMP (E-waste) may take between 12 and 24 months. New infrastructure and processes will be required such as appropriate storage areas at transfer stations, renegotiation of contracts, and record-keeping systems. The Andrews Labor Government acknowledges this and proposes a customised approach to enforcing the new requirements.

For the first 12 months after the WMP (E-waste) takes effect, EPA will expect that a person managing e-waste is working towards compliance with the WMP (E-waste). To demonstrate this, a person must be able to show evidence of their plans for meeting the requirements, such as infrastructural upgrades, system changes, training and education programs, procedures, compliance plans etc needed to address the risks that e-waste presents to the environment and human health.

This approach to enforcement allows time to develop and implement systems, controls and processes that support safe recovery of e-waste.

After the first 12 months, EPA will expect compliance with all requirements in the WMP (E-waste), and enforce in accordance with EPA's *Compliance and Enforcement Policy*, that is, apply a risk-based approach. The EPA will focus on areas that:

- present the greatest risk to the environment and human health, particularly those areas that may result in dust emissions, contamination of land and groundwater, and fire. In particular, measures that prevent breakage and crushing of e-waste, that control and monitor dust, and that minimise incidents of fire will be important.
- prevent e-waste contamination of general waste and other recycled streams
- support a person to understand their obligations.

EPA will make both planned and random inspections of operations that manage e-waste at any time after the date the WMP (E-waste) takes effect. The WMP (E-waste) will be enforced via administrative notices as first recourse, with the potential to take enforcement action for breach of notice if the duty holder fails to comply.

5.3.3 Education and awareness campaign

This component of the approach is a three-year, state-wide, e-waste education and awareness campaign. By implementing a consistent and coordinated campaign, those involved in the generation, collection, transportation, treatment and disposal of e-waste will be informed of the shared responsibility to protect the environment and human health. They'll also have access to information on safe management options for e-waste.

The campaign aims to divert e-waste from landfill through improved recovery of e-waste by:

- increasing community participation and understanding of e-waste management and resource recovery infrastructure and services, and
- promoting available options for managing e-waste – by recycling, reusing and disposing of e-waste responsibly

The campaign will be shaped by social research and stakeholder consultation. Stakeholders across the e-waste value chain will be engaged to support practical and effective design and implementation. The target audiences and key stakeholder groups are likely to include households, small to medium enterprises, large organisations, local government, and waste management and resource recovery service providers, and the e-waste recycling industry.

The Andrews Labor Government has allocated $1.5 million over three years to design and implement this campaign. While further detail is yet to be determined, the campaign package will likely include campaign creative, educational resources for local government, local government engagement, digital platform and advertising covering print (limited), radio and digital advertising (display and social media) and metropolitan and regional television.

The education and awareness campaign will need to include intensive community education and information in the lead-up to and immediately following key changes, and on an ongoing basis. This is based on similar, waste- and environment-related education campaigns costed and/ or implemented in Victoria and elsewhere in Australia including, for example, water efficiency education programs implemented in the 2000s in Victoria and litter and recycling education programs implemented or costed for Victoria and NSW. The key stages would be:

- Stage 1 - Pre-ban program– This stage of the program aims to inform key audiences of what e-waste is, and the ban.
- Stage 2 - Post-ban program– This stage of the program will inform all Victorians of the ban and the disposal and recycling opportunities for e-waste.
- Ongoing - There will also be an ongoing element to the campaign. Materials such as flyers, videos and messaging that can be adapted to different regions and councils, will be developed in partnership with councils and be accessible on an ongoing basis.

The campaign will be delivered in accordance with the Victorian Government Campaign processes, managed by the Department of Premier and Cabinet. This covers campaign approvals, media buy processes and campaign evaluation.

The reach of the campaign will benefit strongly from the willingness of stakeholders to disseminate information and provide advice on e-waste recycling options. Help will particularly be important from local government, e-waste recycling industry representatives, e-waste product stewardship operators, relevant peak bodies and industry associations, charitable recycling organisations and community organisations.

Timing: Stage 1: January - March 2018

Stage 2: March – September 2018

Roles and responsibilities:

Organisation	Roles and responsibilities
SV	• designing and implementing the campaign and associated tools • supporting key delivery partners, e.g. local councils with training and materials etc • evaluating the campaign
EPA	• input into design of the program, including funding distribution criteria
DELWP	• input into design of the program, including funding distribution criteria
WRRGs	• input into design of the program, including funding distribution criteria • supporting local councils to utilise the tools developed by SV
Local government	• input into design and development of campaign resources and tools • supporting the delivery of education materials to community

5.3.4 Improved collection network

This component of the approach will address the components in the proposed policy package that relate to collection infrastructure and a collection service. Development of the component will need to consider necessary upgrades to collection infrastructure, collection services and capacity building support, to ensure there is an adequate collection network across Victoria for e-waste generators to drop off their items, and for those sites to safely store e-waste items until they can be transferred for processing.

The Andrews Labor Government has allocated $15 million over four years to design and implement this program. Further assessment will be needed to confirm how the funding will be applied, but at this stage, the program will likely result in the following components:

Stage 1: Analysis of the existing state-wide e-waste collection network to provide advice on:

- the extent of the existing collection system, including the number of collection points and services available and their ability to meet new requirements
- how the design choice in the initial modelling of the access level (outlined in section 3.3.3) addresses on-the-ground needs, and therefore any gaps in the proposed model
- the capacity and capability of these collection options to receive and store e-waste in line with the existing AS/NZS 5377:2013 *Collection, storage, transport and treatment of end of life electrical and electronic equipment*.

- the cost of upgrades and any new services identified as necessary

Stage 2: Funding program to address areas in Victoria where there is inadequate access to e-waste collection sites or facilities that cannot safely store e-waste. It will initially target transfer stations and resource recovery centres to improve storage infrastructure, and where possible, develop other measures to support those managing e-waste.

Proposed timing: Stage 1: July – September 2017

Stage 2: September 2017 – September 2018

Roles and responsibilities:

Organisation	Roles and responsibilities
SV	• assessing current state collection network • implementing a program to improve e-waste collection infrastructure • supporting key delivery partners, e.g. local councils
EPA	• input into funding distribution criteria • oversight of compliance with WMPs
DELWP	• input into design of the program
WRRGs	• input into design and development of the collection infrastructure program, including funding distribution criteria
Local government	• input into the development of the collection infrastructure program • supporting collection and drop-off services for householders and SMEs • ensuring collection /drop-off sites are safely managed to minimise environmental and health risks
E-waste industry, relevant peak bodies and industry associations, product stewardship operators	• providing feedback on efficiency of network • promoting e-waste recycling options

5.4 Risk management

Table 20 outlines the key risks that may result from the implementation of the preferred option, as discussed in section 4.3.3. It lists measures that are in place already, those that are proposed as part of the preferred policy package, and other planned mitigation work.

Table 20: Risks and mitigation measures

Risk	How the preferred option will mitigate this risk	Measures already in place	Other planned mitigation work
Inappropriate disposal - dumping	An improved collection network aims to reduce the barriers e-waste generators may face when managing e-waste. The education and awareness campaign aims to encourage more e-waste generators to use the collection network.	EPA's Illegal Dumping Strikeforce tackles large scale dumping. Victoria's WRRGs are working to better understand local government dumping issues, with the aim of identifying priority wastes and regions to focus further efforts.	The Andrews Labor Government's pilot Officers for the Protection of Local Environment (OPLE) program will support councils to tackle a range of local issues, including illegal dumping of waste. The pilot will run from September 2017 – December 2018.
Inappropriate disposal – mixing e-waste in other types of waste destined for landfill	Education and awareness campaign aims to prevent householders mixing e-waste with general waste or recyclables. The new WMP (E-waste) requires e-waste recyclers to keep records of incoming and outgoing e-waste. If inspected, these records would highlight significant imbalances.	EPA's industrial waste regulations require categorisation of solid industrial waste before disposal from industrial sites.	
Inappropriate disposal – stockpiling	The new WMP (E-waste) requires a person to minimise how long they store e-waste.	E-waste recyclers licensed by EPA are subject to a condition that limits storage volumes. The Andrews Labor Government has established a taskforce to audit recycling facilities across Victoria, and identify and prioritise sites that require extra management measures to ensure community safety. To complement this work, an interim waste management policy has been prepared to require facilities to appropriately store materials, assess risks, and comply with fire services guidelines.	The Andrews Labor Government's pilot Officers for the Protection of Local Environment (OPLE) program aims to support councils to tackle a range of local issues, including unsafe stockpiling. The pilot will run from September 2017 – December 2018. Other EPA and local government compliance activity may uncover these scenarios.

Risk	How the preferred option will mitigate this risk	Measures already in place	Other planned mitigation work
Inappropriate disposal – illegal export	Clause 3 in the WMP (E-waste) requires a duty-holder to ensure that all e-waste services used comply with the WMP. Clause 4 in the WMP (E-waste) requires an e-waste service to keep records that show destination of outgoing e-waste. If inspected, these records would uncover inappropriate receivers of e-waste.	The Basel Convention and the Commonwealth's *Hazardous Waste (Regulation of Exports and Imports) Act 1989* acts to deter illegal export.	Guidance will be developed to help duty-holders comply with the WMP (E-waste). This will include guidance and resources to ensure the relevant requirements for interstate or international movement of e-waste are well understood. Collaboration with Commonwealth will be required to strengthen how the Basel Convention is enforced in Australia.
Unreasonable financial burden on e-waste collectors from uncommon or unpredictable market influences, e.g. excessive reprocessing costs	Improvements to the collection network, as outlined in section 5.3.4, will reduce initial costs associated with adapting sites to meet new requirements.	SV's new Better Practice Guide for Resource Recovery Centres[155] will assist transfer station operators to operate as efficiently as possible. Targets for the National Scheme will increase over time (to 80% by 2027) which will further reduce the cost of televisions and computers over time. For those who can demonstrate they have strong case for disposal to landfill, e.g. in the case where there is no (safe or viable) alternative, an existing approval process (under section 30A of the EP Act) will be available.	The option of including other types of e-waste in the National Scheme is currently being assessed by the Commonwealth.
Environmental, OH&S risks during reprocessing	The new WMP (E-waste) applies to all e-waste reprocessors and specifies a range of measures that aim to control environmental risks.	E-waste reprocessors licensed by EPA must comply with conditions that aim to control environmental risks. These will be enforced through EPA's compliance and enforcement program. WorkSafe Victoria Compliance Codes help dutyholders, such as employers and managers, understand how they can comply with Victorian OH&S standards.	DELWP will liaise with WorkSafe Victoria during the implementation of the policy package to ensure any emerging OH&S related issues are identified and addressed as soon as possible.

[155] Sustainability Victoria (2017) Better Practice Guide for Resource Recovery Centres <not yet published>

5.5 Resourcing

Table 21 summarises the resources required to implement this policy package.

Table 21: Resources needed

Resource breakdown	Estimated need	Who
WMPs	Approximately $200,000 per year to support compliance activities and enforcement of WMPs, as outlined in the cost-benefit analysis	EPA
	Approximately $500,000 across all councils per year to support regulation and administration of WMPs, as outlined in the cost-benefit analysis	Local government
Improved collection network	$15 million for program design and delivery	SV
	Project management support	Local government
Education and awareness campaign	$1.5 million for campaign design and delivery	Victoria
	Supporting delivery of campaign	Local government

6 Evaluation strategy

This evaluation will enable the Victorian Government to know whether the preferred policy package was effective in achieving its objectives, to understand how it can be improved, and to ensure the integrity of Victoria's environmental framework. The package is formed around the broad assumption that it will divert more e-waste from landfill to safe recovery processes. This relies on the ability to achieve certain intermediate outcomes, as shown in the intervention logic in Figure 14.

This evaluation will monitor and assess information at various points to determine how well the policy package is performing against the long-term objectives stated in section 3.1 and the intermediate outcomes.

Figure 14: E-waste policy package intervention logic

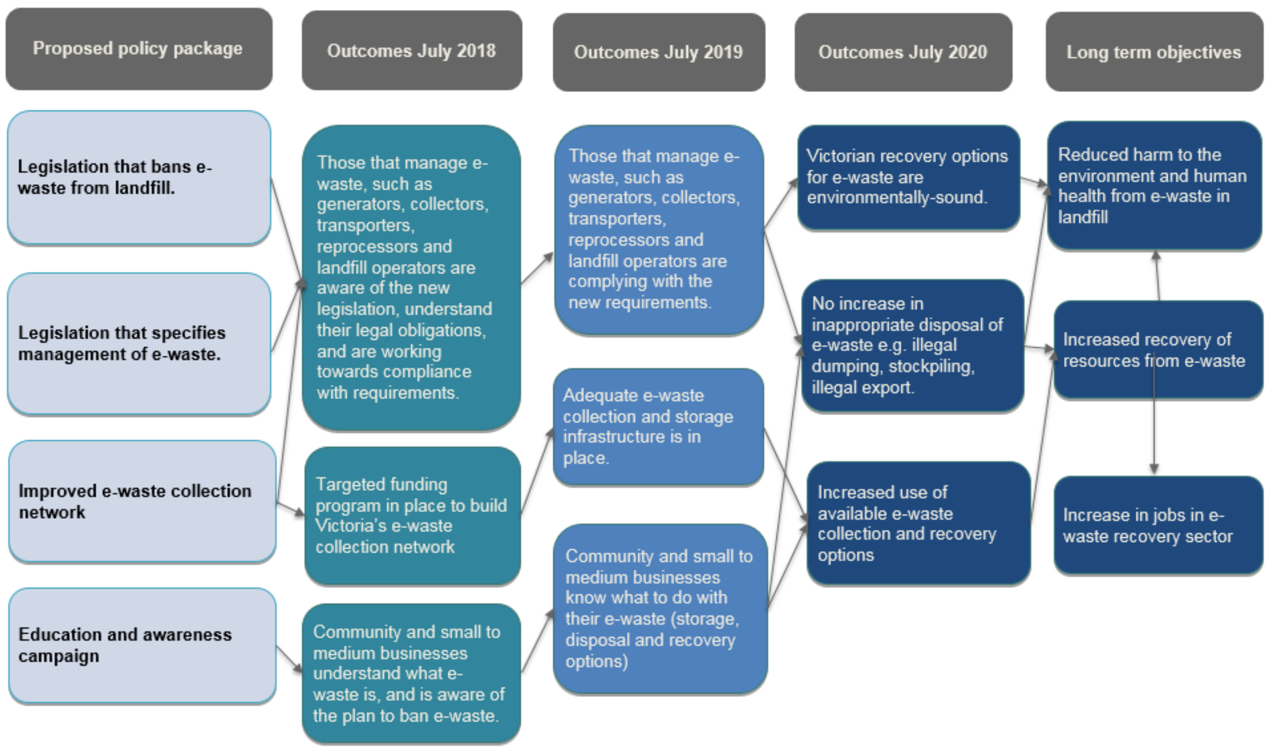

Table 22 lists what outcomes and long term objectives will be measured, how and when they will be measured, and who will be responsible.

Table 22: Measuring outcomes and long-term objectives

Outcome	Indicator	How	Who	When	Baseline
Improved compliance against legislated requirements	Number of warnings, PANs applied to e-waste managers Number of reported non-compliances by e-waste managers	Reports from compliance inspections and responses to community reports Annual performance statements from licence-holders (self-reported)	EPA	Annual, as targeted through EPA's Annual Compliance Plan	EPA inspections planned for 2017-18 to understand baseline level of compliance
Adequate access to e-waste collection points	Number of transfer stations and collection points available for e-waste collection	Assessments through collection network improvement projects	WRRGs, SV	2017 – 2019: every 6 months	Initial assessment planned for late 2017
Increased use of e-waste collection network	Volumes of e-waste collected at transfer stations	Local government annual survey	SV	2018-2020: annually	Initial assessment planned for late 2017
Improved community understanding of e-waste	Level of community knowledge of what e-waste is	Social research (e.g. survey of households and SMEs)	SV	2018-2022: biannually	BehaviourWorks householder and SME survey 2017
No increase in illegally dumped e-waste	Volumes and types of e-waste being illegally dumped	Local council illegal dumping tool (currently being developed by SV) (small scale) EPA Illegal Dumping Strikeforce (large scale)	SV, WRRGs	2018-2020: annually	Initial assessment through local council dumping tool (no robust available data to date)
Increased level of understanding of ban and associated obligations by e-waste generators	Volumes of e-waste identified and rejected at landfill gate	Annual performance statements from licence-holders (self-reported)	EPA	2018-2020: annually	Volumes estimated in e-waste material flow analysis[156]
Increased e-waste recovery rate	Volumes accepted by recyclers	Data obtained directly from e-waste recyclers through industry survey	SV	2018-2020: annually	Volumes estimated in e-waste material flow analysis

[156] Randell, Pickin and Latimer, 2015, *Victorian E-waste Market Flow Analysis* accessed via http://www.sustainability.vic.gov.au/publications-and-research/research

Outcome	Indicator	How	Who	When	Baseline
		(requisite for Victorian Government funding recipients)			
Financial viability of e-waste recycling industry	Costs and benefits over time	Data obtained directly from e-waste recyclers through industry survey (requisite for Victorian Government funding recipients)	SV	Every five years	E-waste CBA[157]

[157] Marsden Jacob Associates (2017) *Cost benefit analysis of options to reduce e-waste from landfill,* report prepared for the Department of Environmental, Land, Water and Planning Victoria

DELWP will coordinate the overall policy evaluation, in close collaboration with EPA as the regulator of the regulatory component, and SV and Victoria's WRRGs as key deliverers of the non-regulatory components.

Evaluation of the preferred policy package will inform review of the waste management policies, which, according to the EP Act, must occur within 10 years after the day they come into effect. The evaluation will also inform the evaluations required for delivery of the non-regulatory components of the policy package, which will be funded by the Andrews Labor Government.

7 Stakeholder consultation

The development of the preferred policy package has been led by the E-waste Working Group in consultation with a wide range of stakeholders. Consultation activities to date have been both general and targeted and are summarised in Table 23. Government consultation with key stakeholder groups will be necessary during and after the implementation of the proposed package to ensure all components are monitored and progressively improved where possible.

Table 23: Stakeholder consultation

Purpose	When	How	Who
Initial information gathering	February – June 2015	One-on-one meetings WRR site visits Interjurisdictional meetings	Some Victorian state departments and agencies, including WorkCover Victoria, Department of Economic Development, Jobs, Transport and Resources South Australian Government counterparts EPA South Australia, ZeroWaste South Australia South Australian waste and resource recovery industry representatives Government waste policy counterparts from other jurisdictions
Further information gathering	September 2015 – March 2016	Information sessions Release of discussion paper Managing e-waste in Victoria – starting the conversation WRR site visits	General public Local councils WRR industry, including landfill and transfer station operators, e-waste recyclers, National Television and Computer Recycling Scheme participants and administrators
Testing high level policy positions	April – December 2016	Targeted stakeholder workshops WRR site visits One-on-one meetings Presentations	Local councils E-waste recyclers including social enterprises WRR industry, including peak bodies Property service contractors Victorian government departments, including Department of Health and Human Services
Testing details of possible policy interventions	February – July 2017	Reference group meetings WRRG forum presentations Transfer station network meetings Industry association conferences	Local councils E-waste recyclers Material recovery facilities Waste management contractors
Consultation on proposed policy package	August – November 2017	Release of policy impact assessment Information sessions Presentations	General public, including householders and businesses that generate e-waste Community groups Local councils WRR industry

Appendix 1 - Cost benefit analysis report

REVISED REPORT

APRIL 2017

Cost Benefit Analysis of Options to Reduce E-Waste from Landfill

Prepared for the Department of Environment, Land, Water and Planning, Victoria

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Glossary

Business-as-usual (BaU)	The outcome that would occur in the absence of a proposed new option (policy or program). BaU does not generally mean a frozen or static state. In the case of e-waste, BaU is associated with continued absolute growth in e-waste consumption, recycling and disposal to landfill
Benefit cost ratio (BCR)	In cost-benefit analysis, BCR identifies an option that provides the highest net community benefit per unit of cost relative to BaU.
Cost-benefit analysis (CBA)	CBA is a widely accepted method that compares the benefits and costs associated with alternative options quantified in monetary ($) terms. The scope of CBA is on economic (society wide) costs and benefits as opposed to the private benefits and costs assessed in a financial analysis
Distributional analysis	Analysis of the impacts of a policy or program on different sectors and stakeholder groups
E-waste	End of life electrical and electronic goods
E-waste diversion	Diversion of e-waste from direct disposal to landfill to an alternative end of life pathway (re-use or recycling)
E-waste recovery	The proportion of diverted e-waste that is recycled or re-used after taking into account waste that is a by-product of the recycling process
Hazardous waste	Waste that poses a recognised threat to human health and/or the environment and generally are listed in Annex I to the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal*.
Net present value (NPV)	In cost-benefit analysis NPV measures the expected benefit (or cost) to society of implementing a policy or program relative to BaU, expressed in monetary terms. It equals the present value of benefits less present value of costs (see present value below).
Present value (PV)	Present value is the value of a stream of costs or benefits that occur in the future, discounted to reflect their current value.
Willingness to pay (WTP)	The value that the community places on the wellbeing that it derives from an activity or outcome (in this analysis recycling of e-waste)

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Key findings

- Options 1a, 1b, 1c and Option 3 both have a small positive NPV and BCR, meaning that if either option were implemented there is a reasonable chance it would deliver a net benefit to the community based on central assumptions applied in the analysis.
- Option 2 has a negative NPV and BCR suggesting that it is unlikely to deliver a net benefit to the community based on central assumptions. A substantially lower average value of recovered materials under Option 2 is a major factor explaining its poor outcome relative to Options 1 and 3.
- Sensitivity analysis produces BCRs for Options 1a, 1b, 1c and 3 ranging from a low of 0.6 to a high of 1.8 (central estimate 1.0-1.1) and for Option 2 ranging from 0.4 to 1.3 (central estimate 0.7). Differences in assumptions about material values recovered through e-waste recycling is a key factor driving differences between the 'low' and 'high' estimates.
- It is highly unlikely that a landfill ban will be effective in achieving substantial improvements in e-waste recycling rates unless an identified 'gap' in the cost of collecting, sorting and transporting e-waste intended for recycling is met through additional investment by State government.
- The levels of investment required are somewhat lower under Options 1b and 1c than under Option 1a. A trade-off associated with implementing Option 1b or 1c in preference to Option 1a though, is a significantly lower rate of e-waste recycling.

Executive summary

Introduction

Marsden Jacob Associates, Blue Environment and Ascend Waste & Environment have been engaged by the Department of Environment, Land, Water & Planning (DELWP) to undertake a cost-benefit analysis (CBA) of options to reduce e-waste from landfill. The CBA is part of a broader process around a commitment by the Victorian Government to ban e-waste from landfill.

Five options have been assessed in the CBA incrementally to the base case option, referred to hereafter as 'business-as-usual' (BaU). BaU and options are all assessed over the period 2017-2035. The options are summarised below.

Business-as-usual (BaU)

- No regulatory landfill ban on e-waste
- Continued absolute growth in e-waste consumption, recycling and disposal to landfill
- No additional investment in collection, storage and processing infrastructure
- No additional investment in specific education campaign

Option 1a: Comprehensive landfill ban (with domestic kerbside collection service in metropolitan areas and permanent drop-off points in regional areas)

- Ban all e-waste from landfill
- Require specific management of e-waste
- Substantial additional investment in e-waste collection, transfer and transport services:
  - kerbside collection service provided in metropolitan areas for all domestic e-waste (overall universal access)
  - permanent drop-off points provided in regional areas for all domestic e-waste (very high level of access overall)
  - commercial collection service used in metropolitan areas for commercial e-waste
- Substantial additional investment in specific education campaign
- Ban in place June 2018
- Penalties to apply from June 2019

Option 1b: Comprehensive landfill ban (with permanent drop-off points in all areas for domestic e-waste)

- With the exception of e-waste collection services (see following point), the central features of this option are the same as for Option 1a)
- Significant additional investment in e-waste transfer and transport services:
  - permanent drop-off points provided in metropolitan areas for all domestic e-waste (high level of access overall)

- permanent drop-off points provided in regional areas for all domestic e-waste (moderate level of access overall)
- commercial collection service used for commercial e-waste in metropolitan areas

Option 1c: Comprehensive landfill ban (with permanent drop-off points in all areas for domestic e-waste plus collection 'events')

- With the exception of e-waste collection services (see following point), the central features of this option are the same as for Option 1a)
- Significant additional investment in e-waste collection, transfer and transport systems:
  - permanent drop-off points provided in metropolitan areas for all domestic e-waste plus a series of collection events (very high level of access overall)
  - permanent drop-off points provided in regional areas for all domestic e-waste plus a series of collection events (high level of access overall)
  - commercial collection service used for commercial e-waste in metropolitan areas

Option 2: Ban hazardous e-waste from landfill

- Ban specified e-waste containing significant hazardous material (see Table 3)
- Require specific management of e-waste
- Significant additional investment in collection and transfer systems as per Option 1 a)
- Residential collection service as per Option 1a)
- Greater education investment than Option 1, noting complexity of ban

Option 3: No regulatory landfill ban on e-waste

- No ban on e-waste going to landfill
- Significant additional investment in collection and transfer systems as per Option 1 a)
- Significant additional education investments as per Option 1

The purpose of the CBA is to assess the economic costs and benefits of each of the options incrementally to BaU. The CBA model integrates an economic model with a material flows analysis (MFA) model, noting that the physical flow of e-waste ultimately drives many (although not all) of the costs, benefits and distributional impacts of the options.

Cost-benefit analysis

Results

Results of the CBA are summarised in Tables ES.1 and ES.2.[1] The results show net costs and benefits of options relative to BaU assessed over the total period of the analysis, 2017-2035[2]. They are based on central or 'most likely' assumptions for cost and benefit items and material flows.

Key results are as follows:

[1] See Table 6, main report, for detailed results

[2] Note, although the ban is not in place until June 2018 some initial costs are assumed to be incurred in 2017.

- Options 1a, 1b, 1c and 3 all have small positive NPVs and BCRs greater than 1, meaning that if any of these options is implemented there is a reasonable chance it would deliver a net benefit to the community based on central assumptions applied in the analysis.
- Option 1a has a slightly higher NPV ($20 million) than Option 3 ($5 million) reflecting significantly higher benefits under Option 1 compared to Option 3 but also significantly higher costs.
- Option 1a also has a marginally higher NPV than either Option 1b ($10 million) or Option 1c ($13 million) reflecting significantly lower collection costs for councils but much higher participation costs for residents.
- Option 2 has a negative NPV and a BCR of 0.7, suggesting that it is unlikely to deliver a net benefit to the community based on central assumptions. The poor outcome for Option 2, relative to Options 1 and 3, reflects somewhat higher unit collection costs, significantly higher unit processing costs and a substantially lower average value of recovered materials.

It is important to note that differences between the options, in terms of net costs and benefits, are relatively small. The difference between Options 1a, 1b and 1c are insignificant, being within normal margins of error for major cost and benefit assumptions.

Table ES.1: CBA results summary, Options 1a, 2 and 3, Net Present Value (2017-2035)

	Present value of costs and benefits relative to BaU (2017-2035)		
	Option 1a	Option 2	Option 3
Collection costs	-$65,139,770	-$32,881,137	-$51,416,795
Metro	-$65,849,220	-$33,247,082	-$51,700,289
Non-metro	$709,450	$365,945	$283,494
Sorting costs	-$13,411,008	-$10,552,825	-$12,140,255
Metro	-$4,650,194	-$2,339,050	-$3,721,194
Non-metro	-$8,760,814	-$8,213,775	-$8,419,061
Transport to recyclers	-$59,598,172	-$22,387,651	-$40,470,316
Metro	-$27,915,569	-$9,426,416	-$20,483,570
Non-metro	-$31,682,603	-$12,961,235	-$19,986,746
Processing costs	-$280,448,146	-$116,100,059	-$200,150,945
E-waste	-$279,227,031	-$116,100,059	-$199,207,524
Metal	-$1,221,115	$0	-$943,421
Regulatory	-$8,642,371	-$6,758,160	-$909,049
Education costs	-$6,341,701	-$6,341,701	-$8,966,018
Total costs	**-$433,581,168**	**-$195,021,534**	**-$314,053,377**
Value of material recovered	$426,030,399	$123,943,626	$298,094,421
Avoided landfill costs	$13,679,920	$8,322,626	$10,463,081
Avoided environmental impacts of landfills	$13,948,262	$6,213,653	$10,146,454
Total benefits/ avoided costs	**$453,658,580**	**$138,479,905**	**$318,703,957**
NPV	**$20,077,412**	**-$56,541,629**	**$4,650,579**
BCR	**1.05**	**0.71**	**1.01**
WTP Threshold per tonne	**$931**	**$995**	**$942**

Table ES.2: CBA results summary, Options 1a, 1b and 1c, Net Present Value (2017-2035)

	Present value of costs and benefits relative to BaU (2017-2035)		
	Option 1a	Option 1b	Option 1c
Collection costs	-$65,139,770	-$2,335,417	-$8,355,239
Metro	-$65,849,220	-$2,960,254	-$7,561,739
Non-metro	$709,450	$624,837	-$793,500
Sorting costs	-$13,411,008	-$33,615,073	-$33,871,477
Metro	-$4,650,194	-$15,087,245	-$15,281,884
Non-metro	-$8,760,814	-$18,527,828	-$18,589,593
Transport to recyclers	-$59,598,172	-$33,185,411	-$36,856,336
Metro	-$27,915,569	-$15,897,484	-$17,454,594
Non-metro	-$31,682,603	-$17,287,927	-$19,401,742
Processing costs	-$280,448,146	-$157,901,270	-$172,746,104
E-waste	-$279,227,031	-$157,110,682	-$171,662,813
Metal	-$1,221,115	-$790,588	-$1,083,290
Regulatory	-$8,642,371	-$8,642,371	-$8,642,371
Education costs	-$6,341,701	-$6,341,701	-$6,341,701
Total costs	**-$433,581,168**	**-$242,021,243**	**-$266,813,229**
Benefits			
Value of material recovered	$426,030,399	$235,678,052	$261,961,112
Avoided landfill costs	$13,679,920	$8,603,681	$9,238,031
Avoided environmental impacts of landfills	$13,948,262	$8,157,340	$8,937,175
Total benefits/ avoided costs	**$453,658,580**	**$252,439,072**	**$280,136,317**
NPV	**$20,077,412**	**$10,417,830**	**$13,323,088**
BCR	**1.05**	**1.04**	**1.05**
WTP Threshold per tonne	**$931**	**$915**	**$915**

Sensitivity analysis

The CBA is necessarily based on a series of assumptions that mean there is a degree of uncertainty around the results. Sensitivity testing has been undertaken to clarify which assumptions can materially change the results. In particular, synchronised changes were made to a range of key cost and benefit items. This 'tornado' analysis provides feasible upper and lower bounds for the NPVs and BCRs for each of the options – referred to as 'high', 'low' analysis. Results of the 'high, low' analysis are presented in Table ES.3. They reveal:

- All options are sensitive to changes in cost and benefit assumptions, with BCRs for the options ranging from 0.6 to 1.8 for Option 1a, 0.6 to 1.8 for Option 1b, 0.6 to 1.8 for Option 1c, 0.4 to 1.3 for Option 2 and 0.6 to 1.7 for Option 3 (see numbers shaded in yellow).
- Options are particularly sensitive to changes in benefit assumptions, with material values being the key variable here (see numbers in red bold).
- Options are also sensitive to changes in cost assumptions, with changes to processing costs and collection, sorting and transport costs being equally significant (see lighter shaded areas).

Table ES.3: Results of 'high, low' sensitivity analysis (BCRs)

		Change benefits		
		Low case	Central case	High case
Option 1a				
Change costs	Low case	0.59	0.85	1.12
	Central case	0.73	1.05	1.38
	High case	0.92	1.33	1.75
Option 1b				
Change costs	Low case	0.58	0.83	1.10
	Central case	0.72	1.04	1.38
	High case	0.94	1.36	1.80
Option 1c				
Change costs	Low case	0.59	0.84	1.11
	Central case	0.73	1.05	1.38
	High case	0.94	1.36	1.80
Option 2				
Change costs	Low case	0.39	0.57	0.75
	Central case	0.49	0.71	0.95
	High case	0.64	0.93	1.25
Option 3				
Change costs	Low case	0.57	0.82	1.08
	Central case	0.71	1.01	1.34
	High case	0.91	1.31	1.73

Willingness to pay threshold analysis

Given uncertainties with the values attached to key benefit items in the analysis (i.e. value of recovered materials and value of avoided pollution from landfills) we have sought to estimate the community's willingness to pay (WTP) for the increased e-waste recycling that could be expected to occur with the implementation of either Options 1, 2 or 3. To do this we have interpolated results of a previous study into WTP for e-waste recycling (Rolls, Brulliard & Bennett, 2009), to derive a WTP estimate.

The result of that interpolation exercise is a WTP estimate of $884/ tonne of additional e-waste recycling plus a premium of $128 for each tonne of e-waste that is recycled via a kerbside collection system. Thus derived, an estimate of the community's WTP for additional e-waste recycling achieved through implementing either Option 1a, 2 or 3 is $1,012/ tonne. For Options

1b and 1c, which do not involve kerbside collection systems, the community's WTP for additional e-waste recycling is $884/ tonne.

These estimates can be compared to WTP threshold values of $931, $915 and $915 shown in Table ES.1 for Options 1a, 1b and 1c respectively and $995 and $942 shown in Table ES.2 for Options 2 and 3 respectively.

Drivers, risks and conclusions

Table ES.4 provides an understanding of the key factors driving results of the CBA and differences between the options.

Table ES.4: Key variables influencing CBA results

	Tonnes e-waste diverted from landfill relative to BaU, 2019-2035 ('000)		Net benefit (cost) per tonne diverted (PV$/ PV tonne)	Collection, sorting, transport & disposal costs (PV$/ PV tonne)	Processing costs (PV$/ PV tonne)	Value of materials recovered (PV$/ PV tonne)
	Actual	Present value (PV)[3]				
Option 1a	922	451	$44	($276)	($621)	$944
Option 1b	520	255	$41	($237)	($619)	$924
Option 1c	573	282	$47	($248)	($614)	$931
Option 2	393	188	($301)	($306)	($618)	$660
Option 3	664	322	$14	($290)	($621)	$925

Key information emerging from this table are:

- Each additional tonne of e-waste that is recycled (and therefore is diverted from landfill) is associated with net collection, sorting, transport and disposal costs of $276/ tonne (Option 1a), $237/ tonne (Option 1b), $248/ tonne (Option 1c), $306/ tonne (Option 2) or $290/ tonne (Option 3). The factors driving differences in collection costs between the options are:
  - Options 2 and 3 have slightly higher collection and sorting costs than Option 1a because the volumes of additional e-waste recycled under Options 2 and 3 are significantly less than under Option 1a, whereas some costs, notably upfront costs associated with upgrading transfer stations, are not proportionately lower; and
  - Options 1a and 1b have somewhat lower costs than Option 1a due to the use of drop-off points and collection events in metropolitan areas under those options rather than more expensive kerbside collection systems. It is important to note however, that much of the cost savings to councils and/or state government under Options 1b and 1c relative to Option 1a are offset by increases to household participation costs (see section 3). Furthermore, on a $/ tonne basis, costs associated with transporting the e-waste to recyclers are as significant under these two options as they are under Option 1a.
- Each additional tonne of e-waste processed or recycled has an average cost of $621/ tonne (Option 1a), $619/ tonne (Option 1b), $614/ tonne (Option 1c), $618/ tonne (Option 2) or $614/ tonne (Option 3). These differences are minimal and are within the normal range of margins of error.

