A Study of Australia's Current and Future E-Waste Recycling Infrastructure Capacity and Needs

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Disclaimer

Revision History

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EXECUTIVE SUMMARY

The Australian Government, with the active support of State and Territory Governments, plans to establish a national framework for product stewardship and extended producer responsibility. The initial product stewardship scheme is to facilitate recovery and recycling of discarded televisions and computers. It is expected to commence in mid 2011. It may later be extended to drive recovery and recycling of other e-waste products such as household appliances. The scheme was assessed in the recently published *Decision Regulatory Impact Statement*[1] (RIS).

The purpose of this study is to provide both a reliable estimate of current e-waste infrastructure capacity, and future requirements for e-waste infrastructure to support a product stewardship scheme that meets community and Government expectations. The study was commissioned by the Department of the Environment, Water, Heritage and the Arts to provide input to the development of legislation and product stewardship arrangements.

Current E-Waste Recycling Demand and Capacity (Chapters 2, 3 and 4)

The study commenced with a survey of e-waste resource recovery and processing in Australia. The aim was to establish an estimate of current e-waste recycling and reuse *demand*, and provide a reliable estimate of the *capacity* available in the Australian e-waste resource recovery industry. This survey indicated that current demand for e-waste recycling and reuse services exceeds 4 million units/year (around 25,000 tonnes) – only around 10% of the discarded e-waste is recovered and processed.

Some 50% of e-waste recycled today is computers and computer peripherals, with the vast majority of this sourced from the commercial sector. However, the number of televisions presenting is increasing rapidly, as more drop-off/collection events are promoted and as more people switch from analogue to digital televisions.

The survey revealed that the e-waste resource recovery sector has ample capacity to process the current demand level. And reserve capacity is available to absorb some further years of growth at the present rate. Furthermore, capacity could be moderately enlarged without significant capital investment – by adding more labour and additional product dismantling equipment, or by adding a further operations shift. This might buy a few more years of surplus processing capacity during the early years of increased e-waste recycling following introduction of a product stewardship scheme.

The main resource recovery practices applied to discarded e-waste, in order of descending volume, are: disassembly or shredding for recycling of materials; refurbishment for reuse; and disassembly for recovery of usable

[1] Environment Protection and Heritage Council. *Decision Regulatory Impact Statement: Televisions and Computers.* (PricewaterhouseCoopers and Hyder Consulting) October 2009.

parts. The process of recycling, which applies to the majority of e-waste, is a sequence of successive stages of component disassembly operations to incrementally derive value from the former product. Glass, steel and plastics undergo downstream processing in Australia; electronic components are largely exported for specialised metals recovery.

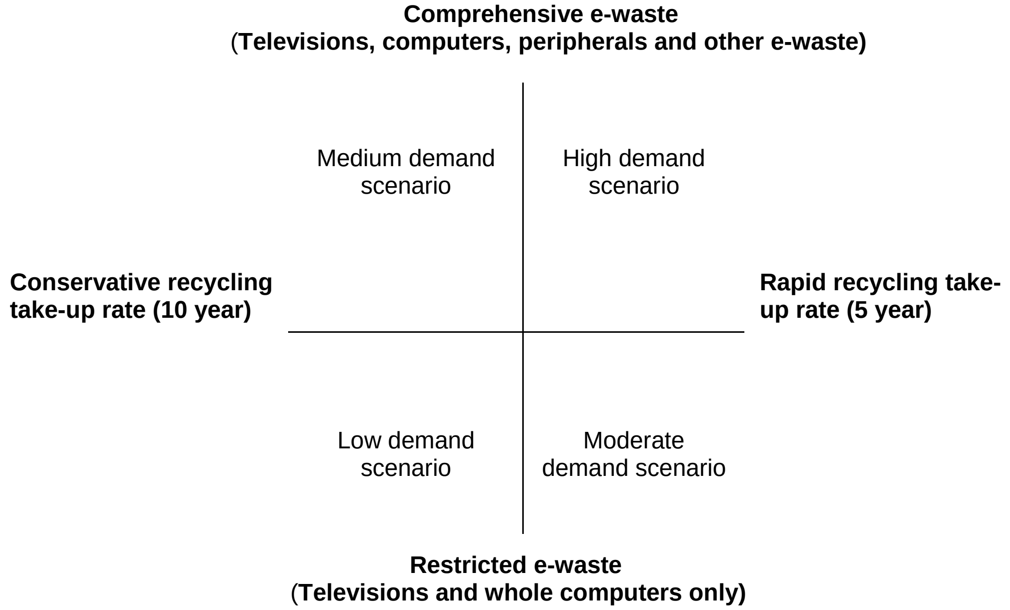
End of life product discard rates (i.e. the rate at which products are no longer wanted by consumers and are discarded) for televisions and computers have consistently been around half of product sales volumes. This has resulted in a progressive building of product stocks by households and business. Mobile phone hoarding is even more entrenched. This low level of discard action is expected by industry associations to progressively lift following introduction of a product stewardship program, so that annual end of life discard rates should soon approach sales volume.

Future Demand Scenarios (Chapter 5)

The amount of discarded e-waste actually collected and processed each year following commencement of product stewardship is likely to dramatically increase after introduction of the first e-waste product stewardship scheme. However, the rate of take-up of recycling opportunities is uncertain and the pace of introduction of schemes applied to e-waste beyond televisions and computers is not yet determined.

Four distinctly different scenarios were developed describing how recovery and recycling demand may play out as product stewardship schemes are implemented. They are depicted at Figure ES-1.

Figure ES-1 Summary Scenario Diagram



All four scenarios feature a substantial increase in e-waste resource recovery and recycling – from the current position of just over 4 million units/year (25,000 tonnes) to between 33 and 41 million units/year (116,000 to 169,000 tonnes/year). The main differences between scenarios are:

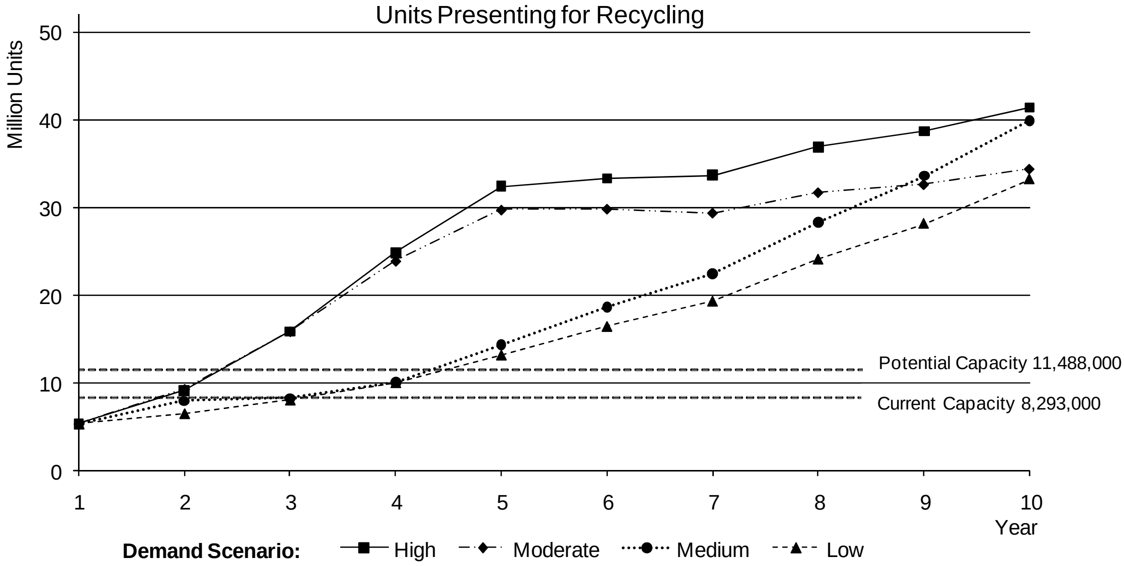
- The rate of resource recovery and recycling take-up (horizontal axis) – so that at one extreme the established target, of collecting and processing 80% of end of life discarded products, is met within 5 years; at the other extreme the timeframe to the resource recovery and recycling target is 10 years.

- The product coverage of the product stewardship schemes (vertical axis) – at one extreme all e-waste, including televisions, computers, peripherals, mobile phones, appliances, and other e-waste; at the other extreme a restricted product span comprising televisions and whole computers only.

Forecast e-waste recovery and recycling demand, as represented by the four scenarios, is presented at Figure ES-2. This graph also includes a plot of current infrastructure capacity.

This graph demonstrates the differences in forecast recycling take-up between the *High* and *Moderate* Demand Scenarios on one hand, and the *Medium* and *Low* Demand Scenarios on the other hand. The differences in demand between these two sets of scenarios are pronounced. Scenario differences related to e-waste product coverage are less distinct than those evident in relation to the rate of recovery and recycling take-up.

Figure ES-2 Modelled Demand Outstrips Current Capacity (units)



Demand and Capacity Findings (Chapters 5 and 6)

Recovery and Recycling Demand will Increase Rapidly

While each scenario is considered plausible, the very rapid (five year) recovery and recycling growth rate associated with the *High Demand Scenario* and the *Moderate Demand Scenario* may stretch industry capacity to develop infrastructure to match recovery and recycling demand. This could result in excessive inventories of e-waste products awaiting recycling.

On the other hand, the *Medium Demand Scenario* and the *Low Demand Scenario* feature a ten year recovery and recycling take-up rate to the 80% target. This allows scheme administrators to adopt a more conservative pace to develop community education capacity and deploy collection points for discarded products. And it allows for the recycling industry to progressively invest in and develop recycling capacity beyond the current reserve.

The *Medium Demand Scenario* has the additional benefit of incorporating collection and recycling of other e-waste products, from year 5, while allowing mobile phone collection and recycling to continue flourishing.

The *Medium Demand Scenario* is considered to be both the most likely and the most desirable for orderly implementation of e-waste product stewardship arrangements. In summary, the scenario is based on two main policy settings:

- a ten year time frame to achieve the established target of collecting and processing 80% of end of life discarded products; and

- progressive introduction of new product stewardship schemes to provide coverage of all e-waste products (rather than just televisions and whole computers).

This progressive roll-out should allow the e-waste recycling industry adequate time to develop further capacity – provided momentum is maintained by the parties liable for post-consumer fate of e-waste: the Product Responsibility Organisations (PROs) and other liable parties.

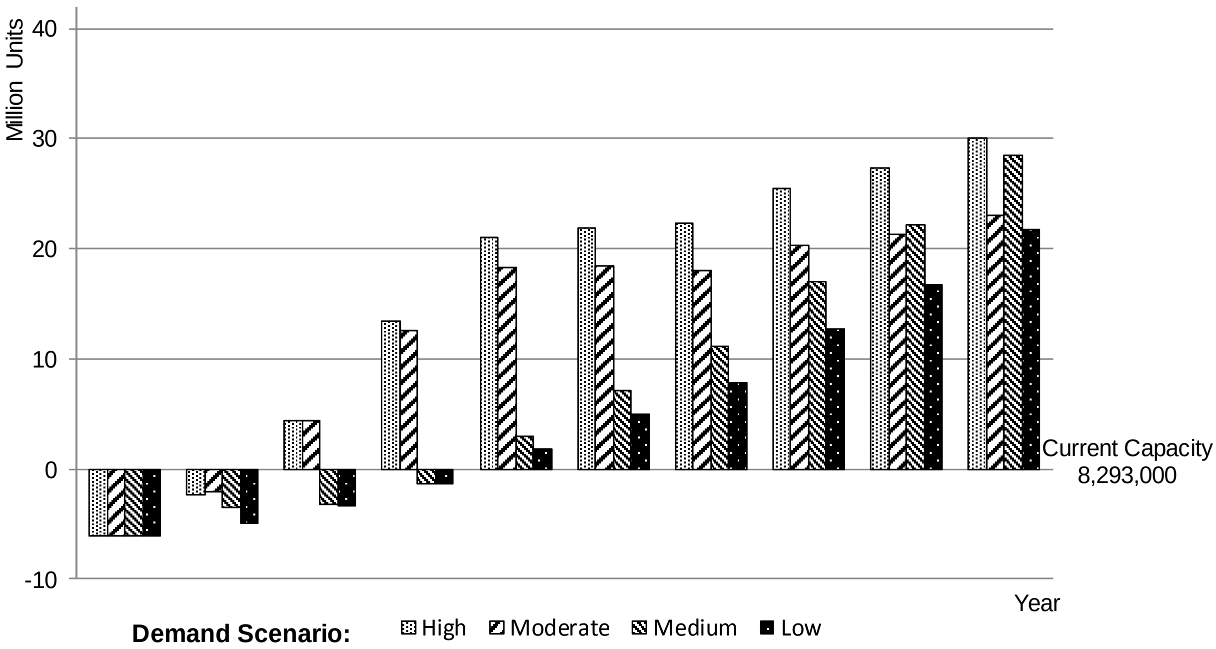
Televisions and computers are forecast to continue to dominate collected e-waste, with televisions ultimately replacing computers as the most collected e-waste (by weight). Mobile phones and other e-waste will remain (by weight) a modest proportion of the total resource recovery pool.

Substantial New Primary Recycling Capacity will be Required

Implementation of e-waste product stewardship would need to be supported by an early and rapid increase in primary e-waste recycling infrastructure and capacity for downstream processing of some components. Increasing community demand for e-waste recycling should propel addition of primary recycling capacity – but capacity additions will need to match the evolving demand.

The indicative estimated increases in primary recovery and recycling capacity requirements for each of the demand scenarios are shown at Figure ES-3.

Figure ES-3 Annual Demand and Available Capacity (units)



The Downstream Recycling Capacity Position is Mixed

There is significant general capacity in Australia for downstream processing of glass, steel, and plastics recovered from e-waste products. This processing infrastructure existed prior to the introduction of e-waste recycling and does not depend on materials from e-waste recycling to remain commercially viable. Indeed, the amount of materials arising from the e-waste recycling sector is very modest when compared with the steel, plastic and glass recycling material flows from other sources.

However, Australia has little capacity to process electronic waste and no commercial-scale facilities suitable for e-waste precious metals recovery. Moreover, recyclers have little interest in establishing facilities in Australia for downstream processing of component subassemblies to recover precious metals in circuit boards etc, based on e-waste products alone – the current technologies are complex and the potential yield is insufficient to support investment.

The main current recovery and recycling practices applied to discarded e-waste are likely to remain relevant, at least until 2020/21. However, progressive reduction of material value used in products, and changes in technologies embodied in electrical and electronic equipment will reduce the (already marginal) recycling value proposition. While there may be minor endeavours at specialised resource recovery in Australia, the trend toward reduced inherent value in components is likely to prompt more recyclers to adopt the practice of whole product shredding followed by material sorting and material processing in lieu of manual product disassembly and sorting (to both material and component) for downstream processing.

Discarded Product Collection Logistics

The PSA and AIIA have advised they are developing plans to provide for multiple types of collection and transfer pathways, including special events and council collections as well as designated drop-off/collection points. They expect that community drop-off and industry collection from designated sites, such as well-known retailers and public waste transfer stations, will become important pathways. This collection pathway has been shown to be successful through the Byteback program.

A case study was used to test the impact of peak collection demand on an apparently reasonable deployment of collection points. The actual number of collection points required to accommodate developing demand will progressively increase and can be readily adjusted.

The case study illustrates that deployment of (say) two drop-off/collection points in each of the 14 Sydney Regions (28 locations across Sydney or one drop-off/collection point for each 150,000 people) together with occasional event-based collections, would provide for a manageable e-waste collection scale with a maximum expected travel distance of 20km. For the *High Demand Scenario*, an average of around 12 tonnes/week would be collected at each location during year 5 (2015/16); around 15 tonnes/week during year 10 (2020/21).

As around 88% of Australia's population lives in major cities and inner regional cities and towns, a similar scale of distribution should apply for drop-off/collection points in these locations. On a simple scale-up basis, 120 to 140 collection points would be required to service major cities and inner regional cities and towns across Australia. Depending on the collection policy adopted for regional and remote collection, a further 100 to 200 drop-off/collection points may be required to service outer regional and remote towns.

An alternative collection point strategy would be to deploy one collection point at each of Australia's 564 local government areas. This would provide for 40 collection points across Sydney, which may be considered as a peak requirement.

Strategic Implementation Risks and Directions for Implementation (Chapter 7)

The Pace of Capacity Creation is Critical

Market dynamics will be changed strikingly with the introduction of a product stewardship scheme. Demand on the e-waste recycling industry will be controlled by the PRO and other liable parties. The major liable parties will be in a commanding position in the procurement of recycling services; a situation new to an industry sector used to surviving on innovative sourcing of e-waste feedstock. The biggest governance risk will be to ensure that the progressive development of e-waste recovery and recycling *capacity* keeps pace with progressive increase in e-waste recycling *demand*.

There is potential for e-waste recycling industry capital allocation to be compromised by procurement action taken by a major liable party with significant market representation. This condition may come about as a result of a competitive tendering regime which awarded major recycling contracts to just a small number of participants in the industry. Such procurement action has the potential to confer high recycling volume contracts on a small number of the 14 existing main recyclers. The successful few, in such a scenario, would be positioned to flourish while their rivals would need to continue to seek out commercial e-waste (outside the product stewardship scheme), and possibly focus their attention on other parts of their diversified businesses.

This scenario also raises the issue that new entrants to the e-waste recycling industry may have difficulty establishing a position from which to demonstrate competence and win recycling tenders. This may not be consistent with Australia's international obligations to foster domestic capacity.

At a time when rapidly expanding demand will require a maximum of readily available expert recycling capacity, a wise procurement strategy may be to tender numerous modest-sized blocks of e-waste processing on 3-5 year contracts. As well as promoting increased rivalry among existing recyclers, this regime could encourage market entry by new recycling firms.

Although the primary risk for the balanced performance of the e-waste recycling program is clearly assumed by the liable parties, the Australian Government appears to carry a secondary risk. One way to minimise the risk that sub-optimal procurement action may adversely impact the timely creation of industry capacity, would be for the Government to establish a set of procurement principles and conditions. These could establish product stewardship governance arrangements and KPIs so that the Government could set the basis on which the product stewardship scheme could be delegated to industry and would form a basis for monitoring performance. Thoughtful governance arrangements would allow the liable parties to operate independently, but would provide strategic input by the Government

Community Expectations Must be Managed

The liable parties may also have some responsibility for the pace at which new drop-off and collection points are rolled out and the geographic priorities adopted. The major liable parties could thus control both *actual* and *latent* demand for recycling services. They could control the volume of recycling demand actually collected by adjusting the pace of collection point roll-out. But this pace may not align with community expectations for recycling opportunities following product stewardship launch.

There is a potential risk of imbalance between e-waste recycling demand and supply. This condition could result if the timing of collection point roll-out and award of recycling contracts does not keep pace with community expectations.

Two extreme possibilities are apparent. The first is that collection points are rolled-out apace, in advance of securing recycling capacity to match collected volume. This possibility would result in a surplus of e-waste to be stored awaiting processing. It may lead to pragmatic decisions to dispose of a proportion of the e-waste inventory, especially if surplus stocks are accumulated at processing facilities or collection points with easy access to disposal facilities.

The second possibility is that the pace of collection point roll-out fails to match community expectations – that are likely to be amplified following publicity accompanying the launch of the scheme. This may result in complaints from communities unable to take near-term recycling action.

Although the primary risk in both the above cases is clearly assumed by the liable parties, it appears the Australian Government carries secondary risk for the balanced roll-out of the e-waste recycling program. In keeping with the suggestion made above, the Government could establish a set of principles and conditions governing collection point roll-out. These would allow the liable parties to operate independently, but would provide strategic input by the Government.

