Chapter 12

# E-waste Management in Australia: Current Status

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## 1 Introduction

Rapid advances in technology and ready availability of newer designs at low prices have motivated customers to discard old electrical and electronic equipment (EEE) even before its useful life is over. This has resulted in mountains of used EEEs, referred to as electronic waste or E-waste, to be managed by the relevant authorities. Finding a sustainable, economically viable, technically feasible, and socially acceptable strategy to deal with end-of-life (EOL) management of EEEs has been not easy due to their large quantities and toxic nature. Recyclable materials in E-waste are a valuable resource which could be explored by efficient systems. The Asia-Pacific region contributes to the largest revenue share in the global E-waste management market. Emerging economies in Asia Pacific such as Korea, India, China, Japan, Vietnam, and Taiwan are expected to be the fastest growing markets for E-waste recycling. The generation of reliable data on the exact amount of E-waste generated in different regions of the world is difficult to achieve as the amount of used EEE reaching its end of life cannot be measured directly with some reliability. The Global E-waste Monitor 2014, published by the United Nations University (Baldé et al., 2015) estimates that the global quantity of E-waste generation in 2014 was around 41.8 million tonnes (Mt); see Fig. 1 for regional/national details of this estimate. This amount is estimated to reach 50 Mt by 2018, with an annual growth rate of 4%–5%. The latest report from the United Nations University estimates E-waste generated in East and South-East Asia rose by 63% during 2010–15 (Honda et al., 2016).

The significant quantity of E-waste generated is not the only issue faced by the solid waste managers but also its composition. Fig. 2 indicates the six categories of EEE as per the size and purpose of the original device (Baldé et al., 2015). E-waste contains more than 1000 different substances, many of which

**Electronic Waste Management and Treatment Technology.** https://doi.org/10.1016/B978-0-12-816190-6.00012-1

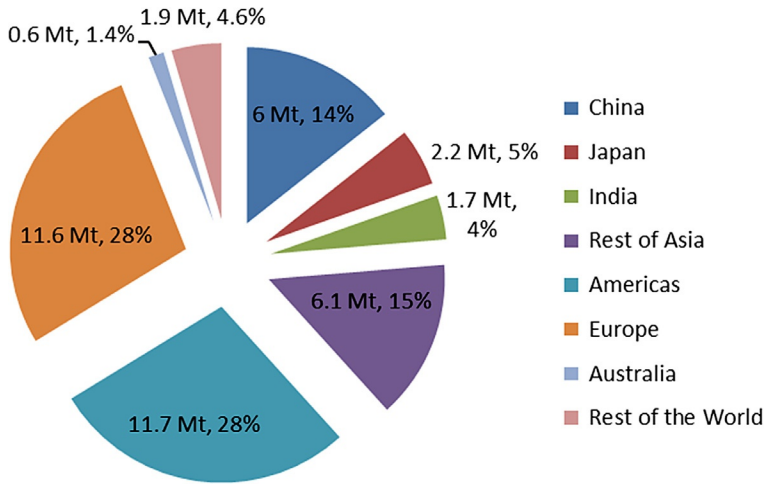


**FIG. 1** Global quantities of E-waste generation.

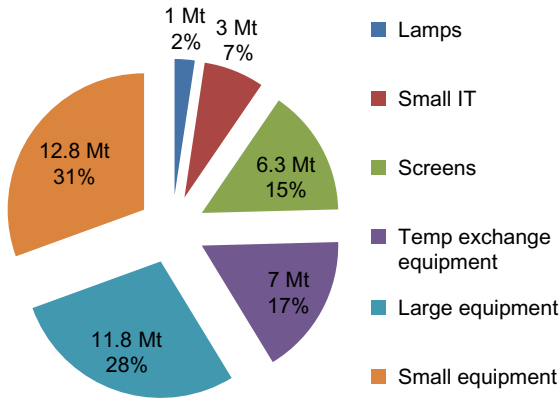


**FIG. 2** Categories of E-waste, 2014 global data.

are toxic metals such as lead, arsenic, cadmium, hexavalent chromium, and flame retardants used in the plastics. The regulations being developed around the world are demanding the replacement of many of these materials, but they will remain in the waste stream for some time.