[3] See glossary for definition of present value (PV)

- Each additional tonne of e-waste processed has a material value of $944/ tonne (Option 1a), $924/ tonne (Option 1b), $931/ tonne (Option 1c), $660/ tonne (Option 2) or $925/ tonne (Option 3). With the exception of Option 2, these differences are minimal and probably within the normal range of margins of error. Option 2 however, has a substantially lower average value of materials than the other options. This reflects the narrow range of products recovered under Option 2 compared to Options 1 and 3 and the intrinsically low value of materials in some of those products (e.g. CRT TVs and computers contain leaded glass which has a substantial negative value).

The low value of material recovered under Option 2 is the most important single factor explaining its low NPV and BCR relative to the other options.

Analysis of the key drivers reveals that there are substantial additional costs associated with collecting, sorting and transporting each tonne of recovered e-waste relative to the costs associated with collecting, transporting and disposing the e-waste to landfill.

The net collection costs of $276/ tonne, $306/ tonne and $290/ tonne respectively for Options 1a, 2 and 3 are likely to fall substantially on local councils (collection costs, sorting costs and some or all of costs associated with transporting the e-waste to recyclers), with a relatively small proportion of the costs falling on residential generators of e-waste (principally in regional areas). These collection, sorting and transport costs represent a substantial cost gap that will need to be met through investment by a third party - most likely by State Government – if an e-waste ban is to be effective in achieving assumed recycling rates.

Under Options 1b and 1c the net collection costs of $237/ tonne and $248/ tonne respectively are likely to be distributed more equally between residential consumers (participation costs) and local councils (sorting costs and costs associated with transporting the e-waste to recyclers). This means that the investment gap under these two options is less substantial than under Option 1a, albeit still significant. The key additional risk of these two options however, is that because households in metropolitan areas are being expected to participate more actively in the e-waste collection process compared to Option 1a (either through dropping off e-waste at transfer stations or retail outlets or during collection events) they will be less inclined to be involved in the e-waste recycling process, with the result that e-waste recycling rates are likely to be substantially lower under Options 1b and 1c than under Option 1a. There is also a risk that illegal dumping of e-waste will be greater under Options 1b and 1c than under Option 1a.

It is apparent that there are significant risks associated with implementing any of the options assessed through the CBA. Given those risks, and the need for ongoing investment to ensure effective recovery of e-waste, avoid e-waste stockpiling and/or illegal dumping and to minimise OH&S risks, consideration will need to be given to ways of encouraging e-waste recovery while avoiding the potential pitfalls associated with the options assessed through this CBA.

Distributional impacts

Stakeholder group impacts

Distributional impact analysis has been undertaken to provide information on the distribution of costs and benefits across different stakeholder groups.

Results of the distributional analysis are summarised in Figures ES. 1 and ES.2. The results reveal that a substantial proportion of the overall costs of implementing either Option 1a, 2 or 3 are expected to fall on local councils. Most of these costs are associated with collection and transport of e-waste. This further highlights the key risk to the success of an e-waste landfill ban should there be insufficient investment in e-waste collection, storage and transport infrastructure and services. On the other hand, under Options 1a and 1b there is a substantial shift of collection and sorting costs to residents, one consequence of this being low recycling rates relative to Options 1a.

Figure ES.1: Distributional impacts of options on stakeholder groups, Options 1a, 2 and 3 ($2016)

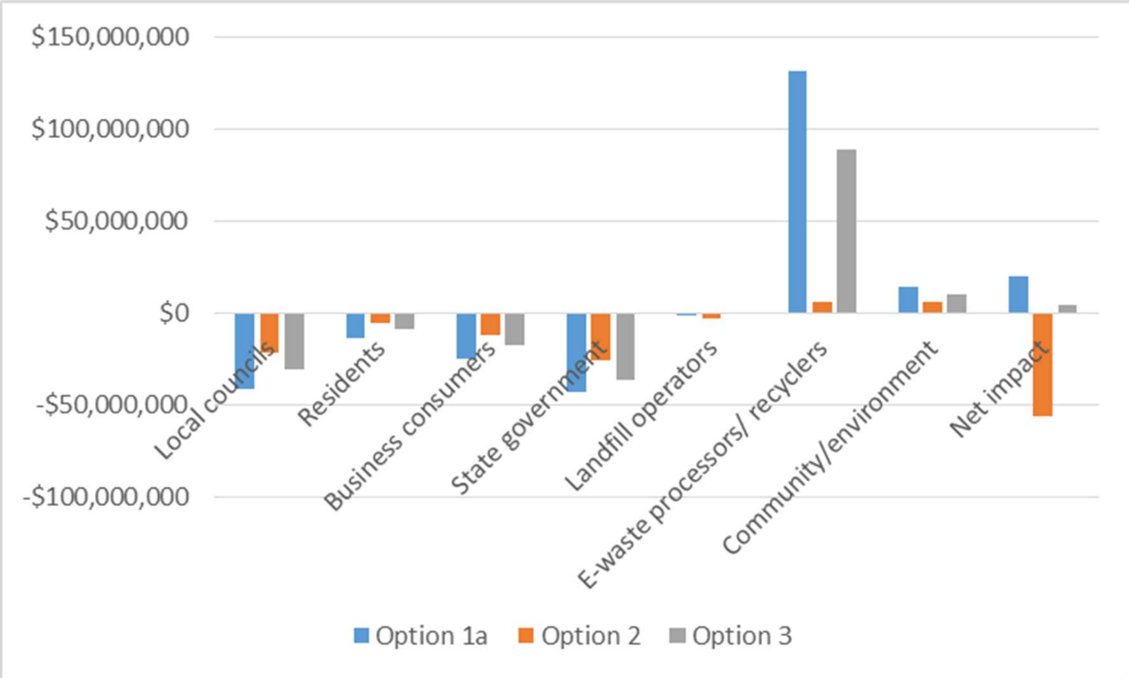
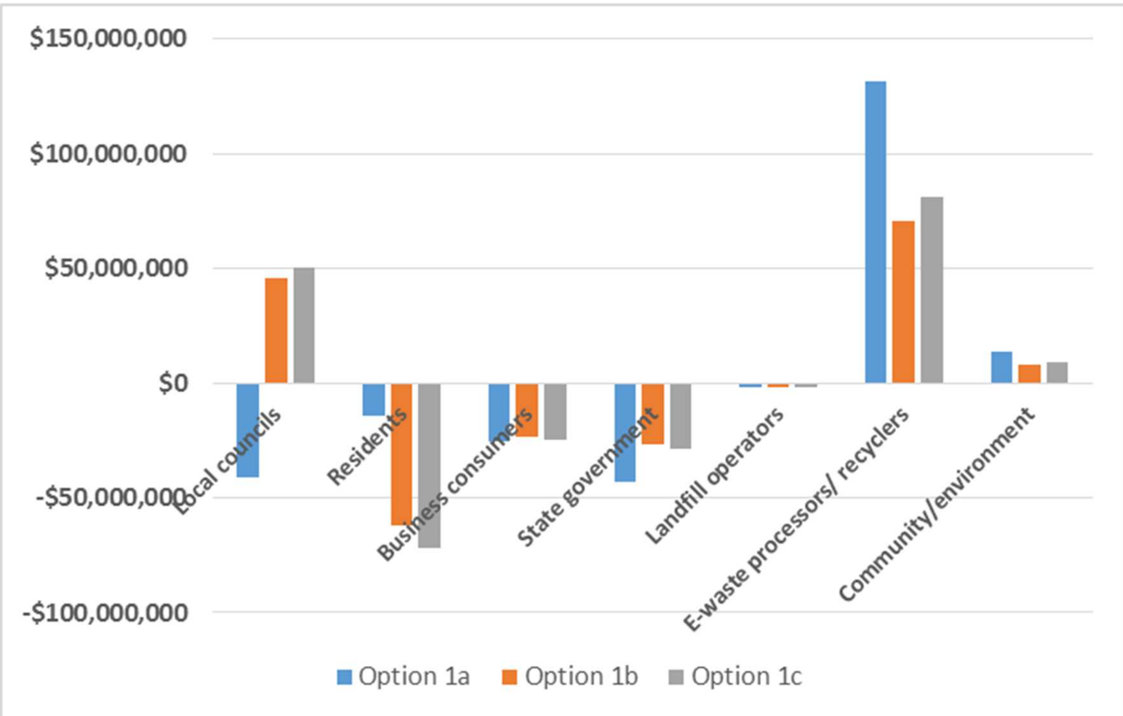


Figure ES.1: Distributional impacts of options on stakeholder groups, Options 1a, 1b and 1c ($2016)



High level analysis of the regional distribution of costs and benefits of the options has also been undertaken. The regional analysis – metropolitan areas versus non-metropolitan areas – reveals that the net benefits of options will largely flow to metropolitan areas, with non-metropolitan areas likely to have net costs. This outcome largely reflects the location of most e-waste processing facilities in metropolitan areas, and the high costs of transporting e-waste to the processing facilities from non-metropolitan areas (estimated on average to be approximately $342/ tonne).

In non-metropolitan areas, the net cost of Option 1a of $32.9 million over the period of the analysis (2017-2035) represents a cost per Local Government Area (LGA) of approximately $0.7 million or a cost per person of about $22. In metropolitan areas, the net benefit of $52.9 million over the period of the analysis for Option 1a represents a benefit per LGA of about $1.7 million or a benefit per person of about $3. It is important to note however, that most of those benefits will not be realised at the local government level.[4]

Analysis of alternative collection systems

An analysis of alternative collection and handling systems under Options 1a, 1b and 1c has also been undertaken. The analysis includes a financial analysis of the options from the perspective of public sector costs and a cost effectiveness assessment (CEA) of the alternatives.

Financial analysis

This section provides an assessment of costs to the public sector (state government and/ or councils) associated with implementing Options 1a, 1b and 1c. It is important to stress that because the financial analysis focusses on public sector costs, costs associated with aspects of the e-waste supply chain that fall on other sectors (e.g. metal recyclers, e-waste processors and household and business consumers) are excluded from the analysis. As a financial analysis, it also excludes non-financial economic costs.

Table ES.5 sets out results of the financial analysis. The analysis indicates that Option 1b is likely to entail the lowest public sector costs of the three options, followed by Option 1c, with Option 1a being the most expensive. The key factor driving lower costs under Option 1b relative Option 1a is the shift to a collection system based on permanent drop-off points in metropolitan areas rather than system based on kerbside collection. Costs under Option 1c are higher than Option 1b reflecting the additional costs of collection events that are being held under Option 1c.

Two cost totals are presented in the analysis:

- net costs, which includes savings to councils in garbage and hard waste collection costs, under Options 1b and 1c, stemming from diversion of e-waste from ‘standard’ council garbage and hard waste collection systems; and
- total costs excluding the savings in garbage and hard waste collection costs. The rationale behind this total is that in practice it is quite unlikely that these costs savings will be realised by councils, especially if the services are being provided by waste contractors who are unlikely to pass on savings. Arguably therefore, it is the more realistic total.

[4] Excluding benefits, which large go to metropolitan processors

Table ES.4: Public sector costs 2017-2035 associated with Options 1a, 1b and 1c (PV $2016)

	Option 1a	Option 1b	Option 1c
Collection & drop-off	**$25,866,533**	**-$83,241,687**	**-$88,595,149**
Metro	$42,773,307	-$73,879,197	-$78,181,305
Non-metro	-$16,906,775	-$9,362,490	-$10,413,844
Events	$0	$0	**$5,668,097**
Handling & sorting	**$4,415,214**	**$29,421,872**	**$29,678,276**
Metro	$3,489,446	$13,616,965	$13,811,603
Non-metro	$925,768	$15,804,907	$15,866,673
Transport to recyclers	**$59,598,172**	**$33,185,411**	**$36,856,336**
Metro	$27,915,569	$15,897,484	$17,454,594
Non-metro	$31,682,603	$17,287,927	$19,401,742
Education	**$6,341,701**	**$6,341,701**	**$6,341,701**
Regulation	**$8,642,371**	**$8,642,371**	**$8,642,371**
Investment in infrastructure	**$8,995,794**	**$4,193,201**	**$4,193,201**
Metro	$1,160,748	$1,470,280	$1,470,280
Non-metro	$7,835,047	$2,722,921	$2,722,921
TOTAL	**$113,859,785**	**-$1,457,131**	**$2,784,834**
TOTAL (excluding savings in collection costs)	**$130,766,560**	**$81,784,556**	**$91,379,983**

Cost effectiveness analysis

Although Options 1b and 1c entail significantly lower overall public sector costs than Option 1a, these are not the only factors that should be considered in an analysis of this type. Also relevant is the extent to which the alternative collection systems divert e-waste from landfill and the cost-effectiveness of doing so.

Table ES.6 provides results of a cost-effectiveness analysis, indicating the potential cost to government for each tonne of e-waste diverted from landfill under Options 1a, 1b and 1c. As indicated in the table, Option 1a ($290/ tonne) is the most cost effective of the three options, followed by Options 1b ($321/ tonne) and 1c ($325/ tonne). This suggests that although Option 1a entails greater levels of public sector costs than Options 1b and 1c, from a public sector cost-effectiveness investment perspective, there may be some merit in implementing Option 1a.

Table ES.6: Cost effectiveness of alternative collection systems, Options 1a, 1b and 1c

	E-waste diverted from landfill (PV 2017-2035)	Public sector cost (PV 2017-2035)	Gov't $/tonne diverted
Option 1a	451,257	$130,766,560	$290
Option 1b	255,060	$81,784,556	$321
Option 1c	281,525	$91,379,983	$325

1. Introduction

1.1 Background

Marsden Jacob Associates (Marsden Jacob), Blue Environment and Ascend Waste & Environment have been engaged by the Department of Environment, Land, Water & Planning (DELWP) to undertake a cost-benefit analysis (CBA) of options to reduce e-waste from landfill. The CBA is part of a broader process around a commitment by the Victorian Government to ban e-waste from landfill (see DELWP, 2015).

Table 1: Main categories of e-waste as defined for this analysis[5]

Category A Large appliances	Category B Professional tools & equipment	Category C Small household tools & appliances	Category D Computers, TVs, IT	Category E Lighting & mobile phones	Category F Leisure, PV
- refrigerators - washing machines - cookers - microwaves - electric fans - air conditioners	- welding, soldering, milling - medical devices - monitoring and control equipment - automatic dispensers	- irons - toasters - coffee machines - hair dryers - electric tools - sewing machines - musical instruments - Hi fi	- computers - monitors - laptops - mice, keyboards, routers - printers - CRT TVs - Flat screen TVs (LCD, LED, plasma)	- fluorescent lamps - high intensity discharge lamps - compact fluorescent lamps - LEDs - mobile phones	- toys - game consoles - cameras - portable audio & video - remote controls - Photosensitive semiconductor devices (PV)[6]

In Australia e-waste is growing at three times faster than general municipal waste. E-waste from televisions and computers alone is expected to grow from 138,000 tonnes in 2012-13 to 223,000 tonnes in 2023-24. In Victoria, e-waste is expected to grow to almost 300,000 tonnes by 2035.

E-waste contains hazardous materials, which can create environmental and health impacts. These impacts are partly contained through regulation of landfills under the auspice of EPA Victoria. Nevertheless, there is likely to still be impacts under even the best managed landfills and significant impacts associated with illegal dumping[7]. These environmental impacts are not necessarily reflected in the price of e-products.

E-waste also contains resources, including precious metals, which can have a significant market value. Market failures and barriers (such as barriers to investment in collection infrastructure) mean that these resources are often not recovered[8].

[5] These categories are similar to those defined in the European Union's Waste Electrical and Electronic Equipment Directive (EU 2012).

[6] PV devices include photovoltaic cells, light emitting diodes and invertors.

[7] See for example Donevska et al. 2010 and European Union 2012

[8] See for example Marsden Jacob 2016

The National Television and Computer Recycling Scheme (NTCRS) is currently the main driver of e-waste recycling in Australia. The scheme is regulated by the Australian Government, under the Product Stewardship Act 2011 and the Product Stewardship (Televisions and Computers) Regulations 2011. It has been in effect since July 2012 and requires television and computer industries to pay for the collection and recycling of a proportion of these items each year. In 2015-16, this proportion is set at 50%. By 2025-26 it will increase to 80%. There are a number of other programs that focus on preventing e-waste from ending up in landfill including not-for-profit programs and programs by some local councils.

1.2 Assessed options

Five options have been assessed in the CBA incrementally to the base case option, referred to hereafter as 'business-as-usual' (BaU). BaU and options are all assessed over the period 2017-2035. The options are summarised below and are detailed in Table 2.[9]

Business-as-usual (BaU)

- No regulatory landfill ban on e-waste
- Continued absolute growth in e-waste consumption, recycling and disposal to landfill
- No substantial new investment in collection, storage and processing infrastructure
- No additional investment in specific education campaign

Option 1a: Comprehensive landfill ban (with domestic kerbside collection service in metropolitan areas and permanent drop-off points in regional areas)

- Ban all e-waste from landfill
- Require specific management of e-waste
- Substantial additional investment in e-waste collection, transfer and transport services:
  - kerbside collection service provided in metropolitan areas for all domestic e-waste (overall universal access)
  - permanent drop-off points provided in regional areas for all domestic e-waste (very high level of access overall)
  - commercial collection service used in metropolitan areas for commercial e-waste
- Substantial additional investment in specific education campaign
- Ban in place June 2018
- Penalties to apply from June 2019

Option 1b: Comprehensive landfill ban (with permanent drop-off points in all areas for domestic e-waste)

- With the exception of e-waste collection services (see following point), the central features of this option are the same as for Option 1a)
- Significant additional investment in e-waste transfer and transport services:

[9] Section 4 also provides further detail on the alternative e-waste collection systems provided under each of the options and discussion of the level of access provided through those collection systems.

- permanent drop-off points provided in metropolitan areas for all domestic e-waste (high level of access overall)
- permanent drop-off points provided in regional areas for all domestic e-waste (moderate level of access overall)
- commercial collection service used for commercial e-waste in metropolitan areas

Option 1c: Comprehensive landfill ban (with permanent drop-off points in all areas for domestic e-waste plus collection 'events')

- With the exception of e-waste collection services (see following point), the central features of this option are the same as for Option 1a)
- Significant additional investment in e-waste collection, transfer and transport systems:
  - permanent drop-off points provided in metropolitan areas for all domestic e-waste plus a series of collection events (very high level of access overall)
  - permanent drop-off points provided in regional areas for all domestic e-waste plus a series of collection events (high level of access overall)
  - commercial collection service used for commercial e-waste in metropolitan areas

Option 2: Ban hazardous e-waste from landfill

- Ban specified e-waste containing significant hazardous material (see Table 3)
- Require specific management of e-waste
- Significant additional investment in collection and transfer systems as per Option 1 a)
- Residential collection service as per Option 1a)
- Greater education investment than Option 1, noting complexity of ban

Option 3: No regulatory landfill ban on e-waste

- No ban on e-waste going to landfill
- Significant additional investment in collection and transfer systems as per Option 1 a)
- Significant additional education investments as per Option 1

Table 2: Options assessed in the CBA

<table>
<tr><th>Option</th><th>General description</th><th>Types of e-waste covered</th><th>Conditions and assumptions</th></tr>
<tr><td>Business-as-usual (BaU)</td><td>No items of e-waste banned from landfill</td><td>Not applicable</td><td>No regulatory landfill ban on e-waste
National Television and Computer Recycling Scheme (NTCRS) continues
Incremental increases in volumes of e-waste recycled as per Victorian E-waste Market Flow Analysis – part 1 report (2015), reflecting continuation of NTCRS and existing policies and investments
No investment in specific education campaign
Changes to Environment Protection (Scheduled Premises) Regulations 2007 in place
Large volumes of small batteries and automotive batteries are banned from landfill (small batteries dispersed in small quantities are not)</td></tr>
<tr><td>Options 1a, 1b, 1c</td><td>Ban all e-waste from landfill</td><td>All e-waste types as defined as ‘any end-of-life ‘equipment which is dependent on electrical currents or electromagnetic fields in order to work properly’ (United Nations Environment Programme).[i]</td><td rowspan="2">Ban to be in place by June 2018
Penalties to apply from June 2019
All items within scope of option banned at once
All items within scope of option banned in all of Victoria
Maximum contamination level allowed at landfill (e.g.10% by volume per load)[ii]
Required compliance with Occupational Health & Safety standards: 100%
Process for allowing e-waste to be disposed to landfill: use existing provision of the EP Act, section 30A[iii]
Maximum percentage of e-waste processing residue disposed to landfill: <10% for products processed by e-waste recyclers and <16% for products processed by metal recyclers
Education: awareness and behaviour change campaign developed for community and business
Additional investment in collection, transfer and transport systems (see section 4)</td></tr>
<tr><td>Option 2</td><td>Ban hazardous e-waste from landfill</td><td>E-waste types that have relatively high concentrations of hazardous chemical elements. Includes IT, TVs, photovoltaic systems, lighting. (See Table 3).</td></tr>
<tr><td>Option 3</td><td>No regulatory ban (but support other conditions)</td><td>All e-waste types as per Option 1</td><td>Education: awareness and behaviour change campaign developed for community and business
Additional investment in collection, transfer and transport systems (see section 4)</td></tr>
</table>

i. This definition has been broadened to align with both the UNEP definition EPA Victoria’s approach to processors of e-waste.
ii. This is based on the assumption that a visual inspection by a landfill ‘spotter’ will recognise a 10% level of contamination, pers. comm. EPA Victoria, July 2016
iii. S30A of the Environment Protection Act 1970 allows for emergency storage or discharge of waste under certain circumstances, such as community hardship, public nuisance, or other emergency.

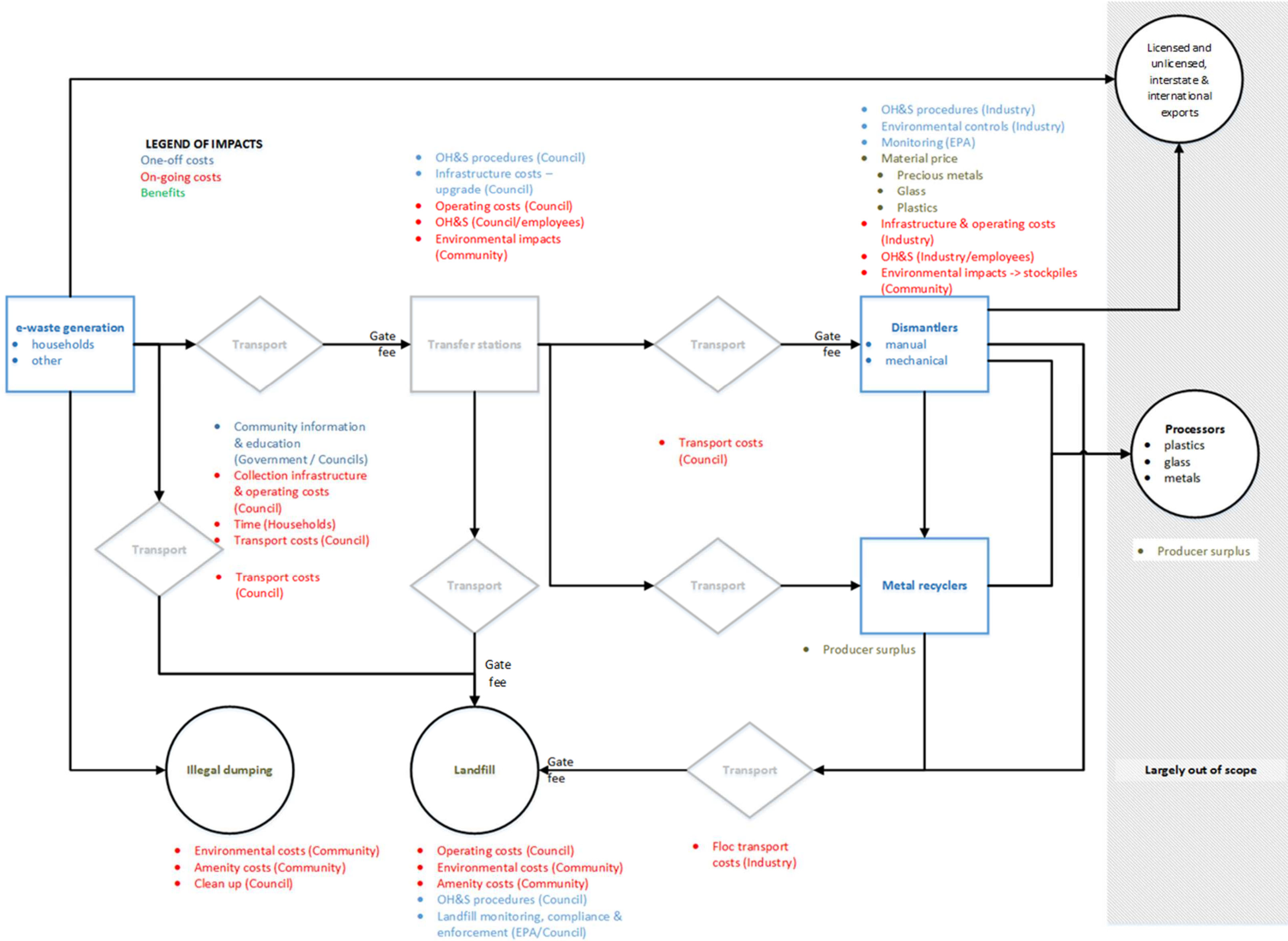
Table 3: E-waste products covered by Option 2 and the hazardous components of those products

E-waste category	Sub-category	Element	Persistent organic pollutants (POPs)	Ecological source of exposure
IT and telecommunications equipment (excluding monitors)	Printed circuit boards (including capacitors, semi-conductors, resistors and inductors)	Lead, cadmium, mercury, beryllium barium	Brominated flame retardants	Air, dust, food (POP), water, and soil
	Batteries	Nickel, lithium, lead		Air, soil, water, and food (plants)
	Power supply boxes	Beryllium		Air, food, and water
Cathode ray tube (CRT) monitors and TVs	Tubes	Lead, cadmium, mercury, zinc, barium		Air, vapour, water, soil, and food (bioaccumulative in fish)
Flat panel monitors and TVs	Tubes	Lead, mercury		Air, vapour, water, soil, and food (bioaccumulative in fish)
Lighting	Fluorescent lamps	Barium, mercury	Possibility of Polychlorinated biphenyls (PCBs) in old ballast transformers.	Air, vapour, water, soil, and food (bioaccumulative in fish)
	Light bulbs	Lead		Air, dust, water and soil
Photovoltaic panels		CdTe (Cadmium telluride), Lead, c-Si (crystalline silicon),Chromium		Air, Dust, Water and Soil

Sources: Grossman 2006; Townsend et al. 2004; UNEP 2005; e-waste guide[10]

[10] Sourced at: http://ewasteguide.info/hazardous-substances

Figure 1: Chain of 'physical flows' and associated costs, benefits and transfers



1.3 Approach to the analysis

1.3.1 Overview

The purpose of the CBA is to assess the costs and benefits of each of the options incrementally to BaU. This is done through a detailed economic model, which disaggregates impacts across two regions: metropolitan (metro) and non-metropolitan (non-metro).

Economic impacts (costs and benefits) are assessed in the model by aggregating the relevant subset of financial (distributional) impacts and externality impacts. This approach reflects the fact that all costs and all market benefits associated with options will have a financial impact on one or more stakeholder group. Financial transfers between stakeholder groups (such as landfill levies and gate fees) have been excluded from the analysis because they do not result in a net economic cost or benefit. However, they are considered in the distributional impact analysis.

The aggregated costs and benefits are expressed for each option as a Net Present Value (NPV) and Benefit Cost Ratio (BCR), providing a comparable basis for prioritising between the options.

The CBA model integrates an economic model with a material flows analysis (MFA) model, noting that the physical flow of e-waste ultimately drives many (although not all) of the costs, benefits and distributional impacts of the options. Thus a conceptual 'physical flow' of waste is used as the basis for identifying the costs and benefits and distributional impacts (see Figure 1). For each option, this process involved:

1. Mapping out the individual steps in the e-waste 'supply chain' from source to destination;
2. Identifying, at each point in the supply chain, the cost and (for some points in the chain) benefit items that arise (including transfers); and
3. Assigning values to each cost and benefit item in the model and aggregating them for each stakeholder group.

1.3.2 Limitations

Data uncertainties

Assessed costs and benefits of options are dependent on data assumptions that underpin key cost and benefit variables. Although considerable background analysis (including stakeholder consultation) has gone into assigning suitable values to the variables, in practice there are still uncertainties around the estimated values for a number of variables. Even variables that are directly valued in the market (e.g. value of recovered material) are subject to uncertainty due, for example, to substantial fluctuations in market values over time.

Therefore, where data assumptions have the potential to significantly affect outcomes of the analysis, we have tested uncertainties through sensitivity analysis. This has been done by means of scenarios that involve changes to a number of key assumptions, applying the changes across all options to test the impact of changes on the net benefit/cost of the options. Details of the sensitivity analysis are provided in section 2.2 following discussion of the main results.

Unquantified benefits

A number of potential benefits of implementing options are not directly reflected in market prices. Because of this, it can be difficult to ascribe dollar values to those benefits or at least values that provide a true reflection of their economic value. Potential non-market benefits of options relative to BaU include:

- avoided environmental and social externalities associated with landfills;
- reduced resource depletion; and
- avoided environmental externalities due to reduced resource depletion.

Only the first and (to some extent) second of these benefits have been estimated in the analysis and then only imperfectly.

The absence of a confident valuation of non-market benefits restricts the analysis, since it is only possible to make definitive statements about the economic efficiency of options when all costs and benefits have been fully valued. To help address this limitation therefore, an estimate of the community's Willingness to Pay (WTP) for non-market benefits is provided in the analysis drawing on results of a review of Australian and international literature of households' WTP for e-waste recycling. This is discussed in section 2.4.

1.4 Report structure

This remainder of this report is structured as follows:

- Section 2 provides results of the CBA including key drivers of the results, regional impacts and sensitivity analysis.
- Section 3 provides results of the distributional analysis.
- Section 4 provides results of more detailed financial analysis of the alternative collection systems under Options 1a, 1b and 1c.
- Section 5 details the material flows which underpin assessment of many of the costs and benefits of the options.
- Section 6 details the data assumptions pertaining to the cost and benefit items in the analysis.

2. Cost-Benefit Analysis

This section presents the results of the cost-benefit analysis (CBA), comparing the performance of options using two key metrics:

- Net Present Value (NPV), which is the Present Value (PV) of economic benefits delivered by the option less the PV of economic costs incurred; and
- Benefit Cost Ratio (BCR), which is the ratio of the PV of economic benefits to PV of economic costs.

The NPV measures the expected benefit (or cost) to society of implementing the policy relative to BaU, expressed in monetary terms, whereas the BCR identifies the option that provides the highest benefit per unit of cost relative to BaU, and is therefore a measure of risk.

2.1 Cost-benefit analysis results

Results of the CBA are summarised in Table 4 and Table 5. The results are presented in two tables so as to highlight differences between the options based on the regulatory framework (Options 1a, 2 and 3) and differences based on collection system (Options 1a, 1b and 1c).

Table 4: CBA results summary, Options 1a, 2 and 3, Net Present Value (2017-2035)

	Present value of costs and benefits relative to BaU (2017-2035)		
	Option 1a	Option 2	Option 3
Collection costs	-$65,139,770	-$32,881,137	-$51,416,795
Metro	-$65,849,220	-$33,247,082	-$51,700,289
Non-metro	$709,450	$365,945	$283,494
Sorting costs	-$13,411,008	-$10,552,825	-$12,140,255
Metro	-$4,650,194	-$2,339,050	-$3,721,194
Non-metro	-$8,760,814	-$8,213,775	-$8,419,061
Transport to recyclers	-$59,598,172	-$22,387,651	-$40,470,316
Metro	-$27,915,569	-$9,426,416	-$20,483,570
Non-metro	-$31,682,603	-$12,961,235	-$19,986,746
Processing costs	-$280,448,146	-$116,100,059	-$200,150,945
E-waste	-$279,227,031	-$116,100,059	-$199,207,524
Metal	-$1,221,115	$0	-$943,421
Regulatory	-$8,642,371	-$6,758,160	-$909,049
Education costs	-$6,341,701	-$6,341,701	-$8,966,018
Total costs	**-$433,581,168**	**-$195,021,534**	**-$314,053,377**
Value of material recovered	$426,030,399	$123,943,626	$298,094,421
Avoided landfill costs	$13,679,920	$8,322,626	$10,463,081
Avoided environmental impacts of landfills	$13,948,262	$6,213,653	$10,146,454
Total benefits/ avoided costs	**$453,658,580**	**$138,479,905**	**$318,703,957**
NPV	**$20,077,412**	**-$56,541,629**	**$4,650,579**
BCR	**1.05**	**0.71**	**1.01**
WTP Threshold per tonne	**$931**	**$995**	**$942**

Table 5: CBA results summary, Options 1a, 1b and 1c, Net Present Value (2017-2035)

	Present value of costs and benefits relative to BaU (2017-2035)		
	Option 1a	Option 1b	Option 1c
Collection costs	-$65,139,770	-$2,335,417	-$8,355,239
Metro	-$65,849,220	-$2,960,254	-$7,561,739
Non-metro	$709,450	$624,837	-$793,500
Sorting costs	-$13,411,008	-$33,615,073	-$33,871,477
Metro	-$4,650,194	-$15,087,245	-$15,281,884
Non-metro	-$8,760,814	-$18,527,828	-$18,589,593
Transport to recyclers	-$59,598,172	-$33,185,411	-$36,856,336
Metro	-$27,915,569	-$15,897,484	-$17,454,594
Non-metro	-$31,682,603	-$17,287,927	-$19,401,742
Processing costs	-$280,448,146	-$157,901,270	-$172,746,104
E-waste	-$279,227,031	-$157,110,682	-$171,662,813
Metal	-$1,221,115	-$790,588	-$1,083,290
Regulatory	-$8,642,371	-$8,642,371	-$8,642,371
Education costs	-$6,341,701	-$6,341,701	-$6,341,701
Total costs	**-$433,581,168**	**-$242,021,243**	**-$266,813,229**
Benefits			
Value of material recovered	$426,030,399	$235,678,052	$261,961,112
Avoided landfill costs	$13,679,920	$8,603,681	$9,238,031
Avoided environmental impacts of landfills	$13,948,262	$8,157,340	$8,937,175
Total benefits/ avoided costs	**$453,658,580**	**$252,439,072**	**$280,136,317**
NPV	**$20,077,412**	**$10,417,830**	**$13,323,088**
BCR	**1.05**	**1.04**	**1.05**
WTP Threshold per tonne	**$931**	**$915**	**$915**

The results show net costs and benefits of options relative to BaU over the total assessment period, 2017-2035. They are based on central or 'most likely' assumptions for cost and benefit items.