Export of Electronic Components for Processing Must Continue

A further significant risk associated with greatly increased e-waste recycling demand is the continuity of downstream off-shore processing capacity for electronic components. A serious gap in capacity to process components, such as circuit boards and power units, would arise if off-shore processing capacity is closed or does not expand at a rate which matches progressively increasing demand. Australia has no commercial-scale facilities suitable for e-waste precious metals recovery.

Export of electronic components for downstream processing will likely be a continuing requirement unless facilities are created locally for both e-waste and other related feedstock. E-waste demand alone would not support such investment.

The task of securing and maintaining off-shore contracts for downstream processing of electronic components is clearly a commercial responsibility of each e-waste recycling firm. A role for Government in supporting the maintenance of industry capacity may be to clarify export permitting requirements and establish bi-lateral communications specifically on e-waste electronic processing with relevant OECD countries. In this regard, a proposed near-term review of the *Hazardous (Regulation of Exports and Imports) Waste Act 1989* may provide a basis for consideration of bilateral policy settings.

Transport Costs from Remote Areas can be Affordable

There may be potential for a major liable party to regard as unsustainable the transport economics and scale issues associated with collection, aggregation and transport from remote areas and outer regional areas. The merit of this position may be arguable where there is a high expectation of whole product recovery for refurbishment and product reuse or component reuse. However, this risk is mitigated when e-waste can be loaded to freight containers without need to preserve product integrity, and transported on conventional transport systems. This is the norm when e-waste is to be shredded for material recovery – an appropriate recycling strategy – rather than conserved for reuse.

This risk may be best handled through an agreed implementation plan between the Australian Government and the relevant industry associations or the major liable parties. One option may be to organise annual sweeps of remote and outer regional areas. There may also be opportunities to link with existing programs such as DrumMuster and ChemCollect, or with developing and expanding programs, such as battery collection.

1. INTRODUCTION

The Australian Government, with the active support of State and Territory Governments, plans to establish a national framework for product stewardship and extended producer responsibility. The initial product stewardship scheme is to cover recovery and recycling of discarded televisions and computers, and is expected to commence in mid 2011. The scheme may later be extended to drive recovery and recycling of other e-waste products such as household appliances.

The purpose of this study is to provide both a reliable estimate of both the current status of e-waste processing infrastructure and a reasonable forecast of future requirements for e-waste processing infrastructure to support a product stewardship scheme that meets community and Government expectations. The study was commissioned by the Department of the Environment, Water, Heritage and the Arts to provide input to the development of legislation and product stewardship arrangements.

The Report begins with a detailed description of current technologies and practices used in the e-waste recycling industry. This survey of current arrangements is completed with an estimate of current infrastructure capacity for processing televisions, computers and other e-waste.

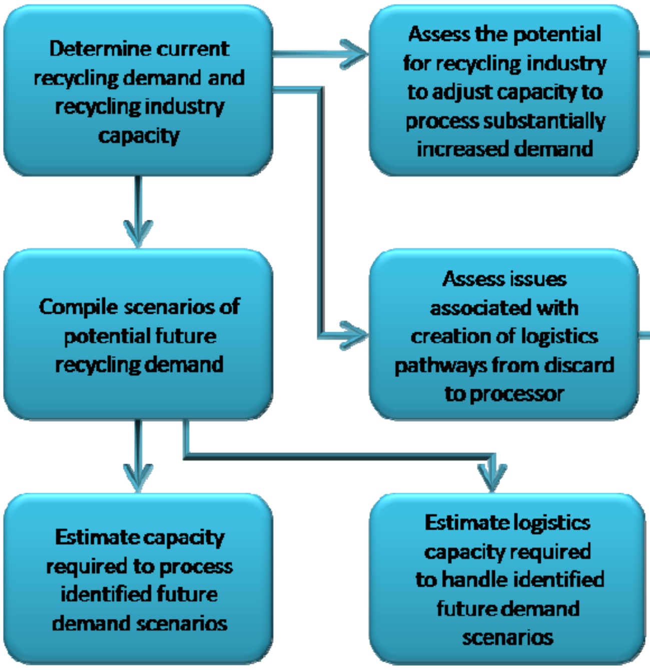
The study also describes alternative recycling demand scenarios that may play out in the first 10 years of a product stewardship scheme. These recycling demand forecasts, under differing program implementation arrangements, provide the basis to forecast infrastructure capacity needs to match expected recycling demand.

The centre-point of this study is a set of forecasts describing the required annual growth of infrastructure capacity and resources. It is clear that considerable additional capacity must be in place to deliver the e-waste product stewardship program.

The report also covers the implications of capacity shortfall and discusses strategic issues associated with implementing product stewardship arrangements for televisions, computers and other e-waste.

The procedure adopted for the study is described pictorially at Figure 1-1.

Figure 1-1 E-Waste Infrastructure Study Procedure



2. SURVEY OF CURRENT INFRASTRUCTURE AND PRACTICES FOR E-WASTE RESOURCE RECOVERY

This Chapter describes current business arrangements for recycling[2] and reuse[3] for e-waste. The primary purpose of the survey reported in this Chapter is to establish an estimate of current recycling and reuse *demand*, and provide a reliable estimate of current recycling and reuse *capacity* available in the Australian e-waste recycling industry.

Note that the information in this chapter has been sourced in discussions with the main recycling industry operators. An undertaking was made to the recycling industry that no specific attribution would be made and that commercially sensitive information would not be revealed.

Key Points

- There are presently 14 e-waste recycling facilities of significance operating in Australia. They are sited in NSW, Victoria, Queensland, South Australia and Western Australia. Numerous small operators active in the market are estimated in this study to total less than 20% of activity.

- The main e-waste recycled today is computers and computer peripherals, with the vast majority of this sourced from the commercial sector. However, the number of televisions presenting is increasing, as more drop-off points are created and special collection events are promoted.

- Three main resource recovery techniques are applied to discarded e-waste: product reuse; disassembly for recycling; and disassembly for spare parts.

- Downstream processing of portions of the e-waste stream in Australia is limited to glass (including CRT leaded glass) steel, plastics, and some electrical cables. These streams are aggregated at recycling facilities and the commodities are sold off to material downstream processing facilities.

- The e-waste recycling sector has ample capacity to process the current demand level. In broad terms, capacity could be enlarged in response to increased demand without significant capital investment – by adding labour and product dismantling equipment or by adding a further operations shift.

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[2] *Recycling* for this study is defined as the act of shredding or disassembling a product to recover materials for further processing or components for further disassembly (often by a third party). In recycling, the focus is on recovering the value in the various materials that comprise the product.

[3] *Reuse* for this study is defined as the act of deliberately maintaining the integrity of the discarded and recovered product, often after disassembling and refurbishing the product, for sale as a unit in good working order.

E-Waste Recycling Facilities and Processes

Currently there are 14 e-waste recycling facilities of significance operating in Australia. These fourteen facilities are estimated to be responsible for recycling over 80 percent of all e-waste currently recycled in Australia. There does not appear to be e-waste recyclers of significant capacity based in the Northern Territory or Tasmania; it is understood that some discarded product from these locations is being transported to the nearest and/or most cost effective e-waste recycler.

The distribution by State and Territory of the e-waste recycling facilities is shown at Table 2-1.

Table 2-1 Distribution of Recycling Facilities of Significance

State/Territory	Total No. of E-Waste Recycling Sites [4]
NSW	3
QLD	2
TAS	Nil
VIC	5
SA	2
WA	2
NT	Nil
ACT	Nil
Total	14

These fourteen facilities of significance range in current capacity from 400 tonnes per annum to 20,000 tonnes per annum, with an average capacity of over 4,500 tonnes per annum for each of the facilities. The number of personnel employed on the significant e-waste recycling sites is between10 and 30.

The range of price for recycling of “mixed e-waste” (mainly televisions and computers) for the small business and residential sector is between $500 and $1000/tonne excluding transport and GST. There is some reluctance in the market to pay this price given e-waste is generally not banned from landfill and landfill disposal is a significantly less expensive than recycling.

Firms in the e-waste recycling sector work on very low margins, and are necessarily nimble and innovative in order to survive; each of the significant recycling facility operators has a variety of related interests that allow for synergistic fixed cost spreading.

[4] Only includes significant sites identified as part of the consultation process.

E-Waste Presenting for Recycling

E-waste recycling facilities in Australia are currently receiving discarded product from both the commercial sector and the small business and consumer sector. The products and materials comprising the e-waste stream are generally discarded because of a loss of functionality or the product is superseded. Typical reasons for discard include those set out at Table 2-2.

Table 2-2 Reasons and Causes for Discard

Reasons	Typical Causes
Loss of functionality, broken etc.	– a user discarding non-repairable product – a retailer or manufacturer discarding damaged product – a retailer or repairer discarding defective products under warranty on behalf of a manufacturer
Superseded technology	– a user upgrading systems and technology – a manufacturer discarding surplus stock of superseded product

Demand Profile

The estimated split between e-waste sourced direct from the small business and residential sector (direct drop-off, council collection, special events and other public collections) and commercial (or OEM) recycling is 41% to 59%.

The main feedstock being received at e-waste recycling facilities today, in terms of both units of product and tonnes of materials, comprises computers and computer peripherals, with the vast majority of this sourced from the commercial sector. Computers and peripherals have for some years dominated the e-waste recycling market, but the position is changing. Increasing numbers of televisions are presenting as more drop-off centres and drop-off events are opening up to the general public for the small business and residential sector to discard their unwanted e-waste.

Demand for television recycling has increased sharply in recent years and now stands at around 350,000 units/year. With a higher unit weight than computers and peripherals, television recycling is growing to become a significant portion of the mass of product processed by the recycling sector. Display screens (mostly CRTs) presenting for recycling are approximately 50% televisions and 50% monitors overall.

The remainder of current feedstock comprises mobile phones, general appliances, electric hand tools and miscellaneous electrical and electronic products.

Resource Recovery Practices

There are three main resource recovery activities being applied to the discarded e-waste items – product reuse, disassembly for recycling, and disassembly for spare parts. E-waste recycling industry activities are briefly discussed below:

(a) Product Reuse – in this instance refurbishment for reuse is mainly applied to computers received by processors from OEM's who deliver bulk quantities of used but serviceable computers arising through technology upgrade contracts for business clients.

The computers are cleaned of previous data, checked for performance, with minor parts replacement where necessary, and repackaged with working computer peripherals for the reuse markets, which are reported to be mainly in the Asia-Pacific Region.

Companies undertaking refurbishment for reuse usually limit candidate computers to near new models and of those of reasonable computing capacity, such as Pentium 4 and above.

(b) Disassembly for Recycling – in this technique, televisions, computers and other e-waste are disassembled, either partly or wholly as a first step towards retrieving primary materials or commodities (metals, plastics, glass, fibre etc.) for recycling. Those operators who adopt the part-disassembly practice, simply remove glass and major hazardous components (such as larger batteries, and toner cartridges) as a pre-cursor to shredding and sorting to material type for subsequent downstream processing – either in Australia or overseas.

Where more complete dismantling is undertaken, a variety of components are generated ranging from prime materials to complex sub-assemblies. In respect of prime materials or commodities, relatively simple dismantling can yield separate streams of steel casings, bulk plastic housings and glass from screens, all of which are suitable for downstream processing in Australia. There is little differentiation between plastics types – most is aggregated and sold as low-grade mixed plastics.

Complex sub-assemblies comprise cables, printed circuit boards, keyboards, hard drives, batteries, power supplies, RAM and other minor sub-assemblies. For these components the common fate is aggregated by material or sub-assembly type and forwarding to downstream processors either in Australia or overseas for further disassembly and eventual processing to recover the prime materials or commodities.

There are no onshore downstream industrial scale processing options for circuit boards that are cost effective to recover precious metals; most recyclers collect circuit boards in three grades (low, medium and high grade) for export;

(c) Disassembly for Parts – computers are disassembled with the object of retrieving component parts for re-building or repairing other computers. This is mainly seen in the not for profit and charity enterprises, as a pre-cursor step to aggregating product for despatch to mainstream e-waste recycling facilities.

The total amount of material retrieved in this disassembly for parts activity is considered to be very small in comparison with mainstream e-waste recycling.

The resource recovery approach adopted for the various e-waste streams is often dictated by the source of the e-waste and the commercial sensitivity of the products. As examples of this selective resource recovery approach based on source, Table 2-3 re-presents the reasons and causes information from the earlier table, and includes additional information on possible resource recovery approaches for each stream.

Table 2-3 Rationale for Resource Recovery Approach

Reasons	Typical Causes for Discard	Recovery Approach
Loss of functionality, broken etc.	- a user discarding non-repairable product	- *commercial* - dismantle for downstream processing, possibly with data destruction of commercial hard drives and security to prevent black market re-birthing; - *residential* - dismantle for downstream processing;
	- a retailer or manufacturer discarding damaged product	- dismantle for downstream processing, possibly with data destruction of hard drives and security to prevent black market re-birthing;
	- a retailer or repairer discarding defective products under warranty on behalf of a manufacturer	- dismantle for downstream processing, possibly with data destruction of hard drives and security to prevent black market re-birthing;
Superseded technology	- a user upgrading systems and technology	- *commercial* - reuse, with data wiping of hard drives; - *residential* - dismantle for downstream processing;
	- a manufacturer discarding surplus stock of superseded product	- destruction to prevent black market re-birthing followed by dismantle for downstream processing.

Protection of corporate information stored on computers is an issue of great commercial sensitivity and customers pay a premium for recycling pathways that ensure security and require report-back validation. With the small business and residential sector this is not usually a requirement passed through to the recycling facilities, so product is generally dismantled for downstream processing immediately on receipt.

Downstream Processing

Downstream processing of portions of the e-waste stream in Australia is limited to glass (including CRT leaded glass) steel, plastics, and some electrical cables. These streams are aggregated at the recycling facilities and the commodities sold off to material downstream processing facilities. When commodity markets are very active and pricing is aggressive, some of these streams may even be exported, even though downstream processing capacity is available in Australia.

For these commodity streams, typical downstream processing options include:

- *steel* – mixing with the scrap steel stream from other sources and processing into new steel product;

- *plastics* – mixing with the recycled plastics streams from other sources for sorting to plastic type, re-polymerisation and incorporation into new products[5];

- *glass* – mixing with the general stream of glass for recycling for melting and reforming into new product; alternatively used as a sand substitute in smelter fluxing.

The majority of the material and sub-component streams that are generated following dismantling and/or shredding and sorting, (including circuit boards and batteries) are aggregated at the recycling facility and either sold directly to the downstream processor, or sold to third party local commodity traders. Two main pathways are common:

- *sorted materials or commodities*, despatched directly to downstream processing facilities that are dedicated to processing similar materials; and

- *sub-components*, exported for further dismantled at overseas recycling facilities and then on-sold to downstream processing facilities that are dedicated to processing similar materials.

  It has been reported that in the course of this second-stage dismantling activity, there may be some component recovery for reuse, in the case of specific micro chips for example, but it is understood that the bulk of the materials are destined for processing for material recovery.

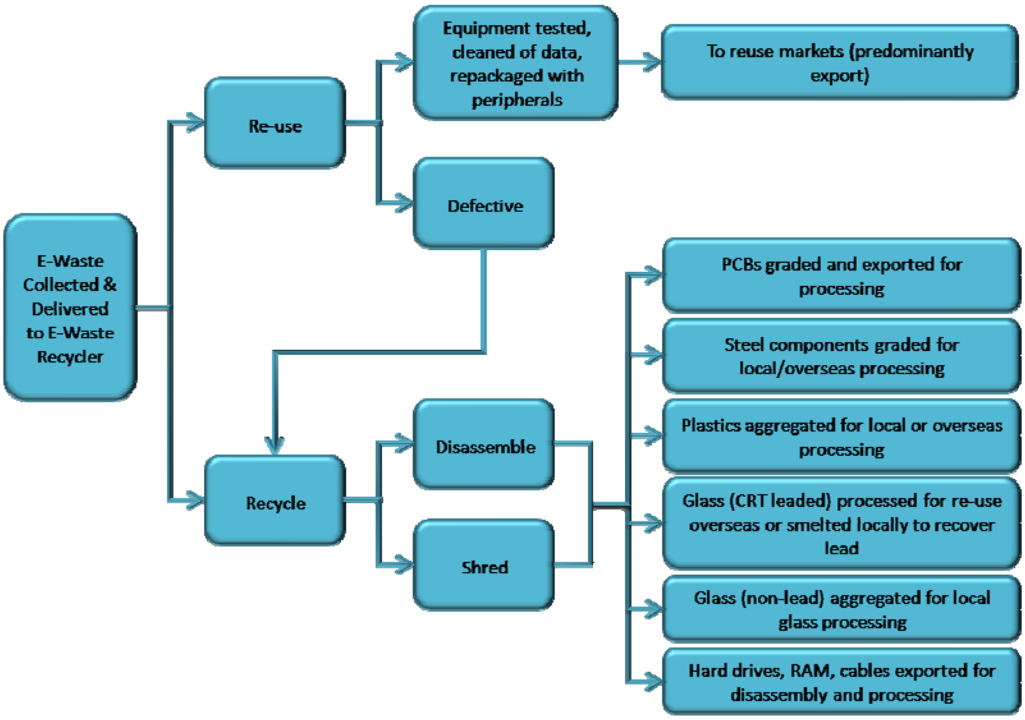
In all instances where downstream processing involves combining the e-waste materials with materials from other sources, the processing facilities already exist to service existing larger markets. The mass of all materials presenting

[5] Recycling industry sources advise that product component embossing of plastic-type from injection moulds is not a reliable indicator of actual plastic-type for subsequent recycling. This arises because moulds are often on-sold to third parties who do not necessarily use plastics of the same type intended by the original manufacturer. Sorting plastics to type requires expert capabilities.

to the downstream processor, in all cases, far exceeds the relatively small mass of materials derived from the e-waste stream.

The relationship between the three pathways for resource recovery and the following downstream processing activity is shown at Figure 2-1 below, with potential destinations of the components indicated.

Figure 2-1 – E Waste Recycling Example Pathways



In respect of the current significant e-waste recycling facilities in Australia, Table 2-4 gives an indication of the extent to which refurbishment for reuse, disassembly (or shredding) for recycling, and disassembly for on-site downstream processing in Australia are practiced at the present time. All main operators conduct disassembly or shredding for recycling; a high proportion refurbish (computers) for reuse (nine of the 14 main recyclers); and few conduct any form of on-site downstream processing; choosing instead to pass components to specialised service providers.

Anecdotal reports from recycling facility operators indicate that they are of the view, that by the time products leave their premises for reuse, or as materials for downstream processing or components for further disassembly and processing, they have achieved, on a weight basis, recycling of better than

94% of the e-waste received. They claim that this is a statistic that they monitor on a regular basis and, where required, report back to their corporate customers.

Table 2-4 E-Waste Recycling Practices by State

State/Territory	No. with Reuse	No. with Disassembly for Recycling	No. With on-site Downstream Processing
NSW	3	3	1
QLD	2	2	
TAS			
VIC	3	5	
SA		2	1
WA	1	2	
NT			
ACT			
Total	9	14	2

E-Waste Recycling Infrastructure and Work Practices

Product Reuse Infrastructure and Work Practices

The reuse operations are primarily applicable where large volumes of the same or similar models of computer are received to enable effective 're-birthing' and subsequent sale of working products into reuse markets.

Nine of the current significant e-waste recycling facilities include in their activity portfolio computer refurbishment for reuse. The bulk of this volume is generated through arrangements that have been put in place between the computer OEM's and the e-waste recyclers.

Large volumes of computers and computer peripherals are generated when the hardware is upgraded. This could typically be every 2-3 years for large organisation looking to keep pace with capability increases delivered through new technology and in line with their leasing arrangements. Thus, computers and peripherals are generally still in good condition and have significant usable life remaining.