The aim of this chapter is to provide an overview of how Australia deals with this emerging issue given its unique geography and the information technology market sector compared to other countries around the world. The text will address the issue of the generation of E-waste in Australia and will investigate the initiatives undertaken by the governments and industry towards end-of-life management of this waste stream. Throughout the chapter, the emphasis will be

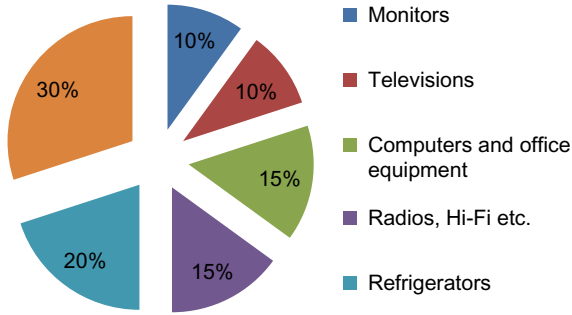


**FIG. 3** Categories of E-waste in Australia.

on computer and television waste, which is the major component of E-waste in Australia. The categorization of E-waste in Australia is indicated in Fig. 3 (Davis and Wolski, 2008).

## 2 Generation of E-waste in Australia

### 2.1 About Australia and Its Information and Communication Technology

Australia occupies an entire continent on the world map and is the sixth largest country in the world by land area after Russia, Canada, China, the United States of America, and Brazil. It occupies some 7.6 million square kilometers with a total population of around 25 million. Australia has one of the most urbanized populations in the world with over 80% of the Australians living in urban centers located within 100 kilometers of the coast. The Australian Federation consists of six States and two Territories; Australian Capital Territory, Western Australia, New South Wales, Victoria, Queensland, South Australia, Northern Territory, Tasmania. The largest state, Western Australia, is about the same size as Western Europe (http://www.dfat.gov.au)

Australia's population concentrates on major capital cities. The major states such as New South Wales, Victoria, and Queensland are heavily populated and are home to the majority of businesses and industry. Due to the large geographical area of the Australian continent, the distance between the major population centers are significantly high, making transport and logistics a major concern in any management system. Generation of different types of waste and uptake of recycling varies across states, for example, South Australia has achieved higher recycling rate for general waste than some other states (Zaman and Lehmann, 2011). Several factors are relevant in further analysis of this fact, such as cost of landfill, logistics for material transport, and policy implementation.

The Australian computer industry considered to be the backbone of ICT consists of some major manufacturers as well as several minor players mainly

as computer assemblers. Large global computer manufacturers such as Hewlett Packard, Dell, Acer, IBM, Toshiba, and Apple dominate the Australian computer market, but they only account for part of the total market. The remainder is dominated by "non-brand" or "white box" computers which are assembled from imported generic parts. Apart from this type of assembly, there is no significant computer manufacturing industry in Australia.

## 2.2 E-waste Generation

As of 2017, there are only very few studies and statistics describing the generation and trends in global E-waste management. In order to fill this gap, the International Telecommunication Union (ITU), the United Nations University (UNU), and the International Solid Waste Association (ISAWA) have formed a "Global E-waste Statistics Partnership" to improve and collect worldwide E-waste statistics (Baldé et al., 2015, 2017; Herat, 2018). The accurate estimate of E-waste generation in Australia (and in many other countries) is a very difficult task due to the low quality of data and the need to make various assumptions to determine the inputs and outputs.

The Australian Bureau of Statistics in 2013 made the following estimates:

- Over 2011–12, an estimated 29 million televisions and computers across Australia reached their end of life.
- 17 million televisions and 37 million computers have been sent to landfill up to 2008.
- Of the 15.7 million computers that reached their end of life in Australia in 2007–08, only 1.5 million were recycled—less than 10%.
- The cumulative volume of televisions and computers reaching the end of their useful life is expected to reach 181,000 tonnes or 44 million units by 2027–28.
- Australians buy more than 4 million computers and 3 million televisions annually.

A more recent estimate by the Australian Government states that during 2012–13, 137,756 tonnes of televisions and computers reached their end of life, out of which 43% (58,857 tonnes) were waste televisions while the remaining 57% (78,900 tonnes) were waste computer products (Commonwealth of Australia, 2014). The growth is fast-paced, expected to grow from 0.4 to 1 Mt between 2014 and 2035 (Pickin and Randell, 2017).

A comparison of population growth and growth in E-waste generation is given Table 1.