Key results of the CBA are as follows:

- Options 1a, 1b, 1c and 3 all have small positive NPVs and BCRs greater than 1 (assessed over the total period of the analysis, 2017-2035), meaning that if any of these options is implemented there is a reasonable chance it would deliver a net benefit to the community based on central assumptions applied in the analysis.
- Option 1a has a slightly higher NPV ($20 million) than Option 3 ($5 million) reflecting significantly higher benefits under Option 1 compared to Option 3 but also significantly higher costs.
- Option 1a also has a marginally higher NPV than either Option 1b ($10 million) or Option 1c ($13 million) reflecting significantly lower collection costs for councils but much higher participation costs for residents (see section 3 for further discussion).
- Option 2 has a negative NPV and a BCR of 0.7, suggesting that it is unlikely to deliver a net benefit to the community based on central assumptions. The poor outcome for Option 2,

relative to Options 1 and 3, reflects somewhat higher unit collection costs, significantly higher unit processing costs and a substantially lower average value of recovered materials (see section 2.4 for further details).

It is important to note that differences between the options, in terms of net costs and benefits, are relatively small. The difference between Options 1a, 1b, 1c are insignificant, being within normal margins of error for major cost and benefit assumptions.

Another important point to emerge from the analysis, apparent in Table 6, is that net benefits associated with implementing the options peak in the early to mid-2020s and decline thereafter, so that by the early to mid-2030s all options have net costs year on year. This situation largely reflects an increase in processing costs over time as the mix of e-waste shifts towards lower value, higher cost products.

Results of all options are presented in detail in Table 6.

Table 6: CBA results, central case ($2016), Options 1a, 1b, 1c, 2 and 3[11]

Option 1a	NPV	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Collection costs	**$65,139,770**	**-$2,206**	**-$2,358**	**$6,540,403**	**$5,033,595**	**$5,416,957**	**$5,834,475**	**$6,291,877**	**$6,554,155**	**$6,832,157**	**$7,126,033**	**$7,439,550**	**$7,771,974**	**$8,118,374**	**$8,477,959**	**$8,849,862**	**$9,233,446**	**$9,627,838**
Metro	$65,849,220	$0	$0	$6,569,343	$5,069,708	$5,461,226	$5,888,021	$6,356,271	$6,622,285	$6,904,131	$7,202,208	$7,521,868	$7,862,497	$8,217,644	$8,586,515	$8,968,234	$9,362,154	$9,767,382
Pick-up	$139,672,380	$0	$0	$11,213,409	$10,473,978	$11,426,350	$12,464,434	$13,604,534	$14,213,111	$14,850,167	$15,520,079	$16,263,198	$17,079,978	$17,928,228	$18,806,368	$19,712,689	$20,646,017	$21,604,646
Garbage collection	-$73,823,160	$0	$0	-$4,644,066	-$5,404,271	-$5,965,124	-$6,576,413	-$7,248,262	-$7,590,826	-$7,946,036	-$8,317,871	-$8,741,330	-$9,217,481	-$9,710,584	-$10,219,853	-$10,744,455	-$11,283,863	-$11,837,264
Non-metro	-$709,450	-$2,206	-$2,358	-$28,940	-$36,113	-$44,270	-$53,546	-$64,394	-$68,130	-$71,974	-$76,175	-$82,318	-$90,523	-$99,270	-$108,556	-$118,372	-$128,708	-$139,544
Pick-up	$16,197,325	$19,868	$20,799	$993,252	$1,121,975	$1,263,074	$1,417,839	$1,589,115	$1,663,735	$1,741,509	$1,823,550	$1,919,290	$2,029,058	$2,143,303	$2,261,841	$2,384,466	$2,511,035	$2,641,337
Garbage collection	-$16,906,775	-$22,074	-$23,157	-$1,022,192	-$1,158,088	-$1,307,344	-$1,471,385	-$1,653,508	-$1,731,864	-$1,813,483	-$1,899,725	-$2,001,608	-$2,119,581	-$2,242,573	-$2,370,396	-$2,502,838	-$2,639,743	-$2,780,881
Sorting costs	**$13,411,008**	**$4,651,113**	**$4,651,165**	**$323,877**	**$332,117**	**$364,392**	**$399,204**	**$436,840**	**$456,596**	**$477,049**	**$498,233**	**$521,188**	**$545,877**	**$571,151**	**$596,962**	**$623,267**	**$650,042**	**$677,256**
Metro	$4,650,194	$600,000	$600,000	$267,161	$268,020	$292,204	$318,142	$345,960	$361,454	$377,468	$393,972	$411,462	$429,882	$448,632	$467,677	$486,983	$506,536	$526,315
Non-metro	$8,760,814	$4,051,113	$4,051,165	$56,716	$64,097	$72,188	$81,062	$90,881	$95,142	$99,581	$104,260	$109,726	$115,995	$122,519	$129,285	$136,284	$143,506	$150,941
Transport to recyclers	**$59,598,172**	**$38,078**	**$39,863**	**$4,078,268**	**$4,337,763**	**$4,808,132**	**$5,319,316**	**$5,877,892**	**$6,147,684**	**$6,427,698**	**$6,719,887**	**$7,046,843**	**$7,408,761**	**$7,782,018**	**$8,165,956**	**$8,559,916**	**$8,963,515**	**$9,376,171**
Metro	$27,915,569	$0	$0	$2,137,289	$2,144,159	$2,337,629	$2,545,135	$2,767,677	$2,891,633	$3,019,747	$3,151,779	$3,291,700	$3,439,054	$3,589,060	$3,741,417	$3,895,862	$4,052,288	$4,210,523
Non-metro	$31,682,603	$38,078	$39,863	$1,940,979	$2,193,603	$2,470,503	$2,774,181	$3,110,216	$3,256,051	$3,407,950	$3,568,109	$3,755,143	$3,969,707	$4,192,958	$4,424,539	$4,664,053	$4,911,226	$5,165,648
Processing costs	**$280,448,146**	**$401,630**	**$371,315**	**$20,982,718**	**$20,630,713**	**$22,683,846**	**$24,923,618**	**$27,391,761**	**$28,594,098**	**$29,843,425**	**$31,157,928**	**$32,673,213**	**$34,392,481**	**$36,176,080**	**$38,020,631**	**$39,922,649**	**$41,879,852**	**$43,888,968**
E-waste	$279,227,031	$401,630	$371,315	$20,740,404	$20,570,030	$22,610,343	$24,835,966	$27,288,596	$28,483,797	$29,725,855	$31,032,966	$32,540,745	$34,252,408	$36,028,306	$37,865,070	$39,759,223	$41,708,482	$43,709,583
Manual	$14,133,326	$401,630	$371,315	$2,003,457	$1,586,493	$1,597,660	$1,611,155	$1,655,741	$1,558,701	$1,452,722	$1,356,716	$1,296,159	$1,267,679	$1,242,819	$1,220,994	$1,201,693	$1,184,516	$1,169,096
Mechanical	$265,093,704	$0	$0	$18,736,947	$18,983,537	$21,012,684	$23,224,811	$25,632,856	$26,925,096	$28,273,133	$29,676,250	$31,244,587	$32,984,728	$34,785,487	$36,644,076	$38,557,530	$40,523,966	$42,540,487
Metal	$1,221,115	$0	$0	$242,314	$60,683	$73,503	$87,652	$103,164	$110,301	$117,570	$124,962	$132,467	$140,074	$147,774	$155,560	$163,427	$171,370	$179,385
Manual	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Mechanical	$1,221,115	$0	$0	$242,314	$60,683	$73,503	$87,652	$103,164	$110,301	$117,570	$124,962	$132,467	$140,074	$147,774	$155,560	$163,427	$171,370	$179,385
Regulatory costs	**$8,642,371**	**$759,917**	**$759,917**	**$1,473,217**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**
Education costs	**$6,341,701**	**$0**	**$1,000,000**	**$1,000,000**	**$1,000,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**
Total costs	**$433,581,168**	**$5,848,531**	**$6,819,901**	**$34,398,483**	**$32,047,488**	**$34,486,627**	**$37,689,913**	**$41,211,671**	**$42,965,833**	**$44,793,629**	**$46,715,381**	**$48,894,094**	**$51,332,393**	**$53,860,923**	**$56,474,808**	**$59,168,994**	**$61,940,155**	**$64,783,534**
Value of material recovered	**$426,030,399**	**$0**	**$0**	**$38,495,499**	**$35,887,549**	**$38,564,039**	**$41,447,007**	**$44,581,517**	**$45,410,257**	**$46,257,202**	**$47,169,822**	**$48,440,493**	**$50,070,226**	**$51,755,420**	**$53,492,017**	**$55,276,335**	**$57,106,667**	**$58,980,086**
Avoided landfill operating costs	**$13,679,920**	**$107,083**	**$113,380**	**$711,539**	**$995,851**	**$1,093,772**	**$1,201,248**	**$1,320,440**	**$1,383,202**	**$1,448,786**	**$1,518,041**	**$1,598,938**	**$1,691,720**	**$1,788,259**	**$1,888,384**	**$1,991,914**	**$2,098,719**	**$2,208,616**
Avoided landfill leaching	**$13,948,262**	**$12,546**	**$13,093**	**$1,032,445**	**$1,188,271**	**$1,279,847**	**$1,379,403**	**$1,502,186**	**$1,509,873**	**$1,517,430**	**$1,528,166**	**$1,564,047**	**$1,626,105**	**$1,692,470**	**$1,762,986**	**$1,837,469**	**$1,915,770**	**$1,997,677**
Total benefits	**$453,658,580**	**$119,629**	**$126,474**	**$40,239,483**	**$38,071,671**	**$40,937,658**	**$44,027,658**	**$47,404,143**	**$48,303,332**	**$49,223,418**	**$50,216,028**	**$51,603,477**	**$53,388,051**	**$55,236,149**	**$57,143,387**	**$59,105,718**	**$61,121,156**	**$63,186,379**
NPV	**$20,077,412**	**-$5,728,902**	**-$6,693,427**	**$5,841,001**	**$6,024,183**	**$6,451,032**	**$6,337,745**	**$6,192,472**	**$5,337,499**	**$4,429,789**	**$3,500,648**	**$2,709,384**	**$2,055,659**	**$1,375,225**	**$668,579**	**-$63,276**	**-$818,999**	**-$1,597,155**

[11] For ease of presentation, results are nor shown for all years of the analysis period, with the years 2034-2035 missing

Option 1b	NPV	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Collection costs	**$2,335,417**	**-$2,206**	**-$2,358**	**$802,424**	**$10,806**	**$57,751**	**$107,300**	**$158,847**	**$179,230**	**$197,762**	**$214,627**	**$233,955**	**$255,802**	**$275,928**	**$294,396**	**$311,305**	**$326,792**	**$341,005**
Metro	$2,960,254	$0	$0	$837,707	$51,671	$104,779	$161,185	$220,680	$242,905	$263,168	$281,887	$304,768	$331,982	$357,768	$382,186	$405,333	$427,341	$448,347
Pick-up	$45,386,058	$0	$0	$3,405,559	$3,202,303	$3,598,103	$4,026,614	$4,496,234	$4,685,197	$4,875,102	$5,070,579	$5,312,669	$5,603,102	$5,900,770	$6,205,371	$6,516,603	$6,834,367	$7,158,396
Garbage collection	-$42,425,805	$0	$0	-$2,567,852	-$3,150,632	-$3,493,324	-$3,865,430	-$4,275,554	-$4,442,292	-$4,611,934	-$4,788,692	-$5,007,900	-$5,271,119	-$5,543,002	-$5,823,185	-$6,111,270	-$6,407,026	-$6,710,050
Non-metro	-$624,837	-$2,206	-$2,358	-$35,283	-$40,865	-$47,027	-$53,885	-$61,832	-$63,675	-$65,406	-$67,260	-$70,813	-$76,181	-$81,840	-$87,790	-$94,028	-$100,549	-$107,342
Pick-up	$8,737,653	$19,868	$20,799	$475,472	$567,070	$667,930	$778,345	$900,761	$932,296	$964,433	$998,316	$1,043,442	$1,100,247	$1,159,267	$1,220,416	$1,283,596	$1,348,739	$1,415,740
Garbage collection	-$9,362,490	-$22,074	-$23,157	-$510,756	-$607,936	-$714,957	-$832,230	-$962,593	-$995,971	-$1,029,839	-$1,065,576	-$1,114,255	-$1,176,428	-$1,241,107	-$1,308,206	-$1,377,624	-$1,449,287	-$1,523,082
Sorting costs	**$33,615,073**	**$2,168,613**	**$2,168,665**	**$2,349,719**	**$2,438,877**	**$2,599,183**	**$2,771,724**	**$2,958,281**	**$3,065,593**	**$3,179,014**	**$3,298,284**	**$3,424,026**	**$3,555,649**	**$3,691,549**	**$3,831,239**	**$3,974,285**	**$4,120,433**	**$4,269,388**
Metro	$15,087,245	$760,000	$760,000	$1,089,798	$1,104,631	$1,185,833	$1,273,623	$1,368,216	$1,420,524	$1,475,561	$1,532,984	$1,593,000	$1,655,259	$1,718,953	$1,783,863	$1,849,808	$1,916,694	$1,984,410
Non-metro	$18,527,828	$1,408,613	$1,408,665	$1,259,921	$1,334,246	$1,413,350	$1,498,101	$1,590,065	$1,645,068	$1,703,454	$1,765,300	$1,831,026	$1,900,389	$1,972,595	$2,047,376	$2,124,477	$2,203,739	$2,284,977
Transport to recyclers	**$33,185,411**	**$38,078**	**$39,863**	**$2,091,533**	**$2,328,389**	**$2,645,453**	**$2,990,448**	**$3,369,108**	**$3,500,719**	**$3,635,782**	**$3,776,534**	**$3,945,900**	**$4,144,523**	**$4,349,113**	**$4,559,352**	**$4,774,914**	**$4,995,620**	**$5,221,173**
Metro	$15,897,484	$0	$0	$1,149,896	$1,205,796	$1,323,617	$1,450,483	$1,587,320	$1,656,253	$1,727,480	$1,800,978	$1,880,934	$1,967,130	$2,054,951	$2,144,247	$2,234,883	$2,326,809	$2,419,934
Non-metro	$17,287,927	$38,078	$39,863	$941,637	$1,122,593	$1,321,837	$1,539,965	$1,781,788	$1,844,466	$1,908,302	$1,975,555	$2,064,966	$2,177,393	$2,294,162	$2,415,105	$2,540,031	$2,668,811	$2,801,239
Processing costs	**$157,901,270**	**$401,630**	**$371,315**	**$11,526,628**	**$11,730,325**	**$12,984,412**	**$14,349,410**	**$15,861,507**	**$16,400,626**	**$16,950,348**	**$17,529,844**	**$18,276,071**	**$19,194,179**	**$20,146,036**	**$21,129,879**	**$22,143,876**	**$23,186,838**	**$24,257,014**
E-waste	$157,110,682	$401,630	$371,315	$11,386,414	$11,696,523	$12,939,911	$14,292,954	$15,791,805	$16,326,115	$16,870,960	$17,445,514	$18,186,740	$19,099,797	$20,046,553	$21,025,251	$22,034,059	$23,071,791	$24,136,696
Manual	$10,204,176	$401,630	$371,315	$1,404,629	$1,172,554	$1,178,156	$1,186,236	$1,225,367	$1,133,286	$1,031,855	$940,035	$883,360	$858,522	$837,101	$818,539	$802,345	$788,120	$775,507
Mechanical	$146,906,506	$0	$0	$9,981,786	$10,523,969	$11,761,756	$13,106,718	$14,566,438	$15,192,830	$15,839,105	$16,505,479	$17,303,381	$18,241,275	$19,209,452	$20,206,712	$21,231,714	$22,283,671	$23,361,189
Metal	$790,588	$0	$0	$140,214	$33,802	$44,501	$56,455	$69,702	$74,510	$79,389	$84,330	$89,330	$94,382	$99,483	$104,629	$109,817	$115,047	$120,318
Manual	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Mechanical	$790,588	$0	$0	$140,214	$33,802	$44,501	$56,455	$69,702	$74,510	$79,389	$84,330	$89,330	$94,382	$99,483	$104,629	$109,817	$115,047	$120,318
Regulatory costs	**$8,642,371**	**$759,917**	**$759,917**	**$1,473,217**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**
Education costs	**$6,341,701**	**$0**	**$1,000,000**	**$1,000,000**	**$1,000,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**
Total costs	**$242,021,243**	**$3,366,031**	**$4,337,401**	**$19,243,521**	**$18,221,696**	**$19,500,100**	**$21,432,182**	**$23,561,043**	**$24,359,468**	**$25,176,207**	**$26,032,587**	**$27,093,252**	**$28,363,453**	**$29,675,925**	**$31,028,166**	**$32,417,680**	**$33,842,985**	**$35,301,880**
Value of material recovered	**$235,678,052**	**$0**	**$0**	**$20,714,939**	**$19,961,836**	**$21,663,431**	**$23,487,371**	**$25,476,841**	**$25,669,146**	**$25,842,600**	**$26,048,083**	**$26,581,050**	**$27,445,797**	**$28,340,816**	**$29,263,929**	**$30,213,128**	**$31,187,453**	**$32,185,254**
Avoided landfill operating costs	**$8,603,681**	**$107,083**	**$113,380**	**$444,374**	**$637,634**	**$700,734**	**$769,354**	**$845,352**	**$877,671**	**$910,743**	**$945,464**	**$989,874**	**$1,044,314**	**$1,100,733**	**$1,159,052**	**$1,219,178**	**$1,281,055**	**$1,344,586**
Avoided landfill leaching	**$8,157,340**	**$12,546**	**$13,093**	**$600,018**	**$720,848**	**$781,559**	**$846,505**	**$930,509**	**$916,307**	**$899,860**	**$884,488**	**$892,194**	**$924,080**	**$958,335**	**$994,871**	**$1,033,582**	**$1,074,380**	**$1,117,136**
Total benefits	**$252,439,072**	**$119,629**	**$126,474**	**$21,759,331**	**$21,320,317**	**$23,145,724**	**$25,103,230**	**$27,252,702**	**$27,463,124**	**$27,653,203**	**$27,878,035**	**$28,463,119**	**$29,414,190**	**$30,399,884**	**$31,417,852**	**$32,465,888**	**$33,542,887**	**$34,646,977**
NPV	**$10,417,830**	**-$3,246,402**	**-$4,210,927**	**$2,515,810**	**$3,098,621**	**$3,645,624**	**$3,671,048**	**$3,691,659**	**$3,103,656**	**$2,476,996**	**$1,845,448**	**$1,369,866**	**$1,050,738**	**$723,959**	**$389,685**	**$48,208**	**-$300,097**	**-$654,903**

Option 1c	NPV	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Collection costs	**$8,355,239**	**-$2,206**	**-$2,358**	**$1,262,612**	**$482,196**	**$557,257**	**$636,497**	**$719,360**	**$772,617**	**$825,594**	**$878,419**
Metro	$7,561,739	$0	$0	$1,192,162	$410,679	$485,611	$565,058	$648,787	$696,379	$743,155	$789,488
Pick-up	$54,289,652	$0	$0	$4,086,733	$3,891,738	$4,330,024	$4,803,508	$5,320,555	$5,559,296	$5,801,364	$6,051,319
Garbage collection	-$46,727,913	$0	$0	-$2,894,571	-$3,481,059	-$3,844,413	-$4,238,451	-$4,671,769	-$4,862,916	-$5,058,210	-$5,261,830
Non-metro	$793,500	-$2,206	-$2,358	$70,450	$71,517	$71,646	$71,439	$70,573	$76,238	$82,439	$88,931
Pick-up	$11,207,344	$19,868	$20,799	$656,758	$760,047	$872,055	$994,304	$1,129,369	$1,174,366	$1,220,780	$1,269,740
Garbage collection	-$10,413,844	-$22,074	-$23,157	-$586,308	-$688,531	-$800,409	-$922,865	-$1,058,796	-$1,098,128	-$1,138,341	-$1,180,809
Participation costs											
Sorting costs	**$33,871,477**	**$2,168,613**	**$2,168,665**	**$2,370,253**	**$2,459,733**	**$2,621,155**	**$2,794,866**	**$2,982,649**	**$3,091,240**	**$3,205,993**	**$3,326,641**
Metro	$15,281,884	$760,000	$760,000	$1,105,804	$1,120,667	$1,202,705	$1,291,369	$1,386,872	$1,440,122	$1,496,131	$1,554,555
Non-metro	$18,589,593	$1,408,613	$1,408,665	$1,264,449	$1,339,066	$1,418,449	$1,503,497	$1,595,777	$1,651,118	$1,709,861	$1,772,086
Transport to recyclers	**$36,856,336**	**$38,078**	**$39,863**	**$2,374,544**	**$2,621,648**	**$2,954,944**	**$3,317,068**	**$3,713,850**	**$3,864,542**	**$4,019,643**	**$4,181,349**
Metro	$17,454,594	$0	$0	$1,277,944	$1,334,083	$1,458,591	$1,592,451	$1,736,567	$1,813,035	$1,892,046	$1,973,551
Non-metro	$19,401,742	$38,078	$39,863	$1,096,600	$1,287,565	$1,496,352	$1,724,617	$1,977,283	$2,051,507	$2,127,597	$2,207,798
Processing costs	**$172,746,104**	**$401,630**	**$371,315**	**$12,678,438**	**$12,894,909**	**$14,215,301**	**$15,650,972**	**$17,238,277**	**$17,857,010**	**$18,490,824**	**$19,158,776**
E-waste	$171,662,813	$401,630	$371,315	$12,518,194	$12,839,404	$14,147,370	$15,569,303	$17,141,530	$17,753,577	$18,380,590	$19,041,636
Manual	$10,654,669	$401,630	$371,315	$1,459,744	$1,224,594	$1,229,519	$1,236,939	$1,275,448	$1,182,789	$1,080,830	$988,522
Mechanical	$161,008,144	$0	$0	$11,058,450	$11,614,810	$12,917,851	$14,332,364	$15,866,082	$16,570,787	$17,299,760	$18,053,114
Metal	$1,083,290	$0	$0	$160,243	$55,505	$67,932	$81,669	$96,747	$103,434	$110,234	$117,140
Manual	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Mechanical	$1,083,290	$0	$0	$160,243	$55,505	$67,932	$81,669	$96,747	$103,434	$110,234	$117,140
Regulatory costs	**$8,642,371**	**$759,917**	**$759,917**	**$1,473,217**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**	**$713,300**
Education costs	**$6,341,701**	**$0**	**$1,000,000**	**$1,000,000**	**$1,000,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**
Total costs	$266,813,229	$3,366,031	$4,337,401	$21,159,064	$20,171,786	$21,561,957	$23,612,702	$25,867,437	$26,798,710	$27,755,354	$28,758,485
Value of material recovered	**$261,961,112**	**$0**	**$0**	**$23,052,656**	**$22,282,217**	**$24,064,778**	**$25,975,655**	**$28,057,800**	**$28,347,974**	**$28,624,196**	**$28,936,909**
Avoided landfill operating costs	**$9,238,031**	**$107,083**	**$113,380**	**$491,248**	**$684,995**	**$751,087**	**$822,957**	**$902,469**	**$938,555**	**$975,652**	**$1,014,650**
Avoided landfill leaching	**$8,937,175**	**$12,546**	**$13,093**	**$667,552**	**$787,668**	**$850,699**	**$918,208**	**$1,005,030**	**$993,905**	**$980,800**	**$969,033**
Total benefits	$280,136,317	$119,629	$126,474	$24,211,457	$23,754,880	$25,666,564	$27,716,819	$29,965,299	$30,280,434	$30,580,648	$30,920,591
NPV	**$13,323,088**	**-$3,246,402**	**-$4,210,927**	**$3,052,393**	**$3,583,094**	**$4,104,607**	**$4,104,117**	**$4,097,862**	**$3,481,724**	**$2,825,294**	**$2,162,106**

Option 2	NPV	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Collection costs	**$32,881,137**	**-$2,206**	**-$2,358**	**$3,495,240**	**$2,536,634**	**$2,698,479**	**$2,882,788**	**$3,094,816**	**$3,220,144**	**$3,358,841**	**$3,511,188**	**$3,681,133**	**$3,868,243**	**$4,067,741**	**$4,278,983**	**$4,501,238**	**$4,733,855**	**$4,976,041**
Metro	$33,247,082	$0	$0	$3,334,471	$2,564,611	$2,731,878	$2,922,429	$3,141,972	$3,269,416	$3,410,320	$3,565,217	$3,739,642	$3,933,282	$4,139,840	$4,358,671	$4,589,036	$4,830,271	$5,081,565
Pick-up	$62,662,668	$0	$0	$4,892,448	$4,502,286	$4,906,542	$5,366,346	$5,896,883	$6,168,455	$6,462,797	$6,784,617	$7,174,712	$7,634,256	$8,121,424	$8,634,995	$9,173,585	$9,735,978	$10,320,664
Garbage collection	-$29,415,587	$0	$0	-$1,557,977	-$1,937,675	-$2,174,663	-$2,443,916	-$2,754,911	-$2,899,039	-$3,052,476	-$3,219,400	-$3,435,071	-$3,700,974	-$3,981,584	-$4,276,324	-$4,584,549	-$4,905,707	-$5,239,099
Non-metro	-$365,945	-$2,206	-$2,358	$160,770	-$27,977	-$33,399	-$39,642	-$47,156	-$49,272	-$51,479	-$54,029	-$58,508	-$65,039	-$72,099	-$79,688	-$87,798	-$96,416	-$105,525
Pick-up	$6,610,524	$19,868	$20,799	$461,134	$397,450	$455,722	$522,483	$600,424	$631,280	$664,516	$701,299	$751,124	$814,419	$881,686	$952,788	$1,027,566	$1,105,872	$1,187,522
Garbage collection	-$6,976,469	-$22,074	-$23,157	-$300,364	-$425,427	-$489,121	-$562,124	-$647,580	-$680,551	-$715,995	-$755,328	-$809,632	-$879,458	-$953,785	-$1,032,476	-$1,115,363	-$1,202,288	-$1,293,047
Sorting costs	**$10,552,825**	**$4,651,113**	**$4,651,165**	**$117,400**	**$107,793**	**$119,475**	**$132,579**	**$147,350**	**$154,695**	**$162,522**	**$170,875**	**$180,812**	**$192,323**	**$204,273**	**$216,627**	**$229,354**	**$242,431**	**$255,832**
Metro	$2,339,050	$600,000	$600,000	$90,889	$84,958	$93,293	$102,568	$112,870	$118,464	$124,405	$130,674	$137,778	$145,683	$153,802	$162,109	$170,580	$179,202	$187,958
Non-metro	$8,213,775	$4,051,113	$4,051,165	$26,511	$22,835	$26,181	$30,011	$34,480	$36,232	$38,116	$40,202	$43,034	$46,640	$50,470	$54,518	$58,773	$63,229	$67,874
Transport to recyclers	**$22,387,651**	**$38,078**	**$39,863**	**$1,634,404**	**$1,461,152**	**$1,642,354**	**$1,847,626**	**$2,082,961**	**$2,187,664**	**$2,299,705**	**$2,421,209**	**$2,574,996**	**$2,761,626**	**$2,957,665**	**$3,162,638**	**$3,376,053**	**$3,597,512**	**$3,826,534**
Metro	$9,426,416	$0	$0	$727,115	$679,660	$746,346	$820,543	$902,964	$947,711	$995,243	$1,045,388	$1,102,224	$1,165,465	$1,230,420	$1,296,874	$1,364,644	$1,433,614	$1,503,662
Non-metro	$12,961,235	$38,078	$39,863	$907,289	$781,492	$896,008	$1,027,083	$1,179,997	$1,239,953	$1,304,462	$1,375,821	$1,472,772	$1,596,161	$1,727,245	$1,865,764	$2,011,409	$2,163,897	$2,322,873
Processing costs	**$116,100,059**	**$401,630**	**$371,315**	**$8,807,471**	**$7,736,805**	**$8,607,913**	**$9,603,003**	**$10,761,469**	**$11,254,105**	**$11,781,663**	**$12,363,039**	**$13,134,797**	**$14,101,696**	**$15,124,874**	**$16,201,723**	**$17,329,445**	**$18,505,659**	**$19,727,504**
E-waste	$116,100,059	$401,630	$371,315	$8,807,471	$7,736,805	$8,607,913	$9,603,003	$10,761,469	$11,254,105	$11,781,663	$12,363,039	$13,134,797	$14,101,696	$15,124,874	$16,201,723	$17,329,445	$18,505,659	$19,727,504
Manual	$13,841,034	$401,630	$371,315	$2,249,340	$1,520,912	$1,532,930	$1,547,257	$1,592,628	$1,496,315	$1,391,004	$1,295,611	$1,235,623	$1,207,678	$1,183,322	$1,161,975	$1,143,130	$1,126,385	$1,111,377
Mechanical	$102,259,025	$0	$0	$6,558,131	$6,215,893	$7,074,982	$8,055,746	$9,168,841	$9,757,790	$10,390,660	$11,067,428	$11,899,173	$12,894,018	$13,941,552	$15,039,748	$16,186,315	$17,379,273	$18,616,126
Metal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Manual	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Mechanical	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Regulatory costs	**$6,758,160**	**$759,917**	**$759,917**	**$1,266,717**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**	**$506,800**
Education costs	**$6,341,701**	**$0**	**$1,000,000**	**$1,000,000**	**$1,000,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**
Total costs	**$195,021,534**	**$5,848,531**	**$6,819,901**	**$16,321,232**	**$13,349,184**	**$14,075,021**	**$15,472,796**	**$17,093,396**	**$17,823,409**	**$18,609,531**	**$19,473,111**	**$20,578,538**	**$21,930,688**	**$23,361,353**	**$24,866,771**	**$26,442,890**	**$28,086,256**	**$29,792,711**
Value of material recovered	**$123,943,626**	**$0**	**$0**	**$14,854,837**	**$11,782,851**	**$12,328,620**	**$12,955,949**	**$13,705,850**	**$13,358,696**	**$13,005,517**	**$12,695,700**	**$12,723,840**	**$13,094,166**	**$13,504,822**	**$13,953,420**	**$14,437,761**	**$14,956,169**	**$15,506,629**
Avoided landfill operating costs	**$8,322,626**	**$107,083**	**$113,380**	**$394,691**	**$560,108**	**$621,206**	**$689,946**	**$768,426**	**$808,806**	**$851,600**	**$897,678**	**$955,040**	**$1,023,977**	**$1,096,382**	**$1,172,110**	**$1,251,000**	**$1,332,924**	**$1,417,713**
Avoided landfill leaching	**$6,213,653**	**$12,546**	**$13,093**	**$415,162**	**$534,384**	**$576,214**	**$623,130**	**$690,285**	**$674,956**	**$658,806**	**$645,214**	**$656,223**	**$692,961**	**$733,621**	**$778,104**	**$826,279**	**$878,008**	**$933,111**
Total benefits	**$138,479,905**	**$119,629**	**$126,474**	**$15,664,690**	**$12,877,343**	**$13,526,040**	**$14,269,024**	**$15,164,561**	**$14,842,457**	**$14,515,923**	**$14,238,593**	**$14,335,103**	**$14,811,104**	**$15,334,825**	**$15,903,634**	**$16,515,040**	**$17,167,101**	**$17,857,453**
NPV	**-$56,541,629**	**-$5,728,902**	**-$6,693,427**	**-$656,542**	**-$471,841**	**-$548,981**	**-$1,203,772**	**-$1,928,836**	**-$2,980,952**	**-$4,093,608**	**-$5,234,518**	**-$6,243,435**	**-$7,119,585**	**-$8,026,528**	**-$8,963,137**	**-$9,927,850**	**-$10,919,156**	**-$11,935,258**

Option 3	NPV	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Collection costs	**$51,416,795**	**-$2,206**	**-$2,358**	**$5,046,165**	**$3,898,304**	**$4,242,002**	**$4,617,758**	**$5,031,333**	**$5,227,270**	**$5,436,435**	**$5,659,145**	**$5,899,339**	**$6,156,494**	**$6,425,825**	**$6,706,679**	**$6,998,316**	**$7,300,161**	**$7,611,437**
Metro	$51,700,289	$0	$0	$4,788,023	$3,919,345	$4,271,334	$4,656,551	$5,081,215	$5,279,340	$5,490,731	$5,715,948	$5,960,513	$6,224,023	$6,500,168	$6,788,291	$7,087,647	$7,397,647	$7,717,498
Pick-up	$105,562,398	$0	$0	$7,783,791	$7,636,955	$8,496,087	$9,436,330	$10,473,978	$10,911,387	$11,370,638	$11,856,469	$12,409,622	$13,031,038	$13,678,862	$14,351,843	$15,048,588	$15,768,072	$16,508,843
Garbage collection	-$53,862,109	$0	$0	-$2,995,768	-$3,717,610	-$4,224,753	-$4,779,779	-$5,392,763	-$5,632,047	-$5,879,907	-$6,140,522	-$6,449,108	-$6,807,015	-$7,178,694	-$7,563,552	-$7,960,941	-$8,370,424	-$8,791,344
Non-metro	-$283,494	-$2,206	-$2,358	$258,142	-$21,042	-$29,332	-$38,793	-$49,882	-$52,070	-$54,295	-$56,803	-$61,175	-$67,529	-$74,342	-$81,612	-$89,330	-$97,486	-$106,062
Pick-up	$10,219,887	$19,868	$20,799	$655,646	$603,512	$727,517	$864,289	$1,016,733	$1,060,380	$1,105,921	$1,154,538	$1,215,737	$1,289,941	$1,367,665	$1,448,789	$1,533,170	$1,620,695	$1,711,203
Garbage collection	-$10,503,381	-$22,074	-$23,157	-$397,504	-$624,554	-$756,849	-$903,082	-$1,066,615	-$1,112,449	-$1,160,216	-$1,211,341	-$1,276,911	-$1,357,470	-$1,442,007	-$1,530,401	-$1,622,500	-$1,718,181	-$1,817,265
Sorting costs	**$12,140,255**	**$4,651,113**	**$4,651,165**	**$222,841**	**$223,875**	**$251,973**	**$282,381**	**$315,405**	**$329,025**	**$343,141**	**$357,806**	**$374,078**	**$391,941**	**$410,260**	**$429,000**	**$448,128**	**$467,627**	**$487,470**
Metro	$3,721,194	$600,000	$600,000	$185,390	$189,417	$210,402	$232,965	$257,247	$268,380	$279,904	$291,802	$304,586	$318,214	$332,098	$346,211	$360,527	$375,034	$389,718
Non-metro	$8,419,061	$4,051,113	$4,051,165	$37,451	$34,457	$41,570	$49,415	$58,158	$60,645	$63,237	$66,004	$69,492	$73,727	$78,162	$82,789	$87,601	$92,592	$97,752
Transport to recyclers	**$40,470,316**	**$38,078**	**$39,863**	**$2,764,800**	**$2,694,575**	**$3,105,886**	**$3,554,859**	**$4,048,332**	**$4,222,493**	**$4,403,401**	**$4,593,260**	**$4,814,917**	**$5,068,875**	**$5,331,719**	**$5,602,988**	**$5,882,204**	**$6,169,065**	**$6,463,123**
Metro	$20,483,570	$0	$0	$1,483,120	$1,515,339	$1,683,219	$1,863,724	$2,057,976	$2,147,042	$2,239,230	$2,334,416	$2,436,687	$2,545,710	$2,656,786	$2,769,688	$2,884,213	$3,000,276	$3,117,743
Non-metro	$19,986,746	$38,078	$39,863	$1,281,681	$1,179,236	$1,422,666	$1,691,135	$1,990,356	$2,075,451	$2,164,171	$2,258,844	$2,378,230	$2,523,165	$2,674,933	$2,833,301	$2,997,991	$3,168,789	$3,345,380
Processing costs	**$200,150,945**	**$401,630**	**$371,315**	**$13,540,070**	**$13,830,660**	**$15,684,528**	**$17,713,184**	**$19,958,749**	**$20,761,381**	**$21,594,948**	**$22,478,519**	**$23,548,645**	**$24,809,726**	**$26,122,932**	**$27,485,697**	**$28,895,308**	**$30,349,866**	**$31,846,720**
E-waste	$199,207,524	$401,630	$371,315	$13,342,683	$13,788,901	$15,631,524	$17,647,628	$19,879,297	$20,676,422	$21,504,363	$22,382,197	$23,446,484	$24,701,634	$26,008,825	$27,365,497	$28,768,944	$30,217,271	$31,707,832
Manual	$11,414,368	$401,630	$371,315	$1,459,118	$1,181,796	$1,248,849	$1,312,802	$1,403,289	$1,309,158	$1,205,847	$1,112,296	$1,054,016	$1,027,673	$1,004,830	$984,919	$967,441	$951,995	$938,222
Mechanical	$187,793,156	$0	$0	$11,883,565	$12,607,104	$14,382,675	$16,334,827	$18,476,008	$19,367,264	$20,298,516	$21,269,901	$22,392,468	$23,673,961	$25,003,995	$26,380,578	$27,801,504	$29,265,276	$30,769,610
Metal	$943,421	$0	$0	$197,386	$41,760	$53,004	$65,556	$79,451	$84,959	$90,585	$96,322	$102,161	$108,092	$114,107	$120,200	$126,363	$132,595	$138,888
Manual	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Mechanical	$943,421	$0	$0	$197,386	$41,760	$53,004	$65,556	$79,451	$84,959	$90,585	$96,322	$102,161	$108,092	$114,107	$120,200	$126,363	$132,595	$138,888
Regulatory costs	**$909,049**	**$323,733**	**$323,733**	**$323,733**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Education costs	**$8,966,018**	**$0**	**$2,000,000**	**$2,000,000**	**$2,000,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**
Total costs	**$314,053,377**	**$5,412,348**	**$7,383,718**	**$23,897,609**	**$22,647,414**	**$23,784,388**	**$26,668,182**	**$29,853,819**	**$31,040,169**	**$32,277,925**	**$33,588,729**	**$35,136,979**	**$36,927,036**	**$38,790,737**	**$40,724,364**	**$42,723,956**	**$44,786,719**	**$46,908,750**
Value of material recovered	**$298,094,421**	**$0**	**$0**	**$24,536,399**	**$23,599,351**	**$26,290,337**	**$29,160,962**	**$32,260,990**	**$32,669,854**	**$33,077,902**	**$33,534,835**	**$34,334,976**	**$35,481,369**	**$36,671,640**	**$37,902,789**	**$39,172,031**	**$40,477,938**	**$41,818,180**
Avoided landfill operating costs	**$10,463,081**	**$107,083**	**$113,380**	**$414,947**	**$725,356**	**$817,111**	**$917,817**	**$1,029,661**	**$1,075,374**	**$1,123,046**	**$1,173,571**	**$1,234,967**	**$1,307,534**	**$1,383,184**	**$1,461,789**	**$1,543,206**	**$1,627,333**	**$1,714,019**
Avoided landfill leaching	**$10,146,454**	**$12,546**	**$13,093**	**$605,812**	**$789,426**	**$895,641**	**$1,009,808**	**$1,147,165**	**$1,143,197**	**$1,138,232**	**$1,135,607**	**$1,157,322**	**$1,204,458**	**$1,255,179**	**$1,309,364**	**$1,366,866**	**$1,427,558**	**$1,491,261**
Total benefits	**$318,703,957**	**$119,629**	**$126,474**	**$25,557,158**	**$25,114,133**	**$28,003,088**	**$31,088,587**	**$34,437,816**	**$34,888,425**	**$35,339,180**	**$35,844,013**	**$36,727,265**	**$37,993,361**	**$39,310,003**	**$40,673,942**	**$42,082,104**	**$43,532,828**	**$45,023,460**
NPV	**$4,650,579**	**-$5,292,719**	**-$7,257,244**	**$1,659,549**	**$2,466,719**	**$4,218,700**	**$4,420,406**	**$4,583,997**	**$3,848,256**	**$3,061,255**	**$2,255,284**	**$1,590,287**	**$1,066,325**	**$519,266**	**-$50,423**	**-$641,853**	**-$1,253,891**	**-$1,885,290**

2.2 Sensitivity analysis

The CBA is necessarily based on a series of assumptions that mean there is a degree of uncertainty around the results. Sensitivity testing has been undertaken to clarify which assumptions can materially change the results.