The process steps for the reuse of computers generally include:

- rigorous stock control and reporting on receipts from OEMs;
- erasing of the hard drive and other memory via strict protocols with associated verification documentation;
- testing of all components using recognised systems with replacement of parts where warranted;

- re-packaging computers accompanied by working peripherals ready for reuse;
- sale of computers into overseas and local reuse markets; and
- detailed reporting back to OEMs on the management and fate of items, including accounting for both re-sale and destruction for recycling.

Any components or units that fail in this process, that are damaged or that are not suitable for reuse, are directed to the disassembly path for recycling. In accounting back to OEMs on the fate of the products and the costs for the service, the revenue from sale of either recycled materials or products sold for reuse will be taken into account.

The infrastructure and equipment used to effect product reuse is in general more technically complex than is used for disassembly for recycling. It generally involves a secure and clean area for managing product, testing and processing equipment, and data wiping and validation equipment.

The operators require a reasonably high level of IT knowledge and qualification and there is a need during some aspects of the work for skilled trades people to be involved.

For the operator of the recycling facility, this infrastructure and labour requirement represents a higher capital cost and higher commitment to labour quality than is the case for disassembly for recycling.

Disassembly Infrastructure and Work Practices

As is noted in Table 2-4, all 14 of the e-waste recycling facilities are presently undertaking various levels of disassembly of e-waste. This disassembly is undertaken to achieve a number of outcomes, including:

- maximising the resource value of the individual components, through separation into like components – there is also some limited reuse from the components (e.g. RAM, hard drives);
- separation of bulky primary commodities such as glass, steel and plastics;
- minimising contamination of the streams destined for downstream processing; and
- reducing the volume of the various streams, especially for export to further disassembly and downstream processing.

Disassembly involves operators working at a workbench surrounded by bins for disassembled components and materials. As the operator removes the outer casing or cladding and discards these into the materials bins (plastic, steel, glass etc.), internal components and sub-components are exposed for removal from carcasses, motherboards and supporting frames. Once disconnected and un-fastened, the components and sub-components are discarded to dedicated bins for like items.

Each operator takes on one item of e-waste and dismantles that item to the level or degree that has been determined for the output products from the facility, before taking on another item for disassembly. With the exception of glass screens, items of e-waste such as computers and televisions pass across the disassembly workbenches only once as they move through the facility. The disassembly process involves the use of hand and powered tools, with the power supply being generally either compressed air or rechargeable batteries.

Screens from the various display units are removed and are generally managed in a separate process step. At some facilities, the screens are retained intact with plasma and liquid crystal display (LCD) screens shipped out as is. The handling of Cathode Ray Tubes (CRTs) varies between facilities and depends on the subsequent process step selected by the facility operator. The common options include:

- separating leaded glass from un-leaded glass and despatching these streams to appropriate downstream processing facilities;
- breaking the CRTs into coarse fragments and despatching the mixed glass to a CRT recycling facility;
- shattering the glass and despatching the mixed glass for use as a metallurgical flux.

The overall disassembly processes can generally be characterised as:

- low technology involving considerable manual effort;
- low capital investment for disassembly infrastructure and equipment;
- high labour demand; and
- low labour cost involving semi-skilled operators.

A significant portion of e-waste infrastructure costs arises from the need to have a site with substantial storage capacity for incoming e-waste streams and for outgoing separated components. The actual workbench areas occupy something less than ten to fifteen percent of the internal floor space, and external storage areas can be equal in size to the total internal working and warehousing area.

Symptomatic of the space demand for e-waste dismantling, and the progressive growth in demand for e-waste disassembly, several of the facility operators reported that they have been obligated to relocate premises on more than one occasion as footprint requirements exceed available space.

The e-waste recycling facilities visited as a part of this study were generally operating on a single 8 to10 hour shift 5 days per week. This would indicate that significant additional capacity could be available by double or triple shifting operations, without the need for any substantial new infrastructure, providing the existing space at facilities can accommodate the additional throughput.

Facility operators have indicated that further technology and/or further disassembly may be introduced in line with volume increases as the labour versus capital economics permit. Until that time, additional labour could reasonably be applied to significantly increase the recycling capacity at the majority of the disassembly sites. A number of the e-waste recyclers indicated that they would consider installing additional processing capacity as the volumes for recycling increased and pricing mechanisms allowed.

There currently appears to be an over-capacity for disassembly of CRTs from televisions and computer monitors in Australia. And there is certainly copious capacity for subsequent downstream processing of the glass in Australia. While this capacity will enable step increases in volumes to be processed within Australia in the short- to medium-term, the rapid demise of CRTs as the foundation of display technology will see this capacity of little value in the years ahead.

Downstream Material or Commodity Processing Infrastructure

There is significant *general* capacity in Australia for downstream processing steel, plastic and glass that is generated from the e-waste recycling sector. This processing infrastructure existed prior to the introduction of e-waste recycling and does not depend on materials from e-waste recycling to remain commercially viable. Indeed, the amount of materials arising from the e-waste recycling sector is very modest when compared with the steel, plastic and glass recycling material flows from other sources.

Downstream processing infrastructure established in Australia *exclusively* for e-waste is limited to preparation of glass for further and more fundamental downstream processing[6]. Specialist facilities for downstream processing of e-waste materials, such as metals recovery from circuit boards, have not been established in Australia. Recycling facility operators argue that the lack of this specialised downstream processing capacity might be due to factors such as:

- the limited volumes being presented for recycling;
- the high capital cost of processing equipment;
- ready availability of export opportunities are for aggregated like-components following disassembly; and
- limited local requirements for recovered resources.

Indeed, forecasts presented elsewhere in this report indicate that by 2020/21 the total tonnage of e-waste material that is presented for recycling might just reach 200,000 tonnes/year. With the bulk of this weight comprised of steel, plastic, and glass, it is inconceivable that dedicated downstream processing

[6] For the purpose of this study, *downstream processing* is defined as changing the form of a component or material through mechanical or chemical means following excluding disassembly.

capacity would be established in Australia exclusively to process these materials streamed from e-waste recycling. E-waste is, of course only a small contribution to the feedstock sourced by Australian materials processing facilities.

And the same appears to be the case for downstream processing facilities outside of Australia – i.e. those processing facilities cannot be financially supported on the basis of feedstock from the e-waste recycling sector alone. They generally source feedstock from other, larger supply markets.

Given the relatively low volumes, it is also unlikely that specialised downstream processing facilities for e-waste precious metals recovery would be established in Australia. Although e-waste contains a number of potentially valuable (and hazardous) metals, these materials are widely dispersed across the e-waste discards.

And recyclers report a clear trend to reduced precious metals content in electronic products as product manufacturers continuously work to reduce unit costs. Recyclers interviewed suggested that this trend would ultimately result in the cost of material recovery exceeding the inherent value realisable in Australia. This underlines the relevance of a product stewardship program.

In the 1990's a metals refiner was operating in the Sydney region to recover precious metals from circuit boards, but has since ceased trading. However, it is important to note the following facts pertaining to that operation:

- the facility was receiving circuit boards from the Department of Defence which demanded total destruction in Australia for reasons of security;
- the circuit boards of that day contained relatively large amounts of precious metals – especially gold, compared with circuit boards of today;
- the refiner only captured the gold content in Australia;
- the refiner exported complex metal matte from the facility to specialised refineries in Europe that were already established to process complex metal mixtures.

Logistics

There appears to be significant volumes of e-waste moving between states; this may be for components to go to suitable recycling or processing sites (e.g. CRTs to SA from WA, and VIC), for aggregation prior to export of components or contracts for e-waste services across a number of states. The preferred transportation method is for discarded e-waste to be containerised into shipping containers and transported on road or rail to the chosen recycling facility.

With low expectations for reuse and component recovery for reuse from e-waste from the small business and residential sector, there is little point in shipping containers being loaded with high levels of care for product integrity or sorting to brand or item type. Using low-cost container filling and container placement on conventional, existing transport systems facilitates lower cost recycling opportunities from jurisdictions without recycling facilities including remote and regional centres.

Logistics issues are discussed further at Chapter 3.

Current E-Waste Recycling Demand and Capacity

The relationship between the current volume of reuse and recycling demand, and the available e-waste recycling capacity at present-day facilities represents an important baseline point in considering future infrastructure requirements. The present position (at 2009/10) is summarised at Table 2-5, which provides an estimate of current e-waste recycling demand, the currently available capacity, and the capacity easily available in the short-term (less than a year) with relatively little additional capital investment.

Recycling capacity is chiefly determined by the availability of workbench space, the labour applied to the disassembly and the floor space of facilities for storage.

Table 2-5 Estimated E-Waste Demand and Capacity (May 2010)

Product	Current Demand		Current Capacity		Potentially Available Capacity[7]	
	(Units)	(Tonnes)	(Units)	(Tonnes)	(Units)	(Tonnes)
Televisions	347,000	8,700	1,365,000	34,100	1,635,000	40,900
Computers (assembled)[8]	570,000	10,900	1,084,000	26,500	1,483,000	34,300
All computers and peripherals[9]	2,892,000	12,500	5,549,000	29,600	7,556,000	38,600
Mobile phones	902,000	180	1,240,250	248	2,029,500	406
Other[10] electrical and electronic	102,000	3,820	138,750	5,252	227,500	9,000

[7] Based on assessed potential for existing operators to easily increase capacity by implementing double shift operations and/or increasing throughput by increasing the number of dismantling benches and personnel.

[8] Minor variation in units/tonne between capacity and demand are due to the specific availability of varying types of capacity.

[9] This product category includes "Computers (assembled)".

[10] Other electrical and electronic items for a number of processors include large-scale computer mainframes, servers, routers etc, which are not part of the product stewardship arrangements for televisions and computers. Only very small quantities of household other electrical and electronic items are being recycled.

Totals	**4,243,000**	**25,200**	**8,293,000**	**69,200**	**11,448,000**	**88,500**

As noted above, it is clear that the capacity of most disassembly operations could be doubled in throughput almost immediately by double or triple shifting current operations, or adding further work stations where floor space permits. This observation has been confirmed with operators.

This summary table also indicates that:

- the current capacity comfortably exceeds current demand;
- the overall capacity is roughly double current recycling demand, in terms of numbers of items processed, and
- the overall capacity is almost three times current recycling demand in terms of tonnes processed.

A number of other important observations relating to current capacity and demand were made during the investigation of e-waste recycling facilities. These are discussed below

Summary of E-Waste Recycling and Capacity Issues

There is ample capacity in the e-waste recycling sector to process the current demand level. In broad terms, capacity could be enlarged in response to increased demand without significant capital investment – by adding labour and product dismantling equipment. Indeed, demand for both television and computer recycling has increased considerably over the last few years and this demand has been accommodated. Would this potentially available capacity be sufficient to accommodate the expanded demand associated with a product stewardship scheme? This issue is tackled at Chapters 4, 5 and 6.

Moderate over-capacity exists in parts of the e-waste recycling sector, and this may lead to some participants leaving the market if volumes do not increase markedly in the next 6-18 months.

The clear message from the facility inspections and consultations is that demonstrable progress will be required in implementing the legislative framework in order to stimulate further investment in recycling and/or reprocessing capacity. The recyclers are keen to see increased volumes of e-waste flowing to the industry from either stockpiles (hoarding) or product currently being sent to landfill.

The recyclers generally acknowledge their ability to readily step-up and virtually double their capability to process further volumes of e-waste. The indicative lead time to increase capacity by a further factor of two is estimated to be 6 to12 months based on the likely time to recruit additional technicians. This has implications for the speed at which the roll-out of collection facilities can be implemented and should be also be considered in establishing policies such as landfill bans that may result in a rapid increase in presentation of e-waste within a short period.

3. SURVEY OF CURRENT E-WASTE LOGISTICS ARRANGEMENTS

Key Points

- There are specific discard pathways available to the commercial sector, and quite separate pathways for consumers from the small business and residential sector. Discards from the commercial sector presently have higher probability of a beneficial outcome.
- Logistics planning is underway for televisions and computers at the relevant industry association level for e-waste sourced from the residential sector, but has not progressed sufficiently to enable review of capacity.
- E-waste recycling firms indicate that used computers from the corporate sector present an attractive opportunity for reuse, and product from the small business and residential sector is rarely presented in a state which makes reuse economically viable.
- For the majority of e-waste, the process of recycling is a sequence of successive stages of component disassembly operations to incrementally derive value from the former product.
- The cost of labour in Australia to implement successive disassembly steps sets a limit to the level of recycling before which export becomes necessary for further disassembly and final resource recovery.

Post-consumer Discard Pathways

Aside from direct disposal to landfill, multiple pathways already exist for consumers to discard redundant and surplus e-waste for the purpose of resource recovery. There are specific pathways available to consumers from the commercial sector, and quite separate pathways for consumers from the small business and residential sector, with some very minor overlaps.

An important issue when examining e-waste recycling, is identification of the party in the logistics chain that makes the determination on end of life fate of the product, as the post-consumer fate will have a significant influence over the cost of re-aggregation and post-consumer management care. The decision-maker will be different for many of the discard pathways, and the decision-maker will determine whether discarded product is reused, recycled, scrapped or dumped, and thus how it is managed.

Commercial Sector Pathways

The discard of unwanted e-waste (mostly computers and peripherals) by most medium to large corporate entities typically forms part of a renewal, upgrade or refurbishment exercise where new devices replace old devices. The service provider contracted for the refurbishment coordinates the full exchange program, and commonly manages the discard pathway of old product. This approach is most common where the computer and electrical devices are leased from an original equipment manufacturer (OEM) or other entity and not owned by the corporate customer.

There is anecdotal information that suggests the availability of computer hardware to be placed on Asia-Pacific reuse markets is higher from Australia than other Asian countries on account of a preference in this country for corporate leasing of computer hardware and a high frequency of equipment roll-over. This supports an observation at many recycling facilities where reuse of corporate e-waste represents an important and valuable part of the business model in place.

The logistics pathway associated with the discard process usually follows the reverse pathway of the new supply, and the service provider is often closely associated with managing and implementing the discard process, including managing security concerns, and the reuse or recycling.

For the commercial consumer, the whole process is seamless, and involves little or no conscious decision-making on the fate of the old devices. The decision on end of life fate for the used devices will typically rest with the OEM or owner of the replaced devices where brand and/or data security are an issue. Alternatively it may lie with the contracted service provider where reuse does not present a problem for former owners or direct recycling is planned.

Where reuse is contemplated, the cost of logistics and post-discard management is higher than where the products are destined directly for recycling due to data recording and product tracking obligations where reuse requires closed-loop reporting back to the OEM or original owner. A further cost pressure is the greater care required in packing potentially reusable products into containers for the journey from corporation to recycler. However, this higher cost is off-set to some degree by a higher return on the sale of reuse product than recycled product.

In smaller corporate businesses, the most commonly used discard pathways are similar to those available for consumers in the residential sector. Here, the corporate entity usually owns the devices outright and therefore makes the decision on discard pathway, but not necessarily end of life fate. In addition, the quantities of product presenting for discard are small compared with the larger businesses, leaving the small business operator little option but to discard along similar pathways to residential consumers.

Small Business and Residential Sector Pathways

For small business and residential sector consumers there are several options available for discard pathways. The majority of these pathways involve re-aggregation of product to assemble commercially viable quantities for transportation, followed by relocation to facilities where the discard fate is determined.

Examples of available starting points for discard pathways for residential and small business consumers include:

- fee for service collections and discards through numerous small, medium and large service providers that collect direct from the owners' premises;
- post-back services to OEMs;
- event-based drop-off locations that are usually organised by Local Government with or without the support of OEMs, state governments and other industry participants; and
- permanent drop-off locations that might be provided by –
  - ✓ retailers,
  - ✓ OEMs,
  - ✓ e-waste recyclers,
  - ✓ charity, voluntary and community businesses,
  - ✓ Councils, and
  - ✓ the operators of permanent waste and recycling facilities such as recycling centres, collection depots, transfer stations and landfills.

The re-aggregation methods adopted by Mobile Muster for mobile phones embraces most of these starting points for discard pathways.

Once product is discarded through one of these pathways, the consumer relinquishes all say in the end of life fate of the items to the parties along the discard pathway. Ownership usually passes to the used product collector.

At the re-aggregation points, product is accumulated until a critical mass is assembled sufficient for uplift and relocation. The degree of sorting, handling care, weather protection and management at the re-aggregation points is firstly related to safety at the site (for both patrons and the persons handling the relinquished products) and then the intended/expected fate of the product. For a large percentage of e-waste arising from the small business and residential sector, reuse is not an option considered by the industry – the products are invariably older and in poorer condition than products sourced from corporate offices. Therefore on-site management of discarded product is kept at the minimum to ensure safety of both patrons and staff, but not focused on product integrity or sorting.

However, in some event-based locations, brand and product identification is a requirement. It was observed that re-aggregation at the drop-off site required care to retain products intact, followed by logging and recording of units on receipt at the recycling facility. If this approach of brand and product identification is carried forward into future programs under EPR schemes, then it can reasonably be expected that there will be material additional costs incurred at both the drop-off sites and the recycling facilities, which adds cost but no value to the materials that are to be recycled.

Anecdotal information from e-waste recycling firms indicates that e-waste from the large corporate sector presents a more attractive opportunity for reuse, and product from the small business and residential sector is rarely presented in either quantity or quality/currency to make attempts at reuse economically viable. For the residential consumer and small business sector, this reduced level of reuse can result in significantly lower re-aggregation, uplift and transportation costs if brand and product identification are not an issue.

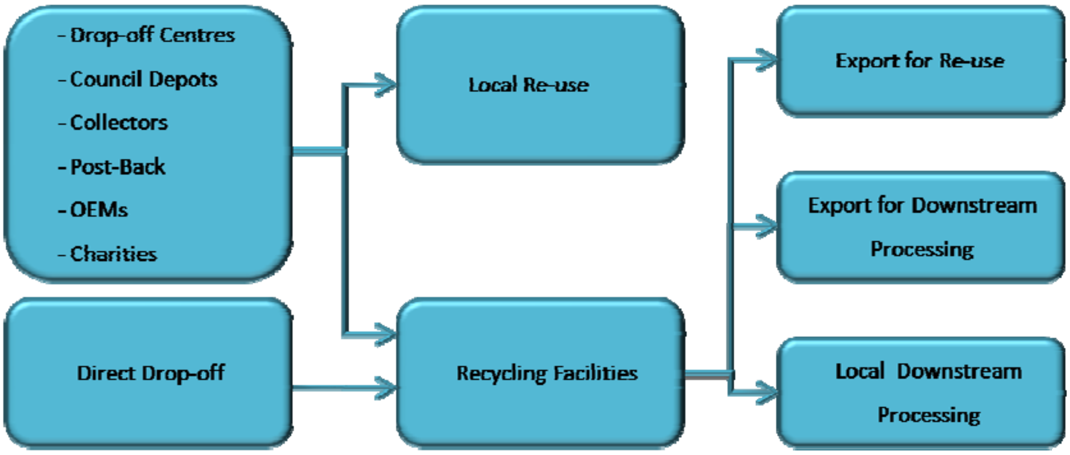
Notwithstanding the predominance of recycling as the end of life fate for e-waste from the small business and residential sectors, most drop-off centres and recyclers place a reasonable level of importance on the maintenance of product integrity at drop-off, in transit, and on receipt at the recycling facility, even where brand and product tracking and identification is not required. This may inadvertently be increasing system costs for both the drop-off centre and the recycler.

Once re-aggregated product is uplifted, it is transported to the recycling facility with whom the drop-off site has contracted. The uplift, transport and recycling costs are usually invoiced at a package price and often include the cost of container hire for those containers that are left at the drop-off site to receive relinquished product.