Golev et al. (2016) attempted to estimate the E-waste generation in Australia by modeling based on the process developed by the United Nations University. Their results show that in the 5 years from 2010 to 2014, the E-waste generation in Australia grew by 43% from 410,000 to 587,000 tonnes. In terms of per capita basis this reflected an increase from 18.6 to 25 kg (Golev et al., 2016). A study

**TABLE 1 A Comparison of Population Growth and Growth in E-waste Generation Across the World and Australia**

| Data | World | Australia |
|---|---|---|
| Population growth rate | 1.09% | 1.7% |
| Recent growth in E-waste | 5% | 43% |
| 2016 E-waste quantities | 49,273,000 tonnes | 587,000 tonnes |
| 2016 Population | 7,383,009,000 | 24,357,000 (0.32%) |
| 2050 Median Projection, est. | 9,771,823,000 | 33,187,000 (0.34%) |

(Data from Golev, A., Schmeda-Lopez, D.R., Smart, S.K., Corder, G.D., McFarland, E.W., 2016. Where next on e-waste in Australia? Waste Manag. 58, 348–358; Davis, G., Herat, S., 2008. Electronic waste: the local government perspective in Queensland, Australia. Resour. Conserv. Recycl. 52(8–9), 1031–1039; ABS, 2013. Australian Bureau of Statistics Catalogue 4602.0.55.005—Waste Account, Australia Exp. Estimate, 2013; Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann, P., 2017. The Global E-Waste Monitor—2017, Quantities, Flows and Resources. United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna. ISBN:978-92-808-9054-9; Australian Government, 2012. Product Stewardship (Televisions and Computers) Regulations 2011; Bigum, M., Petersen, C., Christensen, T.H., Scheutz, C., 2013. WEEE and portable batteries in residual household waste: quantification and characterisation of misplaced waste. Waste Manag. 33(11), 2372–2380.)

conducted by Golev and Corder (2017) on quantifying metal values estimates that the metal recovery value from E-waste in Australia in 2014 was about US$370 million with printed circuit boards contributing to the majority of this (Golev and Corder, 2017). It is estimated that 1 tonne of recycled computers is equivalent to 17 tonnes of gold ore in terms of quantities of recoverable gold (ABS, 2013; UN DESA, 2017; Baldé et al., 2017).

India is one of the major destinations for E-waste exported for recycling from developed countries. India domestically generates approximately 1.85 million tonnes of E-waste annually and is ranked fifth in the world in E-waste generation. It has been estimated that India will generate 5.2 million tonnes by 2020 with a growth rate of 30% (Herat, 2018). Currently, only 1.5% of the generated E-waste is recycled and over 95% of the E-waste generated is managed by the informal sector and scrap dealers without proper infrastructure and poor implementation of legislation. India has made a significant commitment to safe management of E-waste by formulating new E-waste (Management) Rules, 2016. The *Swachh Bharat* initiative by the Government of India aims to put the focus on awareness and aims to ensure 100% collection and scientific processing/disposal reuse/recycle of municipal solid waste. Since over 95% of the E-waste is handled by the unorganized informal sector using nonscientific processing techniques, E-waste is one of the waste streams that needs a lot of consideration to achieve these goals (Herat, 2018; Kush and Arora, 2013; CURE, 2018; Widmer et al., 2005; Ganguly, 2016). A national inventory of produced electronic equipment is under development in India, similar to in China (Sthiannopkao and Wong, 2013).

In contrast to Australia, environmentally sound management (ESM) of E-waste in India is a complex task. In the absence of a coordinated, controlled, and centralized waste management service, transboundary movement of E-waste is a major issue in the region. Dealing with the informal recycling sector is a complex social and environmental issue. Significant amounts of E-waste containing toxic materials can be seen dumped in open spaces and waterways. The open burning of E-waste to recover precious metals causing severe environmental and health impacts is very common. Lack of funds and investment to finance formal environmentally-sound recycling infrastructures, absence of appropriate legislation to deal with the issue, tackling the informal E-waste recycling sector and achieving appropriate technology transfer, are only a few of the challenges faced by India and other developing nations where E-waste recycling is undertaken (Sthiannopkao and Wong, 2013). The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal has been signed by 186 countries (Baldé et al., 2017) aimed at reducing environmentally and socially detrimental hazardous waste trading patterns.

Canada is somewhat comparable with Australia in terms of geographical vastness and population. As per a study published by Statistics Canada, E-waste across Canada has nearly tripled in 4 years. Electronics Product Stewardship Canada (EPS Canada) was founded by 16 leading electronics manufacturers and works with industry government to develop flexible and workable solutions to E-waste problem.

Table 2 compares annual cumulative and per capita E-waste generation across various countries circa 2016 (Baldé et al., 2015, 2017; Herat, 2018).