2.2.1 Discount Rates

In accordance with Department of Treasury and Finance guidelines (DTF 2013, 2014), the stream of costs and benefits (in real terms) has been discounted using a real discount rate of 7%, with sensitivity testing using real discount rates of 4% and 9%. The key point from this sensitivity test is that the discount rate applied makes little difference to the results (Table 7). This is because future streams of costs and benefits change roughly in proportion to each other over time.

Table 7: Results of the discount rate sensitivity analysis

Discount rate	NPV ($m)				
	Option 1a	Option 1b	Option 1c	Option 2	Option 3
4%	$24	$13	$16	-$76	$6
7%	$20	$10	$13	-$57	$5
9%	$18	$9	$12	-$47	$4

2.2.2 High, low, sensitivity analysis

Sensitivity analysis was also undertaken to test synchronised changes to a range of key cost and benefit items. This 'tornado' analysis provides feasible upper and lower bounds for the NPVs and BCRs for each of the options. The costs and benefit items examined in the analysis include:

- all collection, sorting and transport costs;
- processing costs;
- disposal costs;
- value of recovered materials; and
- avoided environmental and health impacts associated with the disposal of e-waste to landfill.

The ranges of values applied to these variables are shown in the relevant costs and benefits tables in section 6. Results of the 'high, low' analysis are presented in Table 8.

Table 8: Results of 'high, low' sensitivity analysis (BCRs)

Option 1a				
		Change benefits		
		Low case	Central case	High case
Change costs	Low case	0.59	0.85	1.12
	Central case	0.73	1.05	1.38
	High case	0.92	1.33	1.75
Option 1b				
		Change benefits		
		Low case	Central case	High case
Change costs	Low case	0.58	0.83	1.10
	Central case	0.72	1.04	1.38
	High case	0.94	1.36	1.80
Option 1c				
		Change benefits		
		Low case	Central case	High case
Change costs	Low case	0.59	0.84	1.11
	Central case	0.73	1.05	1.38
	High case	0.94	1.36	1.80
Option 2				
		Change benefits		
		Low case	Central case	High case
Change costs	Low case	0.39	0.57	0.75
	Central case	0.49	0.71	0.95
	High case	0.64	0.93	1.25
Option 3				
		Change benefits		
		Low case	Central case	High case
Change costs	Low case	0.57	0.82	1.08
	Central case	0.71	1.01	1.34
	High case	0.91	1.31	1.73

Results of the sensitivity analysis presented in Table 8 reveal:

- All options are sensitive to changes in cost and benefit assumptions, with BCRs for the options ranging from 0.6 to 1.8 for Option 1a, 0.6 to 1.8 for Option 1b, 0.6 to 1.8 for Option 1c, 0.4 to 1.3 for Option 2 and 0.6 to 1.7 for Option 3 (see numbers shaded in yellow).
- Options are particularly sensitive to changes in benefit assumptions, with material values being the key variable here (see numbers in red bold).
- Options are also sensitive to changes in cost assumptions, with changes to processing costs and collection, sorting and transport costs being equally significant (see lighter shaded areas).

2.3 Willingness to pay threshold analysis

Benefits/ avoided costs associated with reducing the disposal of e-waste to landfill and increasing recycling of e-waste potentially include:

- sustainability/ reduced resource scarcity;
- avoided environmental and health impacts associated with the disposal of e-waste to landfill (especially pollutants entering the environment via landfill leachate);
- a sense of 'civic duty' that accompanies recycling and waste avoidance; and
- avoided environmental impacts associated with resource extraction and processing[12].

Only the first two of these benefits have been valued in the CBA. Even then, the values ascribed to them are highly uncertain noting that:

- as we have seen, material prices are subject to considerable fluctuations in the short and medium terms and might not necessarily reflect the level of scarcity of the materials in the longer term; and
- the values ascribed to the avoided health impacts of pollutants entering the environment via landfill leachate are subject to a great deal of uncertainty (see sections 0 and 6.3.2).

Given these uncertainties, we have also sought to estimate the community's willingness to pay (WTP) for the increased e-waste recycling that could be expected to occur with the implementation of either Options 1, 2 or 3. WTP refers to the value that the community places on the wellbeing that it derives from an increase in recycling. WTP is generally estimated using 'stated preference' economic techniques such as choice modelling. A new choice modelling study was beyond the scope of this study. Instead, we have applied a benefit transfer approach, interpolating results of a previous study into WTP for e-waste recycling (Rolls, Brulliard & Bennett, 2009), to derive a WTP estimate.

The result of that interpolation exercise, which is discussed in section 6.3.3, is a WTP estimate of $884/ tonne of additional e-waste that is recycled plus a premium of $160 for each tonne of e-waste that is recycled via a kerbside collection system. On a weighted average, when applied to the systems assumed to be in place for Options 1, 2 and 3 this represents a premium of approximately $128/ tonne. Thus derived, an estimate of the community's WTP for additional e-waste recycling achieved through implementing either Option 1a, 2 or 3 is $1,012/ tonne. For Options 1b and 1c, which do not involve kerbside collection systems, the community's WTP for additional e-waste recycling is $884/ tonne.

These estimates can be compared to WTP threshold values of $931, $915 and $915 shown in Table 4 for Options 1a, 1b and 1c respectively and $995 and $942 shown in Table 5 for Options 2 and 3 respectively. Those thresholds represent the respective WTP values that would be needed for Option 1, 2 or 3 to achieve a BCR >1 (positive NPV), after excluding 'material values' and 'avoided environmental impacts of landfills' from the cost-benefit analysis. Using WTP estimates in the CBA therefore, in place of 'material values' and 'avoided environmental impacts of landfills', indicates that Options 1a (BCR 1.08) and 3 (BCR 1.07) are now the highest ranked options, ahead of Option 2 (BCR 1.02), 1b (BCR 0.97) and 1c (BCR 0.97). The improved position of Option 2 reflects the fact that community members do not make a

12 Analysis that seeks to cost 'upstream impacts', such as environmental impacts associated with resource extraction and processing, for completeness would also need to assess the benefits of those processes such as producer surplus of the mining and processing industries.

distinction between material types when expressing WTP to reduce e-waste. The reduced position of Options 1b and 1c reflects the lower community WTP for options that do not entail kerbside collection.

2.4 Drivers, risks and conclusions

2.4.1 Drivers of results

Table 9 provides an understanding of the key factors driving results of the CBA and differences between the options.

Key information emerging from this table are:

- Each additional tonne of e-waste that is recycled (and therefore is diverted from landfill) is associated with net collection, sorting, transport and disposal costs of $276/ tonne (Option 1a), $237/ tonne (Option 1b), $248/ tonne (Option 1c), $306/ tonne (Option 2) or $290/ tonne (Option 3). The factors driving differences in collection costs between the options are:
  - Options 2 and 3 have slightly higher collection and sorting costs than Option 1a because the volumes of additional e-waste recycled under Options 2 and 3 are significantly less than under Option 1a, whereas some costs, notably upfront costs associated with upgrading transfer stations, are not proportionately lower; and
  - Options 1a and 1b have somewhat lower costs than Option 1a due to the use of drop-off points and collection events in metropolitan areas under those options rather than more expensive kerbside collection systems. It is important to note however, that much of the cost savings to councils and/or state government under Options 1b and 1c relative to Option 1a are offset by increases to household participation costs (see section 3). Furthermore, on a $/ tonne basis, costs associated with transporting the e-waste to recyclers are as significant under these two options as they are under Option 1a.
- Each additional tonne of e-waste processed or recycled has an average cost of $621/ tonne (Option 1a), $619/ tonne (Option 1b), $614/ tonne (Option 1c), $618/ tonne (Option 2) or $614/ tonne (Option 3). These differences are minimal and are within the normal range of margins of error.
- Each additional tonne of e-waste processed has a material value of $944/ tonne (Option 1a), $924/ tonne (Option 1b), $931/ tonne (Option 1c), $660/ tonne (Option 2) or $925/ tonne (Option 3). With the exception of Option 2, these differences are minimal and probably within the normal range of margins of error. Option 2 however, has a substantially lower average value of materials than the other options. This reflects the narrow range of products recovered under Option 2 compared to Options 1 and 3 and the intrinsically low value of materials in some of those products (e.g. CRT TVs and computers contain leaded glass which has a substantial negative value).

The low value of material recovered under Option 2 is the most important single factor explaining its low NPV and BCR relative to the other options.

Table 9: Key variables influencing CBA results

	Tonnes e-waste diverted from landfill relative to BaU, 2019-2035 ('000)		Net benefit (cost) per tonne diverted (PV$/ PV tonne)	Collection, sorting, transport & disposal costs (PV$/ PV tonne)	Processing costs (PV$/ PV tonne)	Value of materials recovered (PV$/ PV tonne)
	Actual	Present value (PV)				
Option 1a	922	451	$44	($276)	($621)	$944
Option 1b	520	255	$41	($237)	($619)	$924
Option 1c	573	282	$47	($248)	($614)	$931
Option 2	393	188	($301)	($306)	($618)	$660
Option 3	664	322	$14	($290)	($621)	$925

2.4.2 Risks

Risks associated with alternative e-waste collection, sorting and transport systems

Options 1a, 2 and 3

Analysis of the key drivers reveals that there are substantial additional costs associated with collecting, sorting and transporting each tonne of recovered e-waste relative to the costs associated with collecting, transporting and disposing the e-waste to landfill[13]. As discussed further in section 3, the net collection costs of $276/ tonne, $306/ tonne and $290/ tonne respectively for Options 1a, 2 and 3 are likely to fall substantially on local councils (collection costs, sorting costs and some or all of costs associated with transporting the e-waste to recyclers), with a relatively small proportion of the costs falling on residential generators of e-waste (principally in regional areas).

Some of the costs falling on councils could feasibly be passed on to other stakeholders - including to residential or business generators of e-waste via gate fees or rate charges or to processors through, for example, processors forgoing collection/transport charges). Either way however, these collection, sorting and transport costs represent a substantial cost gap that will need to be met through investment by a third party - most likely by State Government – if an e-waste ban is to be effective in achieving assumed recycling rates. Without the necessary investment to cover a combination of collection (including kerbside collection and 'drop-off'), transport and sorting capital and operating costs, there will be little incentive for councils and for residential and business e-waste generators to engage in e-waste recovery activities. The net result will be minimal additional genuine recovery of e-waste, with e-waste either being stockpiled, illegally dumped or continue to be sent to landfill.

Options 1b and 1c

Under Options 1b and 1c the net collection costs of $237/ tonne and $248/ tonne respectively are likely to be distributed more equally between households (participation costs) and local councils (sorting costs and costs associated with transporting the e-waste to recyclers). This means that the investment gap under these two options is less substantial than under Option 1a, albeit still significant.

13 Note, the 'collection, sorting, transport & disposal costs' presented in Table 7 for each option are net of avoided costs associated with landfill disposal of the e-waste.

The key additional risk of these two options however, is that because households in metropolitan areas are being expected to participate more actively in the e-waste collection process (either through dropping off e-waste at transfer stations or retail outlets or during collection events) they will be less inclined to be involved in the e-waste recycling process. Evidence for this is provided in a number of studies into recycling behaviour, including a study into kerbside recycling in metropolitan Melbourne (MWMG 2010), which indicates that for a very substantial proportion of households commitment to recycling is tempered by the level of effort required. As a consequence, e-waste recycling rates are assessed to be substantially lower under Options 1b and 1c than under Option 1a. There is also a risk that illegal dumping of e-waste will be greater under Options 1b and 1c than under Option 1a.

Based on this evidence recycling rates under Options 1b and 1c are assessed to be substantially less than under Option 1a (Table 10, see also Section 4).

Table 10: Estimated tonnes diverted from landfill relative to BaU, Options 1a, 1b, 1c, 2 and 3

	Tonnes diverted from landfill (2019-2035)
Option 1a	922,057
Option 1b	519,818
Option 1c	573,650
Option 2	392,977
Option 3	663,544

Health and safety issues

An additional risk associated with implementing either of Options 1, 2 or 3 is the occupational health and safety impacts (OH&S) associated with handling additional e-waste during the collection, transport, sorting and processing stages of e-waste recovery. There are three important points to note in response to this.

First, with respect to OH&S issues associated with the collection of e-waste, we have assumed that collection systems will need to be designed to a sufficiently stringent level to meet OH&S requirements. High collection costs for e-waste assumed in the analysis relative to other waste in part reflects this (see section 0).

Second, with respect to OH&S issues associated with sorting e-waste, we have assumed that substantial additional infrastructure investment will be required at transfer stations to ensure that they meet the Australian Standard 'Collection, storage, transport and treatment of end-of-life electrical and electronic equipment' (AS5377). Most of that investment will need to occur in transfer stations located outside of the metropolitan region (see section 0).

Finally, in line with proposed revisions to the *Environment Protection (Scheduled Premises) Regulations,* e-waste recyclers will be required to have stringent environmental and OH&S controls in place under BaU. This requirement is likely to cover all processors recycling 500 tonnes/year of e-waste or greater (i.e. all but a few small manual facilities).

Export of e-waste without a license

Another risk that will need to be carefully considered in the design and implementation of an e-waste landfill ban is export of e-waste without a license (or uncontrolled interstate movement). In the course of consultations some stakeholders indicated, anecdotally, that this may already be happening, although it could not be verified. The Victorian State Government will need to work closely with other state governments and with Commonwealth government agencies to ensure that implementation of a ban under Options 1 or 2 does not lead to this outcome.

2.4.3 Conclusions considering drivers and risks

It is apparent that there are significant risks associated with implementing any of the options assessed through the CBA. Given those risks, and the need for ongoing investment to ensure effective recovery of e-waste, avoid e-waste stockpiling and/or illegal dumping and to minimise OH&S risks, consideration will need to be given to ways of encouraging e-waste recovery while avoiding the potential pitfalls associated with the options assessed through this CBA. Extending product stewardship arrangements that currently apply under the National Television and Computer Recycling Scheme (NTCRS) to increase the breadth and depth of e-waste covered by the scheme may be one way of doing this.

3. Distributional and Other Impacts

This section details the results of the distributional impacts of the proposed options on different stakeholder groups. Distributional impact analysis has been undertaken to provide information on the distribution of costs and benefits across different stakeholder groups as well as providing some information on the regional split of costs and benefits. The distributional analysis draws upon information from the CBA modelling.

3.1 Stakeholder groups and impacts

The analysis focuses on several stakeholder groups:

- State Government;
- Local councils/ residents[14];
- Business consumers of e-products;
- Landfill operators[15];
- Broader community/ environment;
- Processing industry and metal recyclers.

3.1.1 Costs and benefits

Table 11 outlines the potential impacts of the options, both positive and negative, on these stakeholder groups.

Key cost and benefit items and stakeholders affected include:

- costs associated with the collection or drop-off of e-waste, which are assumed at present to fall on local councils/ residents or business generators of e-waste;
- additional transfer station capital and operating costs, which are assumed to fall on local councils;
- costs associated with transporting e-waste to recyclers, which are assumed to fall mainly on local councils or business consumers of e-waste, although it is acknowledged that these costs sometimes fall on the recyclers (this is particularly so with respect to metals recycling);
- processing costs, which are assumed to fall on the recyclers;
- value of recovered materials, which are assumed to go principally to the recyclers; and
- avoided impacts associated with disposal of hazardous materials to landfill, which are assumed to benefit the environment/ broader community.

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[14] Although local councils and local residents are two distinct groups, in practice it is difficult to delineate between the two groups when ascribing costs and benefits associated with the introduction of an e-waste landfill ban and more extensive e-waste recycling.

[15] It is recognised that in some cases operators of landfills will be local councils.

Table 11: Impacts (costs, benefits and transfers) of options on stakeholder groups

Costs		Benefits/ avoided costs	
Item	**Stakeholders**	**Item**	**Stakeholders**
Regulatory and administrative costs (option development, ongoing administration of the option; monitoring and enforcement)	State government	Value of recovered materials	Reprocessors/ metal recyclers
Information & education	State government	Avoided impacts associated with disposal of hazardous materials to landfill	Environment/ community
Compliance costs	Local councils, reprocessors/metal recyclers, landfill operators	Avoided transport costs to landfill (direct disposal)	Local councils/residents, business generators of e-waste
Collection and participation costs	Local councils/residents, business generators of e-waste	Avoided landfill operating costs (direct disposal)	Local councils/residents, business generators of e-waste
Transfer site capital costs (including storage)	State government		
Transfer site operating costs	Local councils/residents		
Reprocessing facility capital costs	Reprocessors/metal recyclers, state government		
Reprocessing facility operating costs	Reprocessors/metal recyclers, state government		
Transport costs to reprocessing facilities	Local councils/residents, business generators of e-waste		
Transport costs to landfill (indirect disposal)	Reprocessors/metal recyclers		
Landfill operating costs (indirect disposal of residual waste)	Reprocessors/metal recyclers		
Onsite stockpiling impacts (environment, amenity)	Not included		
Impacts of illegal dumping (environment, amenity)	Not included		

3.1.2 Transfers

Some transfers have also been included in the distributional analysis. Transfers refer to financial transactions between two or more stakeholder groups that are not of themselves an economic cost or benefit and are therefore not included in the CBA. Transfers typically include taxes, and charges and government grants. Table 12 provides an overview of potential transfers associated with the handling of e-waste indicating whether or not they have been included in the distributional analysis. With respect to gate fees charged at various points along the e-waste supply chain, it is important to note that these fees do not necessarily reflect the costs of providing the activity for which the fee is being charged – sometimes gate fees are charged, sometimes they are not and when a fee is charged it is often not fully cost reflective. Importantly, the actual costs of the activity itself are included in the CBA and distributional analysis.

Table 12: Transfers included/not included in the distributional analysis

Item	Stakeholders impacted (+/-)	Included in analysis?
Avoided landfill levy (direct disposal)	Local councils/residents (+)/ state government (-)	Yes
Increased landfill levy (indirect disposal)	State government (+)/ reprocessors/ recyclers (-)	Yes
Transfer station gate fees	Local councils/ transfer station operators (+), residents, business generators of e-waste (-)	No
Recycler gate fees	Reprocessors/recyclers (+), local councils/ residents (-)	No
Infrastructure grants	Reprocessors/recyclers, local councils/ residents (+)/ state government (-)	No
Non-compliance penalties	Landfill operators, recyclers, local councils/ residents (-), state government (+)	No

3.2 Distributional analysis results

Results of the distributional analysis are presented in Figure 2, Figure 3, Table 13 and Table 14. The results reveal that a substantial proportion of the overall costs of implementing either Option 1a, 2 or 3 are expected to fall on local councils. Most of these costs are associated with collection and transport of e-waste. This further highlights the key risk to the success of an e-waste landfill ban, discussed in section 2.4.2, should there be insufficient investment in e-waste collection, storage and transport infrastructure and services. On the other hand, under Options 1a and 1b there is a substantial shift of collection and sorting costs to residents, one consequence of this being low recycling rates relative to Options 1a.

The distributional analysis also reveals that recyclers are the stakeholder group most likely to benefit from implementing Options 1a, 1b, 1c or 3. Although e-waste recyclers have substantial costs associated with e-waste processing, these are more than offset by the value of recovered materials. The net benefits largely evaporate under Option 2 because the value of recovered materials are likely to be much lower and the costs of recycling greater under this option than under the other two options. It is important to also to note that even under Options 1a, 1b, 1c and 3, the benefits of increased e-waste recycling are more likely to be realised by the larger, mechanical processors than smaller, manual processors.

Figure 2: Distributional impacts of options on stakeholder groups, Options 1a, 2 and 3 ($2016)

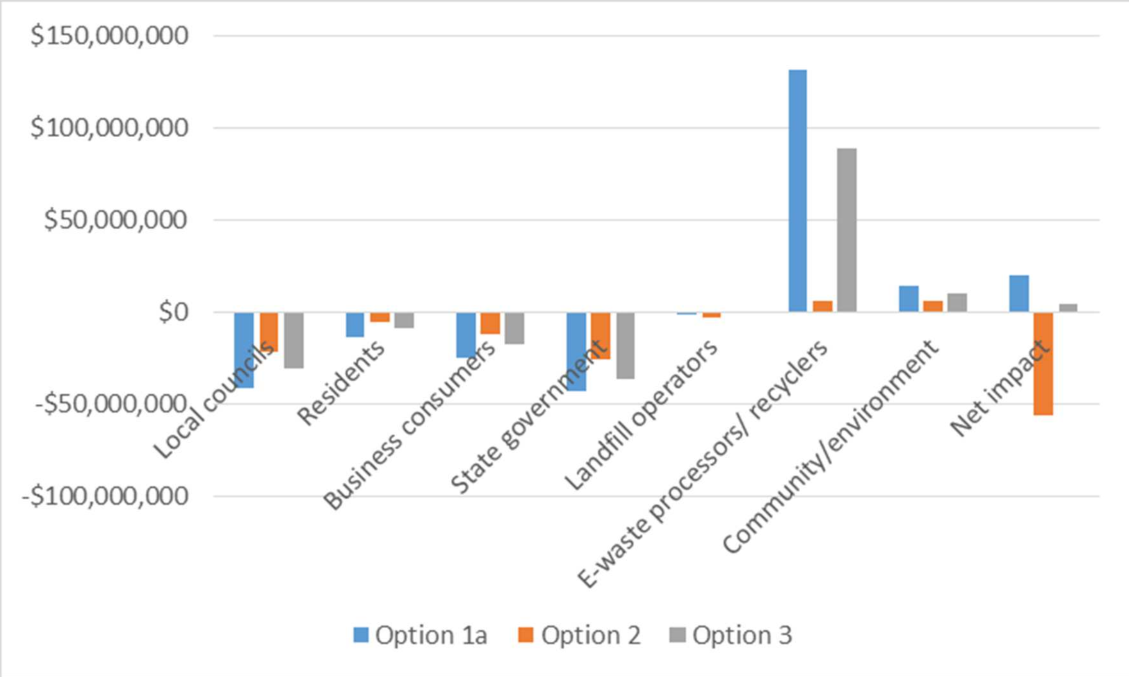


Table 13: Distributional impacts of options on stakeholder groups, Options 1a, 2 and 3 ($2016)

	Distribution of costs & benefits relative to BaU (Present Value: 2017-2035)		
	Option 1a	Option 2	Option 3
Local councils	-$41,187,962	-$21,986,169	-$31,067,922
Residents	-$14,087,923	-$5,648,023	-$8,901,321
Business consumers	-$25,185,314	-$12,094,058	-$17,753,179
State government	-$42,826,675	-$26,070,984	-$36,425,264
Landfill operators	-$1,801,675	-$2,822,625	$0
E-waste processors/ recyclers	$131,218,701	$5,866,576	$88,651,811
Community/environment	$13,948,262	$6,213,653	$10,146,454
Net impact	**$20,077,412**	**-$56,541,629**	**$4,650,579**

Figure 3: Distributional impacts of options on stakeholder groups, Options 1a, 1b and 1c ($2016)

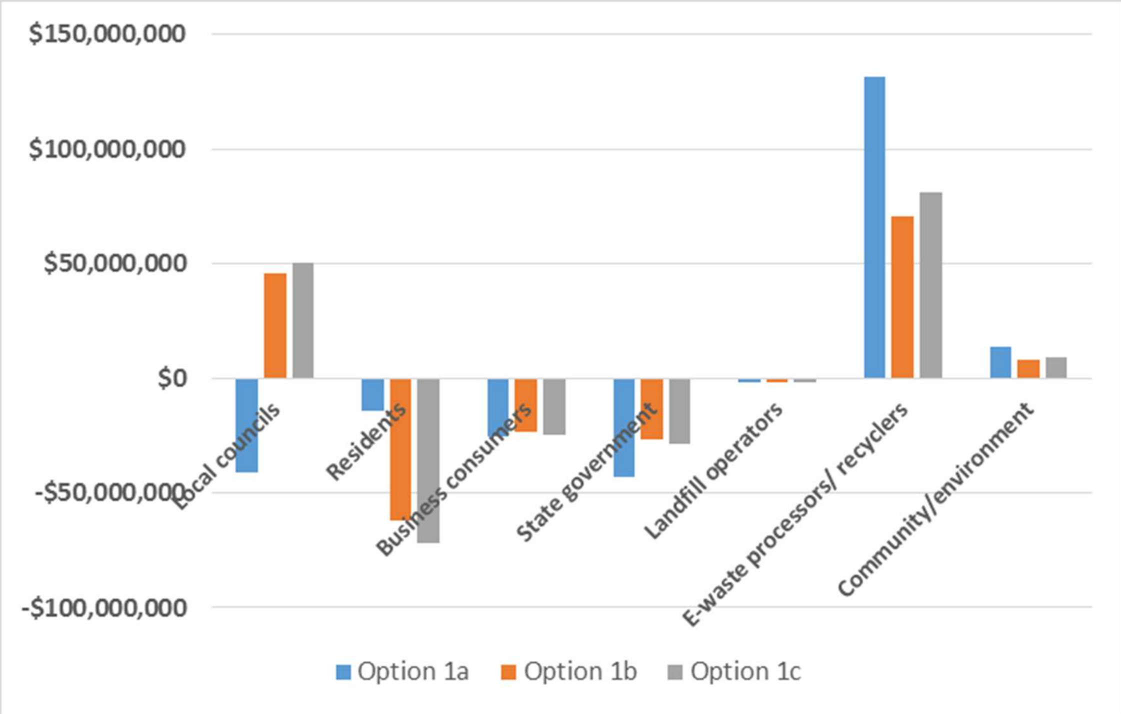


Table 14: Distributional impacts of options on stakeholder groups, Options 1a, 1b and 1c ($2016)

	Distribution of costs & benefits relative to BaU (Present Value: 2017-2035)		
	Option 1a	Option 1b	Option 1c
Local councils	-$41,187,962	$45,828,886	$50,435,607
Residents	-$14,087,923	-$62,080,447	-$72,140,274
Business consumers	-$25,185,314	-$23,496,656	-$24,810,114
State government	-$42,826,675	-$27,004,605	-$28,479,741
Landfill operators	-$1,801,675	-$1,801,675	-$1,801,675
E-waste processors/ recyclers	$131,218,701	$70,814,988	$81,182,111
Community/environment	$13,948,262	$8,157,340	$8,937,175
Net impact	**$20,077,412**	**$10,417,830**	**$13,323,088**

3.3 Regional impacts

High level analysis of the regional distribution of costs and benefits of the options has also been undertaken. The regional analysis – metropolitan areas versus non-metropolitan areas – reveals that the net benefits of options will largely flow to metropolitan areas, with non-metropolitan areas likely to have net costs (Table 15). This outcome largely reflects the location of most e-waste processing facilities in metropolitan areas, and the high costs of transporting e-waste to the processing facilities from non-metropolitan areas (estimated on average to be approximately $342/ tonne).

In non-metropolitan areas, the net cost of Option 1a of $32.9 million over the period of the analysis (2017-2035) represents a cost per Local Government Area (LGA) of approximately $0.7 million or a cost per person of about $22. In metropolitan areas, the net benefit of $52.9

million over the period of the analysis for Option 1a represents a benefit per LGA of about $1.7 million or a benefit per person of about $3. It is important to note however, that most of those benefits will not be realised at the local government level.

Table 15: Impacts of options on regions, Options 1a, 2 and 3 ($2016)

	Regional distribution of costs and benefits ($ 2016)				
	Option 1a	Option 1b	Option 1c	Option 2	Option 3
Costs					
Metro	($393,847,201)	($206,830,326)	($228,028,393)	($174,212,469)	($285,931,065)
Non metro	($39,733,967)	($35,190,917)	($38,784,836)	($20,809,065)	($28,122,313)
Benefits					
Metro	$446,793,769	$248,274,439	$275,620,300	$134,868,056	$313,583,078
Non metro	$6,864,811	$4,164,633	$4,516,018	$3,611,849	$5,120,879
Net impact					
Metro	$52,946,568	$41,444,114	$47,591,907	($39,344,412)	$27,652,013
Non metro	($32,869,156)	($31,026,284)	($34,268,818)	($17,197,216)	($23,001,434)
Total	$20,077,412	$10,417,830	$13,323,088	($56,541,629)	$4,650,579

3.4 Impacts on small business

When assessing the impacts of an e-waste landfill ban on small business, two aspects of the issue need to be considered:

- impacts of the policy on small business in the waste management sector; and
- impacts of the policy on small business more generally.

Impacts on small business in waste management

Noting that most waste management businesses in Victoria meet the Australian Securities and Investment Commission (ASIC) definition of a small business[16], it is likely that implementation of either Options 1a, 1b, 1c or 3 (all of which have a small positive NPV) will result in positive impacts to waste management small businesses. Without more detailed analysis, it is not possible to be precise about the extent of this impact.

A preliminary assessment of the employment impacts of introducing either Option 1a, 1b, 1c, 2 or 3 has been made however. That assessment, presented in Table 16, draws on an Access Economics (2009) study which estimates that the direct full time equivalent (FTE) employment per additional 10,000 tonnes of waste recycled is 9.2 and for landfills is 2.8. Under Option 1a, this equates to approximately 50 additional jobs in recycling, offset by a loss in landfill employment of 15, meaning a net increase in employment of 35 (ongoing). Most of those jobs are likely to be in the small business sector.

There will also be flow-on effects from the employment generated in the waste sector. Based on an estimated multiplier in the waste sector of 1.84 (Access Economics 2009), this equates to additional indirect employment of about 30 under Option 1a.

Direct and indirect employment under Options 1a, 1b, 2 and 3 will be less than under Option 1a.

[16] Defined as a business with an annual turnover of <$25 million

Table 16: Impacts of options on employment

	Increase in resource recovery	Direct employment impact (FTE)			Indirect employment
	('000s t/ yr)	Recycling	Landfill	Net impact	(FTE)
Option 1a	54,239	49.9	- 15.2	34.7	29.2
Option 1b	30,578	28.1	- 8.6	19.6	16.4
Option 1c	33,744	31.0	- 9.4	21.6	18.1
Option 2	23,116	21.3	- 6.5	14.8	12.4
Option 3	39,032	35.9	- 10.9	25.0	21.0

Source: Marsden Jacob drawing on Access Economics 2009

Impacts on small business economy wide

Under a partial economic analysis provided by a CBA it is not possible to estimate the broader economic implications of implementing a landfill ban including impacts on small business. That requires general equilibrium analysis, which is outside the scope of this study.

We can state however, that implementation of any of the options is likely to increase costs for small businesses associated with the disposal of end of life e-waste. For most small businesses, waste disposal is a small percentage of their total costs (<1 percent), so the cost impact is likely to be relatively minor.

3.5 Competition impacts

Through the National Competition Council, governments in Australia have a long standing commitment to ensuring that government policies, programs and investments encourage competition. As discussed in the recent competition policy review (Harper et al. 2015), this requires that government policies (amongst other objectives):

- make markets work in the long-term interests of consumers;
- foster diversity, choice and responsiveness in government services;
- encourage innovation, entrepreneurship and the entry of new players; and
- promote efficient investment in and use of infrastructure and natural resources.

Following are two principles of competition policy that are relevant particularly relevant to these objectives in the context of an e-waste landfill ban.