An exception to this common approach has been observed at one permanent drop-off point. All product is regarded from the outset as unsuitable for reuse, but suitable for disassemble for recycling. No special measures are taken at the drop-off site to retain product integrity. E-waste is simply loaded into containers using front end loaders and some measure of compaction is used to achieve relatively high container load weights. On receival at the recycler's facility, the e-waste is unloaded in a similar fashion and break-down of the items continues into the recycling process. This procedure is likely to be common for future e-waste collected in a product stewardship program.

At Figure 3-1 the various discard pathways are illustrated.

Figure 3-1 Logistics Pathways



Transition to Product Stewardship

At the present time, the e-waste recycling industry is heavily focused toward the commercial sector, where supply is significant and regular, and the high value-add opportunities of reuse are greatest. For this sector, unit counts and brand recognition are essential parts of the accounting, security and tracking obligations. The costs associated with that inventory management work are built into the logistics framework and are recoverable.

The consumer and small business sector is evolving as a supplier to the e-waste recycling industry, and formal logistics frameworks are still being developed by the recyclers and their transport partners. There is little doubt that the recycling industry is waiting for the introduction of co-ordinated and funded schemes for re-aggregation of e-waste. However, with recycling the predominant end of life fate for this e-waste, the recycling industry is cautious about inventory management systems that might require brand and unit accounting as this will impact on drop-off centre management and therefore the cost at those centres.

For the recycling industry, e-waste product rapidly becomes a set of commodities to be managed – and a commodity accounted for in terms of tonnage handled. The complexities of unit counts and brand recognition, and the rapidly changing dynamics of product weights and design configurations means that for the industry, the earlier in the discard pathway that e-waste becomes a commodities management issue, the lower the cost to the system.

Logistics planning is underway by PSA and AIIA for televisions and computers sourced from the residential sector and initial ideas appear to favour the establishment of designated drop-off/collection points, possibly supplemented by collection events similar to those presently promoted. The industry associations are presently considering how best to optimise the logistics chain in which community convenience, aggregation and temporary storage costs, and pick-up and transport costs all must be weighed to determine the most appropriate logistics configuration.

Post-Recycler Pathways to Markets

There are two fundamental post-recycler pathways to market – reuse and downstream processing. In both pathways product may be sold into domestic markets or exported to markets off-shore.

The reuse market is fundamentally a computer-related opportunity. Reuse for other e-waste does not appear to be a common option currently considered by the recyclers. For reuse in the export market, whole packages of computers – box, screen, keyboard and mouse – are set up for export. These products are exported under normal export trade regulations on the basis that they are products in good working order, have been fully tested, and are not wastes. This approach is consistent with the requirements of Australia's *Hazardous Waste (regulation of Exports and Imports) Act 1989* and, as a result, ensures that these products do not trigger the controls of the Hazardous Waste Act which implements Australia's obligations under the Basel Convention on the

Control of Transboundary Movement of Wastes and their Disposal (Basel Convention).

This pathway of export for reuse is highly vulnerable to unscrupulous operators who seek to circumvent the regulatory controls in place through the Hazardous Waste Act and the Basel Convention. Every recycling company interviewed for this study reported approaches from foreign buyers of e-waste who did not appear to have reliable credentials or intentions in respect of export of e-waste under the Basel Convention. As the number of recyclers increases, and the quantity of product in the market grows, great care will need to be taken to ensure that export of scrap is undertaken in a way that meets Australia's obligations under the Basel Convention.

For the majority of the e-waste recycling sector, the process of recycling can best be described as a sequence of successive disassembly and separations of components and materials to incrementally increase the value of the whole. By adding labour through disassembly, the recyclers are progressively increasing the value that can be recovered from the original products, which in initial discard form represent an expensive and complex mix of materials with relatively low value.

As a general rule, the earlier in the recycling chain (i.e. the nearer to the discard point) that products are shredded and the materials intimately mixed, the lower the value of the composite mix, due to the increasing cost of separation of materials from the complex mix.

The extent to which e-waste recycling occurs in Australia will be determined by the limit to which further investment in disassembly is no longer matched by a corresponding increase in value for the resultant materials and components. The recyclers interviewed advised that the cost of labour in Australia to implement successive disassembly and disaggregation steps sets a limit to the degree of disassembly achieved and the point at which export becomes necessary for further disassembly and final resource recovery.

Items and materials physically processed into new products in Australia typically include ferrous metals, plastics, timber, glass and plastic/copper cables. PCBs and items with PCBs embodied within the item are generally exported for further disassembly and eventual downstream processing. This latter category includes power supplies, hard drives and DVDs.

It is critical to the industry in Australia to understand the inter-relationship between degree of disassembly in Australia and the trigger point for export controls under the Basel Convention for export of hazardous wastes – i.e. which items or products constitute a hazardous waste under the Basel Convention and at what stage of disassembly does the hazardous waste label apply.

4. PRODUCT FLOWS – SALES, DISCARDS, AND RECYCLING

This Chapter presents snapshot estimates of recent sales, end of life, and recycling volume for televisions, computers and other electrical and electronic products. The base year for data reference is 2007/08. This coincides with the base year used in preparing the RIS.

Key Points

- Discard rates for televisions and computers have consistently been around half of sales volumes. The current low level of discard action is expected by industry associations to progressively lift following introduction of a product stewardship scheme, so that annual end of life discard volume soon matches sales volume.

- The amount of e-waste (particularly televisions) collected and recycled each year has markedly increased since 2007/08.

- The amount of e-waste collected and recycled each year following commencement of product stewardship programs is likely to dramatically increase as the liable parties[11] progress toward published targets.

Liable parties will be those parties that have legal responsibilities or duties arising from statutory obligations (in this context, collection, re-use and recycling) as defined under the proposed national product stewardship legislation).

Current Sales Volumes

Sales volume of televisions, computers, and other electrical and electronic products has increased substantially over the last 15 years. In 2007/08, television sales reached 3.1 million units, computer sales were 4.5 million units[12], and sales of computers and peripherals collectively was nearly 29 million units. Sales of other e-waste products (dominated by mobile phones) were around 18 million units[13]. The positive sales trend coincides with a long period of favourable economic conditions, and was boosted by frequent model improvements and some step changes in technology, appearance and functionality. These product improvements were accompanied by a general trend of reducing product pricing.

Sales data were drawn from various sources to compile estimates for the various product groups. For televisions and computers, the main source was information used in preparation of the *Decision Regulatory Impact Statement:*

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[11] Liable parties will be those parties that have legal responsibilities or duties arising from statutory obligations (in this context, collection, re-use and recycling) as defined under the proposed national product stewardship legislation).

[12] Laptops and assembled desktop computers only. Sales of all computers and peripherals were 28.6 million units.

[13] Other e-waste includes mobile phones, small household appliances, home/office communications devices, electric hand tools, and consumer equipment.

Televisions and Computers[14] (RIS). This is considered a reliable source of sales data. Information on mobile phones was readily available from AMTA and Mobile Muster, and these also are considered to be reliable sources of sales information.

Sales volume for other electrical and electronic products was estimated on the basis of Australian Customs data on merchandise imports[15]. As the Customs data sets are presented as dollar values it was necessary to estimate product value and convert aggregate values to product units. This analysis was tested by reference to a United Nations University study[16] which considered UK purchase decisions for electrical and electronic products. This study noted the difficulty of obtaining reliable data on electrical and electronic products.

Sales volume at the base year (2007/08) are summarised at Table 4-1. This table also sets out an order of confidence rating for data reliability associated with each product group.

Table 4-1 Estimated 2007/08 Sales Volumes

Product	**Sales Volume** (million units)	**Sales Volume** (tonnes)	**Estimate Confidence**
Televisions	3.1	68,200	High
Computers (laptops and assembled computers)	4.5	35,000	High
All computers and peripherals	28.6	69,600	High
Mobile phones (2008/09)	9.0	1,806	High
Small household appliances	3.7	18,500	Moderate
Consumer equipment	3.2	16,000	Moderate
Home/office communications devices	2.4	24,000	Moderate
Electric hand tools	1.0	8,000	Moderate

Source: Estimated by WCS/Rawtec drawing for televisions and computers on RIS data, Mobile Muster for mobile phone data, and ABS Catalogue 5368.0 for other electrical and electronic products.

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[14] Environment Protection and Heritage Council. *Decision Regulatory Impact Statement: Televisions and Computers,* (PriceWaterhouse Coopers and Hyder Consulting). October 2009.
[15] ABS Catalogue 5368.0, *International Trade in Goods and Services*, Table 34 Merchandise Imports.
[16] United Nations University, *2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE)* August 2007.

Current End of Life Discard Volumes

Product life-span has declined over time, partly in response to increased product appeal, and this too has contributed to the strong sales growth recorded over recent years. Annual product discard rates have for some years failed to match new product sales rates as both domestic and commercial consumers have built stocks of operational products by purchasing new equipment and retaining or redeploying working but superseded products.

Television discard rates in particular have been low. According to the RIS, only 1.2 million television units were discarded as end of life product in 2007/08 despite sales of 3.1 million units. This 39% discard rate indicates that many television units had not reached end of life and were retained for further use or passed to a second owner for second life.

The television industry association, PSA, has argued in a submission to this study[17], that the 2007/08 end of life volume used in the RIS is significantly lower than the industry's estimate. The PSA has estimated 2007/08 end of life volume as 2.0 million television units; a 63% discard rate. The facts are cannot be verified because no audit of television discards is available. However, despite this starting point difference, both data sets share similar end of life volume forecasts at the planned product stewardship scheme start date of 2011/12.

The discard rate for assembled computers was also low at 2.1 million units against sales of 4.5 million units – a 47% discard rate. The proportion of end of life computers and peripherals discarded was slightly higher at 55% of sales or around 15.7 million units in contrast with sales volume 28.6 million units.

The discard rate for post-use mobile phones is reported by Mobile Muster to be a very low 18% of sales[18]. Mobile Muster puts this down to a combination of factors including the past lack of collection facilities, consumer reluctance to discard equipment that has continuing operating capability, and a widespread practice of passing replaced mobile phones to friends and family for further use.

End of life volumes for 2007/08 covering the various other electrical and electronic products (excluding mobile phones) were set at a uniform 60% of estimated sales. This rough estimate, based on discussion with industry sources, is considered to be adequate for the purpose of estimating future end of life flows and infrastructure capacity needs.

Estimated end of life volume data are summarised at Table 4-2.

[17] Product Stewardship Australia. Personal communication. Doug Walter, Director. 25 May 2010
[18] Mobile Muster. Personal communication. Rose Read. 28 May 2010.

Table 4-2 Estimated 2007/08 End of Life Discard Volume

Product	End of Life Volume (million units)	End of Life Volume (tonnes)
Televisions	1.2	27,700
Computers (laptops and assembled computers)	2.1	49,000
All computers and peripherals	15.7	78,300
Mobile phones (2008/09)	1.6	319
Small household appliances	2.2	11,000
Consumer equipment	1.9	9,500
Home/office communications devices	1.4	14,000
Electric hand tools	0.6	4,800

Source: Estimated by WCS/Rawtec drawing for televisions and computers on RIS data, Mobile Muster for mobile phone data, and ABS Catalogue 5368.0 for other electrical and electronic products.

Current Recycling and Reuse Volumes

Collection and recycling or reuse of e-waste was uniformly low in comparison with the more high profile recycling activity associated with domestic kerbside recycling of containers and paper/cardboard. As shown at Table 4-3, the brightest spots were computer recycling and mobile phone recycling. Both activities are practiced on a voluntary basis without the assistance of government support.

The main recycling and reuse contractors also accept for recycling *other electric and electronic products,* including mobile phones, and occasional small quantities of electric tools and consumer products such as cameras and kitchen appliances.

Table 4-3 Estimated 2007/08 Recycling Rates and Volumes

Product	End of Life Volume (million units)	Combined Recycling and Reuse Rate (proportion of EOL volume)	Combined Recycling and Reuse Volume (million units)
Televisions	1.2	1%	0.012
Computers (laptops and assembled computers)	2.1	13%	0.273
All computers and peripherals	15.7	13%	1.959
Mobile phones (2008/09)	1.6	38%	0.806
Small household appliances	2.2	0%	0
Consumer equipment	1.9	0%	0
Home/office communications devices	1.4	0%	0
Electric hand tools	0.6	0%	0

Source: Estimated by WCS/Rawtec drawing for televisions and computers on RIS data, and Mobile Muster for mobile phone data.

Forecast Sales Volume

Sales forecasts for televisions and computers were made with the RIS being the primary reference point. The forecasts were compiled in consultation with the industry associations and both PSA and AIIA confirm they are comfortable with the forecasts. The AMTA/Mobile Muster forecast for mobile phone sales was readily available and is also considered to be reliable within the order of accuracy required for this study.

No sales forecasts are available for other electrical and electronic products. Future sales growth has been forecast on the basis of the import trend for the period 2000/01 to 2007/08.

Sales forecasts at the projected start year for the product stewardship framework legislation and e-waste product stewardship scheme (2011/12) are summarised at Table 4-4. This table also sets out the forecast annual sales volume growth rate.

Table 4.4 Forecast Sales Volumes – start year and annual growth rate

Product	Forecast Sales Volume 2011/12 (million units)	Forecast Sales Volume 2011/12 (tonnes)	Forecast Annual Growth Rate
Televisions	3.5	87,000	3%[19]
Computers (laptops and assembled computers)	4.6	30,000	1%
All computers and peripherals	28.9	60,000	1%
Mobile phones	10.1	2,025	4%
Small household appliances	3.9	19,250	1%
Consumer equipment	3.5	17,320	2%
Home/office communications devices	2.5	24,970	1%
Electric hand tools	1.1	8,660	2%

Source: Estimated by WCS/Rawtec drawing for televisions and computers on RIS data, Mobile Muster for mobile phone data, and ABS Catalogue 5368.0 for other electrical and electronic products.

Forecast End of Life Discard Volumes

Discard rates for televisions and computers have consistently been around half of sales volumes, as demonstrated at Table 4-2. The current low level of discard action is expected by industry associations to progressively lift so that annual end of life discard volume soon matches sales volume. They believe that a product stewardship scheme would propel more active discarding behaviour following purchase of new products, and result in increased discarding of unused surplus products. Input by Hyder Consulting[20] to the RIS was based on discard growth rates for televisions and computers that comprehended numerous variables including sales volume, technology shifts, product lifespan and scope for local reuse after initial use period.

Forecast end of life volumes at the product stewardship start year (2011/12) are summarised at Table 4-5. This table also sets out the forecast annual end of life volume growth rate. The derivation of the forecasts is described below.

[19] The RIS forecast assumed 3% sales growth in 2008/09 declining to 1% by 2030/31.
[20] Hyder Consulting. *Consultation RIS – Televisions and Computers. Report Prepared for PricewaterhouseCoopers*. Report 1. 29 April 2009.

Table 4-5 Forecast End of Life (EOL) Volumes – start year and annual growth rate

Product	Forecast EOL Volume 2011/12 (million units)	Forecast EOL Volume 2011/12 (tonnes)	Forecast Annual EOL Growth Rate
Televisions	2.5	75,000	8%
Computers (laptops and assembled computers)	4.0	26,000	5%
Computers and peripherals	26.7	76,000	5%
Mobile phones	2.0	404	6%
Small household appliances	2.3	11,500	1%
Consumer equipment	2.1	10,500	2%
Home/office communications devices	1.5	15,000	1%
Electric hand tools	0.7	5,600	2%

Source: Estimated by WCS/Rawtec drawing for televisions and computers on RIS data, Mobile Muster for mobile phone data, and ABS Catalogue 5368.0 for other electrical and electronic products.

Hyder Consulting forecast a growth rate for television end of life volume of approximately 8% annually. The PSA was broadly comfortable with the end of life growth rate used in the RIS (which it understood to be 5%) but added a further two percentage points each year of the three year digital changeover period. Thus the two forecasts are in reasonable alignment within the order of accuracy of this study. The Hyder Consulting forecast results in end of life volume matching forecast sales volume by 2018/19.

Hyder Consulting forecast a growth rate for computer and peripherals end of life volume of approximately 5% annually. The AIIA was broadly comfortable with the end of life growth rate used in the RIS. This forecast results in end of life volume matching forecast sales volume by 2012/13. This rapid catch-up is the result of anticipated widespread moves to clean out stored and aging technology in favour of low cost laptop computers.

The end of life discard rate for mobile phones has been low, but active promotion by Mobile Muster and other mobile phone collection groups is apparently resulting in increased discards of surplus mobile phones currently in storage. Accordingly it is expected that the growth in discard rate will slightly exceed the growth in sales volume.

Growth in end of life discard rates for other electrical and electronic products is much more difficult to forecast. Discard action is expected to be closely aligned with purchase action because there is little motivation for used product hording. On the other hand, introduction of a product stewardship scheme may possibly result in a surge in discarding of unused surplus products that do exist. Given the uncertainty, and the trivial impact of alternative assumptions, the forecast growth in end of life discard rates adopted for this study are in line with forecast sales volume growth rates.

Forecast Recycling Volume

The amount of e-waste collected and recycled each year following commencement of product stewardship programs is likely to dramatically increase as the liable parties progress toward published targets.

Table 4-6 presents a comparison of estimated recycling rates for 2009/10. The Hyder estimate formed part of the data input to the RIS; the WCS/Rawtec estimate was made on the basis of inspection of Australian recycling facilities and production data obtained for these facilities.

Table 4-6 Recycling Volumes – Comparison of Hyder Consulting Estimates and Study Estimates – Current Year (2009/10)

Product	**Hyder Estimated Recycling and Reuse Volume 2009/10** (million units)	**Hyder Estimated Recycling and Reuse Volume 2009/10** (tonnes)	**WCS/Rawtec Estimated Recycling and Reuse Volume 2009/10** (million units)	**WCS/Rawtec Estimated Recycling and Reuse Volume 2009/10** (tonnes)
Televisions	0.024	600	0.347	8,700
Computers (laptops and assembled computers)	0.320	2,500	0.570	10,900
Computers and peripherals	2.400	15,000	2.892	12,500

Source: Drawn data prepared for RIS and estimated by WCS/Rawtec.

Current recycling volume is a good reality check on the Hyder Consulting estimates. Table 4-7 sets out the adopted start year recycling and reuse volumes. These were used as key input to the model.

Table 4-7 Forecast Recycling/Reuse Volumes at Start Year – 2011/12

Product	Forecast Recycling/Reuse Volume 2011/12 (million units)	Forecast Recycling/Reuse Volume 2011/12 (tonnes)
Televisions	0.500	12,000
Computers (laptops and assembled computers)	0.600	11,000
Computers and peripherals	3.426	15,000
Mobile phones	1.425	285
Small household appliances	<0.001	<5
Consumer equipment	<0.001	<5
Home/office communications devices	<0.001	<5
Electric hand tools	<0.001	<5

Source: Estimated by WCS/Rawtec drawing for televisions and computers on RIS data, Mobile Muster for mobile phone data.

Table 4-8 sets out the recycling targets proposed by the PSA (televisions), AIIA (computers), and by Mobile Muster (mobile phones).

Table 4-8 Recycling Targets Proposed by Industry

Product	RIS Recycling Target (million units)	Industry Proposed Recycling Target (tonnes)
Televisions	70% by year 8 (preferred option)	40% by year 2; 55% by year 3; 70% by year 4; 80% by year 5 [21].
Computers (laptops and assembled computers)	70% by year 8 (preferred option)	80% by year 10
Computers and peripherals	70% by year 8 (preferred option)	80% by year 10
Mobile phones (Mobile Muster)	N/A	90% by 2012/13
Small household appliances	N/A	Nil
Consumer equipment	N/A	Nil
Home/office communications devices	N/A	Nil
Electric hand tools	N/A	Nil

Source: RIS and PSA for televisions; RIS and AIIA for computers; and Mobile Muster for mobile phone data.