1. **Competitive neutrality**

   Will the implementation a landfill ban unfairly favour some businesses (in the waste management sector) at the expense of others or create barriers to market entry?

   In response, there is no reason why implementation of a landfill ban on e-waste is intrinsically at odds with the competitive neutrality principle. Provided design of the implemented option is not done in a way that specifically favours specific businesses or sub-sectors of the waste management industry then the costs and benefits associated with a landfill ban should in general terms affect all industry players more or less equally.

2. **Government procurement**

   Government procurement decisions can shape the structure and functioning of competition in markets. In line with recommendations of the competition policy review (Harper et al. 2015) it is important that any investment undertaken by State government as part of implementing a landfill ban on e-waste (either directly or indirectly) is done in a way that promotes competition.

4. Analysis of Alternative Collection Systems

This section provides an analysis of alternative collection and handling systems under Options 1a, 1b and 1c. The analysis includes a detailed description of the different collection systems, a financial analysis of the options from the perspective of public sector costs, an assessment of government investments likely to be required under the options, and a cost effectiveness assessment (CEA) of the alternatives.

4.1 Alternative collection systems

Options 1a), 1b) and 1c) all entail a comprehensive ban on e-waste going to landfill. The key distinguishing characteristic of the three variations of this option is the type of e-waste collection and handling systems being provided. Following are details of the e-waste collection systems assumed under each of the options and discussion of the level of access provided through those alternatives. It is important to note that different types of collection system not only entail different costs but also different recycling and net recovery rates (see section 4.3). It is also important to note that the collection system described for Option 1a is also assumed to apply to Options 2 and 3.

Option 1a: residential kerbside collection service in metropolitan areas and permanent drop-off points in regional areas

The collection system under this option consists of the following elements:

Metropolitan areas

- A ‘day-after’ collection service will be provided for small domestic e-waste.
- The most likely system would involve households placing their e-waste in a bag that has been provided specifically for that purpose, with the bag placed in turn in the recycling bin (for protection). The bag would be collected from the bin and loaded manually on to tray trucks. A replacement bag would then be provided to the household. This system would be quite time and labour intensive but would minimise breakages and OH&S risks.
- Collection of larger residential e-waste items will be undertaken drawing on existing hard waste collection services, also using tray trucks.
- Kerbside collection services will be provided throughout metropolitan Melbourne providing almost universal access for households (see Box 1).
- There will be 2-4 small e-waste collections per year in each municipality.
- There will be 1-2 larger e-waste collections per year.
- Commercial e-waste (small and large) will (continue to) be collected through commercial collection services (generally via a booking system).
- Major upgrades required to an estimated 8 transfer stations.
- Further upgrades to most of the other 16 transfer stations will also be required in the future to deal with increases in e-waste throughput.

Regional and rural areas

- Regional and rural areas will be serviced by permanent drop-off points.

- Permanent drop-off points will be available for both residential and commercial e-waste[17].
- A very high level of access to the drop-off points (see Box 1).
- 157 of the 245 transfer stations currently located in regional and rural areas will be able to accept e-waste (i.e. one for every population centre of 1500 or greater). Consistent with the model of reasonable access set out for Option 1a, approximately 91% of people in regional and rural areas will have reasonable access to e-waste drop-off facilities.
- At present, an estimated 49 regional transfer stations currently meet AS5377 (analysis based on Randell et al. 2015), this means that an additional 108 additional regional transfer stations will need to be upgraded to meet this option.
- Minor upgrades to drop-off stations that already meet AS5377 are assumed also to be required to meet increased throughput over time (including for example in Geelong, Ballarat, Bendigo, Melton and Shepparton).

Option 1b: permanent drop-off points in all areas for domestic e-waste

The collection system under this option consists of the following elements:

Metropolitan areas

- Drop-off facilities will be located at transfer stations based on the Option 1b 'reasonable access' definition for metropolitan areas provided in Box 1.
- A minimum of 24 drop-off facilities in metropolitan Melbourne will be able to accept e-waste, 8 more than are currently provided through the NTCRS.
- All 24 drop-off facilities must be able to accept all e-waste and must meet AS5377.
- Major upgrades will therefore be required at 8 transfer stations.
- Minor upgrades to most of the other 16 transfer stations will also be required in the future to deal with increases in e-waste volumes.
- Permanent drop-off facilities will be supplemented by drop off points at up to 75 retail outlets and some council offices, libraries and other public buildings.
- Retail outlets will only be able to accept e-waste covered by the NTCRS and/or mobile phones. Council offices and public buildings will only be able to accept mobile phones and batteries because….
- Commercial e-waste (small and large) will (continue to) be collected through commercial collection services (generally via a booking system).

Regional and rural areas

- Permanent drop-off points will be available for both residential and commercial e-waste.
- Location of transfer station drop-off facilities will be based on the Option 1b 'reasonable access' definition for regional areas provided in Table 17.
- 80 drop-off facilities across regional and rural Victoria will be able to accept e-waste (i.e. one for every municipality and one for every other town of 4000 people). This is substantially more than are currently provided through the NTCRS or through the

[17] In principle commercial collection services could be used in regional areas for commercial e-waste. In practice, they are likely to be prohibitively expensive and therefore used only minimally.

Household Chemical Collection system. This will provide reasonable access to about 78% of regional Victorians (as defined in Table 17).

- All 80 drop-off facilities must be able to accept all e-waste and meet AS5377.
- Major upgrades will therefore be required at an estimated 31 transfer stations.
- Minor upgrades to drop-off stations that already meet AS5377 are assumed also to be required to meet increased throughput over time.
- Permanent drop-off facilities will be supplemented by drop off points located at up to 20 retail outlets and some council offices, mostly in major regional centres (e.g. Geelong, Ballarat, Bendigo, Melton and Shepparton).
- Retail outlets will only accept e-waste covered by the NTCRS and/or mobile phones. Council offices will only accept mobile phones and batteries.

Option 1c: permanent drop-off points in all areas for domestic e-waste plus collection 'events'

This option involves supplementing Option 1b - i.e. permanent drop-off points - with a minimum number of mobile collection events held each year in metropolitan and regional Victoria. The collection events would be similar in design to Household Chemical Collection mobile events. The collection system under Option 1c consists of the following elements:

- The same number and location of permanent drop-off points will be provided as per Option 1b.
- Mobile collections will be used to supplement permanent drop-off points. Thus the opportunity for e-waste drop-off will be enhanced under Option 1c relative to Option 1b.
- Mobile events will generally be held in local government areas that do not have permanent drop-off facilities or in parts of a municipality that are relatively remote from permanent drop-off points.
- Approximately 75 mobile collection events will be held each year, with about 50 being held in regional and rural areas and 25 in metropolitan areas. Combined with permanent drop-off points, this will enable approximately 99% of metropolitan and 88% of regional and rural Victorians to have reasonable access to an e-waste service.
- Events are likely to be held in accessible public places. This could include transfer stations or reserves.
- Events will need to be heavily promoted.

Box 1: Level of access provided by alternative collection systems

'Reasonable access' is a concept promoted in relation to a range of government services. There is no hard and fast definition of reasonable access. With waste management services, for example, different definitions of reasonable access are applied to designing collection systems for the National Television and Computer Recycling Scheme (NTCRS) and Victoria's Household Chemicals Collection Program. The definition of reasonable access adopted for this analysis is stricter than either of those two programs, noting that the level of access under those schemes is deemed by many stakeholders to be inadequate, especially in regional areas[18].

The reasonable access definition is presented in Table 17. The definition varies according to the option, with Option 1a providing the greatest level of access and Option 1b the least. The level of access provided under Option 1c is greater than Option 1b but less than Option 1a. The level of access provided by each of the options is presented in Table 18.[19]

It is important to note that a high access rate will not of itself ensure a high e-waste recycling rate. Other key factors influencing recycling rates include household and business 'propensity to recycle' and 'ease of access' (see section 5 for further discussion of recycling rates under the different options).

Table 17: Reasonable access definitions for Options 1a, 1b and 1c

Region	Key criteria		
	Option 1a	Option 1b	Option 1c
Metropolitan	Kerbside collection service for every municipality (domestic)	One permanent drop-off point for every 250,000 people	One permanent drop-off point for every 250,000 people plus mobile collection events in municipalities that don't have permanent points and in metropolitan fringe
Regional	One permanent drop-off point for every municipality plus one for every town of 1500 people	One permanent drop-off point for every municipality plus one for every town of 4000 people.	One permanent drop-off point for every municipality plus one for every town of 4000 people plus mobile collection events for every town of 2000 people

Table 18: Estimated level of access provided under Options 1a, 1b and 1c

Region	Estimated level of access[20]		
	Option 1a	Option 1b	Option 1c
Metropolitan	>99%	90%	98%
Regional	93%	78%	88%

[18] This view was expressed by a number of stakeholders during the course of consultations undertaken for this study.

[19] Note, the level of access provided under Options 2 and 3 is the same as for Option 1a.

[20] The estimated level of access is based on a travel distance of less than 10 kilometres each way in metropolitan areas, which requires less than 20 minutes of driving time each way in non-peak hour traffic. In regional areas the estimated level of access is based on the proportion of the population living within 25 kilometres of towns providing an e-waste service, which also requires less than 20 minutes of driving time each way.

4.2 Financial analysis

4.2.1 Overview

The analysis presented in this section provides an assessment of costs to the public sector (state government and/ or councils) associated with implementing Options 1a, 1b and 1c. It is important to stress that because the financial analysis focusses on public sector costs, costs associated with aspects of the e-waste supply chain that fall on other sectors (e.g. metal recyclers, e-waste processors and household and business consumers) are excluded from the analysis. As a financial analysis, it also excludes non-financial economic costs.

Table 19 sets out results of the financial analysis. The analysis indicates that Option 1b is likely to entail the lowest public sector costs of the three options, followed by Option 1c, with Option 1a being the most expensive.

Table 19: Public sector costs 2017-2035 associated with Options 1a, 1b and 1c (PV $2016)

	Option 1a	Option 1b	Option 1c
Collection & drop-off	**$25,866,533**	**-$83,241,687**	**-$88,595,149**
Metro	$42,773,307	-$73,879,197	-$78,181,305
Non-metro	-$16,906,775	-$9,362,490	-$10,413,844
Events	$0	$0	**$5,668,097**
Handling & sorting	**$4,415,214**	**$29,421,872**	**$29,678,276**
Metro	$3,489,446	$13,616,965	$13,811,603
Non-metro	$925,768	$15,804,907	$15,866,673
Transport to recyclers	**$59,598,172**	**$33,185,411**	**$36,856,336**
Metro	$27,915,569	$15,897,484	$17,454,594
Non-metro	$31,682,603	$17,287,927	$19,401,742
Education	**$6,341,701**	**$6,341,701**	**$6,341,701**
Regulation	**$8,642,371**	**$8,642,371**	**$8,642,371**
Investment in infrastructure	**$8,995,794**	**$4,193,201**	**$4,193,201**
Metro	$1,160,748	$1,470,280	$1,470,280
Non-metro	$7,835,047	$2,722,921	$2,722,921
TOTAL	**$113,859,785**	**-$1,457,131**	**$2,784,834**
TOTAL (excluding savings in collection costs)	**$130,766,560**	**$81,784,556**	**$91,379,983**

Two important points to note about these results are:

1. The costs are total present value costs for the period 2017-2035.
2. Two totals are presented:
   i) Net costs, which includes savings to councils in garbage and hard waste collection costs, under Options 1b and 1c, stemming from diversion of e-waste from 'standard' council garbage and hard waste collection systems.
   ii) Total costs excluding the savings in garbage and hard waste collection costs. The rationale behind this total is that in practice it is quite unlikely that these costs savings will be realised by councils, especially if the services are being provided by waste contractors. This is because e-waste represents a relatively small proportion of the total waste stream, so cost savings associated with diverting e-waste from these waste streams will be hard to demonstrate. Arguably therefore, this second total is a more

realistic estimate of the net financial costs to councils and government of the collection systems. It is therefore used as the basis for the financial analysis.

The key factor driving lower costs under Option 1b relative Option 1a is the shift to a collection system based on permanent drop-off points in metropolitan areas rather than system based on kerbside collection. This entails a significant shift in costs from councils/ state government to households, as well as a reduction in financial costs in absolute terms. Costs under Option 1c are higher than Option 1b reflecting the additional costs of collection events that are being held under Option 1c.

4.2.2 Annual public sector costs/ investment requirements over time

Drawing on outputs of the financial analysis, Table 20 provides estimates of annual public sector investment required in the first 10 years under Options 1a, 1b and 1c if effective implementation of their collection, sorting and transport systems is to be ensured. Apart from some education and regulatory costs and significant upfront investment in upgrading transfer stations, most of the required investment relates to ongoing operational costs. As detailed in section 6.2.3, discussions with councils and waste contractors suggest that additional capital costs associated with kerbside collection systems under Option 1a and transport of e-waste to recyclers (Options 1a, 1b and 1c) are likely to be relatively minor. Increases in public sector investment requirements over time therefore, largely reflect expected increased volumes of e-waste being collected and transported over time. It is important to note that these public sector investment requirements will continue beyond 2026 and are likely to continue to increase as e-waste volumes increase.

4.2.3 Cost assumptions underpinning financial analysis

Key costs that are included in the financial analysis (and which are also reflected in the CBA) are as follows.

- For Option 1a):
  - small e-waste kerbside collection costs of approximately $295/tonne and large e-waste of approximately $302/ tonne in metropolitan areas; and
  - transfer station upgrade costs of $9.3 million spread over two years.
- For Option 1b):
  - transfer station upgrade costs of $4.3 million spread over two years; and
  - additional handling and sorting costs of e-waste at permanent drop-off sites at transfer stations of approximately $81/ tonne.
- For Option 1c):
  - transfer station upgrade costs and handling and sorting costs as per Option 1b; and
  - costs associated with staging e-waste collection events of $179/ tonne in metropolitan areas and $217/ tonne in regional areas.
- For all options:
  - costs associated with transporting the e-waste to processors and recyclers of approximately $1.90/ tonne/ kilometre.

Further details of these costs are provided in section 6.2.

Table 20: Approximate annual public investment required in first 10 years under Options 1a, 1b and 1c ($/ year)

Option 1a	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Ongoing	**$500,000**	**$500,000**	**$10,745,198**	**$9,322,768**	**$10,010,261**	**$10,759,426**	**$11,580,065**	**$12,028,846**	**$12,503,481**	**$13,004,727**
Collection & drop-off	$0	$0	$5,129,753	$3,439,589	$3,624,437	$3,827,606	$4,052,032	$4,211,265	$4,385,434	$4,573,307
Events	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Handling & sorting	$0	$0	$323,877	$332,117	$364,392	$399,204	$436,840	$456,596	$477,049	$498,233
Transport to recyclers	$0	$0	$4,078,268	$4,337,763	$4,808,132	$5,319,316	$5,877,892	$6,147,684	$6,427,698	$6,719,887
Regulation	$0	$0	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300
Education	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Upfront	**$5,909,917**	**$5,909,917**	**$1,259,917**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Regulation	$759,917	$759,917	$759,917	$0	$0	$0	$0	$0	$0	$0
Education	$500,000	$500,000	$500,000	$0	$0	$0	$0	$0	$0	$0
Transfer station upgrades	$4,650,000	$4,650,000	$0	$0	$0	$0	$0	$0	$0	$0
Total	**$6,409,917**	**$6,409,917**	**$12,005,115**	**$9,322,768**	**$10,010,261**	**$10,759,426**	**$11,580,065**	**$12,028,846**	**$12,503,481**	**$13,004,727**

Option 1b	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Ongoing	**$500,000**	**$500,000**	**$5,654,552**	**$5,980,565**	**$6,457,937**	**$6,975,472**	**$7,540,689**	**$7,779,612**	**$8,028,096**	**$8,288,117**
Collection & drop-off	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Events	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Handling & sorting	$0	$0	$2,349,719	$2,438,877	$2,599,183	$2,771,724	$2,958,281	$3,065,593	$3,179,014	$3,298,284
Transport to recyclers	$0	$0	$2,091,533	$2,328,389	$2,645,453	$2,990,448	$3,369,108	$3,500,719	$3,635,782	$3,776,534
Regulation	$0	$0	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300
Education	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Upfront	**$3,427,417**	**$3,427,417**	**$1,259,917**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Regulation	$759,917	$759,917	$759,917	$0	$0	$0	$0	$0	$0	$0
Education	$500,000	$500,000	$500,000	$0	$0	$0	$0	$0	$0	$0
Transfer station upgrades	$2,167,500	$2,167,500	$0	$0	$0	$0	$0	$0	$0	$0
Total	**$3,927,417**	**$3,927,417**	**$6,914,469**	**$5,980,565**	**$6,457,937**	**$6,975,472**	**$7,540,689**	**$7,779,612**	**$8,028,096**	**$8,288,117**

Option 1c	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Ongoing	**$500,000**	**$500,000**	**$6,389,953**	**$6,735,604**	**$7,256,711**	**$7,820,537**	**$8,434,752**	**$8,725,290**	**$9,028,024**	**$9,344,843**
Collection & drop-off	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Events	$0	$0	$431,856	$440,923	$467,313	$495,304	$524,953	$556,207	$589,089	$623,553
Handling & sorting	$0	$0	$2,370,253	$2,459,733	$2,621,155	$2,794,866	$2,982,649	$3,091,240	$3,205,993	$3,326,641
Transport to recyclers	$0	$0	$2,374,544	$2,621,648	$2,954,944	$3,317,068	$3,713,850	$3,864,542	$4,019,643	$4,181,349
Regulation	$0	$0	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300	$713,300
Education	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Upfront	**$3,427,417**	**$3,427,417**	**$1,259,917**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Regulation	$759,917	$759,917	$759,917	$0	$0	$0	$0	$0	$0	$0
Education	$500,000	$500,000	$500,000	$0	$0	$0	$0	$0	$0	$0
Transfer station upgrades	$2,167,500	$2,167,500	$0	$0	$0	$0	$0	$0	$0	$0
Total	**$3,927,417**	**$3,927,417**	**$7,649,870**	**$6,735,604**	**$7,256,711**	**$7,820,537**	**$8,434,752**	**$8,725,290**	**$9,028,024**	**$9,344,843**

4.3 Cost effectiveness analysis

Although Options 1b and 1c entail significantly lower overall public sector costs than Option 1a and are likely to require lower year on year investment by government, these are not the only factors that should be considered in an analysis of this type. Also relevant is the extent to which the alternative collection systems divert e-waste from landfill and the cost-effectiveness of doing so.

Table 21 provides results of a cost-effectiveness analysis, indicating the potential cost to government for each tonne of e-waste diverted from landfill under Options 1a, 1b and 1c. As indicated in the table, Option 1a ($290/ tonne) is the most cost effective of the three options, followed by Options 1b ($321/ tonne) and 1c ($325/ tonne). This suggests that although Option 1a entails greater levels of public sector costs than Options 1b and 1c, from a public sector investment perspective, there may be some merit in implementing Option 1a.

Table 21: Cost effectiveness of alternative collection systems, Options 1a, 1b and 1c

	E-waste diverted from landfill (PV 2017-2035)	Public sector cost (PV 2017-2035)	$/tonne diverted
Option 1a	451,257	$130,766,560	$290
Option 1b	255,060	$81,784,556	$321
Option 1c	281,525	$91,379,983	$325

5. Material Flows

5.1 Material flows analysis

As noted in section 1.3.1 and illustrated in Figure 1 many of the costs and benefits underpinning the CBA are linked to e-waste material flows. Recognising this, a comprehensive and detailed material flows analysis (MFA) covering flows of e-waste and of the hazardous waste components of e-waste was undertaken to support the CBA. The MFA includes:

- a detailed and comprehensive disaggregation of e-waste by product code[21];
- a breakdown of each product by material type and hazardous waste component;
- classification of products by fate category (i.e. recovery mode);
- e-waste flows (generated, processed, landfilled, exported) under BaU and options for the period 2016 to 2035;
- quantities of recovered materials (iron/steel, copper, lead, aluminium, precious metals and rare earths, glass, leaded glass, plastics, BFR containing plastics and other); and quantities of hazardous materials (lead, cadmium, chromium, nickel, mercury, antimony, indium, americium, POP-BDEs, other BFRs)

Further details of the method and assumptions applied to the MFA are provided in section 6.4.

5.2 E-waste flows under BaU and options

5.2.1 E-waste generation

Total e-waste generated in Victoria in 2015 was estimated to have been approximately 109,000 tonnes. This is projected to grow to approximately 256,000 tonnes in 2035, a growth of more than 4% per annum (Figure 4).

Most of the growth in e-waste is expected to be in:

- Category A (large appliances) - from 35,866 tonnes in 2015 to 82,212 tonnes in 2035;
- Category C (small household tools & appliances) - from 27,035 tonnes in 2015 to 66,731 tonnes in 2035; and
- Category F (leisure and PV) - from 14,575 tonnes in 2015 to 46,785 tonnes 2035, most of which will be growth in PV (solar) panel waste.

By contrast, Category D e-waste (NTCRS products including computers and TVs), is projected to have only minimal growth - from 26,922 tonnes in 2015 to 29,768 tonnes in 2035. As a consequence, the share of NTCRS products in the e-waste stream is projected to fall from almost 25% in 2015 to less than 12% in 2035.

[21] There is no specific consideration of batteries in the material flows. They would form part of the recycled or disposed product. However we considered batteries in determining whether a product would be included in the hazardous stream, and would be therefore be subject to a ban under Option 2. An example of a product type included as hazardous due to batteries is '0702 games consoles'.

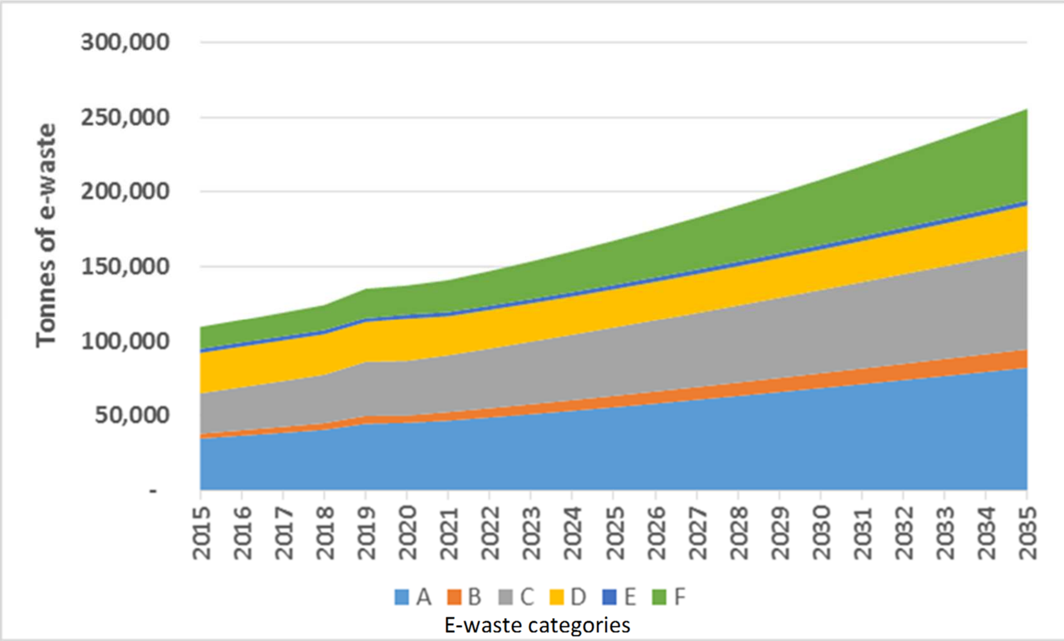


Figure 4: Projection of e-waste generation in Victoria by category (tonnes)

5.2.2 E-waste recovery

Figure 5 shows e-waste recovery percentages under BaU and Options 1a, 2 and 3.

Figure **6** show e-waste recovery percentages under BaU and Options 1a, 1b and 1c.

Figure 5: E-waste recovery, BaU and Options 1a, 2 and 3 (%)

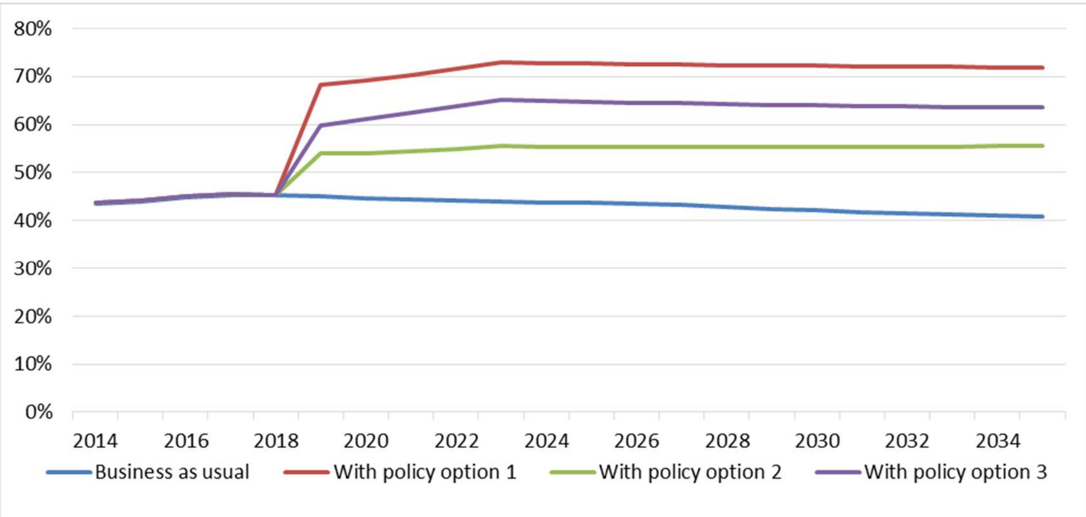
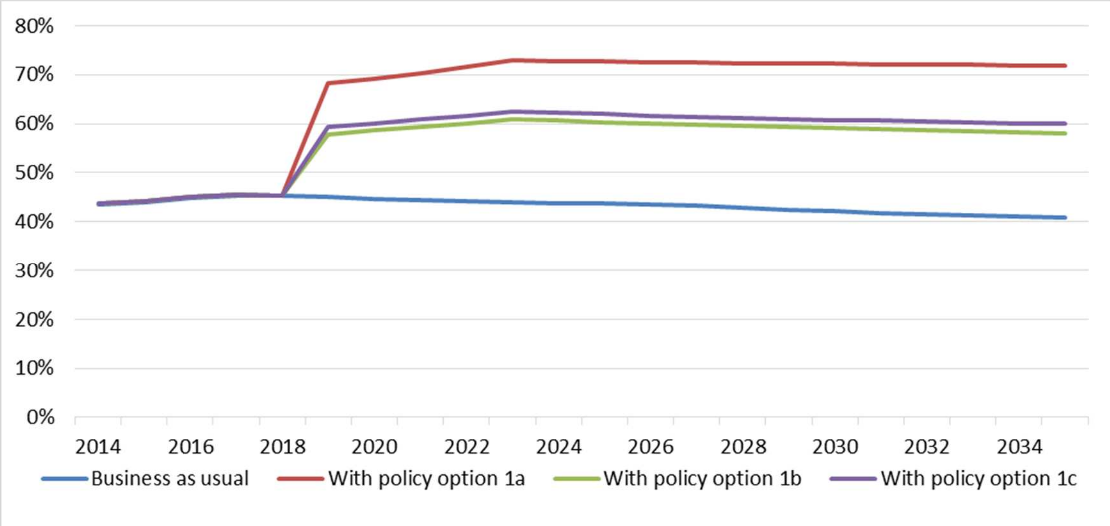


Figure 6: E-waste recovery, BaU and Options 1a, 1b and 1c (%)



Under BaU, net recovery of e-waste is projected to increase from 45,000 tonnes in 2015 to 104,000 tonnes in 2035. However, this represents a reduction in the recovery rate (from 43% to 41%).

Option 1a (landfill ban all e-waste, kerbside collection systems in metropolitan areas) is expected to produce the most substantial growth in net recovery of e-waste, from 43% to 72% (184,000 tonnes) by 2035. This growth will be driven by a combination of the landfill ban and substantial investment in e-waste collection, transport and storage infrastructure and services.

Option 1b (landfill ban all e-waste, permanent drop-off sites) is expected to produce less significant growth in net recovery of e-waste, from 43% to 61% by 2024 before declining slightly to 58% (149,000 tonnes) by 2035[22]. The lower recovery rate under this option, relative to Option 1a, reflects the use of drop-off sites rather than a kerbside collection system in metropolitan areas. As discussed in section 2.4.2, available evidence (e.g. (MWMG 2010) indicates that 45-50% of households will be less inclined to undertake recycling if significant effort is required on their part to do so.

Option 1c (landfill ban all e-waste, permanent drop-off sites plus collection events) is expected to produce slightly higher e-waste net recovery rates than Option 1b, from 43% to 62% by 2024 before declining slightly to 60% (153,000 tonnes) by 2035. A series of approximately 75 collection events under this option (in addition to the permanent drop-off sites as per Option 1b), is estimated to recover an additional 3,000 tonnes per annum of e-waste.

Option 2 (landfill ban, hazardous e-waste only) is expected to produce only modest growth in the net recovery of e-waste from 43% to 56% (142,000 tonnes) by 2035. This reflects the fact that hazardous materials containing e-waste (see Table 3) are, with the exception of PV panels, expected to be a declining proportion of e-waste in the future. For example, the share of NTCRS products in the e-waste stream is projected to fall from almost 25% in 2015 to less than 12% in 2035.

[22] This decline reflects a move over time to e-products that have a relatively low proportion of recoverable components.

Option 3 (no landfill ban, focus on e-waste education and investments) is expected lead to significant growth in the net recovery of e-waste from 43% to 64% (162,000 tonnes) by 2035. Without the 'stick' of a landfill ban however, e-waste recovery will not be as significant as under Option 1.

5.2.3 E-waste to landfill

The impact of options on e-waste disposed to landfill is the converse of e-waste recovery (Figure 7). Under BaU, e-waste disposed to landfill is expected to increase from 51,000 tonnes in 2016 (plus 7,000 tonnes disposed indirectly) to 134,000 tonnes by 2035 (plus 18,000 tonnes disposed indirectly). By contrast under Option 1 e-waste disposed to landfill will increase to just 44,000 tonnes by 2035 (plus 27,000 tonnes disposed indirectly).

Figure 7: E-waste disposed directly to landfill, BaU and Options 1a, 2 and 3 (tonnes)

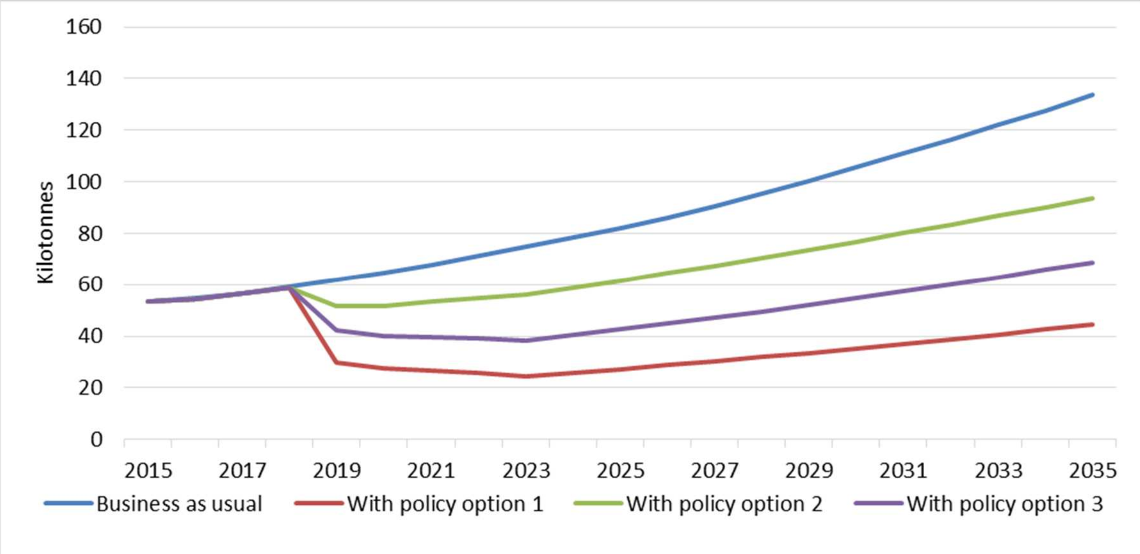
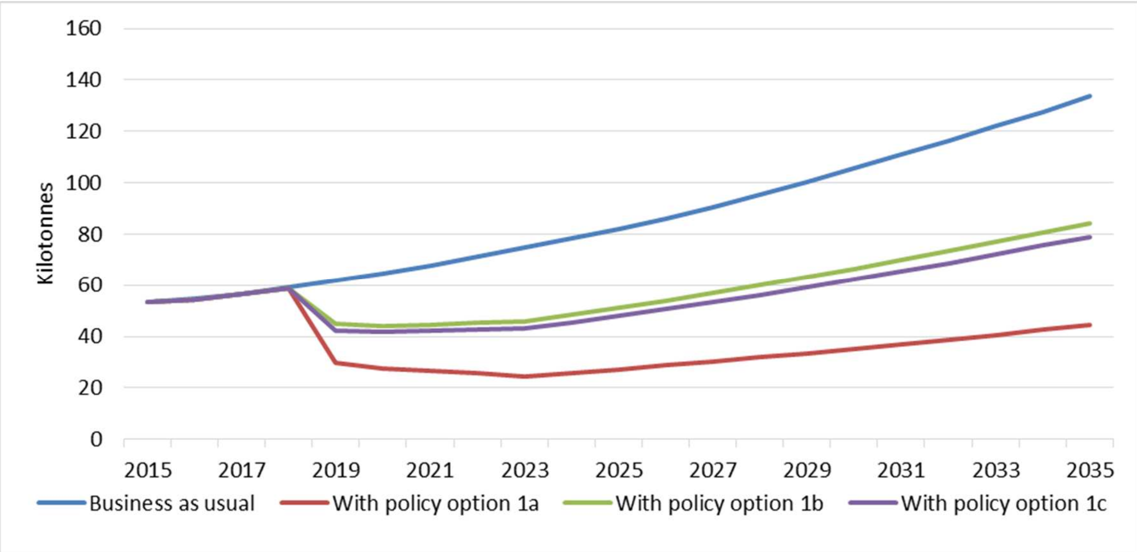


Figure 8: E-waste disposed directly to landfill, BaU and Options 1a, 1b and 1c (tonnes)



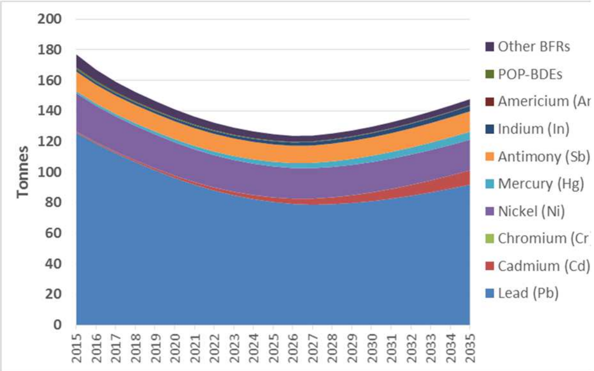
5.3 Hazardous waste flows under BaU and options

5.3.1 Hazardous waste flows to landfill

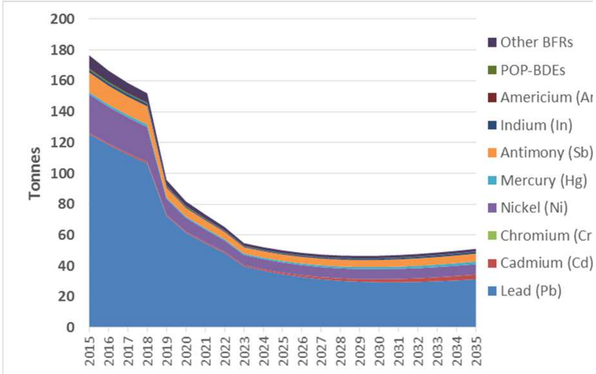
Implementing Option 1, 2 or 3 is expected to reduce the hazardous components of e-waste being disposed to landfill. Under BaU, hazardous materials[23] entering landfills via e-waste (including lead, cadmium, mercury, chromium, nickel and POP BDEs) are expected to initially decline from current levels of approximately 177 tonnes per year in 2015 to 124 tonnes by 2026, before increasing again to 148 tonnes by 2035 (Figure 9).

Figure 9: Hazardous components of E-waste disposed to landfill, BaU and options

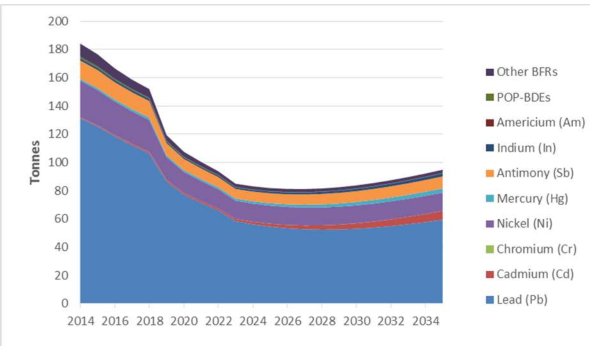
BaU



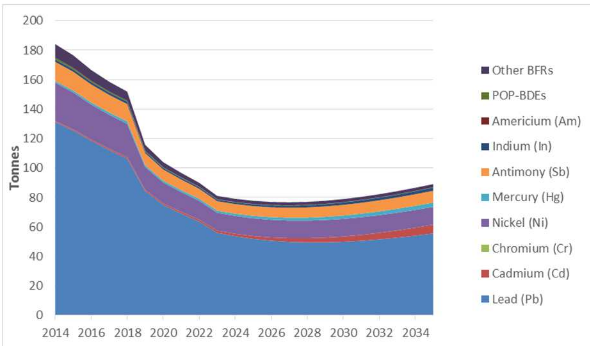
Option 1a,



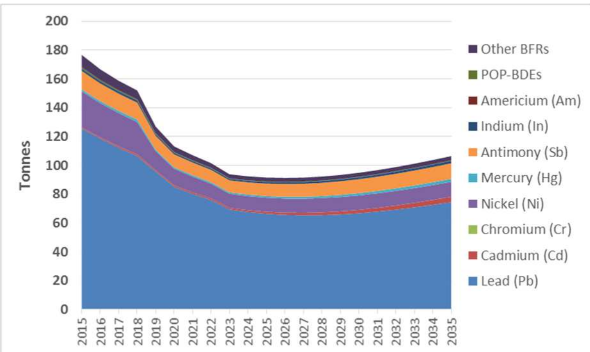
Option 1b



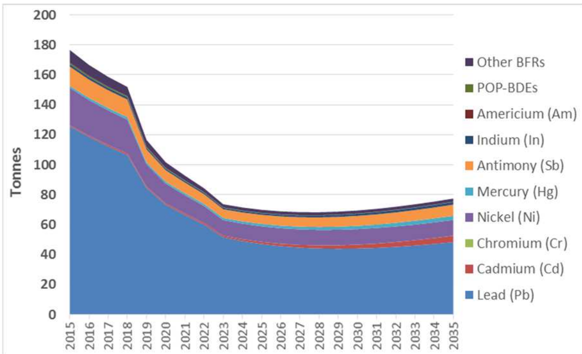
Option 1c



Option 2



Option 3



[23] Hazardous materials include: Lead, Cadmium, Chromium, Nickel, Mercury, Antimony, Indium, Americium and POP BDEs.

The reduction in CRTs going to landfill is a significant factor driving the initial decline, but continued growth of other e-waste going to landfill, including PV panels, will eventually reverse the decline in hazardous waste entering landfills.

Under Option 1a, hazardous waste entering landfills via e-waste are expected to decline to 51 tonnes per year by 2035. The decline in hazardous materials entering landfills under Options 1b, 1c, 2 and 3 is less than under Option 1a but still significant (95, 89, 106 tonnes and 77 tonnes in 2035 under Options 1b, 1c, 2 and 3 respectively).

A seemingly anomalous outcome of implementing Option 2 (given that this option specifically targets e-waste containing hazardous materials) is that hazardous waste entering landfill via e-waste under this option is significantly greater than either Option 1a or Option 3. This outcome reflects the fact that e-waste products targeted by the Option 2 landfill ban become much smaller shares of e-waste over time (e.g. TVs and computers which decline from 25% of all e-waste to 12%) and, conversely, e-waste products not targeted by the Option 2 landfill ban, but containing very small quantities of hazardous materials, become larger shares of e-waste over time.

5.3.2 Landfill leachate

Hazardous material compositions in e-waste have been used to estimate the quantities of hazardous materials that leach into the environment from e-waste that is disposed to landfills in Victoria[24]. This has been done by applying the following steps:

1. Deriving estimates of ***hazardous material composition*** in various types ***of e-waste***.
2. Determining the total ***hazardous components of e-waste disposed to landfill***.
3. Determining the ***landfill fate of these hazardous materials*** as they leach out of e-wastes in landfill and become ***leachate contaminants.***
4. Estimating the environmental fate of these hazardous materials as landfill leachate containing them leaks out of landfill over time, causing them to become ***environmental pollutants.***
5. Taking the same underlying data***, normalizing the hazardous characteristic of each hazardous material*** to equate them to a single measure of hazard (with reference to mercury), based on reference to hazardous waste/ substance contaminant threshold limits used in Victorian waste classification.
6. Estimating the ***total normalized hazard (as mercury equivalents)*** for each e-waste type.
7. Estimating the ***landfill fate of normalized hazard (as mercury equivalents)*** leaching out of e-wastes in landfill and into leachate.
8. Estimating the ***environmental fate of normalized hazard (as mercury equivalents)*** as landfill leachate containing them leaks out of landfill over time.

Table 22 reveals estimates of the flows of hazardous materials in e-waste to the environment in Victoria via landfill leachate. The hazardous materials include mercury, lead, cadmium, chromium, nickel, antimony, americium, indium, BFRs and POP BDEs but applying Step 6

[24] Estimates are averages based on an assumption that a majority of landfills in Victoria receiving e-waste operate according to best practice guidelines (EPA 2015).

(from the list of steps outlined above) the quantities of these materials have been normalised to mercury equivalents.

Based on these estimates and applying the 8 steps outlined above, the total quantities of hazardous materials contained in e-waste that enter the environment in Victoria as pollutants each year via landfill leachate is estimated to be approximately 0.2 tonnes (mercury equivalents) per year in 2016, increasing over time to approximately 0.3 tonnes (mercury equivalents) per year in 2035. Reducing the quantities of e-waste disposed to landfill under Options 1a, 1b, 1c, 2 and 3 will reduce the quantities of these pollutants.

The method, assumptions and sources of data applied to estimating these pollutant flows under BaU and the options are detailed in section 6.4.4.

Estimates of the environmental fate of the normalised hazard are in turn used to estimate the value of avoided health impacts of pollutants entering the environment via landfill leachate under Options 1a, 1b, 1c, 2 and 3 (see section 6.3.2).

Table 22: Flow of hazardous materials in e-waste to the environment via landfill leachate

E-waste product	Hazard to environment in mercury (Hg) equivalents (tonnes/ 100 tonnes of e-waste)
Professional Heating & Ventilation (excl. cooling equipment)	0.0004
Dishwashers	0.0002
Kitchen (f.i. large furnaces, ovens, cooking equipment)	0.0002
Washing Machines (incl. combined dryers)	0.001
Dryers (wash dryers, centrifuges)	0.001
Household Heating & Ventilation (f.i. hoods, ventilators, space heaters)	0.0004
Fridges (incl. combi-fridges)	0.0003
Freezers	0.0003
Air Conditioners (household installed and portable)	0.0003
Other Cooling (f.i. dehumidifiers, heat pump dryers)	0.0003
Professional Cooling (f.i. large airconditioners, cooling displays)	0.0004
Microwaves (incl. combined, excl. grills)	0.0004
Photosensitive semiconductor devices (PV)	0.03
Other Small Household (f.i. small ventilators, irons, clocks, adapters)	0.007
Food (f.i. toaster, grills, food processing, frying pans)	0.007
Hot Water (f.i. coffee, tea, water cookers)	0.008
Vacuum Cleaners (excl. professional)	0.008
Personal Care (f.i. tooth brushes, hair dryers, razors)	0.007
Small IT (f.i. routers, mice, keyboards, external drives & accessories)	0.1
Desktop PCs (excl. monitors, accessories)	0.1
Laptops (incl. tablets)	0.08
Printers (f.i. scanners, multifunctionals, faxes)	0.08
Telecom (f.i. (cordless) phones, answering machines)	0.15
Mobile Phones (incl. smartphones, pagers)	0.1
Professional IT (f.i. servers, routers, data storage, copiers)	0.1
Cathode Ray Tube Monitors	0.4
Flat Display Panel Monitors (LCD, LED)	0.06
Small Consumer Electronics (f.i. headphones, remote controls)	0.02
Portable Audio & Video (f.i. MP3, e-readers, car navigation)	0.02
Music Instruments, Radio, HiFi (incl. audio sets)	0.07
Video (f.i. Video recorders, DVD, Blue Ray, set-top boxes)	0.07
Speakers	0.05
Cameras (f.i. camcorders, foto & digital still cameras)	0.06
Cathode Ray Tube TVs	0.4
Flat Display Panel TVs (LCD, LED, Plasma)	0.06
Lamps (f.i. pocket, christmas, excl. LED & incandescent)	0.02
Straight Tube Fluorescent Lamps	0.02
Special Lamps (f.i. professional mercury, high & low pressure sodium)	0.02
Household Luminaires (incl. household incandescent fittings)	0.02
Professional Luminaires (offices, public space, industry)	0.02
Household Tools (f.i. drills, saws, high pressure cleaners, lawn mowers)	0.006
Professional Tools (f.i. for welding, soldering, milling)	0.006
Toys (f.i. car racing sets, electric trains, music toys, biking computers)	0.008
Game Consoles	0.03
Non Cooled Dispensers (f.i. for vending, hot drinks, tickets, money)	0.002
Cooled Dispensers (f.i. for vending, cold drinks)	0.002

6. Data Assumptions

6.1 Introduction

Results of the CBA and distributional analysis, presented in sections 2 and 3, are contingent on values ascribed to cost and benefit items examined in the analyses. Table 23 provides a summary of the main cost and benefit items applied in the analysis. These are discussed in detailed in the following sections.

Values applied in the analysis come from a number of sources including:

- discussions with industry and council stakeholders undertaken for this analysis;
- previous waste management studies;
- Victorian waste management data compiled by Government agencies including Sustainability Victoria; and
- commodities market data available online. [25]

Where specific references are used for a data source these are provided in the discussion.

Additionally, as outlined in Figure 1, most of the key costs and benefits are volume dependent and their values therefore are significantly influenced by assumptions applied in the material flows analysis (MFA). Key MFA assumptions are therefore also discussed below.

[25] Studies and data bases sourced include: Khaliq et al. 2014; Marsden Jacob 2014, 2016, Randell et al. 2015; Rolls et al. 2016; SMEC 2014; Spadaro & Rabl, 2008; Sustainability Victoria 2011, 2015

Table 23: Costs and benefits of options relative to BaU

Cost items	Benefit/ avoided cost items
Policy, regulatory and administrative costs - Government regulatory (including policy development, policy administration, monitoring and reporting) - Information and education programs - Compliance costs (industry, landfill operators and councils) **Collection and transport costs** - Collection and transport from source - Transfer station infrastructure upgrades - Handling and sorting costs - Transport to processors and metal recyclers - Household and business participation costs (drop-off) **Processing costs** - E-waste processing, hazardous and non-hazardous (mechanical) - E-waste processing (manual) - Metal recycling	**Avoided collection and transport costs** - Garbage collection and transport **Avoided landfill costs** - Landfill operating costs - Landfill externalities (environment, health and amenity) **Recovered material value** - Iron/ steel - Copper - Aluminium - Precious metals - Rare earth elements - Plastics - Glass[26]

6.2 Costs

6.2.1 Policy, regulation and administration costs

State government and local councils (and contractors responsible managing transfer stations and landfills) are expected to be subject to additional regulatory and administrative costs associated with implementing an e-waste landfill ban and/or encouraging greater e-waste recovery. The costs fall into two broad categories: costs associated with policy development and implementing the preferred option and costs associated with ongoing regulation of the option including monitoring and enforcement costs (State government) and compliance costs (Local councils and contractors). Information relating to these costs were provided by DELWP and were updated following consultations with stakeholders. The costs are detailed in Table 24.

Important points to note about the policy, regulation and administration costs are as follows:

- It is assumed that every local council will need to update their waste management plans to accommodate the introduction of Option 1a, 1b, 1c, 2 or 3. While the cost to each individual council is relatively small (estimate at $22,750/ per council). Across all councils this comes to a substantial amount.
- There will also be significant costs to councils associated with ongoing administration of the plans.
- There will be significant costs to State government involved in monitoring compliance with a ban under Options 1a, 1b, 1c and 2.

[26] Note, glass recovered from e-waste has a limited value or in the case leaded glass has a negative value

- There will be substantial ongoing costs to landfill operators associated with monitoring compliance with a ban under Options 1a, 1b, 1c and 2.

Table 24: Policy, regulation, administration and compliance costs

Start-up regulation and administration costs ($)	Options 1a, 1b, 1c	Option 2	Option 3
State government			
e-waste strategy development, legislative drafting and implementation	175,500	175,500	117,000
Consultation processes	125,000	125,000	62,500
Total State government start-up	300,500	300,500	179,500
Local councils			
Development of e-waste management plan (0.25 FTE/ council, 0.1 FTE Option 3)	***1,979,250***	***1,979,250***	***791,700***

Annual regulation and administration costs ($/year)	Option 1	Option 2	Option 3
State government			
Bin audits: 8 councils per year (2 in metro region, 1 for every other region)	160,000	160,000	-
Inspections of transfer stations: 16 sites per year (4 in metro region, 2 for every other region)	6,300	6,300	-
Response to e-waste related reports @ transfer stations: 16 sites per year	7,200	7,200	-
Inspections of licensed recycling sites: BAU inspections of licensed sites: 16 sites per year (4 in metro region, 2 in each regional area)	6,300	6,300	-
Response to e-waste related reports @ recycling sites: 16 sites per year	7,200	7,200	-
Two-day roadside inspection blitzes: 1 per year	6,000	6,000	-
Inspections of landfill licensed sites: BAU inspections of licensed sites: 12 sites per year(2 in each regional area)	6,300	6,300	-
Response to e-waste related reports @ landfills: 16 sites per year	7,200	7,200	-
Total state government annual	***206,500***	***206,500***	**-**
Local councils/ contractors (transfer stations, landfills)			
e-waste management plan implementation (5 days/ year/ council)	152,250	152,250	-
Inspections of transfer stations: 16 sites per year (4 in metro region, 2 for every other region)	4,900	4,900	-
Response to e-waste related reports @ transfer stations: 16 sites per year	5,600	5,600	-
Inspections of licensed recycling sites: BAU inspections of licensed sites: 16 sites per year (4 in metro region, 2 in each regional area)	4,900	4,900	-
Response to e-waste related reports @ recycling sites: 16 sites per year	5,600	5,600	-
Inspections of landfill licensed sites: BAU inspections of licensed sites: 12 sites per year(2 in each regional area)	4,900	4,900	-
Response to e-waste related reports @ landfills: 16 sites per year	5,600	5,600	-
Ongoing monitoring @ licensed landfill sites (0.05 FTE/ site)	323,050	323,050	-
Total local council/ contactors annual	***506,800***	***506,800***	**-**

It is also important to note that while additional occupational health and safety (OH&S) and environmental regulatory costs could potentially result from the introduction of Options 1a, 1b, 1c, 2 or 3, due to proposed revisions to the *Environment Protection (Scheduled Premises) Regulations*, many of these costs are assumed to be captured under the base case (BaU). Under the proposed revisions, e-waste recyclers will be required to have stringent environmental and OH&S controls in place and will cover all processors recycling 500 tonnes/year of e-waste or greater (i.e. all but a few small manual facilities). The costs associated with these revisions will impact on both the State Government (EPA Victoria) and recyclers.

6.2.2 Education and information costs

The design of Options 1a, 1b, 1c, 2 and 3 assumes that implementing either option will need to be accompanied with a comprehensive information and education campaign. The campaign will need to include intensive community education and information in the lead-up to and immediately following introduction of the option and ongoing education over the life of the option. An ongoing campaign is critical as available evidence from waste and other environmental programs and policies indicates that while information and education can play a significant complementary role (to regulatory measures and incentives) in facilitating behavioural change, the campaign needs to be ongoing to ensure that behavioural change is not spasmodic or short lived (Gardner & Stern 2002, OECD 2008, 2011).

Costs detailed in Table 25 are based on preliminary data provided by DELWP on the potential cost of either a 'high impact', 'medium impact' or 'low impact' education and awareness campaign. This data was then cross-referenced against similar, waste- and environment-related education campaigns costed and/ or implemented in Victoria and elsewhere in Australia including, for example, water efficiency education programs implemented in the 2000s in Victoria and litter and recycling education programs implemented or costed for Victoria and NSW. These indicate the need for a medium to high impact education program to accompany initial implementation of an e-waste plan, with ongoing funding for a lower level campaign over the period of the analysis. The cost of the campaign is assumed to be significantly greater under Option 2 than Options 1a, 1b, 1c and 3 during the implementation phase because of the added complexities of introducing a ban under Option 2 that entails only certain types of e-waste.

Table 25: Education and information costs

E-waste education and information costs ($)	Year 1	Year 2	Year 3	Years 4 to 20
Options 1a, 1b, 1c				
Information, education and awareness campaign (medium to high impact). Includes TVC campaign metro and regional, outdoor advertising, , press, council engagement, website	1,000,000	1,000,000	1,000,000	500,000
Option 2				
Information, education and awareness campaign (high impact). Includes TVC campaign metro and regional, outdoor advertising, , press, council engagement, website	2,000,000	2,000,000	2,000,000	500,000
Option 3				
Information, education and awareness campaign (medium to high impact). Includes TVC campaign metro and regional, outdoor advertising, , press, council engagement, website	1,000,000	1,000,000	1,000,000	500,000

Source: DELWP

6.2.3 Collection, sorting and transport costs overview

Collection, transport, sorting and disposal costs are all assessed in the analysis on a $/tonne basis. They are therefore assumed to vary depending on changes to the quantities of e-waste flows going through the different collection, transport, sorting and disposal systems under the base case and changes to those flows under the options.

Table 26 provides an overview of collection and transport costs applied in the analysis. Sources of information for these costs estimates include recent data on costs currently incurred by waste management services (e.g. Sustainability Victoria 2015) and discussions with stakeholders, especially regarding recent experience with pilot e-waste collection and drop-off schemes.

Table 26: Collection, transport, sorting and disposal costs applied in the central, high and low cases[27] ($/tonne)

Cost item	Waste type	Region	Central case	High case	Low case
Residential & commercial garbage collection	General waste	Metro	**165**	132	198
		Non-metro	**168**	134	202
Residential kerbside collection	Small e-waste	Metro	**295**	236	354
Residential hard waste collection	General waste & whitegoods	Metro	**201**	161	242
Residential hard waste collection (e-waste)	Large e-waste	Metro	**302**	242	362
Commercial e-waste collection	All e-waste	Metro	**312**	250	374
Residential e-waste drop-off (participation)	All e-waste	Metro	**168**	134	202
		Non-metro	**178**	142	214
Commercial e-waste drop-off (participation)	All e-waste	Non-metro	**154**	123	185
Handling costs	All e-waste	All	**10**	8	12
Handling & sorting, permanent drop-off sites	All e-waste other than whitegoods	Metro (Options 1b & 1c only)	**81**	65	97
		Non-metro	**81**	65	97
Events handling, sorting & organising (Option 1c)	All e-waste	Metro	**179**	143	215
		Non-metro	**217**	174	260
Transport to processors	All e-waste	Metro	**80**	64	96
		Non-metro	**342**	274	410
Landfill operating costs	All e-waste	Metro	**46**	37	55
		Non-metro	**60**	48	72

Details of the collection systems/ drop-off systems applying to each of the options and the financial costs associated with those systems are provided in sections 4.1 and 4.2.

[27] The Central case is the most likely outcome of the CBA. The High case is the case that produces the highest feasible outcome (in terms of NPV and BCR). The Low case is the case that produces the lowest feasible outcome.

Key points to note regarding collection, transport, handling and landfill costs include the following:

- Under Options 1a, 2 and 3 all small residential e-waste is assumed to be collected via a kerbside system in metropolitan areas. The significant cost of this service reflects the likely need to use tray trucks and associated significant handling costs and the relatively low volumes involved.
- Under Options 1a, 2 and 3 all large residential e-waste is assumed to be collected via a kerbside hardwaste system in metropolitan areas. The significant cost of this service also reflects the need to use tray trucks and substantial handling costs.
- In metropolitan areas (Options 1b and 1c only) and non-metropolitan areas (all options) small and large residential e-waste is assumed to entail a drop-off system. The principal costs involved in a drop-off system are:
  - the participation costs of residents encompassing transport costs and the opportunity cost of time; and
  - costs at transfer stations associated with additional staff needed to coordinate the drop-off system and to handle and sort the e-waste.
- Under Options 1a, 2 and 3 e-waste that goes through transfer stations via kerbside systems is assumed to incur a nominal handling cost of $10/ tonne.
- Under all options transfer stations will need to be upgraded to ensure that they are compliant with the Australian Standard for the Collection, storage, transport and treatment of end-of-life electrical and electronic equipment (AS5377). The number and cost of the upgrades will depend on the level of access assumed under each of the options, with Options 1a, 2 and 3 (which assume very high levels of access) having greater upgrade costs ($9.3 million over two years) than Options 1b and 1c ($4.3 million over two years).
- All small and large commercial e-waste is assumed to entail a collection system in metropolitan areas similar to commercial collection services currently provided for general waste and recycling.
- All small and large commercial e-waste is assumed to entail a drop-off system in non-metropolitan areas. The principal costs involved in a drop-off system are the participation costs of business employees encompassing transport costs and the opportunity cost of time.
- Virtually all additional e-waste recycling is assumed to take place in metropolitan Melbourne. Therefore significant distances (and therefore costs) will be involved in the transport of e-waste from transfer stations to the recyclers, especially from regional areas, with costs estimated at approximately $1.90/tonne/kilometre.
- All residential and commercial e-waste that is recovered and therefore is not disposed to landfill avoids costs associated with the traditional waste collection and disposal system (i.e. landfill disposal costs and for some e-waste, the residential and commercial garbage collection system).
- However, residual waste (i.e. floc) following e-waste processing will entail landfill disposal costs.

Further details of key aspects of collection, sorting and transport costs are provided in the following section.

6.2.4 Further details of collection, sorting and transport costs

Kerbside collection systems (Options 1a, 2 and 3)

As detailed in section 4.1, Option 1a (and also Options 2 and 3) are assumed to involve special kerbside collection systems for small e-waste (day after recycling bins) and large e-waste (hard waste).

In the case of a hard waste collection service for large e-waste, we note that current data (SV 2016) suggests that hard waste collection services in metropolitan areas typically cost in the order of $201/ tonne (excluding the extra costs of transporting hard waste 'garbage' to landfill and landfill gate fees). Discussions with councils and waste contractors indicate that the use of tray trucks for hard waste services are substantially greater than the average however, which more often than not use compactor trucks. This is because the tray trucks carry much smaller loads (2 tonnes/ load compared to 6-7 tonnes/ load) but also involve greater manual handling costs. Overall, taking account of some cost savings associated with the use of tray trucks compared to compactor trucks (e.g. lower capital costs and lower fuel costs) we estimate that the use of tray trucks for an e-waste hard waste collection service will entail a cost premium of 50% compared to the average cost of a hard waste collection service in metropolitan areas, i.e. approximately $302/ tonne.

In the case of small e-waste collection systems, cost have been estimated drawing on cost of pilot schemes and existing recycling schemes. Costs of bin-based kerbside e-waste collection systems have been estimated at up to 40c/ kg ($400/ tonne) for some pilot schemes involving a combination of bags placed inside recycling bins. We estimate that the large-scale introduction of a scheme of this nature will involve significant cost-savings due to economies of scale. Our estimate of $295/ tonne is nevertheless substantially greater than the cost of traditional kerbside recycling collection services (typically $110-210/ tonne), because although the frequency of the e-waste service will be much lower than the other recycling services (quarterly instead of weekly or fortnightly) the quantities of waste collected will still be quite lower by comparison. As well, tray trucks rather will need to be used for the collection rather than compactor trucks, which as previously discussed are estimated to cost approximately 50% higher than the compactor trucks. Costs are slightly lower for the small e-waste collections than the hard waste collections due to slower handling costs linked to the use of bags for small e-waste.

Permanent drop-off systems

As detailed in section 4.1 Options 1a and 1b entail establishing permanent drop-off points in metropolitan areas, in place of a kerbside collection system. Permanent drop-off points are assumed to be in place in regional areas under all options.

Upfront capital costs associated with upgrading transfer stations to enable them to accept e-waste are discussed in section 6.2.5. In addition to the capital costs, the use of transfer stations as permanent drop-off points is estimated to require additional staffing. In discussions with councils and contractors involved in managing transfer stations they indicated that in most cases 'some' additional resources would be required to deal with handling and sorting e-waste if, as is expected under an e-waste ban, substantial additional e-waste was to pass through transfer station drop-off points. Stakeholders were not clear as to how many additional resources would be required.

Drawing on estimates of hard waste that currently pass through metropolitan transfer stations, average levels of staffing at those transfer stations and quantities of additional e-waste that would pass through the transfer stations under Options 1b and 1c, an estimate has been made of the additional resources that would be needed at metropolitan transfer stations in order to effectively handle the additional e-waste. Based on current average staffing of approximately 12.5 full time equivalent, it is estimated that approximately 0.8 additional staff members will be required for each of the 24 metropolitan transfer stations at which a permanent e-waste drop-off point is established. This would enable approximately 840 additional tonnes of e-waste to be handled per annum at each site (20,000 tonnes/ annum across all sites) at a handling rate of approximately 0.5 tonnes/ person/ hour.

At a cost approximately $65,000 for labour (including on-costs) plus an additional $3,000 per site each year to cover promotion, this represents a unit cost equivalent of $81/ tonne of e-waste (excluding whitegoods which are assumed to already be covered through existing staffing arrangements).

In regional areas annual throughput of e-waste is likely to be much lower than at metropolitan transfer stations, with the result that additional staffing needs will be much lower – estimated to be approximately 0.1 additional staff members for each of the 80 transfer stations – but with the same overall cost of approximately $81/ tonne of e-waste.

Events

Estimates of costs to hold collection events under Option 1c were based on cost estimates for collection events held under the NTCRS scheme. Estimates of costs include infrastructure (40' containers) labour, event management and promotion.

In metropolitan areas, based on an estimated cost of $10,717/ event, with each event collecting an average of 60 tonnes, this represents a unit cost of approximately $179/ tonne collected.

In regional areas, based on an estimated cost of $6,496/ event, with each event collecting an average of 30 tonnes, this represents a unit cost of approximately $217/ tonne collected.

Transport to recyclers

Discussions with councils and e-waste processors suggest that sometimes e-waste processors pay for the cost of transporting e-waste to the processors but that generally these costs are borne by councils, the generators of e-waste (in the case of businesses) or by co-regulatory coordinators (in the case of e-waste covered by the NTCRS). It is expected that under an e-waste ban, under all options, these costs would generally be borne by councils, especially if the e-waste is being generated in regional areas.

Costs of transporting e-waste from transfer stations and other collection points have been estimated at $1.91/ tonne kilometre. This estimate is based on data provided through the NCTRS and through a number of councils and e-waste processors. In metropolitan areas the average distance of e-waste from the collection point (e.g. transfer station) to processor is estimated, on a populated weighted basis, to be 42 kilometres, giving an estimated transport cost of $80/ tonne. In regional areas the average distance of e-waste from the collection point to processor is estimated, on a populated weighted basis, to be 179 kilometres, giving an estimated transport cost of $342/ tonne.

6.2.5 Transfer station upgrades

There are an estimated 296 transfer stations in Victoria, 55 in metropolitan areas and 241 in regional areas. It is estimated that only 65 of these are both able to collect e-waste and are currently compliant with the Australian Standard for the Collection, storage, transport and treatment of end-of-life electrical and electronic equipment (AS5377) (Randell, Pickin and Latimer, 2015)[28]. Sixteen of these are in metropolitan areas and 49 in regional areas.

If e-waste is banned from landfills in Victoria under Options 1a, 2 or 3 we assume that 181 transfer stations will need to be able to accept e-waste to meet the reasonable access definition for those options. This means that 116 transfer stations will need to be upgraded - 8 in metropolitan areas and 108 in regional areas. Upgrades are likely to require establishing a fully enclosed storage area with a concrete floor and contained storage areas or bins (SMEC 2014). The estimated cost of these upgrades under Options 1 and 2 is approximately $9.3 million, comprising:

- 108 smaller regional transfer stations at $75,000 per upgrade; and
- 8 larger metropolitan transfer stations at $150,000 per upgrade.

These costs are assumed to be spread out over two years.

Under Options 1b and 1c, the requirement for access to a fully compliant transfer station is less stringent than under Option 1b (see section 4.1), with the result that only 39 transfer stations require major upgrades - 8 in metropolitan areas and 31 in regional areas. However, under these options we have assumed that all 65 transfer stations that currently meet AS5377 will also need minor upgrades to enable them to establish permanent collection points capable of accepting significantly increased volumes of e-waste. These upgrades have been estimated at $20,000 per metropolitan site and $10,000 per regional site.

6.2.6 Processing costs

E-waste processing costs include capital (fixed) costs and operating costs. For the purpose of this analysis we have converted all processing costs to a $/ tonne basis noting that analysis by Randell, Pickin and Latimer (2015) and discussions with recyclers for this analysis indicates that, for the foreseeable future, there are no significant infrastructure constraints on substantially increasing volumes of e-waste being processed.

In discussions with recyclers, differences in processing costs have been identified between e-waste processing and metals recycling and between manual e-waste processing and mechanical e-waste processing. The cost of mechanical e-waste processing is estimated to be approximately 20% lower than manual e-waste processing reflecting:

- scale, with mechanical processing generally entailing significantly larger volumes than manual processing; and
- the nature of the e-waste process, with manual processing often associated with dismantling e-waste products and recovering higher value materials (e.g. circuit boards) before lower value items are sent for shredding via a mechanical process.

For this analysis we have estimated that approximately 70% of collected e-waste is recovered primarily through a mechanical process with the remaining third being recovered through a manual process. This is a slightly greater proportion of e-waste being recovered mechanically than is currently the case (Randall et al. 2015), but based on discussions with e-waste processors it seems likely that a higher proportion of e-waste processed under an e-waste ban will need to go through a mechanical process, at least in part. This is particularly true of e-waste containing significant quantities of hazardous materials.

[28] Including 30 that have undergone upgrades in the past 12 months

Metals recycling is also primarily a mechanical process, with the very low costs reflecting the straightforward nature of the process and relatively large volumes.

Table 27: Processing costs applied in the central, high and low cases ($/tonne)[29]

Cost item	Central case	High case	Low case
Manual e-waste processing	**660**	594	726
Mechanical e-waste processing	**550**	495	605
Metals recycling[30]	**71**	64	79

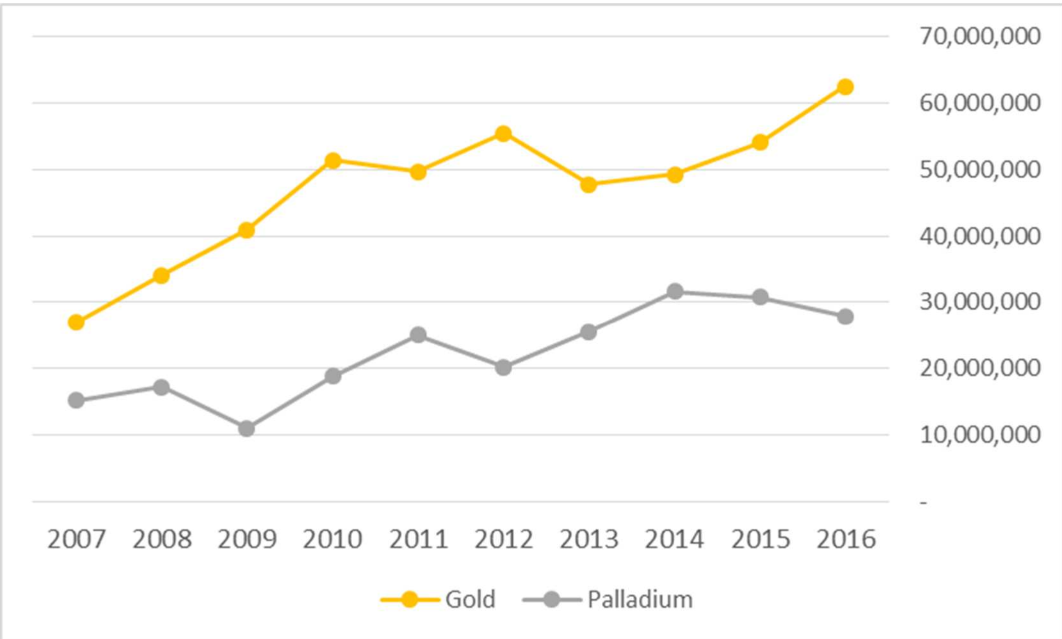
6.3 Benefits

6.3.1 Material values

Notwithstanding availability of substantial market data on material values, which is reinforced with information provided by recyclers on prices they have received for recovered materials, there is a great deal of uncertainty about the future value of materials recovered through increased recycling of e-waste. This uncertainty reflects:

- prices are largely driven by global factors, with prices in the short term being driven by a variety of factors including political and socio-economic issues, and prices in the medium and longer terms being driven by global demand and supply – as a result prices have fluctuated significantly over the past few years (see Figure 10);
- the range of materials recovered from e-waste and their very different values (see Table 28).