[21] The PSA target of 80% by year 5 was a stretch target initiated by the PSA prior to the announcement of the proposed scheme in November 2009. The PSA target is now 80% by year 10.

5. DEMAND MODELLING SCENARIOS

Future change in the amount of e-waste product being collected for reuse or recycling after reaching end of life discard status cannot be forecast with precise certainty. In this Chapter, plausible scenarios have been developed and modelled based on realistic forecasts of sales volume, discard volume, and collection for beneficial purposes. In this forecast modelling the term "e-waste recycling" is intended to cover both the reuse of e-waste products components as well as the recycling of components, parts and materials.

Key Points

- There is a wide spectrum of possible introduction timeframes for product stewardship programs covering the three nominated e-waste product groups. And the rate of take-up by the community of opportunities to surrender e-waste for recycling and reuse is equally uncertain.

- From these two primary uncertainties, four distinctly different, but plausible, scenarios can be developed describing how recycling and reuse demand may play out as product stewardship programs are implemented.

- All scenarios feature a substantial increase in e-waste recovery and recycling – from the current position of just over 4 million tonnes/year (25,000 tonnes) to between 33 and 41 million units/year (116,000 to 169,000 tonnes/year) by 2020/21.

Modelling Approach

The scenario planning method has been adopted to consider demand for e-waste recycling and reuse over the next ten years. This approach is usually commenced by isolating an issue of concern – in this case, what is the likely e-waste recovery demand following introduction of a product stewardship program? The various factors that might influence future demand are then isolated and assessed for importance and uncertainty. The results of this assessment of demand-influencing factors provide the scenario logics; usually in the form of axes depicting fundamental differences between possible outcomes.

The process of determining the scenario logics is described below.

Product Group Possibilities

The electrical and electronic product sales analysis described at Chapter 4 provides a basis on which to establish possible foundation implementation sets for the proposed e-waste product stewardship scheme according the main product groupings of interest:

- Product Group A, televisions and (assembled desktop and laptop) computers.

- Product Group B, televisions, all computers, and peripherals.

- Product Group C, e-waste generally (including televisions, computers, peripherals, mobile phones, small household appliances, home/office communications equipment, and electric hand tools).

Drawing on the estimated sales data presented in Chapter 4, it is possible to aggregate annual sales volumes to the above product groupings. Cumulative sales volume spans a range starting at around 7.6 million units for Product Group A (televisions and computers), through 31.7 million units for Product Group B (televisions, computers, and peripherals), and reaching some 55 million units for Product Group C (all e-waste generally).

The proposed *National Television and Computer Product Stewardship Scheme,* due to commence in mid 2011, will likely cover the widely defined television and computer set: Product Group B – televisions, computers, and peripherals. Further, the computer industry association, AIIA, advises it is moving to implement a program based on Product Group B. Moreover, computer recyclers already handle thousands of peripherals, such as monitors, keyboards and mice, as a matter of course along with assembled desk top computer and laptops.

In these circumstances, Product Group A may be an unlikely, though not implausible implementation step: circumstances could arise in which the initial business plans of (say) new entrants in computer recycling may restrict recycling of peripherals to a number akin to the volume associated with the number of desktop and laptop computers they receive for recycling. It is likely that any initial focus on recycling Product Group A will be brief.

At the opposite end of the product group continuum, additional product stewardship schemes could be introduced to cover e-waste products other than televisions and computers (included in Product Group C). Unlike computers, which have mildly attractive material value, most of these products are unlikely to generate voluntary recycling by the sorts of entrepreneurial firms which have been the early adopters of computer recycling.

It is noted that several successful voluntary programs exist for mobile phone collection and recycling. However, industry bodies are unlikely to initiate voluntary programs, of the Mobile Muster style, to capture the diverse *other e-waste* arisings that make up Product Group C.

It is clear there is a wide spectrum of possible introduction timeframes for product stewardship programs covering the three nominated e-waste product groups: A, B and C. The roll-out order is logical, but the introduction timing possibilities are considered to be one of the critical uncertainties associated with implementing e-waste product stewardship.

Rate of Recycling Take-up Possibilities

A supplementary, and intersecting, set of critical implementation uncertainties is based on the *rate of take-up* of collection and recycling of products discarded by domestic and commercial consumers. The product collection take-up volume in any year is a function of three key demand-side variables: sales volume; EOL volume and, most importantly, consumer willingness to discard EOL products to organised collection and recycling pathways rather than the waste bin or the storage shelf.

The RIS contained detailed forecasts of annual sales volume and EOL volume covering televisions, computers and peripherals. These thoroughly developed forecasts were prepared by Hyder Consulting for input to the RIS and are considered to be sufficiently robust for the purpose of providing input data to the forecasting of EOL volumes as an input to recycling forecasts and consequent infrastructure requirements. As pointed out in Chapter 4, the television industry association, PSA, has argued, in a submission to this study[22], that the 2007/08 starting EOL volume used in the RIS is lower than the industry estimate. However, in the context of this study, the difference is insignificant and is extinguished by the proposed start date for the product stewardship scheme.

A significantly greater level of uncertainty is associated with the amount of e-waste actually collected and available for recycling. The amount and growth rate of future aggregate collection haul especially uncertain as current program planning is based on the idea of voluntary drop-off facilities. The target recovery rates planned by each industry association provide one basis for a likely collection and recycling take-up trajectory.

However, the planned take-up rates vary: the computer recycling target is 80% by year 10; the television recycling target has been a challenging 80% by year 5. The RIS chose a standard 70% maximum recycling for each option evaluated, based on the understanding that drop-off for recycling would be the exclusive logistics pathway. Varying take-up speeds to the attainment of the maximum recycling level were examined in the RIS – essentially in the range 5 to 9 years.

This study has adopted a *maximum* recycling rate of 80% consistent with both the Government target and industry targets. Based on the uncertainty surrounding the recycling take-up rate, alternative take-up rates of 5 years and 10 years (to attain 80% recycling) are considered plausible take-up rates for television and computer recycling. Thus, the spectrum of possible recycling take-up rates can be considered as forming a further axis representing this set of critical uncertainties associated with implementing e-waste product stewardship.

The two primary uncertainties are thus:

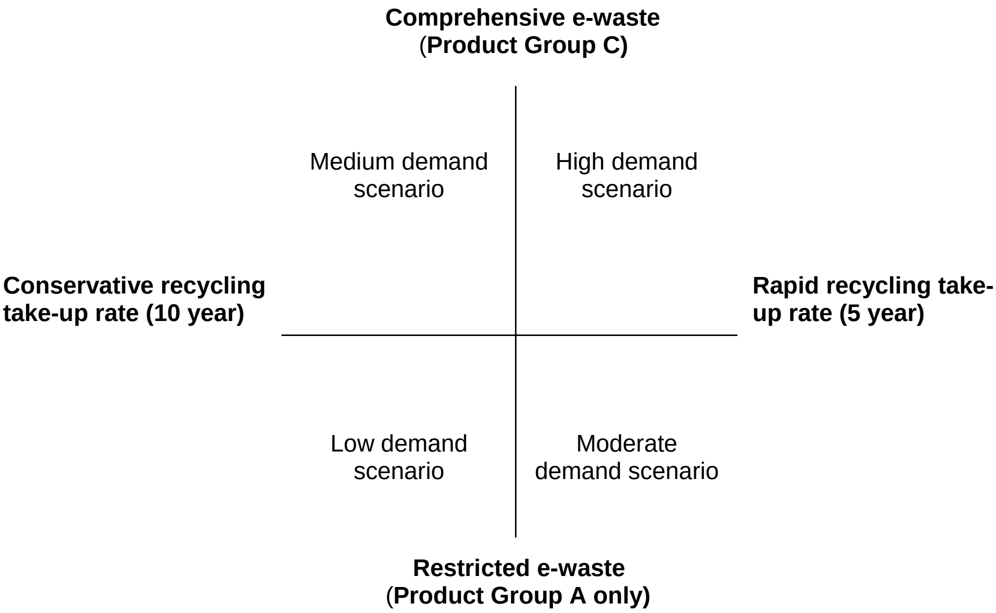
- The possible introduction timeframes for product stewardship programs covering the three nominated e-waste product groups: A, B and C.
- The rate of collection and recycling take-up.

These two major uncertainties can be combined as the two axes of critical uncertainties as shown at Figure 5-1. By combining these axes, this diagram depicts four distinctly different, but plausible, scenarios describing how

[22] PSA. *Op cit.*

recycling demand may play out as product stewardship programs are implemented.

Figure 5-1 Summary Scenario Diagram



Description of Modelled Scenarios

Each of the scenarios has a number of features that describe the story of how the critical uncertainties might play out during the implementation of the overall product stewardship scheme from 2011/12 to 2020/21.

High Demand Scenario

This scenario is based on immediate (year 1) adoption of Product Group B (skipping the narrower Product Group A) and extension to Product Group C from the start of year 5. It features rapid take-up of recycling opportunities by the community and business, so that the 80% (of EOL) collection and recycling rate for televisions and computers is attained in year 5. Rapid take-up of collection and recycling also applies to Product Group C, which is assumed to reach 90% of EOL recycling for mobile phones by year 2, with other e-waste reaching 60% recycling of EOL by year 10.

Moderate Demand Scenario

This scenario is based on a two year start-up with Product Group A and extension to Product Group B from the start of year 3. It features rapid take-up of recycling opportunities by the community and business, so that the 80% collection and recycling rate (of EOL) for televisions and computers is attained in year 5. Mobile phone collection and recycling is assumed to reach 90% of EOL by year 2. No formal extension to Product Group C is commenced by year 10.

Medium Demand Scenario

This scenario is based on immediate (year 1) adoption of Product Group B (skipping the narrower Product Group A) and extension to Product Group C from the start of year 5. It features a conservative take-up rate of recycling opportunities by the community and business, so that the 80% (of EOL) collection and recycling rate for televisions and computers is attained in year 10.

The conservative rate of take-up of collection and recycling also applies to Product Group C. Mobile phone collection and recycling is assumed to reach 70% by year 2 and 90% of EOL by year 5. Other e-waste products are assumed to reach 40% collection and recycling of EOL by year 10.

Low Demand Scenario

This scenario is based on a two year start-up with Product Group A and extension to Product Group B from the start of year 3. It features a conservative take-up rate of recycling opportunities by the community and business, so that the 80% collection and recycling rate (of EOL) for televisions and computers is attained in year 10. Mobile phone collection and recycling is assumed to reach 70% by year 2 and 90% of EOL by year 5. No formal extension to Product Group C is commenced during the project period.

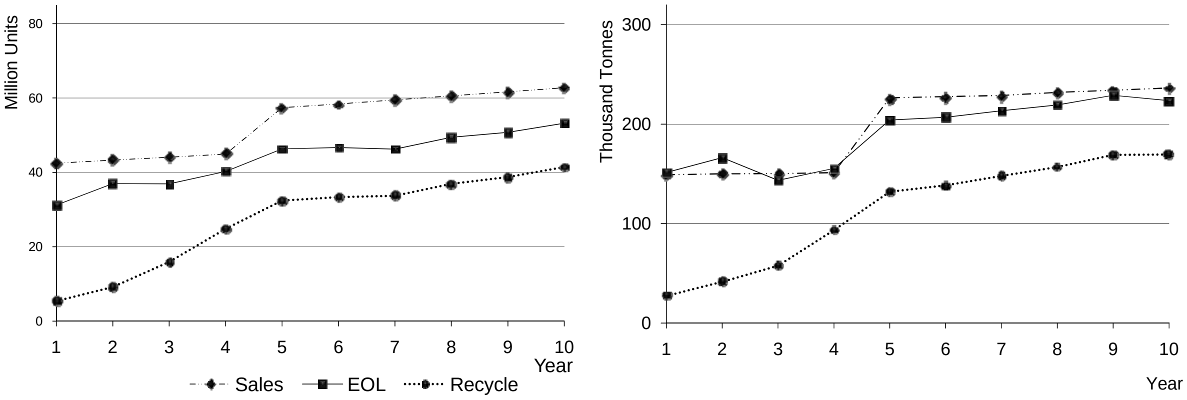
Scenario Modelling Results

Each of the four scenarios was modelled for the ten year review period (2011/12 to 2020/21) with key input data comprising forecast sales and end of life volumes covering each separate product. The overall results for each scenario are presented below at Figures 5-2 to 5-5. Detailed modelling inputs are reported at Attachment A.

High Demand Scenario

Overall reuse and recycling rises rapidly from just under 5 million units/year (16,000 tonnes) in 2011/12 to reach more than 32 million units (132,000 tonnes) at year 5 (2015/16). Growth from 2015/16 is more modest because the 80% recycling rate has been accomplished for televisions and computers by year 5. At 2020/21 total e-waste recycling demand would be 41 million items or 169 million tonnes.

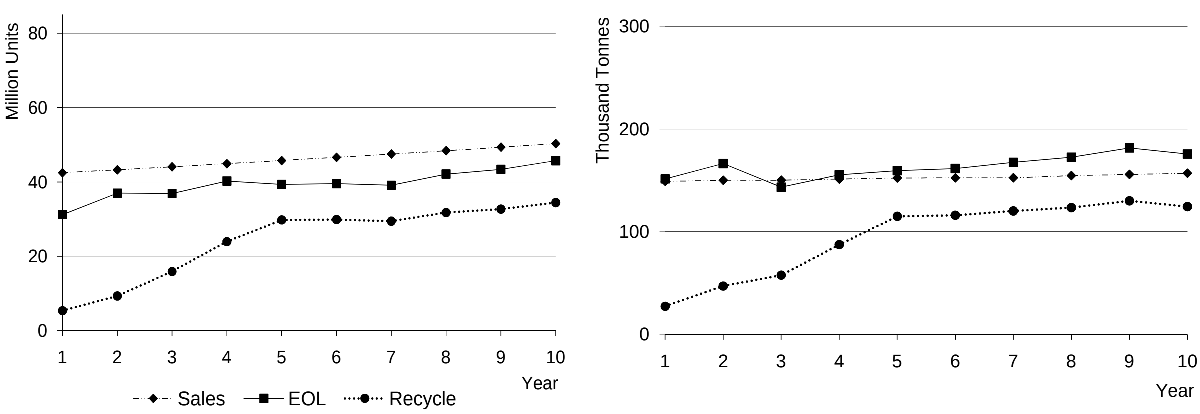
Figure 5-2 Resource recovery take-up profile – High Demand Scenario



Moderate Demand Scenario

In this scenario overall reuse and recycling again rises rapidly for the first five years, but across a narrower range of product groups than the High Demand Scenario. E-waste recovery demand reaches 30 million units (115,000 tonnes) at year 5 (2015/16) and extends to 34 million units (125,000 tonnes) by 2020/21.

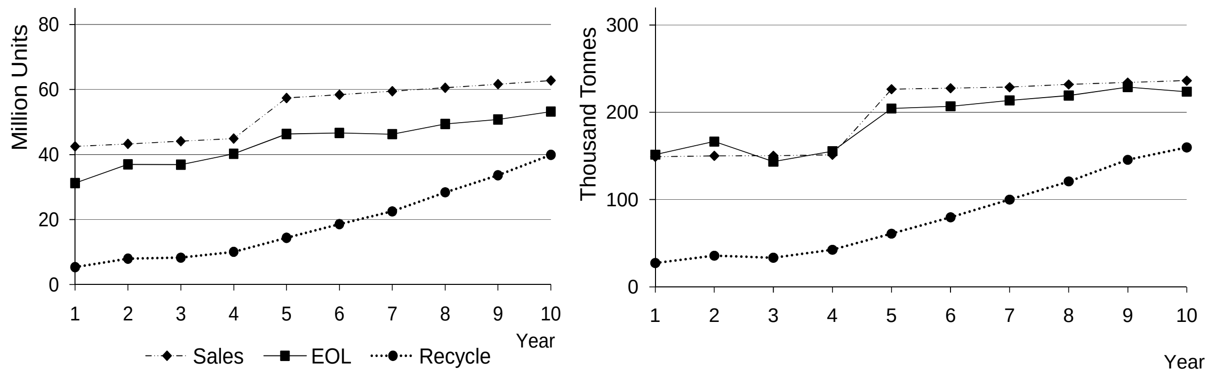
Figure 5-3 Resource recovery take-up profile – Moderate Demand Scenario



Medium Demand Scenario

Reuse and recycling take-up in this scenario is sedate for the first five years, reaching only 14 million units (53,000 tonnes) at year 5. Demand growth increases more rapidly in the second five year period to reach 40 million units (160,000 tonnes) by 2020/21.

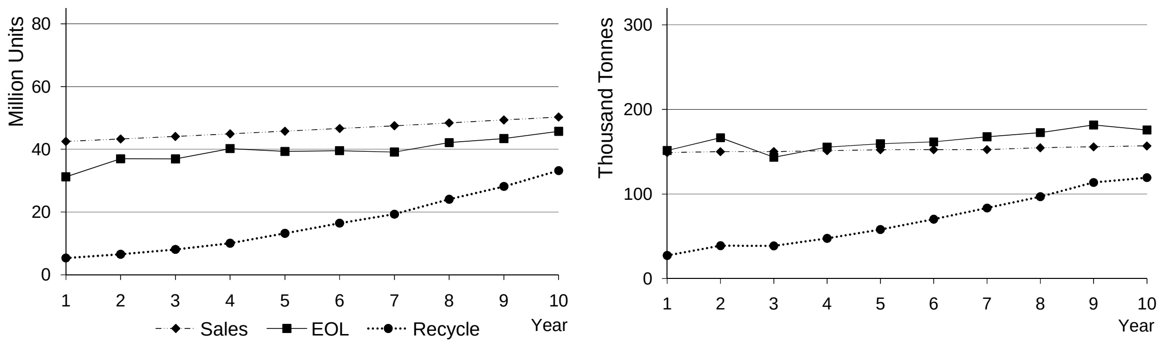
Figure 5-4 Resource recovery take-up profile – Medium Demand Scenario



Low Demand Scenario

In this scenario overall reuse and recycling again grows at a sedate pace for the first five years to reach only 13 million units (45,000 tonnes) by 2015/16. Demand growth increases only slightly more rapidly in the second five year period to reach 33 million units (116,000 tonnes) by 2020/21.