Figure 10: Gold and Palladium price movements 2007-2016 ($/ tonne)



29 Note, processing costs do not include transport costs and costs of disposing residual waste which are covered elsewhere

30 This cost does not include transport costs which are often borne by the metal recyclers.

Table 28 provides a summary of the material values applied in the analysis. Important points to note from the data presented in the table are:

- As far as possible we have attempted to reflect prices that could reasonably be expected to be received for the materials over the next few years considering medium term trends.
- Because of the high level of uncertainty about future prices, a wide range of prices have been applied in the sensitivity analysis (see section 2.2.2).
- The prices of precious metals (gold, palladium, silver) and rare earths are especially uncertain. Therefore, although only very small quantities of precious metals and rare earths are found in e-waste, their extremely high values mean that results of the analysis are particularly susceptible to assumptions about prices of the materials and also their recovery rates from e-waste.
- On this point, we have assumed recovery rates for precious metals and rare earths that are the same as recovery rates/ levels of wastage associated with e-waste process generally (i.e. approximately 7% wastage - see section 6.4). This level of wastage is broadly consistent with recovery rates stipulated in the literature of approximately 93-97% for precious metals during e-waste processing (Khaliq et al. 2014).
- Leaded glass, contained principally in Cathode Ray Tube (CRT) TVs, involves a substantial cost to reprocess. It could be treated as an additional processing cost in the analysis or as a negative material vale – we have taken the latter approach. The high cost (negative value) of the leaded glass reflects the fact that glass generally has little or no value and that as a 'Category A' Prescribed Industrial Waste (PIW), already banned from landfill, the leaded glass must be transported to the only facility in Australia that can process it (the Nyrstar lead smelter in Port Pirie). Although this represents a significant cost under BaU, we have assumed that under Options 1, 2 and 3 more CRT TVs will be diverted from landfill than under BaU.

Table 28: Material values applied in the central, high and low cases ($/tonne)

Material	Central case	High case	Low case
Metals			
Iron/steel	**110**	160	60
Aluminium	**1,000**	1,200	800
Copper	**3,625**	4,625	2,625
Gold	**27,557,345**	36,493,040	19,915,377
Silver	**778,137**	1,143,821	516,007
Palladium	**22,327,796**	31,664,419	15,149,021
Rare Earths			
Neodymium	**128,026**	223,464	61,150
Praseodymium	**86,730**	181,564	25,168
Dyprosium	**1,376,950**	2,920,592	328,638
Other			
BFR containing plastics	**50**	100	0
Plastics general	**200**	300	100
Glass	**0**	0	0
Leaded glass	**-400**	-400	-400

6.3.2 Avoided health impacts from pollutants in landfill leachate

As outlined in section 5.3.2 and detailed in section 6.4.4, the quantities of hazardous pollutants (including mercury, lead, cadmium, chromium, nickel, antimony, americium, indium, BFRs and POP BDEs) that leach into the environment from e-waste disposed to landfill have been estimated under BaU, with reduced quantities then estimated for each of Options 1, 2 and 3. These quantities have then been normalised to mercury (Hg) equivalents based on their hazard levels relative to mercury.

The avoided quantities of the hazardous pollutants (Hg equivalent) under each option have in turn been used to estimate the value of avoided health and environmental impacts. This has been done by applying estimates of the health damage of mercury to the estimates of avoided hazardous pollutants (Hg equivalent) under each of the options.

Mercury has been used as the material against which to normalise hazardous pollutants because substantial work has been undertaken internationally to assess the economic costs of mercury pollution, with that work being recently applied, using the benefit transfer technique, to estimate the economic benefits of reduced mercury pollution in Australia (Marsden Jacob 2015).

Spadaro and Rabl (2008) have provided estimates of the value of the harm caused by mercury in the United States, principally to the IQ of children. They have also propose a formula for identifying the likely cost in other countries. The United States costs based on the IQ decrement is adjusted to other countries using the Gross Domestic Product (GDP) per capita expressed as Purchasing Power Parity (PPP) as a weighting factor. Where C_i is a damage cost in a specific country and C_{USA} is the damage cost in the United States.

$$C_i = C_{USA} \frac{(GDPppp / capita)_i}{(GDPppp / capita)_{USA}}$$

Using this formula the value of mercury costs as it would apply in Australia is A$ 4,862/kg, assuming a threshold above which mercury levels have an adverse impact or A$ 11,093/kg if no threshold is assumed (see Table 29).

Table 29: Australian estimate of harm caused per kg of mercury (benefit transfer)

	Harm /kg mercury	
	USD$ (2008)	AUD$ (2016)
With threshold	$4,380	$4,862
Without threshold	$9,993	$11,093

Source: Spadaro and Rabl 2008, Marsden Jacob 2015

The without threshold value is applied to estimating avoided hazardous waste pollution (Hg equivalent) under Options 1a, 1b, 1c, 2 and 3. The without threshold value is used because:

- analysis by Spadaro and Rabl 2008 and others indicates that although IQ loss in children is the most significant harm caused by mercury in the environment, environment and health damages caused by exposure to mercury in the environment extend well beyond this; and

- there are numerous other studies estimating the costs of harm caused by mercury in the environment, with some providing estimates similar to the without threshold estimate of Spadaro and Rabl.

Nevertheless, there is a great deal of uncertainty attached to the estimate applied in this analysis, both because of the process of normalising all hazardous pollutants from e-waste to mercury equivalents and because of the uncertainty attached to the economic cost of mercury pollution entering the environment. This uncertainty is addressed to some extent through the application of a range of values (ranging from 28% to 124% of the central value, as recommended by Spadaro and Rabl 2008) in the sensitivity analysis and by the application of willingness to pay (WTP) as alternative approach to assessing benefits in the analysis.

Table 30: Value of avoided hazardous pollutants applied in analysis

	($/ tonne avoided)		
	Central case	Low case	High case
Avoided hazardous pollutants (Hg equivalent)	**$11,093,000**	$3,106,040	$13,755,320

6.3.3 WTP for e-waste recycling

Noting uncertainties with material values and the value of avoided hazardous pollution, we have estimated the community's willingness to pay (WTP) for e-waste recycling as an alternative approach to capturing benefits in the analysis.

This has been done by interpolating results of a previous study into WTP for e-waste recycling (Rolls, Brulliard & Bennett, 2009), to derive a WTP estimate suitable for use in this analysis (Table 31).

Table 31: Interpolation of WTP estimate

Willingness to pay benefit transfer estimate	
Melbourne WTP for a 1% increase in e-waste recovery/ item purchased/ household ($2015/16)	$ 0.50
e-waste items/ tonne	37.9
WTP for a 1% increase in e-waste recovery/ tonne purchased/ household	$ 18.92
e-waste generated annually in Victoria (tonnes)	114,292
Households in Victoria	2,267,587
e-waste generated per household annually (tonnes)	0.05
e-waste generated per household annually (items)	1.9
Household drop-out rate	0.137
WTP for a 1% increase in e-waste recovery all households	$1,866,248
WTP/ tonne recovered	**$ 1,633**
Adjustment factor (average price of all e-waste products/average price of TVs and computers)	0.54
WTP for a 1% increase in e-waste recovery all households (adjusted)	1,010,167
WTP/ tonne recovered (adjusted)	**$ 884**

This entailed using the WTP estimate in the Rolls et.al (2009) study of $0.50/ e-product item purchased/ household for a 1% increase in e-waste recovery and converting that estimate to a $/ tonne value – estimated at $1,633/ tonne.

A complicating factor in using this estimate however, is that the Rolls et.al study only considered e-waste covered by the NTCRS scheme (i.e. computers and TVs), whereas the options being considered in this analysis are targeting a much broader range of e-waste. To accommodate this difference therefore an adjustment has been made to the WTP estimate to account for a difference in size and value of the broad range of e-waste relative to computers and TVs. This was done by deriving an adjustment factor based on weighted average of the weight and value of all e-waste products in the e-waste stream relative to weight and value of computers and TVs.

After applying the adjustment factor the WTP estimate becomes $884 for each additional tonne of e-waste recovered (see Table 31). To this estimate can be added a premium for each additional tonne of e-waste that is recycled via a kerbside collection system, estimated at $160/ tonne based on analysis by Rolls et.al (2009).

6.4 Material flows

6.4.1 Material flows under BaU and options

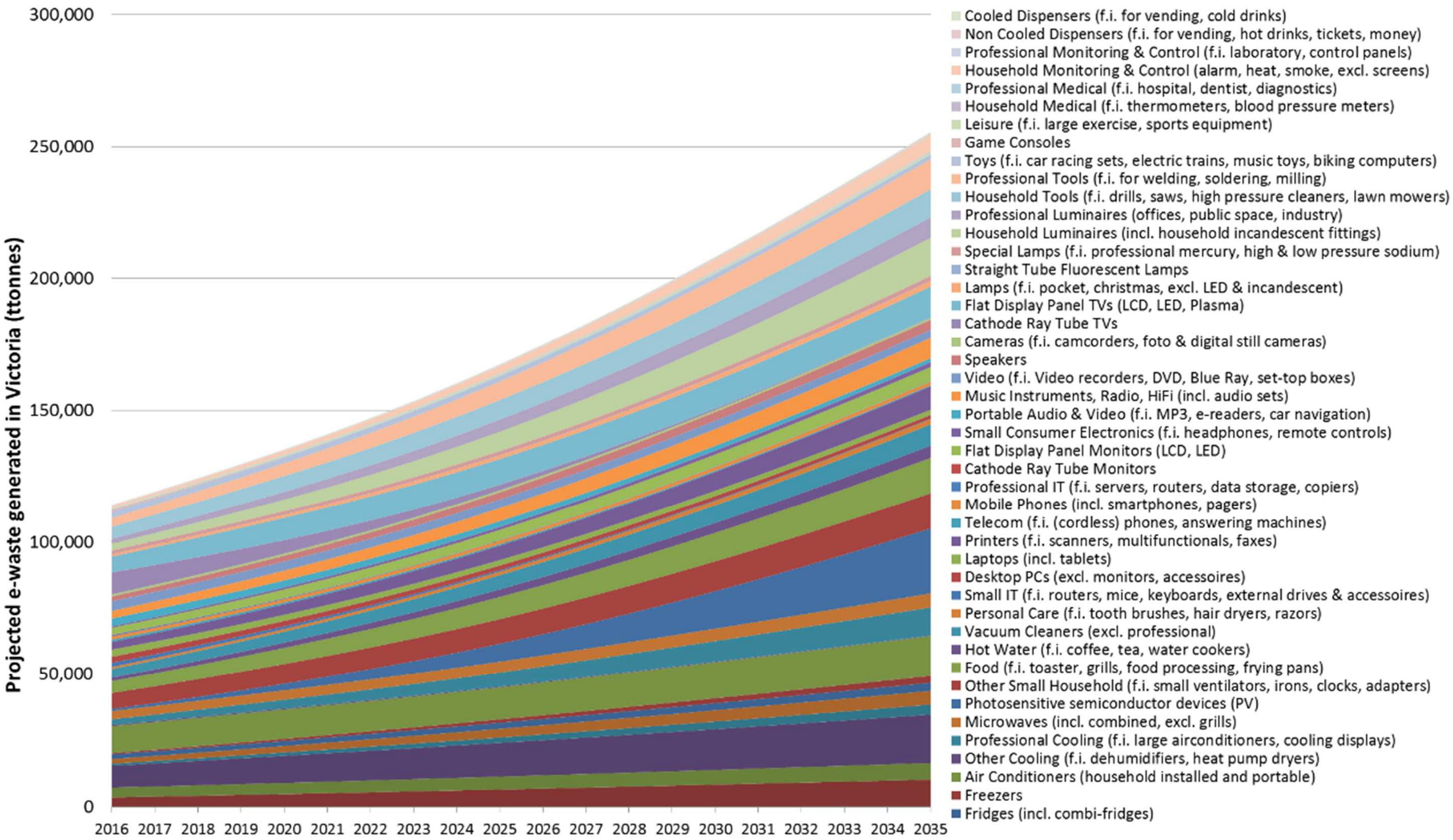
The material flows analysis (MFA) that underpins the CBA and distributional analysis discussed in this report is based on a MFA that was undertaken for Sustainability Victoria in 2015. A detailed discussion of the approach to estimating current and projected future e-waste material waste material flows is provided in the report *Victorian E-waste Market Flow Analysis* (Randell, Pickin and Latimer, 2015). In summary, through that analysis, e-waste flows covering consumption (see Figure 11) and fate (landfill, recovery or export) were produced for approximately 50 e-waste product types for the period 2014-2035 assuming existing policy settings (i.e. BaU).

For this study, further additions to the MFA have since been undertaken covering:

- an updated consumption database to include recent consumption data;
- a comprehensive breakdown of e-waste material flows based on their materials composition;
- estimates of the impacts of options on levels of recovery for each e-waste product type; and
- estimates of the hazardous materials composition of e-waste and their ultimate fate as pollution into the environment.

The last three points are discussed further in the following sections.

Figure 11: Total e-waste generation by product type in Victoria, 2016-2035



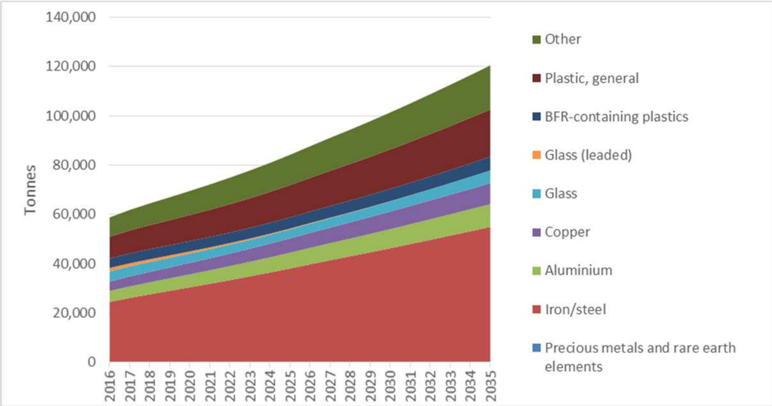
6.4.2 Materials composition

A detailed materials composition analysis was undertaken for this study as part of the MFA. The materials composition analysis was necessary in order to estimate the quantities and value of materials recovered when e-waste is recycled.

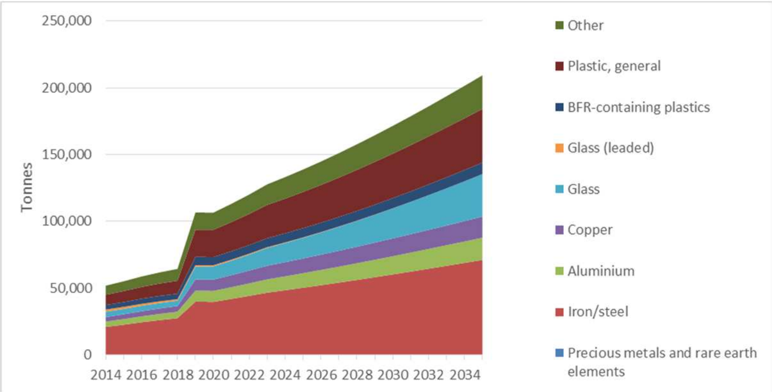
The materials composition analysis involved a detailed materials analysis for all e-waste product types, product-by-product. The analysis drew on a range of literature sources and databases. Outputs of the analysis are summarised in Figure 12.

Figure 12: Estimates of material recovery from recycling, BaU and options

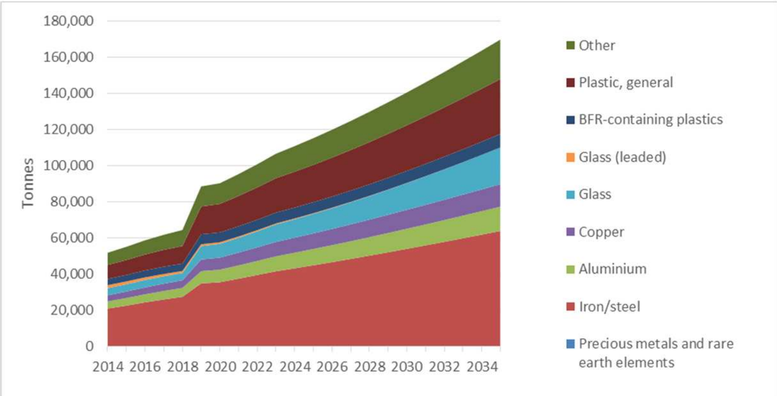
BaU



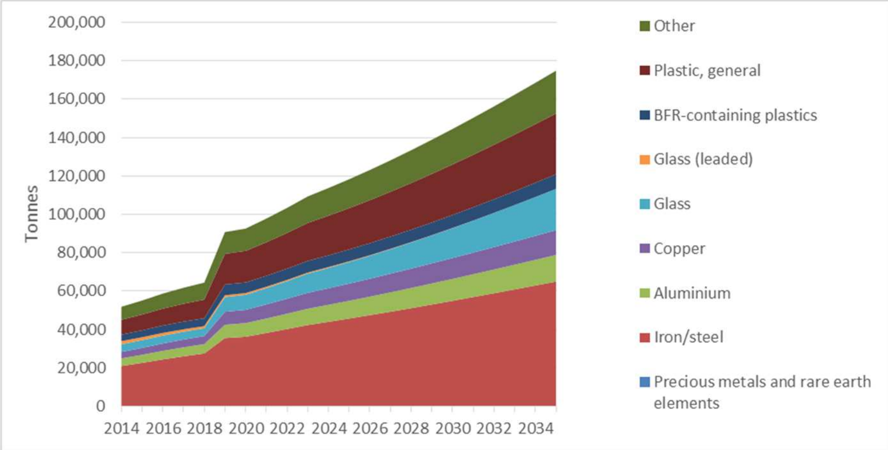
Option 1a



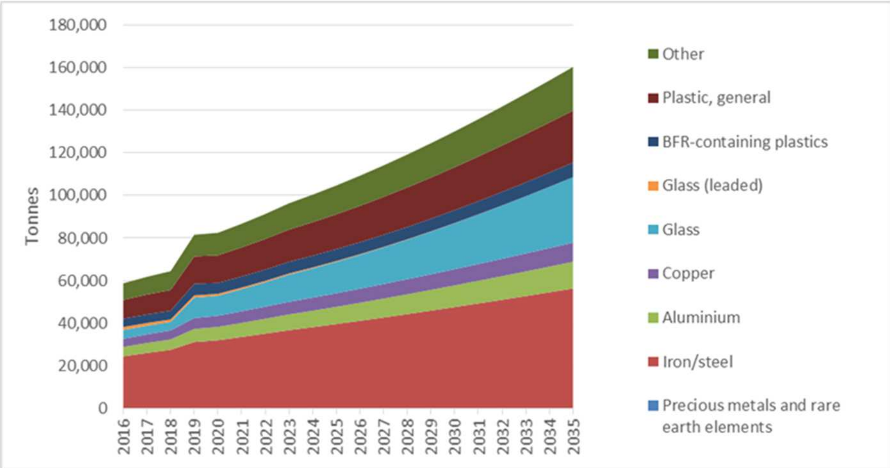
Option 1b



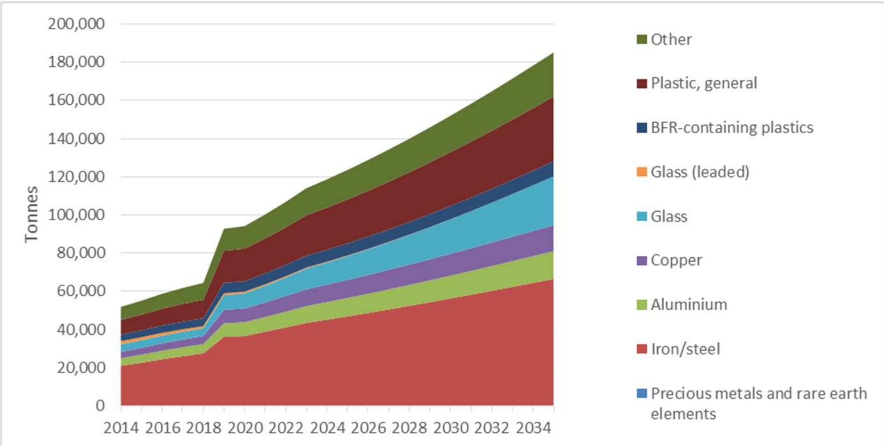
Option 1c



Option 2



Option 3



6.4.3 Impact of options on e-waste recovery

An assessment of the percentage of e-waste diverted from landfill under the options was made drawing on discussions with DELWP, members of the project working group and stakeholders. Outputs of that assessment are provided in Table 32 to Table 34 below.

Under BAU, the assumed diversion rates were based on consideration of:

- for NTCRS wastes, the targets established under the scheme converted from financial to calendar year for consistency with the Comtrade data that populate the waste model; and
- for non-NTCRS wastes, comparison of the results of a survey of e-waste recyclers in 2014 and the outputs of the e-waste generation model.

Table 32: Assumptions about e-waste recovery rates under options 1a, 2 and 3

Assumptions about e-waste recovery under the options			BaU	Option 1a	Option 2	Options 3
			% of all e-waste	*% of all e-waste*	*% of haz. e-waste*	*% of all e-waste*
Management of wastes covered by the NTCRS (fate category D)		Year 1	See Table 34			
		Year 5				
Proportion of small e-waste items sent for recycling from domestic sources with access to kerbside recycling		Year 1	See footnote[31]	70%	65%	50%
		Year 5		80%	75%	60%
Proportion of small e-waste items sent for recycling from domestic sources lacking access to kerbside recycling		Year 1		40%	35%	20%
		Year 5		50%	45%	30%
Proportion of large e-waste items sent for recycling from domestic sources	Large items in BAU fate category A	Year 1	100%	100%	n/a	100%
		Year 5				
	Large items in BAU fate category B	Year 1	95%	97%		96%
		Year 5		99%		97%
	Large items in BAU fate category C	Year 1	30%	60%		40%
		Year 5		70%		50%
	Large items in BAU fate category F	Year 1	10%	50%	50%	20%
		Year 5		70%	70%	30%
Proportion of small e-waste items sent for recycling from commercial sources in Melbourne and major provincial cities		Year 1	See footnote[32]	50%	45%	30%
		Year 5		60%	55%	40%
Proportion of small e-waste items sent for recycling from commercial sources in other areas		Year 1		30%	25%	10%
		Year 5		40%	35%	20%
Proportion of large e-waste items sent for recycling from commercial sources	Large items in BAU fate category A	Year 1	90%	93%	n/a	93%
		Year 5		95%		95%
	Large items in BAU fate category B	Year 1	80%	90%		85%
		Year 5		95%		90%
	Large items in BAU fate category C	Year 1	20%	50%		40%
		Year 5		60%		50%
	Large items in BAU fate category F	Year 1	10%	50%	50%	20%
		Year 5		70%	70%	30%

31 Other than NTCRS products, recovery rate = tonnes reported in 2014 Vic survey data / tonnes generated in Vic (based on model).

32 As above

Table 33: Assumptions about e-waste recovery rates under options 1a, 1b and 1c

Assumptions about e-waste recovery under the options			BaU	Option 1a	Option 1b	Options 1c
			% of all e-waste	*% of all e-waste*	*% of haz. e-waste*	*% of all e-waste*
Management of wastes covered by the NTCRS (fate category D)		Year 1	See Table 35			
		Year 5				
Proportion of small e-waste items sent for recycling from domestic sources with access to kerbside recycling		Year 1	See footnote[33]	70%	33%	38%
		Year 5		80%	38%	43%
Proportion of small e-waste items sent for recycling from domestic sources lacking access to kerbside recycling		Year 1		40%	15%	20%
		Year 5		50%	25%	30%
Proportion of large e-waste items sent for recycling from domestic sources	Large items in BAU fate category A	Year 1	100%	100%	100%	100%
		Year 5				
	Large items in BAU fate category B	Year 1	95%	97%	94%	96%
		Year 5		99%	95%	97%
	Large items in BAU fate category C	Year 1	30%	60%	41%	45%
		Year 5		70%	46%	50%
	Large items in BAU fate category F	Year 1	10%	50%	26%	30%
		Year 5		70%	36%	40%
Proportion of small e-waste items sent for recycling from commercial sources in Melbourne and major provincial cities		Year 1	See footnote[34]	50%	50%	50%
		Year 5		60%	60%	60%
Proportion of small e-waste items sent for recycling from commercial sources in other areas		Year 1		30%	25%	15%
		Year 5		40%	35%	25%
Proportion of large e-waste items sent for recycling from commercial sources	Large items in BAU fate category A	Year 1	90%	93%	90%	92%
		Year 5		95%	92%	94%
	Large items in BAU fate category B	Year 1	80%	90%	87%	90%
		Year 5		95%	92%	95%
	Large items in BAU fate category C	Year 1	20%	50%	48%	50%
		Year 5		60%	58%	60%
	Large items in BAU fate category F	Year 1	10%	50%	48%	50%
		Year 5		70%	68%	70%

33 Other than NTCRS products, recovery rate = tonnes reported in 2014 Vic survey data / tonnes generated in Vic (based on model).

34 As above

Table 34: Assumptions recovery rates under options 1a, 2 and 3 for NTCRS products

Assumed recovery rates					
Calendar year	NTCRS recovery target	BAU (minimum)	Option 1a	Option 2	Option 3
2014	34%	34%	34%	34%	34%
2015	43%	43%	43%	43%	43%
2016	54%	54%	54%	54%	54%
2017	60%	60%	60%	60%	60%
2018	63%	63%	63%	63%	63%
2019	65%	65%	80%	80%	75%
2020	67%	67%	82.5%	82.5%	78.8%
2021	69%	69%	85%	85%	83%
2022	71%	71%	87.5%	87.5%	86.3%
2023	73%	73%	90%	90%	90%
2024	75%	75%	90%	90%	90%
2025	77%	77%	90%	90%	90%
2026	79%	79%	90%	90%	90%
2027	80%	80%	90%	90%	90%
2028	80%	80%	90%	90%	90%
2029	80%	80%	90%	90%	90%
2030	80%	80%	90%	90%	90%
2031	80%	80%	90%	90%	90%
2032	80%	80%	90%	90%	90%
2033	80%	80%	90%	90%	90%
2034	80%	80%	90%	90%	90%
2035	80%	80%	90%	90%	90%
2036	80%	80%	90%	90%	90%

Table 35: Assumptions recovery rates under options 1a, 1b and 1c for NTCRS products

Assumed recovery rates					
Calendar year	NTCRS recovery target	BAU (minimum)	Option 1a	Option 1b	Option 1c
2014	34%	34%	34%	34%	34%
2015	43%	43%	43%	43%	43%
2016	54%	54%	54%	54%	54%
2017	60%	60%	60%	60%	60%
2018	63%	63%	63%	63%	63%
2019	65%	65%	80%	80%	80%
2020	67%	67%	82.5%	82.5%	82.5%
2021	69%	69%	85%	85%	85%
2022	71%	71%	87.5%	87.5%	87.5%
2023	73%	73%	90%	90%	90%
2024	75%	75%	90%	90%	90%

2025	77%	77%	90%	90%	90%
2026	79%	79%	90%	90%	90%
2027	80%	80%	90%	90%	90%
2028	80%	80%	90%	90%	90%
2029	80%	80%	90%	90%	90%
2030	80%	80%	90%	90%	90%
2031	80%	80%	90%	90%	90%
2032	80%	80%	90%	90%	90%
2033	80%	80%	90%	90%	90%
2034	80%	80%	90%	90%	90%
2035	80%	80%	90%	90%	90%
2036	80%	80%	90%	90%	90%

Under Options 1 to 3, assumed diversion rates were based on consideration of:

- BAU diversion rates;
- diversion rates achieved with other currently recyclable wastes;
- ease of compliance with the ban, which is influenced by the services available to the waste generator;
- the ease of non-compliance with the ban, and in particular whether a waste item fits in household bins;
- the likely effectiveness of the education campaign, which is assumed to be partly dependent on the breadth of the proposed ban;
- whether the waste is generated by households (which are strongly influenced by cultural norms) or a commercial entity (which are more influenced by cost); and
- an assumption that compliance will improve over time as infrastructure is developed, knowledge of the management rules improves and cultural norms develop (diversion rates were assumed to increase over time and peak in year 5).
- The resultant assumed diversion rates under the options vary from a low of 10% (small items from commercial sources in year 1 of option 3) to 100% (large items from domestic sources that are sought by metal recyclers).

6.4.4 Method and assumptions applied to estimating pollutant flows from e-waste disposed to landfill

In addition to deriving estimates of hazardous material composition percentage in various types of e-waste, these compositions have been used to estimate:

1. Landfill fate of these ***hazardous materials*** as they leach out of e-wastes in landfill and become leachate ***contaminants.***
2. Environmental fate of these hazardous materials as landfill leachate containing them leaks out of landfill over time, causing them to become environmental ***pollutants.***
3. Taking the same underlying data, normalize the hazardous characteristic of each hazardous material to equate them to a single measure of hazard (with reference to

mercury), based on reference to hazardous waste/ substance contaminant threshold limits used in Victorian waste classification.

4. Total normalized hazard (as mercury equivalents) for each e-waste type.
5. Landfill fate of normalized hazard (as mercury equivalents) leaching out of e-wastes in landfill and into leachate.
6. Environmental fate of normalized hazard (as mercury equivalents) as landfill leachate containing them leaks out of landfill over time.

These steps are detailed in the two method sections below, with references provided for key data sources.

Fate modelling method

- Identify indicative hazardous component concentrations in indicative types of e-waste (*Data* worksheet), i.e. %, which equals *tonnes of hazardous component per 100 tonnes of e-waste*
- Worksheet *Hazard flows – leachate* takes these % levels and multiplies them by a leaching rate, expressed as the % w/w of original chemical that is estimated to be leachable ($\%chemical_L$), in a typical landfill environment. This provides *tonnes of contaminant (per 100 tonnes of e-waste) that leaches into landfill leachate*
  - $\%chemical_L$ was determined for the individual heavy metals Pb, Cd, Cr VI, and Ni from Ousman (2015), through simulating landfill leaching conditions in the laboratory by the Toxicity Characteristic Leaching Procedure (TCLP) test; a technique used routinely to measure 'leachable' pollutants
  - $\%chemical_L$ was determined for Hg, Sb, In, and Am by comparing relative water solubilities of all the heavy metals of our concern, nominally in their simplest chloride forms, and using order of magnitude comparison to deduce likely leaching rates for these metals as a percentage. These figures are shown in Table 36.
  - $\%chemical_L$ was determined for POP-BDEs by using a mid-point of estimates provided by ESWI (2010) of POP-BDE leachability in landfill of "in the order of 10^{-5} - 10^{-6} of the original contamination in the waste", i.e., 0.0000055 or 0.00055%
  - ($\%chemical_L$) for other BFRs was assumed to be the same as for POP-BDEs, given their general similarities in chemistry
- To determine the flow of contaminants from leachate (in the landfill) out of the landfill and into the environment, an assessment of the likely percentage of leachate that 'leaks' from the confines of a landfill was required.
- This first requires an estimate of leachate volume typically generated within the landfill, which is a complex modelling exercise (using the HELP model or similar) that is site and situation specific, dependent on rainfall but also existing moisture levels in the landfilled waste and its consequent ability to absorb a fraction of rainfall, plus other factors. A reference landfill was used for the purposes of these estimates from Donevska et al (2010) who calculated leachate generation rates using both the HELP model and the Water Balance Method. This paper provides us with 'reference landfill' information such as rainfall and lifetime worked area (8.5 hectares) and a leachate generation rate used for the modelling purposes of this e-waste study of 24,658L/day
- Indicative literature values exist for how much leachate actually leaks from landfill, expressed as L/ha/day, with 'ha' being the worked area over the life of a landfill in hectares.

EPA Victoria's Landfill BPEM (2015) provides maximum levels of leakage via landfill liner performance standards from municipal (putrescible) waste (Type 2) landfills (10L/ha/day) and solid inert waste (Type 3) landfill (1,000L/ha/day).

- These figures were used to calculate leakage in L/day assuming the 'reference' landfill was a) a Type 2 landfill and b) a Type 3 landfill, by multiplying each regulatory leakage rate by 8.5ha to obtain:
  - 85,262 L/day leakage, if it was a Type 2 landfill; and
  - 8,526 L/day leakage, if it was a Type 3 landfill.
- In a Victorian context, it has been assumed for conservative purposes that 80% of the State e-waste tonnage that currently goes to landfill is designed to leak at a rate of 10L/ha/day, while the other 20% of e-waste goes to facilities that are less engineered, leaking at a rate of 1,000L/ha/day. This allows calculation of a weighted average leakage rate for all e-waste going to landfill in Victoria of 7%, i.e. 7 L of leachate is lost to the environment through leakage for every 100 L of leachate generated in the landfill.
- It is assumed that the concentration of contaminant species in the leachate remains constant whether inside or outside of the landfill, which allows the figure of 7% to be used as the percentage of each contaminant that flows out of the landfill to become a pollutant in the environment.
- Hence the 7% leakage figure is multiplied by each leachate concentration figure (per contaminant per e-waste type) to deduce the environmental fate of hazardous material-contaminant-pollutant, or: *tonnes of contaminant (per 100 tonnes of e-waste) that leaks out of landfill (into the environment)*

Table 36: Leaching rate of contaminants from e-waste (into leachate in landfill)

Contaminant	Leaching rate used (%)	Water solubility (of simple chloride, g/100g water at 20°C)
Lead, Pb	8.95	0.98
Cadmium, Cd	17.15	120*
Chromium VI, Cr VI	3.71	169*
Nickel, Ni	0.16	65.6*
Mercury, Hg	***0.02***	6.59
Antimony, Sb	***20***	920.8
Indium, In	***10***	195.1
Americium, Am	***0.002***	'very low'
POP-BDEs	0.00055	N/A
Other BFRs	0.00055	N/A

** Quoted at 25°C. Bolded, italicized items are estimated in orders of magnitude based on comparison of leaching rates and water solubilities for those species where both data exists*

In summary:

- *Tonnes of hazardous component (per 100 tonnes of e-waste* can be multiplied by e-waste generation tonnages in modelled business cases to get the tonnes of each hazardous component going into landfill (or other fate) for each case.

- *Tonnes of contaminant (per 100 tonnes of e-waste) that leaches into landfill leachate* can be multiplied by e-waste generation tonnages in modelled business cases to get the tonnes of each hazardous component that leaches out of e-waste (in landfill) for each case.
- *Tonnes of contaminant (per 100 tonnes of e-waste) that leaks out of landfill (into the environment)* can be multiplied by e-waste generation tonnages in modelled business cases to get the environmental fate (to derive environmental 'costs') for each case.

Relative hazard overlay method

- Regulatory limits (Category: Industrial waste) were taken from Table 2: Solid industrial waste hazard categorisation thresholds" in *IWRG631 – Solid Industrial Waste Hazard Categorisation and Management, June 2009*[35] for those hazardous components listed (Sb, Cd, Cr VI, Pb, Hg, Ni)
- For POP-BDEs and other BFRs the ROHS Directive (Restriction of Hazardous Substances, Directive 2002/95/EC) was used. This EU legislation sets specific limits for metals and organic pollutant levels in e-goods.
- These two data sets were used to 'normalize' individual hazardous component composition percentages in e-waste, to reflect a single and comparable measure of hazard. This was done by comparison to Hg, by multiplying each hazardous component % by (Hg upper limit/ individual hazardous component upper limit), to arrive at a hazard measure in 'mercury equivalents'.
  - For the POP-BDEs and other BFRs, the ROHS upper limits for Hg and the respective POPs were ratio-ed in the same way
  - There was no hazard categorisation data for indium and americium in either regulatory source, so these were assumed as '0' hazard for the sake of the exercise.
  - All data sources relevant for this 'normalization' of individual contaminant hazards relative to mercury are collated in Table 37, including the ratio obtained from dividing the (IWRG or ROHS) mercury level by each contaminant level.
- Worksheet *Relative hazard* lists the results of this normalization calculation, for each e-waste type and hazardous component, in 'mercury equivalents', as well as summing a total hazard (in mercury equivalents). The result set in this worksheet can be described as *Relative hazard contribution (Hg equivalents) % - [hazard tonnes per 100 tonnes e-waste]*
- Worksheets *Hazard flows – leachate* and *Hazard flows – leakage*, in identical fashion to *E-products reference data v9.xls*, provide the resultant fates and flows in 'mercury equivalent' hazard, respectively, as:
  - Tonnes of relative hazard (per 100 tonnes of e-waste) that leaches out of e-wastes in landfill and into leachate
  - Tonnes of relative hazard (per 100 tonnes of e-waste) that leaks out of landfill (into the environment).

[35] http://www.epa.vic.gov.au/~/media/publications/iwrg631.pdf

In summary:

- *Relative hazard contribution (Hg equivalents) % - [hazard tonnes per 100 tonnes e-waste]* can be multiplied by e-waste generation tonnages in modelled business cases to get the tonnes of 'total hazard' going into landfill (or other fate) for each case.
- *Tonnes of relative hazard (per 100 tonnes of e-waste) that leaches out of e-wastes in landfill and into leachate* can be multiplied by e-waste generation tonnages in modelled business cases to get the tonnes of 'total hazard' that leaches out of e-waste (in landfill) for each case.
- *Tonnes of relative hazard (per 100 tonnes of e-waste) that leaks out of landfill (into the environment*) can be multiplied by e-waste generation tonnages in modelled business cases to get the environmental fate (to derive environmental 'costs') for each case.

Table 37: Data sources for normalization of individual contaminant hazards relative to mercury

Contaminant	Industrial waste upper limit (mg/kg) [1]	ROHS upper limit (in e-goods) (mg/kg) [2]	Ratio mercury level/ contaminant level
Lead, Pb	1,500	1,000	0.05
Cadmium, Cd	100	100	0.75
Chromium VI, Cr VI	500	1,000	0.15
Nickel, Ni	3,000	-	0.025
Mercury, Hg	75	100	1
Antimony, Sb	75	-	1
Indium, In	-	-	0
Americium, Am	-	-	0
POP-BDEs	-	1,000	0.1
Other BFRs	-	1,000	0.1

Sources:

[1.] *From: "Table 2: Solid industrial waste hazard categorisation thresholds" (source:* http://www.epa.vic.gov.au/~/media/publications/iwrg631.pdf

[2.] *From: Restriction of Hazardous Substances. RoHS, also known as Directive 2002/95/EC, guidance available at:* http://www.rohsguide.com

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Appendix 1: Stakeholder consultations

Consultation with stakeholders was an important aspect of the research undertaken for the analysis presented in this report. Approximately 32 organisations were consulted over the course of the analysis including from:

- e-waste processors - commercial and social enterprise (6);
- waste management businesses (3);
- landfill operators (1);
- waste management and recycling coordination service providers (4);
- peak waste management and recycling organisations (3);
- metropolitan and non-metropolitan local councils (8);
- regional waste management groups (4); and
- government departments and agencies (3).

Consultations were undertaken on a one-to-one basis, either face-to-face or by telephone.

The primary purpose of the consultations was to:

- obtain information relevant to key cost and benefit assumptions; and to
- seek stakeholder perspectives on opportunities and risks associated with implementing an e-waste landfill ban.

Consultations were undertaken on the basis that information provided by stakeholders would not be individually attributed.

Appendix 2 - Amendment to Waste Management Policy (Siting, Design and Operation of Landfills)

Environment Protection Act 1970

WASTE MANAGEMENT POLICY

(SITING, DESIGN AND MANAGEMENT OF LANDFILLS)

Order in Council The Governor in Council under section 16A(1) of the Environment Protection Act 1970 and on the recommendation of the Environment Protection Authority declares the Waste Management Policy (Siting, Design and Management of Landfills) contained in the Schedule to this Order.

Dated XX Month 2017

Responsible Minister: LILY D’AMBROSIO

Minister for Energy, Environment and Climate Change

Clerk of the Executive Council

Environment Protection Act 1970

WASTE MANAGEMENT POLICY

(SITING, DESIGN AND MANAGEMENT OF LANDFILLS)

Preamble

In line with community expectations, this waste management policy seeks to protect people and the environment, including local amenity, from the inherent risks posed by the disposal of waste to landfill. This is achieved by providing a framework and tools to implement the wastes hierarchy, consistent with the broader objective of ecologically sustainable development.

A key objective of this framework is to drive more efficient use of resources throughout the whole life cycle of goods and services. This will reduce the adverse environmental and social impacts of resource consumption and generate economic benefits.

Landfills represent the least preferred waste management option, therefore as a general principle the disposal of waste to landfill must be minimised. However it is recognised that landfills will be required for the foreseeable future to manage wastes that cannot currently be recycled or reused. Future landfill development should therefore be minimised, taking into account the policy principles.

1. Title

This policy may be cited as the Waste management policy (Siting, Design and Management of Landfills) and is referred to below as "the policy".

2. Commencement

The policy will come into operation upon publication in the Government Gazette.

3. Revocation of State environment protection policy (Siting and Management of Landfills Receiving Municipal Wastes)

The State environment protection policy (Siting and Management of Landfills Receiving Municipal Wastes) as published in the Government Gazette dated 5 July 1991, as amended by Order in Council published in the Government Gazette dated 15 July 1992, is revoked.

4. Application of the Policy

(1) The policy applies throughout the State of Victoria.

(2) Despite subclause (1), the policy only applies to those landfill sites that accept wastes determined by the Authority to be Category C prescribed industrial wastes and/or non-prescribed wastes for disposal to land.

5. Contents of the Policy

The policy is divided as follows:

1. Title.
2. Commencement.
3. Revocation of State environment protection policy (Siting and Management of Landfills Receiving Municipal Wastes).
4. Application of the Policy.
5. Contents of the Policy.
6. Definitions.

PART I – POLICY FRAMEWORK

6. Definitions

In this policy, unless inconsistent with the context or subject matter –

"Act" means the ***Environment Protection Act 1970***.

"Aquifer" has the meaning given to it in the State environment protection policy (Groundwaters of Victoria) 1997.

"Authority" means the Environment Protection Authority established under the Act.

"BPEM" means the Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills, Publication 788, dated 2001, and amended from time to time.

"Category C prescribed industrial waste" has the meaning given to it in the Environment Protection (Industrial Waste Resource) Regulations 2009.

"Sustainability Victoria" means Sustainability Victoria established under the Act.

"E-waste" means waste equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields.

"Groundwater" has the meaning given to it in the State environment protection policy (Groundwaters of Victoria) 1997.

"Landfill cell" means a compartment within a tipping area in which waste is deposited, and enclosed by cover material.

"Landfill site" means a site for the disposal of waste to land.

"Licence" means a licence issued under the Act.

"National environment protection measure" means a measure made under section 14(1) of the **National Environment Protection Council (Victoria) Act 1995** and equivalent provisions of the corresponding Acts of the Commonwealth and each participating State or Territory.
"Neighbourhood environment improvement plan" has the meaning given to it in the Act.
"Notice" means any notice issued under the Act, including, but not limited to a notice under 31A and 62A.
"Occupier" has the meaning given to it in the Act.
"Operator of a landfill site exempt from licensing" includes a prospective or current operator of a premises described in Item 1(e) of Table A of the Environment Protection (Scheduled Premises and Exemptions) Regulations 2017 that is exempt from licensing.
"Planning Authority" means any person or body that is given power under section 8 of the Planning and Environment Act 1987 to prepare a planning scheme or an amendment to a planning scheme.
"Prescribed waste" means a waste or mixture prescribed for the purposes of the Act.
"Regional waste and resource recovery group" has the meaning given to it in Division 2AA of Part IX of the Act.
"Regional waste and resource recovery implementation plan" has the meaning given to it in Division 2AC of Part IX of the Act.
"Responsible Authority" means that person who is responsible for the administration or enforcement of a planning scheme or a provision of a planning scheme as set out in section 13 of the Planning and Environment Act 1987.
"Segment A groundwater" has the meaning given to it in the State environment protection policy (Groundwaters of Victoria) 1997.
"Surface water" has the meaning given to it under the State environment protection policy (Waters of Victoria) 2003.
"Tipping area" means a place within a landfill site in which waste is, has been or will be deposited.
"Works approval" has the meaning given to it in the Act

PART I – POLICY FRAMEWORK

7. Policy Objectives

The objectives of this policy are to:
(a) protect the environment, including human health and amenity, from risks that may be posed by the disposal of waste to landfill;
(b) encourage innovation, cleaner production, resource efficiency and waste reduction, including promoting and facilitating the diversion of waste from landfill, in accordance with the wastes hierarchy; and
(c) minimise the development and use of landfills, consistent with the policy principles.

8. Policy Principles

The policy is guided by the following principles of environment protection.
(1) *Integration of Economic, Social and Environmental Considerations*
(a) Sound environmental practices and procedures should be adopted as a basis for ecologically sustainable development for the benefit of all human beings and the environment.

(b) This requires the effective integration of economic, social and environmental considerations in decision making processes with the need to improve community well-being and the benefit of future generations.

(c) The measures adopted should be cost-effective and in proportion to the significance of the environmental problems being addressed.

(2) *Precautionary Principle*

(a) If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

(b) Decision making should be guided by:

(i) a careful evaluation to avoid serious or irreversible damage to the environment wherever practicable; and

(ii) an assessment of the risk-weighted consequences of various options.

(3) *Intergenerational Equity*

The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

(4) *Conservation of Biological Diversity and Ecological Integrity*

The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.

(5) *Improved Valuation, Pricing and Incentive Mechanisms*

(a) Environmental factors should be included in the valuation of assets and services.

(b) Persons who generate pollution and waste should bear the cost of containment, avoidance or abatement.

(c) Users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including costs relating to the use of natural resources and the ultimate disposal of any wastes.

(d) Established environmental goals should be pursued in the most cost-effective way by establishing incentive structures, including market mechanisms, which enable persons best placed to maximise benefits or minimise costs to develop solutions and responses to environmental problems.

(6) *Shared Responsibility*

(a) Protection of the environment is a responsibility shared by all levels of Government and industry, business, communities and the people of Victoria.

(b) Producers of goods and services should produce competitively priced goods and services that satisfy human needs and improve quality of life, while progressively reducing ecological degradation and resource intensity throughout the full life cycle to a level consistent with the sustainability of biodiversity and ecological systems.

(7) *Product Stewardship*

Producers and users of goods and services have a shared responsibility with Government to manage the environmental impacts throughout the life cycle of the goods and services, including the ultimate disposal of any wastes.

(8) *Wastes Hierarchy*

Wastes should be managed in accordance with the following order of preference:

(a) avoidance;

(b) re-use;

(c) re-cycling;
(d) recovery of energy;
(e) treatment;
(f) containment;
(g) disposal.

(9) *Integrated Environmental Management*

If approaches to managing impacts on one segment of the environment have potential impacts on another segment, the best practicable environmental outcome should be sought.

(10) *Enforcement*

Enforcement of environmental requirements should be undertaken for the purposes of:

(a) better protecting the environment and its economic and social uses;

(b) ensuring that no commercial advantage is obtained by any person who fails to comply with environmental requirements; and

(c) influencing the attitude and behaviour of persons whose actions may have adverse environmental impacts or who develop, invest in, purchase or use goods and services which may have adverse environmental impacts.

(11) Accountability

(a) The aspirations of the people of Victoria for environmental quality should drive environmental improvement.

(b) Members of the public should therefore be given:

(i) access to reliable and relevant information in appropriate forms to facilitate a good understanding of environmental issues; and

(ii) opportunities to participate in policy and program development.

9. Policy Intent

The intent of the policy is that:

(1) the siting, design and management standards established for landfills in Victoria provide the highest practicable level of protection for the community and environment, including local amenity and aesthetic enjoyment.

(2) management standards for landfills apply to all phases of a landfill's operation including construction, operation, rehabilitation and aftercare.

(3) the development and use of landfills for the management of waste in Victoria be minimised, consistent with the policy principles.

(4) wastes shall only be deposited to landfill if there is no other practicable waste management option higher up the wastes hierarchy that does not lead to inferior outcomes in terms of the protection of people and the environment.

(5) the number of landfill sites exempt from licensing be progressively reduced and replaced with a system of resource recovery and waste transfer facilities to service local communities.

(6) while certain parts of the environment will continue to be used for landfilling purposes in the foreseeable future, with consequent limitations on future beneficial uses, the development and use of landfills be cooperatively and strategically planned to minimise the adverse impacts of landfilling wastes.

(7) regional waste and resource recovery implementation plans and municipal strategic statements be consistent with each other particularly with regard to the planning for and siting of landfills.

(8) scientific information, models, research and other knowledge will inform decisions that affect landfill operations made by people, governments and organisations and will be communicated in a manner that meets the needs of stakeholders.

PART II – ATTAINMENT PROGRAM POLICY RESPONSIBILITIES

10. Implementation

(1) When making decisions and formulating strategies, plans and programs that may affect existing or proposed landfill sites in Victoria, the Authority, Sustainability Victoria, regional waste and resource recovery groups, municipal councils, planning authorities, responsible authorities and other protection agencies will pursue the objectives and apply the principles and intent of the policy.

(2) The Authority will work in partnership with municipal councils, regional waste and resource recovery groups, Sustainability Victoria, industry and the community to:

(a) promote strategies and infrastructure developments for the segregation and diversion of reusable and recyclable waste from landfill; and

(b) divert waste from landfill through waste avoidance, re-use, recycling, recovery of energy, and treatment.

(3) The Authority will employ statutory and non-statutory instruments and measures in implementing the policy, including:

(a) licences, works approvals and notices issued under the Act;
(b) regulations and orders made under the Act;
(c) enforcement programs, including the investigation of complaints;
(d) guidelines for environmental management;
(e) risk assessment principles, practices and guidelines;
(f) environmental planning measures;
(g) landfill monitoring and auditing;
(h) environmental monitoring and auditing;
(i) economic instruments, including financial assurances;
(j) consultation with communities and other stakeholders;
(k) public information and education programs to encourage the wastes hierarchy; and
(l) programs of other organisations that may assist in meeting the objectives, principles and intent of the policy.

(4) Sustainability Victoria, after consultation with the Authority and other relevant stakeholders, will:

(a) develop programs and strategies for Victoria on the generation and management of solid waste to assist in the implementation of the policy;
(b) work with industry to undertake research and promotion of market development opportunities for the diversion of wastes currently disposed to landfill; and
(c) support the development of resource recovery infrastructure.

(5) Regional waste and resource recovery groups will:

(a) ensure their regional waste and resource recovery implementation plans are consistent with and assist in the implementation of the policy, including minimising the development and use of landfills;

(b) coordinate the activities of their members to assist in the implementation of the policy; and

(c) work in partnership with municipal councils and any other relevant agencies in the strategic planning, siting, and management of landfills to achieve the highest practicable level of protection of people and the environment.

(6) Operators of landfill sites will site, design and manage their landfill to ensure the protection of all beneficial uses of the environment.

LANDFILL PLANNING AND SITING

11. Strategic Land Use Planning

(1) All persons involved in the planning and siting of landfills must comply with the provisions of each relevant regional waste and resource recovery implementation plan.

(2) Each planning scheme amendment or any review of a municipal strategic statement by a planning authority, must be consistent with the policy and each relevant regional waste and resource recovery implementation plan, especially with regard to landfill siting and scheduling.

(3) In considering a planning permit application in relation to an existing or proposed landfill site, responsible authorities must make decisions consistent with the policy and the BPEM, especially with regard to landfill site selection.

12. Waste Management Planning

(1) In developing a schedule for the proposed sequence for filling of available landfill sites, as required by the Act, each regional waste and resource recovery group must consider the potential to utilise landfill airspace available in surrounding regions.

(2) Each regional waste and resource recovery group must, prior to submitting a draft plan to the Authority, consult with people likely to be affected by:

(a) the scheduling and evaluation of existing and prospective landfill sites; and

(b) the proposed sequence for filling of available landfill sites within the relevant region.

(3) Each regional waste and resource recovery group and Sustainability Victoria must have regard to local planning provisions and requirements in preparing or amending any waste and resource recovery implementation plans.

13. Landfill Site Selection

(1) Each regional waste and resource recovery group in the strategic planning and siting of prospective landfills must take into account siting considerations established in the BPEM including:

(a) alternative potential uses for the site;

(b) community needs;

(c) landfill type;

(d) buffer distances;

(e) groundwater;

(f) surface water;

(g) flora and fauna;

(h) infrastructure;

(i) geology; and

(j) land ownership.

(2) Landfill sites must not be established or extended into any area listed in Schedule A to the policy.

(3) New landfill sites must not be established or extended into any area where an aquifer contains Segment A groundwater, unless the:

(a) landfill operator satisfies the Authority that sufficient additional design and management practices will be implemented; and

(b) the Authority determines that regional circumstances exist that warrant the development of a landfill in the area.

14. Works Approval and Licensing

(1) Applications for works approvals and licences must comply with the provisions of the policy.

(2) All premises that are exempt from either works approvals or licensing must comply with the provisions of the policy.

(3) The Authority will progressively amend existing landfill licences so that they are consistent with the policy.

LANDFILL SITING, DESIGN AND MANAGEMENT

15. General Requirements

(1) Where any provision of the BPEM is inconsistent with the policy, the policy shall prevail.

(2) This clause applies to an applicant for or holder of a works approval or licence for a landfill site, unless provided for in Clause 17.

(3) An applicant for or holder of a works approval or licence for a landfill site must:

(a) comply with the policy as well as all other relevant State environment protection policies and waste management policies;

(b) meet the objectives of the BPEM; and

(c) meet each required outcome of the BPEM.

(4) An applicant for or holder of a works approval or licence for a landfill site should use the suggested measures in the BPEM to demonstrate that subclause (3) will be met.

(5) If an applicant for a works approval, licence or licence amendment proposes measures alternative to the suggested measures of the BPEM, the Authority shall not issue the works approval, licence or licence amendment unless the applicant satisfies the Authority that the alternative measures:

(a) meet the requirements of subclause (3); and

(b) provide at least an equivalent environmental outcome to that provided by the suggested measure.

16. Specific Requirements

(1) The Authority may require, by licence, works approval or notice, the segregation of a specified waste within a landfill cell or elsewhere on site to:

(a) enable the recovery of this material in the future; or

(b) ensure the highest level of protection of people and the environment at any point in time.

(2) All new landfill sites must deposit waste at least two metres above the long term undisturbed depth to groundwater, unless the:

(a) landfill operator satisfies the Authority that sufficient additional design and management practices will be implemented; and

(b) the Authority determines that regional circumstances exist that warrant the development of the landfill.

(3) The holder of a licence for a landfill site in a municipality listed in Schedule C of the Act which is subject to the landfill levy payable under the Act must, within three years of the policy being gazetted, use a weighbridge to measure the quantity of waste accepted at the site.

(4) Once a licensed landfill site has closed, the Authority will require, through a notice, the occupier of the site to undertake ongoing aftercare until such time as the site does not pose a risk to human health or the environment, as determined by the Authority.

17. Landfills Exempt from Licensing

(1) The Authority will work in partnership with local government and regional waste and resource recovery groups to:

(a) develop and implement a strategic program for the management of landfill sites exempt from licensing; and

(b) develop guidelines on the design and management of landfill sites exempt from licensing.

(2) The operator of a landfill site exempt from licensing should use any guidelines developed under subclause (1b) to demonstrate compliance with the policy.

(3) Once a landfill site exempt from licensing has closed, the Authority may, through a notice, require the occupier of the site to undertake ongoing aftercare until such time as the site does not pose a risk to human health or the environment, as determined by the Authority.

18. Recycling Facilities

The Authority may require, by licence, works approval or notice, a landfill operator to provide, operate and maintain facilities for the segregation and collection of reusable and recyclable wastes received at the landfill site.

19. Prohibited Waste to Landfill

(1) The Authority will encourage the diversion of waste from landfill where a higher practicable waste management option exists consistent with the policy.

(2) The Authority may prohibit the disposal of specified wastes to landfill where the Authority determines that a higher practicable waste management option exists consistent with the policy or where a significant environmental risk exists.

(3) Prior to prohibiting specified wastes to landfill in accordance with subclause (2), the Authority will consult with key stakeholders.

(4) The Authority will have regard to the following factors in making decisions about prohibiting the disposal of specified wastes to landfill:

(a) environmental risk; and
(b) practicability of avoidance, reuse and recycling, including:
(i) existing and potential secondary markets; and
(ii) technical, logistical and financial considerations.

(5) The Authority will publish any specified wastes prohibited under subclause (2) in the Government Gazette.

(6) In addition to any waste prohibited under subclause (2) the following wastes must not be deposited for disposal at landfill sites:

(a) category A prescribed wastes under ~~the Environment Protection (Prescribed Wastes) Regulations 1998 other than wastes classified as suitable under~~ the Environment Protection (Industrial Waste Resource) Regulations 2009~~Industrial waste management policy (Prescribed Industrial Waste) 2000~~;
(b) liquid wastes;
(c) automotive batteries;
~~(d) small batteries, except where they are dispersed in small quantities on disposal, such as those from domestic origins;~~
(~~e~~e) night soil;
(~~f~~f) pneumatic automotive tyres (including any tyre which is made either wholly or partly of natural or synthetic rubber or similar material) unless the tyres have been shredded into pieces not exceeding 250 millimetres in size in any dimension;
(~~g~~g) radioactive substances except where the landfill operator has approval or where an exemption has been given in accordance with the requirements of the Health Act 1958; ~~and~~
(~~h~~h) wastes prohibited for disposal to landfill by a national environment protection measure
(i) e-waste.

20. Landfill Gas

(1) In addition to the obligations contained in Clause 15, the Authority may require a landfill operator to install a landfill gas collection system in existing and/or new landfill cells where:

(a) landfill gas emissions are causing or may cause odours;
b) landfill gas emissions represent or may represent a hazard; or
(c) it is necessary to reduce greenhouse gas emissions.

21. Environment Improvement Plan

(1) The Authority will require the holder of a licence for a landfill site to develop and submit an environment improvement plan.

(2) The Authority will encourage the operator of a landfill site exempt from licensing to develop an environment improvement plan.

(3) In preparing an environment improvement plan, operators of landfill sites must take into consideration any relevant neighbourhood environment improvement plan, and any relevant regional waste and resource recovery implementation plan.

SCHEDULE A: AREAS WHERE LANDFILL SITES MUST NOT BE ESTABLISHED OR EXTENDED INTO

(1) Areas where landfill sites must not be established or extended into:

(a) high value wetlands including wetlands of international importance listed under the convention on wetlands (Ramsar, Iran 1971) and listed in a directory of important wetlands in Australia (Environment Australia 2001);

(b) areas of significance for spawning, nursery, breeding, roosting and feeding areas of aquatic species, and fauna listed under the China–Australia Migratory Bird Agreement and Japan–Australia Migratory Bird Agreement, the Convention on Migratory Species of Wild Animals (Bonn, Germany, 1979) and under the Flora and Fauna Guarantee Act 1988;

(c) marine and coastal reserves listed in the National Parks Act 1975;

(d) water supply catchments proclaimed under the Catchment and Land Protection Act 1994, unless otherwise approved by the Authority;

(e) state wildlife reserves listed under the Wildlife Act 1975;

(f) critical habitats of taxa and communities of flora and fauna listed under the Flora and Fauna Guarantee Act 1988;

(g) areas identified by the Water Act 1989 as water supply protection areas, unless otherwise approved by the Authority;

(h) groundwater protection zones prescribed in Schedule A of the State environment protection policy (Groundwaters of Victoria) 1997;

(i) matters of national environmental significance as identified in the Environment Protection and Biodiversity Conservation Act 1999 (Cth); and

(j) surface waters.

SCHEDULE B: EXAMPLES OF ELECTRICAL OR ELECTRONIC EQUIPMENT PROHIBITED FROM LANDFILL

Large appliances	Professional tools & equipment	Small household tools & appliances	Computers, TVs, IT	Lighting & mobile phones	Leisure, PV
- refrigerators - washing machines - cookers - microwaves - electric fans - air conditioners	- welding, soldering, milling - medical devices - monitoring and control equipment - automatic dispensers	- irons - toasters - coffee machines - hair dryers - electric tools - sewing machines - musical instruments - batteries	- computers - monitors - laptops - mice, keyboards, routers - printers - CRT TVs - Flat screen TVs (LCD, LED, plasma)	- fluorescent lamps - high intensity discharge lamps - compact fluorescent lamps - LEDs - mobile phones	- toys - game consoles - cameras - portable audio & video - remote controls - photosensitive semiconductor devices

EXPLANATORY NOTES

Waste management policies (WMPs) are declared by the Governor in Council under section 16(1A) of the Environment Protection Act 1970. WMPs specify requirements to be observed in the management of waste.

BACKGROUND TO POLICY

This policy updates and refines Victoria's established framework for the siting, management and rehabilitation of landfills. This policy provides an improved framework to encourage the minimisation of the development and use of landfills and the diversion of waste materials for re-use and recycling as opposed to disposal. The policy also promotes continuous improvement in the siting, design and management of landfills in Victoria, to ensure that residual waste is managed in a way that protects the environment and human health.

Title

Clause 1 states that the policy title is Waste Management Policy (Siting, Design and Management of Landfills).

Commencement

Clause 2 states when the policy comes into effect.

Revocation of State environment protection policy (Siting and Management of Landfills Receiving Municipal Wastes)

Clause 3 revokes the State environment protection policy (Siting and Management of Landfills Receiving Municipal Wastes).

Application of the Policy

Clause 4 states that the policy applies throughout the State of Victoria, but only applies to landfill sites accepting non-prescribed wastes and/or Category C prescribed industrial wastes.

Contents of the Policy

Clause 5 outlines the content and structure of the policy.

Definitions

Clause 6 provides specific definitions of various words and terms used throughout the policy.

PART I POLICY FRAMEWORK

Policy Objectives

Clause 7 sets out the objectives of the policy, which underlies the specific requirements of the policy.

Policy Principles

Clause 8 indicates the environment protection principles applied by the policy, and are to be used to guide decisions about the siting, design and management of landfills.

Policy Intent

Clause 9 indicates what is to be achieved through the implementation of the policy.

PART II ATTAINMENT PROGRAM

POLICY RESPONSIBILIES

Implementation

Clause 10 outlines the policy responsibilities and commitments of municipal councils, regional waste and resource recovery groups, Sustainability Victoria, EPA Victoria and other protection agencies, and industry.

LANDFILL PLANNING AND SITING

Strategic Land Use Planning

Clause 11 requires those persons involved in the planning and siting of landfills to comply with the policy and any relevant regional waste and resource recovery implementation plan. This will provide a co-ordinated approach to the planning and siting of landfills and ensure that plans reflect local, regional and State priorities, directions and approaches.

Waste Management Planning

Clause 12 requires regional waste and resource recovery groups to consider the available landfill airspace, both existing and planned, in surrounding regions when determining the need for additional landfill airspace within their region. Regional waste and resource recovery groups are also required to consult with those affected by their plans. When preparing or amending their plans, Sustainability Victoria and regional waste and resource recovery groups must take into consideration local planning requirements.

Landfill Site Selection

Clause 13 outlines a number of siting considerations that regional waste and resource recovery groups must take into account in the strategic planning and siting of prospective landfills for their region. This clause specifically states that new landfill sites must not be located in areas where an aquifer contains Segment A groundwater. However as certain regions of the State contain large areas of Segment A groundwater, such as East Gippsland, a landfill may be approved where the operator satisfies the Authority that sufficient additional design and management practices will be implemented and the Authority determines that a specific regional circumstance exists that warrants the development of a landfill in such an area. This clause also refers to Schedule A of the policy, which lists those areas where a landfill must not be established or extended into.

Works Approval and Licensing

Clause 14 requires applications for works approval and/or licence to be consistent with the policy and those landfill sites not subject to these requirements must also comply with the policy.

LANDFILL SITING, DESIGN AND MANAGEMENT

General Requirements

Clause 15 applies to landfills serving 5000 persons or more and requires landfill operators to meet the objectives and required outcomes outlined in the BPEM. This clause also provides a process for alternative measures than those specified in the suggested measures in the BPEM to be evaluated and approved.

Specific Requirements

Clause 16 enables the Authority to require a landfill operator to segregate a specific waste in a landfill cell or elsewhere on site. This clause also requires that all new landfill sites must deposit waste at least two metres above the long term undisturbed depth to groundwater. This means the naturally occurring depth to groundwater that has not been disturbed by human activities or seasonal or climatic variations. A lesser distance may be approved where additional design and management practices will be implemented and the Authority determines that regional circumstances exist that warrant the development of the landfill. This clause requires weighbridges to be used at all licensed landfills sites that are subject to the landfill levy and are located in a municipality listed in Schedule C of the **Environment Protection Act 1970**.

This clause also allows the Authority to require ongoing aftercare of a licensed landfill once it has closed until such time that the site has stabilised and no longer poses a threat to the environment or the community.

Landfills Exempt from Licensing

Clause 17 requires the Authority to work with municipal councils and regional waste and resource recovery groups in the strategic management of unlicensed landfill sites. This will include the development a guideline to assist operators to improve the operation and rehabilitation at these sites, to ensure the environment and community are protected and that the objectives, principles, and intent of the policy are met.

Recycling Facilities

Clause 18 enables the Authority to require a landfill operator to provide, operate and maintain facilities, where practicable, for the segregation and collection of reusable and recyclable wastes received at the site.

Prohibited Waste to Landfill

Clause 19 allows the Authority to prohibit certain wastes from being disposed to landfill if there is a higher waste management option practicably available or the waste poses an unacceptable risk to the environment. It also outlines the factors to which the Authority will have regard in making such a determination and that consultation is required with key stakeholders prior to prohibiting a waste. This clause also outlines those wastes that cannot be disposed of to landfill.

Landfill Gas

Clause 20 allows the Authority to require a landfill operator to install and manage a landfill gas collection system in existing and/or new landfill cells to control odour, where the emissions pose a hazard or to reduce greenhouse gas emissions.

Environment Improvement Plan

Clause 21 requires a licensed landfill operator to prepare and submit an environment improvement plan (EIP) to the Authority. For unlicensed landfill operators, they may voluntarily develop an EIP.

SCHEDULE A – AREAS WHERE LANDFILL SITES MUST NOT BE ESTABLISHED OR EXTENDED INTO.
Identifies areas where a landfill site must not be established or extended into.

Appendix 3 - Waste Management Policy (E-waste)

Contents

1. Title

This policy may be cited as the Waste Management Policy (E-waste) 2018 (Policy).

2. Objectives

The objectives of this policy are to:

(1) Ensure the appropriate management of e-waste in Victoria, in order to effectively implement the banning of e-waste from landfill provided for in the *Waste Management Policy (Siting, Design and Management of Landfills) No. S264*; and
(2) Eliminate, or reduce so far as practicable, the risk of harm to the environment and human health associated with e-waste; and
(3) Maximise the recovery of materials from e-waste; and
(4) Ensure records are available to assess the effectiveness of the policy in achieving the above objectives.

3. Authorising provision

This policy is made under section 16A of the ***Environment Protection Act 1970***.

4. Commencement

This policy comes into operation on 1 July 2018.

5. Definitions

In this policy—

AS/NZS 5377: 2013 means the Australian and New Zealand Standard, *Collection, storage, transport and treatment of end-of-life electrical and electronic equipment*;

collection means an activity that involves receiving and handling e-waste;

e-waste means waste equipment which is dependent on electric currents or electromagnetic fields in order to work properly and waste equipment for the generation, transfer and measurement of such currents and fields, or materials or parts from such equipment;

e-waste service provider	means any person who conducts a business or undertaking that accepts e-waste for collection, storage, handling, transport, reuse, repair or reprocessing;
material recovery rate	has the meaning given in clause 7(6);
output materials	means the products of reprocessing e-waste, which are intended for reuse or recycling;
reprocessing	means changing the physical structure or properties of e-waste to create output materials and residual waste;
residual waste	means the products of reprocessing e-waste, which are intended for disposal;
specified e-waste	means waste rechargeable batteries, cathode ray tube monitors and televisions, flat panel monitors and televisions, information technology and telecommunications equipment, lighting and photovoltaic panels.

6. General requirements

(1) This clause applies to any person involved in the following activities with respect to e-waste:

(a) generation;
(b) collection;
(c) storage;
(d) handling;
(e) transport;
(f) reuse;
(g) repair;
(h) reprocessing.

(2) A person must take all reasonable steps to eliminate or reduce the risk of harm to human health and the environment associated with e-waste.

(3) Without limiting subclause (2), a person must take all reasonable steps to:

(a) prevent e-waste disposal to landfill; and
(b) maximise recovery of output materials from e-waste; and
(c) prevent breakage or spoilage of e-waste that might limit its suitability for reprocessing; and
(d) if applicable, provide e-waste to an e-waste service provider who complies with this policy.

7. Requirements for e-waste service providers

(1) An e-waste service provider must only store e-waste for the purposes of transfer, reuse, repair, recycling or reprocessing.

(2) An e-waste service provider must take all reasonable steps to minimise the duration of storage of e-waste under their control or in their possession.

(3) An e-waste service provider who receives a load of specified e-waste greater than 3 cubic metres must record the following information for the load:

(a) a description or name and address of the person responsible for the generation of the specified e-waste or the name and address of the e-waste service provider previously in possession of the specified e-waste;

(b) the date of receipt of the incoming load;
(c) a description of the specified e-waste;
(d) the amount or quantity of the specified e-waste.

(4) An e-waste service provider who receives specified e-waste that is subsequently transported to another premises must record the following information for each load transported:
(a) the date the specified e-waste is transported;
(b) the name and address of the premises to which the specified e-waste is transported;
(c) a description of the specified e-waste;
(d) the amount or quantity of the specified e-waste.

(5) An e-waste service provider responsible for reprocessing of e-waste must record the following information during a financial year:
(a) the description of incoming e-waste;
(b) the weight of incoming e-waste;
(c) the type of processes used, including all stages of a multi-stage process;
(d) the classification, weight and destination of output materials;
(e) the weight of residual waste.

(6) An e-waste service provider responsible for reprocessing of e-waste must calculate and record material recovery rates, for each financial year, either:
(a) in accordance with the following formula, using the information recorded under subclauses 7(3) and 7(4):

$$\text{Material recovery rate (\%)} = \frac{\text{weight of output materials}}{\text{weight of incoming e-waste}} \times 100$$

or

(b) if batch processing assessment is used to assess and report material recovery rates, by calculating the rates in accordance with Appendix D in AS/NZS 5377:2013.

(7) An e-waste service provider responsible for reprocessing of e-waste must meet or exceed the minimum material recovery rate provided by:
(a) an accredited voluntary or an approved co-regulatory arrangement under the Product Stewardship Act 2011 of the Commonwealth; or
(b) the minimum acceptable processing, end-use and method of disposal requirements in Table 1 of AS/NZS 5377: 2013.

(8) An e-waste service provider must retain records required under this clause for at least 5 years.

8. Deemed compliance

(1) An e-waste service provider is deemed to comply with this policy if it meets the requirements of AS/NZS 5377: 2013.

Table of Applied, Adopted or Incorporated Matter

Policy Provision	Title of applied, adopted or incorporated document	Matter in applied, adopted or incorporated document
Clause 7(6)	AS/NZS 5377: 2013 *Collection, storage, transport and treatment of end-of-life electrical and electronic equipment*	Appendix D
Clause 7(7)	AS/NZS 5377: 2013 *Collection, storage, transport and treatment of end-of-life electrical and electronic equipment*	Table 1
Clause 8	AS/NZS 5377: 2013 *Collection, storage, transport and treatment of end-of-life electrical and electronic equipment*	The whole

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