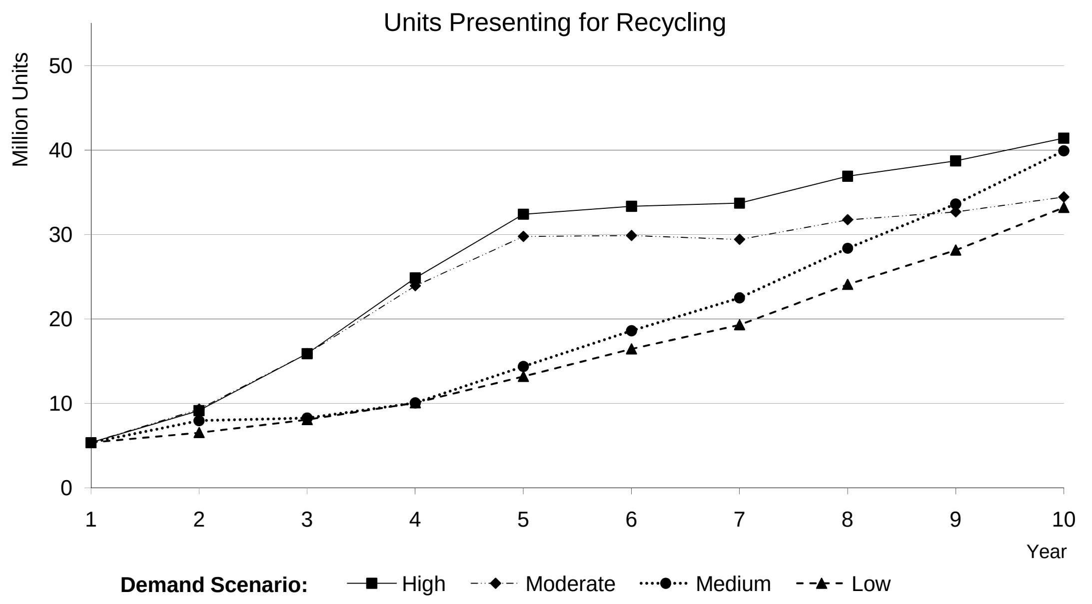
Figure 5-5 Resource recovery take-up profile – Low Demand Scenario

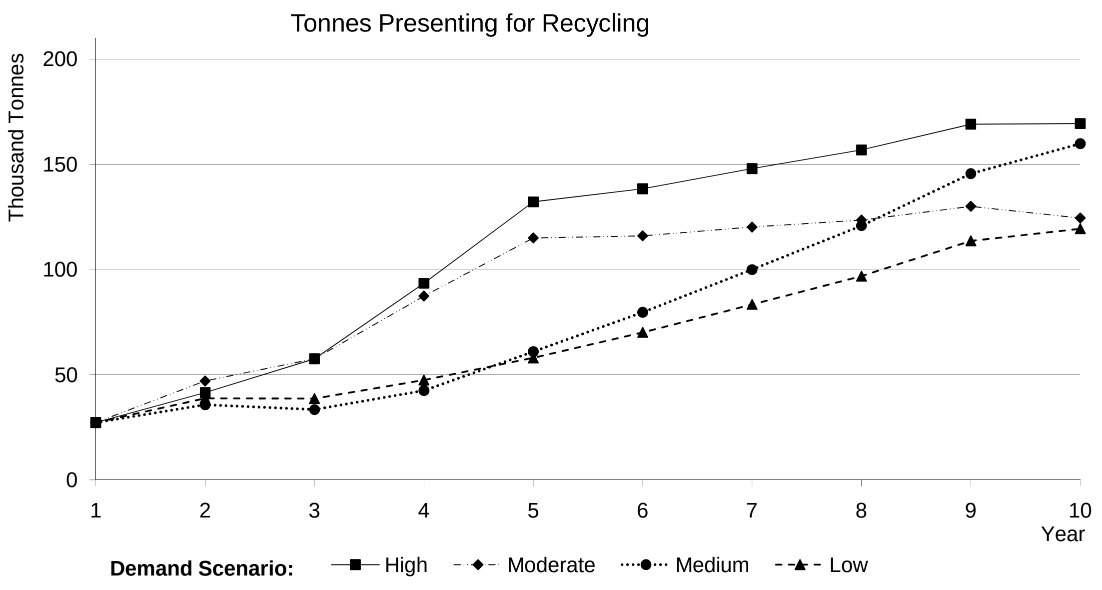


Comparison of Results

The overall scenario results are drawn together at Figure 5-6 which presents overlaid plots of reuse and recycling demand for the four scenarios. This graphical presentation highlights the distinct differences between those scenarios that feature the (5-year) rapid take-up of collection and recovery and those that feature the 10-year conservative take-up rate.

Figure 5-6 Comparison of Resource Recovery Demand





6. E-WASTE INFRASTRUCTURE REQUIREMENTS

This Chapter presents an examination of capacity requirements based on the e-waste demand scenarios developed at Chapter 5. Considerations include expected demand and e-waste product mix, future resource recovery practices, and changes in product technologies. The main feature of the chapter is a comparison of future capacity requirements under each demand scenario.

Key Points

- The *Medium Demand Scenario* is considered to be both the most likely to play out and the most desirable for orderly implementation. It is based on a ten year recycling take-up rate to the 80% target and should allow the recycling industry to progressively develop further recycling capacity.

- Televisions and computers will continue to dominate collected e-waste, with televisions moving to replace computers as the most collected e-waste (by weight).

- The main current resource recovery practices applied to discarded e-waste are likely to remain relevant, at least until 2020/21: refurbishment for reuse; disassembly for recycling of materials; and disassembly for recovery of usable parts.

- Changes made to technologies embodied in electrical and electronic equipment will affect future recycling practices and particularly downstream recycling activities.

- Recyclers have little interest in establishing facilities in Australia for downstream processing of component subassemblies to recover precious metals in circuit boards etc, based on e-waste products alone – the technologies are complex and the potential yield is insufficient to support investment.

- Implementation of e-waste product stewardship would need to be supported by an early and rapid increase in recycling and downstream processing capacity.

- The PSA and AIIA are developing plans to provide for multiple types of collection and transfer pathways. They expect that community drop-off and industry collection from designated sites, such as well-known retailers and public waste transfer stations, will be an important pathway.

- Some 120 to 140 collection points deployed to service major cities and inner regional cities and towns across Australia would provide for a manageable e-waste collection scale with a maximum expected travel distance of 20km. For the *High Demand Scenario*, an average of around 12 tonnes/week would be collected at each location during year 5 (2015/16); around 15 tonnes/week during year 10 (2020/21). A further 100 to 200 drop-off/collection points may be required to service outer regional and remote towns.

A Most Likely Recycling Demand Scenario?

Four distinctly differing scenarios were presented and analysed at Chapter 5. The key factors in each scenario are: (a) the rate of growth in collection and recycling take-up; and (b) rate of expansion of the scheme to other e-waste product groups. While each scenario is considered plausible, the very rapid (five year) recycling growth rate associated with the *High Demand Scenario* and the *Moderate Demand Scenario* may stretch industry capacity to develop infrastructure to match recycling demand. This could result in excessive inventories of products awaiting recycling.

On the other hand, the *Medium Demand Scenario* and the *Low Demand Scenario* are based on a ten year recycling take-up rate to the 80% target. This allows scheme administrators to adopt a more conservative pace to develop community education capacity and deploy collection points for discarded products. And it allows for the recycling industry to progressively invest in and develop recycling capacity beyond the current reserve.

The *Medium Demand Scenario* has the additional benefit of incorporating collection and recycling of other e-waste products from year 5, while allowing mobile phone collection and recycling to continue flourishing and possibly reach 90% recycling by year 5. This scenario is considered to be the most desirable from an orderly implementation perspective.

It would be feasible for the Government to work with the PSA and AIIA, and other industry associations to develop an orderly program for e-waste product stewardship implementation. Such a program would allow for progressive spread of the product stewardship scheme at an implementation rate that promotes progressive addition of e-waste recycling capacity.

The ability to align growth in demand for e-waste recycling with the rate of new market investment in recycling capacity is based on the idea that the growth rate in e-waste presenting for recycling and the actual recycling accomplished can be controlled to a great extent by important actions that are in the hands of the Producer Responsibility Organisation. Specific control actions include:

- the rate of roll-out of new collection points;
- accompanying community and business education activity;
- the rate of awarding contracts and the scale of contracts for specific product resource recovery activities.

Future Mix of Discarded Products Collected for Resource Recovery

The current mix of e-waste products recycled for reuse or materials recovery is dominated by computers and peripherals, but the number of televisions in the recycling mix has greatly increased over recent years. The future product mix has implications for the sorts of recycling technologies and practices adopted, and the recycling costs and potential revenue streams from sale of materials to downstream processors.

Table 6-1 sets out an estimate of current and future reuse and recycling proportions for each of the product groups under consideration. This table demonstrates that, based on the *Medium Demand Scenario*, the large numbers of computers and peripherals collected will continue to dominate the reuse and recycling market. Progressive reduction in unit weight of computers will slightly reduce their significance from a materials recovery perspective. The numbers of televisions presenting will increase substantially, and their more stable unit weight will result in televisions rising to dominate recycling on a weight for weight basis.

The proportion of other e-waste in the recovery mix remains low in this scenario, following the assumed introduction of formal product stewardship action in 2015/16. Despite high volumes of mobile phone collections, the materials yield remains relatively low.

Table 6-1 Product Mix Presenting for Reuse and Recycling – Medium Scenario

Product	Proportion by Unit 2011/12	Proportion by Unit 2020/21	Proportion by Weight 2011/12	Proportion by Weight 2020/21
Televisions	9.3	8.6	43.9	53.4
Computers and peripherals	64.0	76.3	55.0	34.0
Mobile phones	26.7	7.6	0.1	0.4
Small household appliances	0	2.5	0	3.1
Consumer equipment	0	2.5	0	3.1
Home/office communications devices	0	1.6	0	4.1
Electric hand tools	0	0.9	0	1.9
	100.0	100.0	100.0	100.0

Future Developments in Resource Recovery Practices, Infrastructure, and Technologies

Resource Recovery Practices

Chapter 2 described three main resource recovery practices presently applied to discarded e-waste (mainly computers, as the largest volume of the current e-waste recycling haul): refurbishment for reuse; disassembly for recycling of materials; and disassembly for recovery of usable parts. The observation was made that disassembly for recycling of materials is the dominant resource recovery pathway and is estimated to account for some 70% to 80% of current e-waste recovery activity.

Will this continue to be the dominant practice over the next ten years?

Discussions with industry participants have not identified any significant changes to these three pathways in the near future, and most likely not before 2020/21. However, there may well be changes within the current pathways as technologies embodied in electrical and electronic equipment change and as work practices change to reflect changing commercial conditions.

Product Technology Developments

Significant changes have been seen in recent years in television and computer technology and consumer preference. The most profound trend in television products to larger units using LCD and plasma screens rather than the relatively heavy CRT screens. Despite the increase in size, modern televisions have retained a weight in keeping with the weight of the previous CRT screened products. The overall outcome for television frames is reduced glass content and elimination of lead, and reduced plastic content in the carcass.

Both desktop and laptop computers have become smaller and lighter and there has been marked swing away from desktops to laptops. This is expected by the industry to continue. Again, the overall outcome for computer frames is reduced glass and plastic.

Changes have also been made to technologies embodied in electrical and electronic equipment. A number of these technology developments will affect future recycling practices and particularly downstream recycling activities.

Printed circuit boards – the content of metals and other materials of value that is incorporated into the components of circuit boards is falling relatively rapidly. While there has been evidence of first generation circuit boards for new products being relatively rich in precious metals and other recoverables, this does not persist into second and third generation models of those same products. Manufacture of these later models is reportedly often outsourced.

Further, some recyclers have advised that new, alternative materials, such as aluminium are being substituted into some current generation circuit boards. This materials choice may ultimately result in complete replacement of some of the more sought-after precious metal content.

The combined impacts of reduced value content and substitution of alternative materials will likely see the recovery value in circuit boards continue to fall progressively. This has implications for the value proposition which drives the practice of product disassembly and export of components to overseas downstream processing facilities.

Currently three grades of circuit boards are recovered at those facilities where disassembly is practiced – High Grade, Medium Grade and Low Grade. It is reasonable to expect the there will be a reduction in the amount of high grade circuit boards arising and an increase in the medium grade arisings. Low grade circuit boards, which include relatively large heat sink elements of aluminium and other (non-precious) metals, may also increase slightly into the future.

Display units – within current e-waste presenting for recycling, around one third of the total weight handled comprises glass sourced from CRT, LCD and plasma display units from the television and computer streams. Display units, and in particular CRTs, are relatively heavy when compared with most electrical and electronic components, and with the large amount of manual handling in recycling facilities today, they present a constant challenge for operators to ensure safe work practices are followed at all times.

The phasing out of CRT display units in favour of LCD and plasma will see the quantity of these glass components decline rapidly over the next three to five years. The progressive decline in CRT numbers will result in decreased need for specialist leaded-glass handling procedures and facilities. Future glass recycling focus will be on plasma and LCD screens and their various components – glass, gases (plasma) and reuse of sections of LCD screens.

In respect of these screens, there is a noticeable trend for the LCD and plasma screens becoming larger, heavier and in awkward proportions for easy, and safe, manual handling by one person alone. This aspect is likely to see work practices change at those facilities where screens are handled.

Miniaturisation of components – the progressive and parallel miniaturisation and increasing capacity of electrical and electronic goods is exemplified by mobile phone and PDA (personal digital assistant) devices. These today have significant computing and internet browsing capacity embodied in a product that fits easily into the palm of the hand. Industry sources predict that this trend will continue and eventually encompass virtual technologies, such as projected visual images of keyboards on flat surfaces that are used in lieu of a physical keyboard, and screen displays that are projected onto vertical surfaces in lieu of screen hardware.

In addition, there will be a trend for remote data storage through technologies such as cloud computing, that will see memory capacity on computing devices shrink and with this, the overall product envelope will shrink.

As computing devices become smaller, it is likely that the intrinsic value in internal components will fall and disassembly costs will rise, rapidly bringing a decline in the economic value of disassembly.

As a consequence of trends such as those outlined above, it is reasonable that recycling activities in Australia might respond via:

- introduction of mechanical aids for handling of bulky and heavy items;
- diversion of the bulk of glass received direct to glass processors;
- a reduction in the extent of reuse for computers;
- a reduction in the degree of disassembly at work benches; and
- an increase in the application of shredding as a pre-cursor to shipping.

Downstream Processing

There are currently two separate pathways for downstream processing components retrieved from e-waste:

- Australia-based downstream processing firms accept collated glass, steel, electric cables, and plastics as part of their feedstock inflow from various industries for the purposes of processing.
- Export-based downstream processing involving electronic components such as circuit boards, hard drives, power supplies, and a number of other electronic sub-assemblies. Components are sent overseas for recovery of various metals, precious metals (gold, silver, platinum, palladium, ruthenium and iridium), fibre etc.

In both domestic and export situations, the facilities receiving the separate material streams have been established for downstream processing materials sourced from other industry sectors as their primary feedstocks. And the material sourced from the e-waste recycling sector is a small proportion of supply streams from all sources.

In respect of precious metal recovery from e-waste, and especially gold, common techniques for recovery include reverse electroplating, cryogenic processing and smelting. All of these are relatively complex processes requiring reasonable scale of operations for economic viability – scales that will not be supported by materials sourced from e-waste recycling alone.

An order of magnitude estimate of the amounts of materials that would eventuate from recycling and downstream processing e-waste is presented at Table 6-2. This table indicates the modest tonnages that could arise in the *high demand* scenario at 2020/21.

The expected recycling yields for steel, other metals, plastics and glass are exceedingly small in comparison with the feedstock quantities received by materials processing facilities both in Australia and overseas. There is little likelihood that facilities would be established to service e-waste supply alone.

Table 6-2 Indicative Material Content of E-Waste Recycled in 2020/21

Material	Percent	Tonnes
Glass	~30%	50,000
Steel	~30%	50,000
Other Metals (Cu, Al)	~15%	25,000
Plastics	~15%	25,000
Other materials	~10%	20,000
Precious metals	< 0.001%	< 20
Total		**169,000**

For precious metals, it is difficult to get an estimate of content in e-waste, but it is estimated to be significantly less than 0.1% of total weight. At this level, the precious metal yield from all recycled e-waste would be less than 20 tonnes/year by 2020/21. And to recover this small amount of mixed precious metals, a significant amount of waste feedstock would need to be processed.

Discussions with recyclers operating in Australia have revealed there is , little interest in the concept of establishing downstream processing facilities in this country based on e-waste materials alone.

Comparison of Modelled Demand Scenarios and Available E-Waste Recycling Capacity

The estimate of current e-waste recycling capacity developed at Chapter 2 indicated current capacity of 69,000 tonnes/year in comparison with current estimated demand of 25,000 tonnes/year. It was also estimated that improved utilisation of current infrastructure (with double shift operations and/or increased dismantling benches) could inexpensively increase capacity to around 88,000 tonnes/year.

A comparison of available capacity and forecast e-waste recycling demand, as represented by the four scenarios, is presented at Figure 6-1 (expressed in e-waste units) and Figure 6-2 (expressed in e-waste weights).

The slight difference in the timing at which capacity is reached in each of the graphs occurs because the *Current Capacity* estimate takes account of significant under-utilisation of current capacity for processing of some relatively heavy e-waste components. Thus, available capacity in weight significantly exceeds available capacity in units. And it therefore takes somewhat longer for the weight-based capacity to be reached. As these graphs represent forecasts they should be taken as indicative and an appropriate conservative view would be to assume capacity would be reached on the *unit* basis.

Figure 6-1 Modelled Demand Outstrips Current Capacity (units)

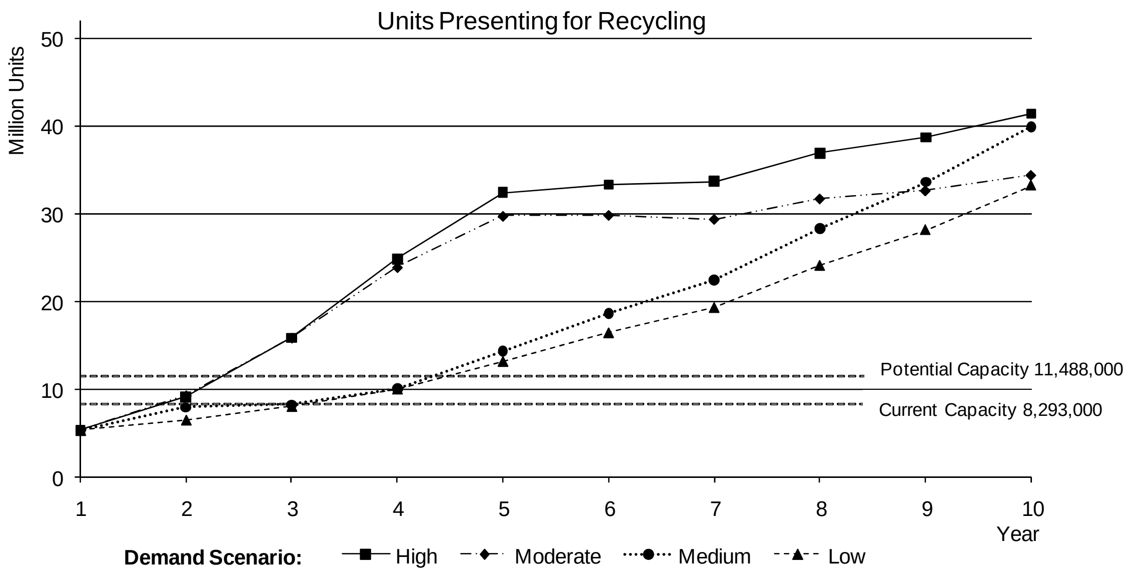
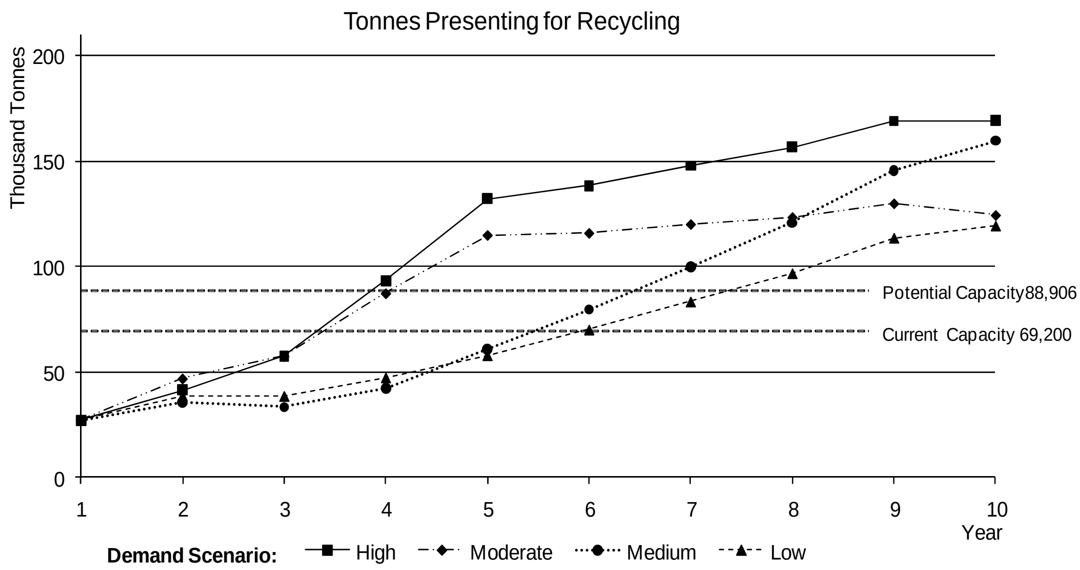


Figure 6-2 Modelled Demand Outstrips Current Capacity (tonnes)



The presentation of these demand scenarios illustrates the comparative pace at which recycling capacity must be added in the early years to service the various demand trajectories. The rapid recycling-take-up scenarios (both the *High Demand Scenario* and the *Moderate Demand Scenario*) clearly require rapid early additions of recycling capacity. For example, the current industry capacity to recycle just over 8 million units would be swamped before the end of year 2 of the program. And the potentially easily scaled-up capacity, to recycle more than 11 million units, would be exceeded in year 3 of the program. On a weight basis, current capacity and easily scaled-up capacity would be exhausted in year 4 if these scenarios were played out.

On the other hand, the conservative recycling-take-up scenarios (both the *Medium Demand Scenario* and the *Low Demand Scenario*) allow large additions of capacity to be postponed or at least phased in at what appears to be a more manageable pace. Note that these scenarios do require substantial additions of recycling capacity during the second five year period.

The forecast growth trajectory for each scenario is shown in tabular form at Tables 6-3 and 6-4, which also report both units and tonnes of recycling demand.

Table 6-3 Comparison of Recycling and Reuse Demand Under the Four Scenarios (Millions of Units)

Scenario	2011/12 Demand	2012/13 Demand	2013/14 Demand	2014/15 Demand	2015/16 Demand	2016/17 Demand	2017/18 Demand	2018/19 Demand	2019/20 Demand	2020/21 Demand
High Demand	5	9	16	25	32	33	34	37	39	41
Moderate Demand	5	9	16	25	30	30	30	32	33	34
Medium Demand	5	6	8	10	14	18	22	28	34	40
Low Demand	5	6	8	10	13	16	19	24	28	33

Table 6-4 Comparison of Recycling and Reuse Demand under the Four Scenarios (Thousands of tonnes)

Scenario	2011/12 Demand	2012/13 Demand	2013/14 Demand	2014/15 Demand	2015/16 Demand	2016/17 Demand	2017/18 Demand	2018/19 Demand	2019/20 Demand	2020/21 Demand
High Demand	16	34	58	93	132	138	148	157	169	169
Moderate Demand	16	34	58	87	115	116	120	124	130	124
Medium Demand	16	17	23	31	53	72	94	117	143	160
Low Demand	16	17	23	31	45	58	74	89	108	116

The rapid rise in demand for recycling capacity relative to current industry capacity is highlighted at Figures 6-3 and 6-4 where annual demand is compared with currently available capacity in terms of both units for recycling and tonnes to be recycled.

Figure 6-3 Annual Demand and Available Capacity (units)

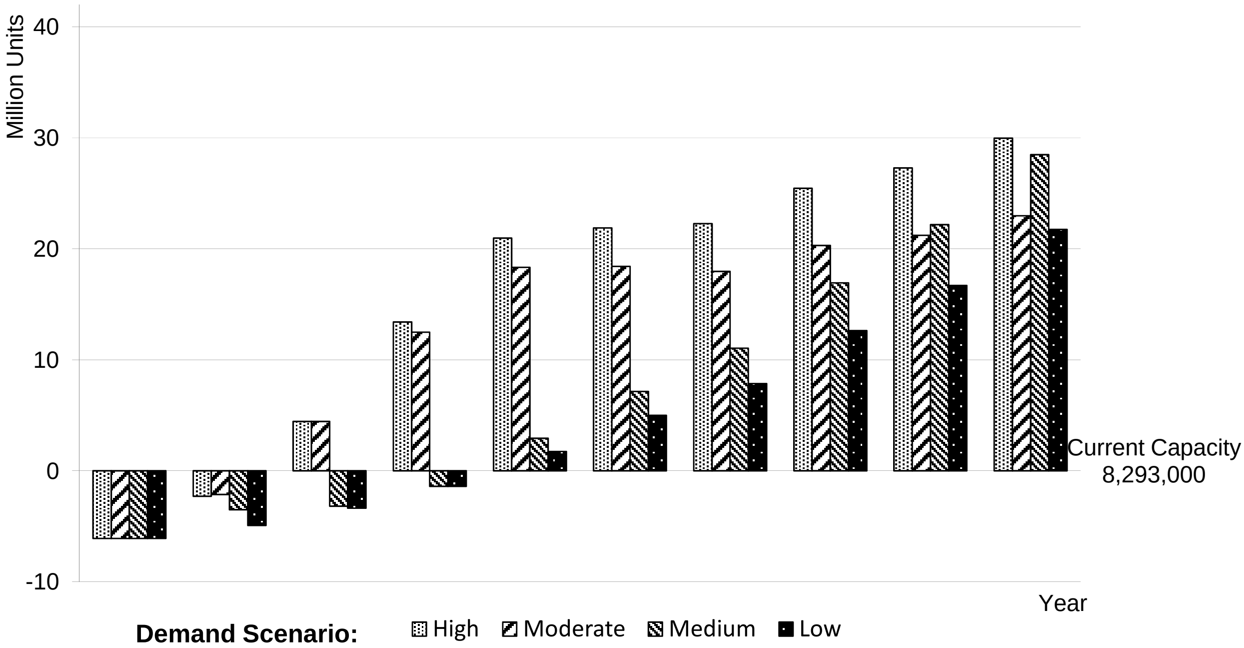
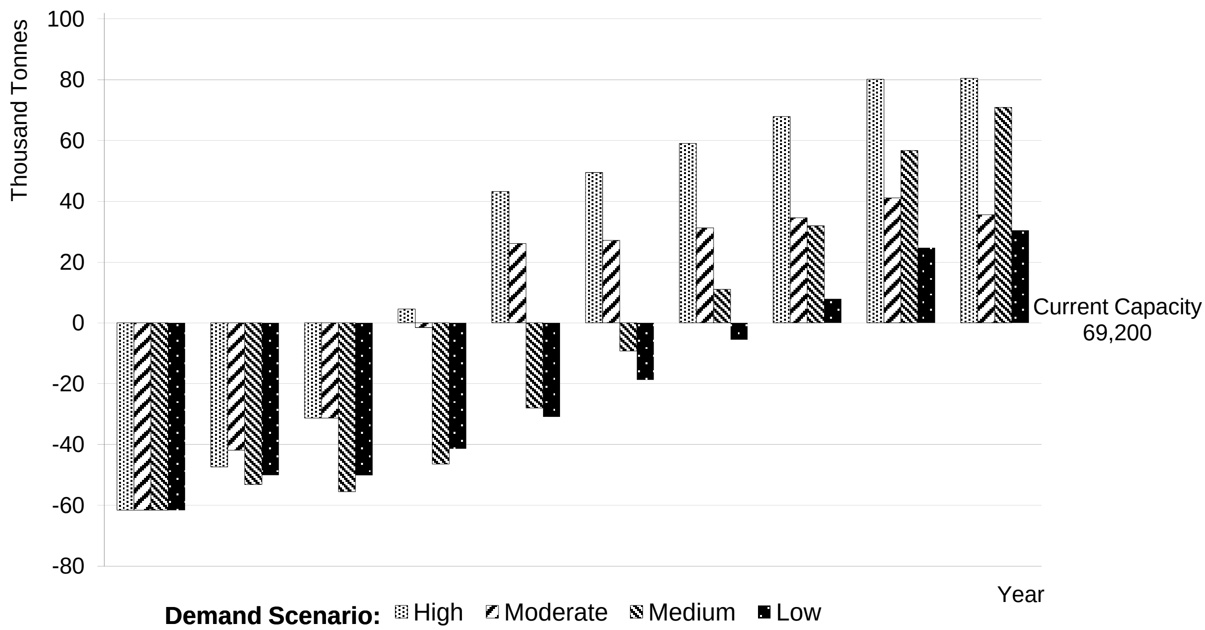


Figure 6-4 Annual Demand and Available Capacity (tonnes)



These figures pinpoint in a more precise way, than the graphs above, the forecast timing when demand outstrips available capacity. Since this metric is changing rapidly with technology evolution it will be important from a governance perspective to monitor capacity constraints as the break-even point time is approached. In respect of reuse of computers, the limiting factor can be expected to be number of units, while in the recycling area, it is likely that tonnage will be the limiting factor, especially as product integrity and item counts become less relevant in recycling activity.

The rapid growth in recycling demand presented in these scenarios would need to be supported by matching growth in recycling capacity. As noted above, it would also require appropriately paced addition of collection logistics – comprising drop-off/collection points and transport systems.

The graphs and scenarios also demonstrate the position that would prevail if the *Medium Demand Scenario* played out. In fact, the current capacity to recycle just over 8 million units would be ample until year 3 of the program – and the potentially easily scaled-up capacity, to recycle more than 11 million units, would be sufficient up to year 5 of the program. On a weight basis, current capacity and easily scaled-up capacity would be not be exhausted until year 6 if the *Medium Demand Scenario* came to fruition. Clearly, more rapid growth in recycling capacity would be required in the later years to service the rapid recycling-take-up required over the last four or five years of the period.

Logistics Requirements

The principal e-waste logistics requirement is for an adequate deployment of drop-off/collection points. Most discarded household and small business e-waste is currently collected on a campaign basis – a practice that has been successful but is unlikely, alone, to accommodate the required future demand. The PSA and AIIA have advised they are developing plans to provide for multiple types of collection and transfer pathways, including special events and council collections as well as designated drop-off/collection points. However, they expect that community drop-off and industry collection from designated sites, such as well-known retailers and public waste transfer stations, will become important pathways. This scheme has been shown to be successful through the Byteback program.

E-waste discarded from the corporate sector is often collected by the supplier of new IT equipment as part of bulk contracts for change-over to new equipment. This practice is likely to continue though, as residential/small business recycling demand grows, this commercial pathway is likely to carry a smaller proportion of total recycling demand.

The case study at Box 6-1 examines possible collection arrangements for the Sydney Metropolitan Area. This case study is provided to consider the impact of peak collection demand on an apparently reasonable deployment of collection points. The actual number of collection points required to accommodate developing demand will progressively increase. The case study illustrates that deployment of two drop-off/collection points in each of the

14 Sydney Regions (28 locations across Sydney or one drop-off/collection point for each 150,000 people) would provide for a manageable e-waste collection scale with a maximum expected travel distance of 20km. For the *High Demand Scenario*, an average of around 12 tonnes/week would be collected at each location during year 5 (2015/16); around 15 tonnes/week during year 10 (2020/21).

As 88% of Australia's population lives in major cities and inner regional cities and towns, a similar scale of distribution should apply for drop-off/collection points in these locations. On a simple scale-up basis, 120 to 140 collection points would be required to service major cities and inner regional cities and towns across Australia. Depending on the policy adopted for regional and remote collection, a further 100 to 200 drop-off/collection points may be required to service outer regional and remote towns.

An alternative collection point strategy would be to deploy one collection point at each of Australia's 564 local government areas. This would provide for 40 collection points across Sydney, which may be considered as a peak requirement.

Box 6-1 Case Study:

Possible E-waste Drop-off/Collection Points for Sydney

The purpose of this case study is to assess on a broad basis whether an apparently reasonable distribution of e-waste drop-off/collection points could manage the forecast flow of e-waste. It is assumed that the *High Demand Scenario* will apply and that 60% of e-waste will be collected at drop-off/collection points, 10% will be collected at special events, and 30% will be collected in bulk from the corporate sector. These assumptions are considered to result a higher-than-likely point source collected volume.

Sydney has a population of around 4.4 million people spread across more than 12,000km^{2,} in 14 designated Regions and served by 40 local government areas. Regional groupings of Councils are active in waste management and resource recovery across Sydney. Deployment of a main drop-off/collection point for each LGA is considered to provide an excessive service level, particularly as numerous small-scale drop-off/collection points are likely to available. However, provision of two main drop-off/collection points for each Region may be appropriate; 28 key locations in total across Sydney – or one main drop-off/collection point for each 150,000 people. It would be expected that some points would be at major retail chain stores, others would be at public waste transfer stations, and some may be at landfill sites. Expected maximum travel distance with this configuration would be 20 km.

The *High Demand Scenario* would result in some 132,000 tonnes of e-waste entering recycling pathways in 2015/16 and some 169,000 tonnes becoming available in 2010/11. On the basis of 60% flow through the 28 designated drop-off/collection points, average weekly volume/location would be in the order of 12 tonnes in 2015/16 and 15 tonnes in 2020/21. This would be roughly one container load each week and would provide for a manageable e-waste collection scale.

7. CAPACITY SHORTFALL IMPLICATIONS AND POLICY OPTIONS

The analysis in Chapter 6 demonstrated the not-surprising fact that as e-waste recycling demand escalates current recycling capacity will be eclipsed within a few years of the start-up date. A central task for the liable parties (including any proposed producer responsibility organisation) will be to ensure that the capacity of the e-waste recycling industry is supplemented in harmony with developing demand and the implementation of e-waste collection arrangements.

This apparently straightforward task is accompanied by risks which will require careful control by the liable parties. Although the primary risk associated with demand/capacity balance is assumed by the liable parties, the Australian Government carries secondary risk and will want to ensure that program governance arrangements are in place with appropriate principles and conditions.

Suggestions are made in this chapter about ways to manage and mitigate these risks.

Key Points

- Market dynamics will be changed markedly with the introduction of a product stewardship scheme. Procurement in the e-waste recycling industry will be controlled by the PRO and other liable parties.

- The major liable parties will be in a commanding position in the procurement of recycling services; the biggest governance risk will be to ensure that the progressive development of e-waste recycling industry *capacity* keeps pace with progressive increase in e-waste recycling *demand*.

- The major liable parties will also have responsibility for the pace at which new drop-off and collection points are rolled out and the geographic priorities adopted. By adjusting the pace of collection point roll-out, they can control the volume of recycling demand actually collected. The major liable parties will thus be in a position to control both actual and latent demand for recycling services.

- A further significant risk associated with greatly increased e-waste recycling demand is the potential discontinuity of downstream off-shore processing capacity for electronic components. Export of electronic components for downstream processing will be a continuing requirement unless facilities are created locally for other feedstocks.

- There may be potential for transport economics and scale issues associated with collection, aggregation, (and possibly recycling) and transport from remote areas and outer regional areas to be regarded by the liable parties as unsustainable.

Strategic Implementation Issues and Risks

The analysis in this report demonstrates how the e-waste recycling market has grown substantially over the last five years. Despite the pace of growth, current capacity comfortably exceeds demand and competition in the sector is high. Each firm operating in this market is working on low margins and is necessarily nimble and innovative in order to source quality e-waste supply, control costs associated with product dismantling, and secure reliable downstream processing alliances. Moreover, each firm has a variety of related synergistic interests in diversified business operations that allow spreading of fixed costs.

Barriers to market entry by new recycling firms are low from the perspective of infrastructure provision – based on the dominant operating technique which involves jobbing style (rather than production line) disassembly of products and distribution of component sub-assemblies and shredded materials to downstream recyclers. However, the new entrant to e-waste recycling faces early difficulties in securing and maintaining upstream feedstock supplies, maintaining and controlling downstream material processing arrangements, and complying with trade and environmental requirements.

Start-up Issues

Market dynamics will be changed markedly with the introduction of a product stewardship scheme. A progressively increasing volume of e-waste will become available for recycling and processing. And, a heightened level of scrutiny will need to be applied to recycling standards. Moreover, procurement in the (currently freewheeling) e-waste recycling industry will be controlled by the PRO/s and other liable parties.

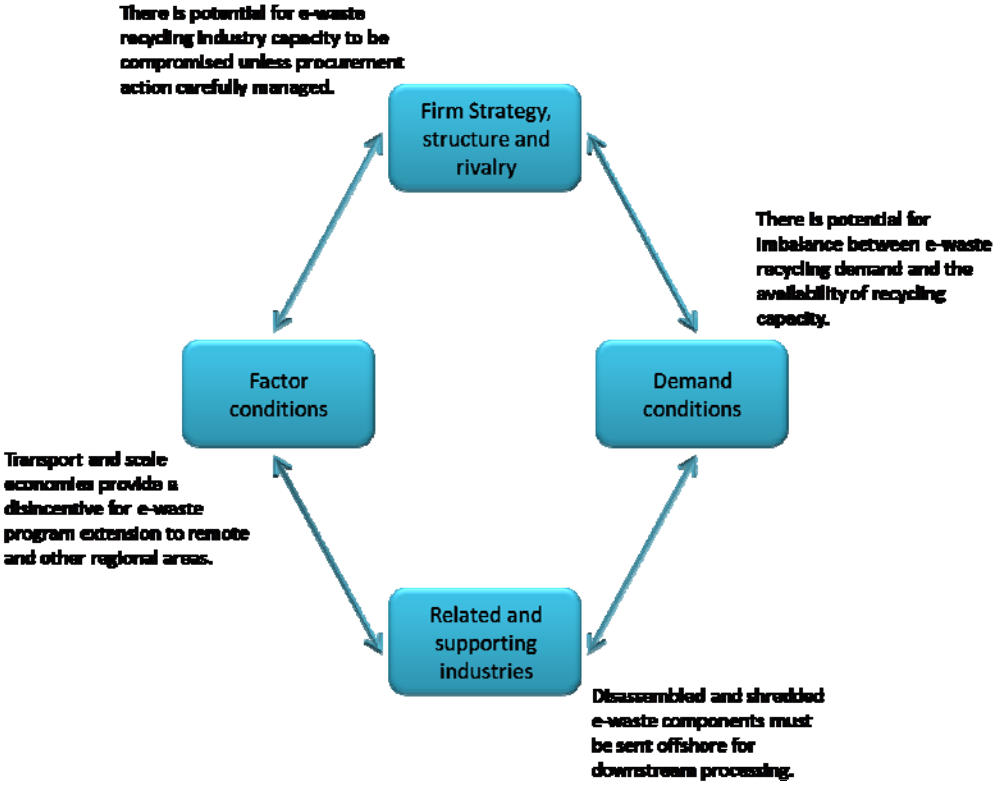
The liable parties will own e-waste collected at its designated drop-off/collection points and will determine the allocation of product for processing in the recycling market. This will put the liable parties in a commanding position in the procurement of recycling services; the biggest governance risk will be to ensure that the progressive development of e-waste recycling industry *capacity* keeps pace with progressive increase in e-waste recycling *demand*.

The liable parties may also have some responsibility for the pace at which new drop-off and collection points are rolled out and the geographic priorities adopted. This would put the major liable parties in a central role in managing both actual and latent demand for recycling services. In fact, the major liable parties could be in a position to control the volume of recycling demand actually collected by adjusting the pace of collection point roll-out.

A further significant risk associated with greatly increased e-waste recycling demand is the continuity of downstream off-shore processing capacity for electronic components. There are no commercial-scale facilities in Australia for e-waste precious metal recovery, and the volume available under even the most optimistic scenario is tiny. If current circumstances continue, as seems likely, export of electronic components for downstream processing will be a continuing requirement unless facilities are created locally for other feedstocks.

The issues and risks associated with implementing the e-waste product stewardship scheme are summarised at Figure 7-1 which borrows from the Porter "diamond"[23] to describe the key influences on industry conditions. These issues and risks are analysed and elaborated at Table 7-1 below.

Figure 7-1 Key Implementation Issues and Risks



[23] Michael E. Porter. *The Competitive Advantage of Nations.* MacMillan Press 1990.

Table 7-1. Product Stewardship Implementation Risks

Industry Issue	Implications and Risks
Firm strategy, structure and rivalry: - Risk associated with procurement action	*Potential for e-waste recycling industry capital allocation to be compromised by procurement action taken by major liable parties.* This condition may come about as a result of a competitive tendering regime which favoured a small number of industry participants. Such procurement action by major liable parties has the potential to confer high recycling volume contracts on a small number of the 14 existing main recyclers, even though all may be accredited. The successful few, in such a scenario, would be positioned to flourish while their rivals would need to continue to seek out commercial e-waste (outside the product stewardship scheme, and possibly focus their attention on other parts of their diversified businesses. Industry dynamics would undoubtedly be changed. Worse, it may jeopardise the commercial viability of some firms unwilling or unable to meet tendered processing price levels. This scenario also raises the issue that new entrants to the e-waste recycling industry may have difficulty establishing a position from which to demonstrate competence and win recycling tenders. This may not be consistent with Australia's international obligations to foster domestic capacity. At a time when rapidly expanding demand will require a maximum of readily available expert recycling capacity, a wise procurement strategy may be to tender numerous modest-sized blocks of e-waste processing on 3-5 year contracts. As well as promoting increased rivalry among existing recyclers, this regime could encourage market entry by new recycling firms. Although the primary risk for the balanced performance of the e-waste recycling program is clearly assumed by the liable parties, the Australian Government carries secondary risk. To minimise the risk that sub-optimal procurement action may adversely impact the timely creation of industry capacity, the Government may wish to negotiate with the liable parties a set of procurement principles and conditions. These could establish product stewardship governance arrangements and KPIs so that the Government could set the basis on which the product stewardship scheme could be delegated to industry and would form a basis for monitoring performance. Thoughtful governance arrangements would allow the liable parties

Industry Issue	Implications and Risks
	to operate independently, but within uniform principles that support diversity in the e-waste recycling industry, and would also provide opportunity for strategic input by the Government in this critical area.
Demand conditions: - Risk associated with program roll-out timing	*Potential for imbalance between e-waste recycling demand and supply.* This condition could result if the timing of collection point roll-out and award of recycling contracts does not keep pace with community expectations. Two extreme possibilities are apparent. The first is that collection points are rolled-out apace, in advance of securing recycling capacity to match collected volume. This possibility would result in a surplus of e-waste to be stored awaiting processing. It may lead to pragmatic decisions to dispose of a proportion of the e-waste inventory, especially if surplus stocks are accumulated at collection points with easy access to disposal facilities. The second possibility is that the pace of collection point roll-out fails to match community expectations – that are likely to be amplified following publicity accompanying the launch of the scheme. This may result in complaints from communities unable to take near-term recycling action. Although the primary risk in both the above cases is clearly assumed by the liable parties, the Australian Government carries secondary risk for the balanced roll-out of the e-waste recycling program. In keeping with the suggestion made above, the Government may wish to negotiate with the liable parties a set of principles and conditions governing collection point roll-out. These would allow the liable parties to operate independently, but within uniform principles that support well planned roll-out of e-waste recycling collection locations, and would also provide opportunity for strategic input by the Government in this critical area..
Factor conditions: - Risk associated with program roll-out to remote areas	*Potential for the liable parties to regard as unsustainable the transport economics and scale issues associated with collection, aggregation and transport of e-waste from remote areas and outer regional areas.* Such a limitation may result from a view by liable parties that the costs to service remote areas and outer regional areas may be prohibitive. This could result in the service being limited to capital cities and main regional towns and cities for an extended period before being delivered to all parts of Australia.

Industry Issue	Implications and Risks
	The merit of this position may be arguable where there is a high expectation of product refurbishment for product reuse or component reuse. However, this risk is mitigated when e-waste can be loaded to freight containers without need to preserve product integrity (see Chapter 2). This is the norm when e-waste is to be shredded for material recovery rather than conserved for reuse. This risk may be best handled through an agreed implementation plan between the Australian Government and the liable parties. One option may be to organise annual sweeps of remote and outer regional areas. There may also be opportunities to link with existing programs such as DrumMuster and ChemCollect or with developing and expanding programs, such as battery collection.
Related and supporting industries: - Continuity of offshore capacity and export processing of electronic components	*Potential for a processing capacity shortfall to arise in offshore arrangements for downstream processing of electronic components.* A serious gap in capacity to process components, such as circuit boards and power units, would arise if off-shore processing capacity is closed or does not expand at a rate which matches progressively increasing demand. Australia has no commercial-scale facilities suitable for e-waste precious metals recovery and, as demonstrated at Chapter 6, the potential volume of future electronic components would not support investment in a precious metals recovery facility exclusively for e-waste. The task of securing and maintaining off-shore contracts for downstream processing of electronic components is clearly a commercial responsibility of each e-waste recycling firm. A role for Government in supporting industry capacity security may be to clarify export permitting requirements and establish bi-lateral communications specifically on e-waste electronic processing with relevant OECD countries. In this regard, a proposed near-term review of the *Hazardous (Regulation of Exports and Imports) Waste Act 1989* may provide a basis for consideration of bilateral policy settings.

8. E-WASTE INFRASTRUCTURE CONSULTATION

Over the course of the E-Waste Infrastructure project, a wide range of industry and stakeholder representatives was contacted for consultation on current and future e-waste recycling activities.

The following list sets outs the names and affiliations of the parties with whom consultations were conducted.

First Name	Last Name	Company
Rod	Welford	ACOR, Australian Council of Recycling
Joshua	Millen	AIIA, Australian Information Industry Association
Michelle	Morton	CRT Recycling Australia
Alex	Young	Dept Environment, Climate Change and Water (NSW)
Paul	Bainton	Dept of the Environment, Heritage, Water & the Arts
Rohini	Tendulkar	Dept of the Environment, Heritage, Water & the Arts
Cathy	McGowan	Dept of the Environment, Heritage, Water & the Arts
Damien	Hall	Dept of the Environment, Heritage, Water & the Arts
Janine	Cullen	Dept of the Environment, Heritage, Water & the Arts
Debbie	Lawrence	Dept of the Environment, Heritage, Water & the Arts
Kylie	Hughes	Dept of the Environment & Resource Management (QLD)
Paul	Starr	Dept of the Environment & Water Heritage & the Arts
Amanda	Jobson	Dept Natural Resources, Environment, the Arts and Sport (NT)
Lakshman	Jayaweera	HydroMet Corp Ltd
Helen	Jarman	Infoactiv
Bob	Verhey	LGSA NSW, Local Government & Shires Association of NSW
Trevor	Munro	Metalcorp NZ
Korina	Munro	Metalcorp NZ
Rose	Read	Mobile Muster
Gerry	Macphail	Molten Media Community Trust
Will	Le Messurier	MRI
Luc	Payet	MRI
Bruce	Jackson	MRI
Sam	Miller	PGM Refiners
Karvan	Jayaweera	PGM Refiners
John	Gertsakis	Product Stewardship Australia

First Name	Last Name	Company
Doug	Walter	Product Stewardship Australia
Jeremy	Thorpe	PWC
Lee	Jollow	PWC
Sarah	Close	PWC
Graham	Muir	Sims Recycling Solutions
David	Brummelen	Sims Recycling Solutions
Jon	Gagliardi	Sims Recycling Solutions
George	Seeley	Sims Recycling Solutions
Joanna	McNamara	SITA Environment Solutions
Nial	Stock	SITA Environment Solutions
Alvin	Piadasa	Tes-Amm Australia
Jim	Perry	Thiess Services
Kane	Siegel	TIC Group
Fabio	Amato	TIC Group
Jeff	Angel	Total Environment Centre
Ian	Coles	Urban Sustainability Strategies
Tony	Cade	Veolia Environmental Services

ATTACHMENT A

SCENARIO SPECIFICATIONS FOR MODELLING INPUT

Assumptions Common to all Scenarios

In all scenarios, forecast sales volume and EOL volume for televisions and computers (Product Groups A & B) are in accord with the Hyder Consulting input to the RIS. Forecasts for other e-waste (other than televisions and computers in Product Group C) have been developed from import data and industry sources.

High Demand Scenario

(a) Product Group A

No adoption of Product Group A in favour of the more extensive Product Group B.

(b) Product Group B

Televisions – program commences year 1 (2011/12)

Sales Yr 1: 3.466 million units (87,000 tonnes); ~3% growth rate according to Hyder Consulting numbers (Tables 8 and 9).

EOL Yr 1: 2.457 million units (75,000 tonnes); ~8% growth rate according to Hyder Consulting numbers (Tables 8 and 9).

Recycling Yr 1: 0.034 million units (850 tonnes); reaching 80% of EOL in yr 5 (2015/16) (20% in yr 2, 40% in yr 3, 60% in yr 4).

Computers and peripherals – program commences year 1 (2011/12)

Sales Yr 1: 28.928 million units (60,000 tonnes); ~1% growth rate according to Hyder Consulting numbers (Tables 10 and 11).

EOL Yr 1: 26.753 million units (76,000 tonnes); ~5% growth rate according to Hyder Consulting numbers (Tables 10 and 11).

Recycling/Reuse Yr 1: 3.426 million units, (15,000 tonnes) reaching 80% of EOL in yr 5 (2015/16) (20% in yr 2, 40% in yr 3, 60% in yr 4).

(c) Product Group C

Mobile phones – program commences from year 1 (2011/12)

Sales Yr 1: 10.1 million units (2,025 tonnes); annual growth rate 4%.

EOL Yr 1: 2.0 million units (404 tonnes); annual growth rate 6%.

Recycling Yr 1: 1.425 million units (285 tonnes) reaching 90% of EOL in yr 2 (2012/13).

Small household appliances – program commences from year 5 (2015/16)

Sales Yr 1: 3.9 million units (19,250 tonnes); annual growth rate 1%.

EOL Yr 1: 2.3 million units (11,250 tonnes) annual growth rate 1%.

Recycling Yr 5: 10% of EOL, reaching 60% of EOL in yr 10 (2020/21).

Consumer equipment – program commences from year 5 (2015/16)

Sales Yr 1: 3.5 million units (17,320 tonnes); annual growth rate 2%.

EOL Yr 1: 2.1 million units (10,500 tonnes); annual growth rate 2%.

Recycling Yr 5: 10% of EOL, reaching 60% of EOL in yr 10 (2020/21).

Home/office communications devices – program commences from year 5 (2015/16)

Sales Yr: 2.5 million units (24,9700); annual growth rate 1%.

EOL Yr 1: 1.5 million units (15,000 tonnes); annual growth rate 1%.

Recycling Yr 5: 10% of EOL, reaching 60% of EOL in yr 10 (2020/21).

Electric hand tools – program continues from year 5 (2015/16)

Sales Yr 1: 1.1 million units (8,660 tonnes); annual growth rate 2%.

EOL Yr 1: 0.7 million units (5,600 tonnes) annual growth rate 2%.

Recycling Yr 5: 10% of EOL, reaching 60% of EOL in yr 10 (2020/21).

Moderate Demand Scenario

(a) Product Group A

Televisions – program commences year 1 (2011/12)

Sales Yr 1: 3.466 million units (87,000 tonnes); ~3% growth rate according to Hyder Consulting numbers.

EOL Yr 1: 2.457 million units (75,000 tonnes); ~8% growth rate according to Hyder Consulting numbers.

Recycling Yr 1: 0.034 million units (850 tonnes); reaching 80% of EOL in yr 5 (2015/16) (20% in yr 2, 40% in yr 3, 60% in yr 4).

Computers (laptops and assembled computers only) – program commences year 1 (2011/12)

Sales Yr 1: 4.600 million units (30,000 tonnes); ~1% growth rate according to Hyder Consulting numbers (Tables 10 and 11).

EOL Yr 1: 4.000 million units (26,000 tonnes); ~5% growth rate according to Hyder Consulting numbers (Tables 10 and 11).

Recycling Yr 1: 0.320 million units, reaching 40% of EOL in yr 3 (2013/14) and extension to include all computers and peripherals.

(b) Product Group B

Televisions – program commenced year 1

See electrical and electronic above

Computers and peripherals – program extends to peripherals year 3 (2013/14)

Sales Yr 1: 28.928 million units (60,000 tonnes); ~1% growth rate according to Hyder Consulting numbers (Table 10 and 11).

EOL Yr 1: 26.753 million units (76,000 tonnes); ~5% growth rate according to Hyder Consulting numbers (Table 10).

Recycling/reuse Yr 1: 3.426 million units (15,000 tonnes) reaching 80% of EOL in yr 5 (2015/16) (40% in yr 3, 60% in yr 4).

(c) Product Group C

Mobile phones – program commences from year 1 (2011/12)

Sales Yr 1: 10.1 million units (2,025 tonnes); annual growth rate 4%.

EOL Yr 1: 2.0 million units (404 tonnes); annual growth rate 6%.

Recycling Yr 1: 1.425 million units, reaching 90% of EOL in yr 2 (2012/13).

Other Group C products

No formal extension of the product stewardship scheme to these products before 2020/21.

Medium Demand Scenario

(a) Product Group A

No adoption of Product Group A in favour of the more extensive Product Group B.

(b) Product Group B

Televisions – program commences year 3 (2013/14)

Sales Yr 1: 3.466 million units (87,000 tonnes); ~3% growth rate according to Hyder Consulting numbers (Tables 8 and 9).

EOL Yr 1: 2.457 million units (75,000 tonnes); ~8% growth rate according to Hyder Consulting numbers (Tables 8 and 9).

Recycling Yr 1: 0.034 million units (850 tonnes); reaching 80% of EOL in yr 10 (2020/21) (20% in yr 4, 40% in yr 6, 60% in yr 8).

Computers and peripherals – program commences year 1 (2011/12

Sales Yr 1: 28.928 million units (60,000 tonnes); ~1% growth rate according to Hyder Consulting numbers (Table 10 and 11).

EOL Yr 1: 26.753 million units (76,000 tonnes); ~5% growth rate according to Hyder Consulting numbers (Table 10).

Recycling/reuse Yr 1: 3.426 million units (15,000 tonnes) reaching 80% of EOL in yr 10 (2020/21) (20% in yr 4, 40% in yr 6, 60% in yr 8).

(c) Product Group C

Mobile phones – program commences from year 1 (2011/12)

Sales Yr : 10.1 million units (2,025 tonnes); annual growth rate 4%.

EOL Yr 1: 2.0 million units (404 tonnes); annual growth rate 6%.

Recycling Yr 1: 1.425 million units, reaching 70% of EOL in yr 2 (2012/13) and 90% by year 5 (2015/16).

Small household appliances – program commences from year 5 (2015/16)

Sales Yr: 10.1 million units (19,250 tonnes); annual growth rate 1%.

EOL Yr 1: 2.3 million units (11,250 tonnes) annual growth rate 1%.

Recycling Yr 5: 10% of EOL, reaching 40% of EOL in yr 10 (2020/21).

Consumer equipment – program commences from year 5 (2015/16)

Sales Yr 1: 3.5 million units (17,320 tonnes); annual growth rate 2%.

EOL Yr 1: 2.1 million units (10,500 tonnes); annual growth rate 2%.

Recycling Yr 5: 10% of EOL, reaching 40% of EOL in yr 10 (2020/21).

Home/office communications devices – program commences from year 5 (2015/16)

Sales Yr: 2.5 million units (24,970); annual growth rate 1%.

EOL Yr 1: 1.5 million units (15,000 tonnes); annual growth rate 1%.

Recycling Yr 5: 10% of EOL, reaching 40% of EOL in yr 10 (2020/21).

Electric hand tools – program continues from year 5 (2015/16)

Sales Yr 1: 1.1 million units (8,660 tonnes); annual growth rate 2%.

EOL Yr 1: 0.7 million units (5,600 tonnes) annual growth rate 2%.

Recycling Yr 5: 10% of EOL, reaching 40% of EOL in yr 10 (2020/21).

Low Demand Scenario

(a) Product Group A

Televisions – program commences year 1 (2011/12)

Sales Yr 1: 3.466 million units (87,000 tonnes); ~3% growth rate according to Hyder Consulting numbers.

EOL Yr 1: 2.457 million units (75,000 tonnes); ~8% growth rate according to Hyder Consulting numbers.

Recycling Yr 1: 0.034 million units (850 tonnes); reaching 80% of EOL in yr 10 (2020/21) (20% in yr 4, 40% in yr 6, 60% in yr 8).

Computers (laptops and assembled computers only) – program commences year 1 (2011/12)

Sales Yr 1: 4.600 million units (30,000 tonnes); ~1% growth rate according to Hyder Consulting numbers (Tables 10 and 11).

EOL Yr 1: 4.000 million units (26,000 tonnes); ~5% growth rate according to Hyder Consulting numbers (Tables 10 and 11).

Recycling Yr 1: 0.320 million units, reaching 20% of EOL in yr 3 (2013/14) and extension to include all computers and peripherals.

(b) Product Group B

Televisions – program commenced year 1

See above

Computers and peripherals – program extends to peripherals year 3 (2013/14)

Sales Yr 1: 28.928 million units (60,000 tonnes); ~1% growth rate according to Hyder Consulting numbers (Table 10 and 11).

EOL Yr 1: 26.753 million units (76,000 tonnes); ~5% growth rate according to Hyder Consulting numbers (Table 10).

Recycling/reuse Yr 1: 3.426 million units (15,000 tonnes) reaching 80% of EOL in yr 10 (2020/21) (20% in year 4, 40% in yr 6, 60% in yr 8).

(c) Product Group C

Mobile phones – program commences from year 1 (2011/12)

Sales Yr 1: 10.1 million units (2,025 tonnes); annual growth rate 4%.

EOL Yr 1: 2.0 million units (404 tonnes); annual growth rate 6%.

Recycling Yr 1: 1.425 million units, reaching 70% of EOL in yr 2 (2012/13) and 90% by year 5 (2015/16).

Other Group C products

No formal extension of the product stewardship scheme to these products before 2020/21.

Other Demand Estimates and Assumptions

Project period

Base year for data sets: 2007/08.
Start year for Product Stewardship Scheme: 2011/12.
End year of analysis period: 2020/21.

Product weight and complexity[24]

Computers – Existing end of life product coming to recyclers:

- Desktop with CRT monitor: 25.5 kg (all at EOL by 2010/11).
- Monitor only: 8 kg.
- Laptop: 3 kg.
- Peripherals; 2.6 kg.
- Sales split: 14% laptops in 1998/99, 54% laptops in 2007/08, 75% by 2020/21.

Computers – Next wave of scrap to recyclers:

- Desktop with LCD monitor: 14 kg in 2007/08, reducing to 10kg by 2020/21.
- LCD monitor: 4kg, reducing to 2.5 kg by 2020/21.
- Laptops: 2.5kg in 2007/08, reducing to 1.5 kg in 2020/21.
- Peripherals: 2.6 kg reducing to 1.6 kg by 2020/21.

Televisions: 25 kg for period 2008/09 onwards.

Other e-waste

- Electrical and electronic equipment:
  - Mobile phones: 0.2 kg (phone with battery and accessories).
  - Small household appliances: 5kg.
  - Home/office communications devices (telephones, faxes, copiers): 10kg.
  - Consumer equipment (cameras, radios, hi-fi equipment, video games): 5kg.
  - Electric hand tools: 8kg.

[24] Based on Hyder/PwC data used in RIS.