**TABLE 2 Annual Cumulative and Per Capita E-waste Generation Across Various Countries Circa 2016**

| Country | Annual E-waste Generation (million tonnes) |
|---|---|
| Australia | 0.57 |
| Canada | 0.73 |
| People's Republic of China | 7.2 |
| India | 2 |
| Japan | 2.1 |
| United States | 6.3 |
| Global | 44.7 |

Data from Baldé, C.P., Wang, F., Kuehr, R., Huisman, J., 2015. The Global E-Waste Monitor – 2014, United Nations University, IAS-SCYCLE, Bonn; Baldé, C.P., Forti, V., Gray, V., Kuehr, R., Stegmann, P. 2017. The Global E-Waste Monitor—2017, Quantities, Flows and Resources. United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna. ISBN:978-92-808-9054-9; Herat, S., 2018. Background paper on 3R technologies for WEEE. In: Eighth Regional 3R Forum in Asia and the Pacific, 9–12 April 2018, Indore MP, India.

Overall in Oceania, the total E-waste generation was 0.7 Mt in 2016. The top country with the highest E-waste generation in absolute quantities is Australia (0.57 Mt). In 2016, Australia generated 23.6 kg/inhabitant and New Zealand 20.1 kg/inhabitant (Baldé et al., 2017).

## 3 Government/Industry Initiatives for Dealing With E-waste

Along with other waste, all waste management is primarily the responsibility of state and territorial government through local governments in cities or regional centers (Councils). Currently, there are four key components of legislation in Australia to manage E-waste (Golev and Corder, 2017):

- National Waste Policy 2009
- Product Stewardship Act 2011
- Product Stewardship (Televisions and Computers) Regulations 2011 (Regulations)
- National Television and Computer Recycling Scheme 2011 (NTCRS)

Individual Councils or regional organizations of councils will have specific waste management policies and strategies according to these components of legislation (Council of the City of Sydney, 2017; Australian Government, 2014; SHOROC (Shore Regional Organisation of Councils), 2010; SWRRIP, 2018; ABC, 2018). The National Television and Computer Recycling Scheme is one of the most significant producer-responsibility schemes to be implemented in Australia under the Australian Government's *Product Stewardship Act 2011*. The Act came into effect on 8 August 2011. Under this Act, the Product Stewardship (Televisions and Computers) Regulations 2011 came into effect on 8 November 2011. This scheme provides Australian householders and small business with access to industry-funded collection and recycling services for televisions and computers. The television and computer industries are required to fund collection and recycling of a proportion of the televisions and computers disposed of in Australia each year, with the aim of increasing the rate of recycling of televisions and computers in Australia from an estimated 17% in 2010–11 to 80% by 2021–22.

The targets set by NTCRS are set at a national level with no specific allocation apportioned to individual state or territory—in other words, there is no target set for any one State or Territory to meet their own minimum volume of E-waste processed (ABC, 2018). The coregulatory aspect is a key feature of the above scheme where the Australian Government, through the Regulations, has set the outcomes to be achieved by industry and how this is to be implemented. The television and computer industries, operating through the approved coregulatory arrangements (Producer Responsibility Organization) will determine how to deliver these outcomes efficiently. The roles and responsibilities and some important features of the scheme are

- Local government can work with coregulatory arrangements to provide the scheme services. They can also manage E-waste outside the scheme, if necessary.

- Householders and small businesses have direct access to the industry-funded scheme E-waste collection services.
- Scheme collection services must provide free-of-charge collection points for E-waste disposal which may include councils, retailers, or other providers
- State and Territory Governments manage the licensing and ensure environmental and work health and safety compliance of the scheme. Also, they are also responsible for overseeing the management of E-waste outside the scheme.
- E-waste Recyclers contract with the coregulatory arrangements to provide recycling services. These recyclers can also work with other businesses and local governments to recycle E-waste outside the scheme.
- Producer Responsibility Organization (Coregulatory arrangements) is responsible for the outcomes of the scheme on behalf of their liable party members. It organizes collection and recycling activities and communicates this information to the public.
- Liable parties (e.g., importers) are required to join and fund a coregulatory arrangement.
- Commonwealth Department of the Environment ensures the compliance of liable parties and coregulatory arrangements meet scheme outcomes.
- Department of Immigration and Border Protection regulate imports and exports and provides import data to the Department of the Environment.

Sustainability Victoria (SV) has identified E-waste as a priority material for waste management and waste and resource recovery infrastructure planning in the state of Victoria (SWRRIP, 2018) with a ban on E-waste from being landfilled. Of the 108,000 tonnes of E-waste managed in 2015–16, 61,000 Mt were landfilled. The total E-waste quantity in 2035 is expected to reach 259,000 tonnes. SV has prioritized developing the necessary resource recovery centers, improving source separation and sorting as well as developing a market for recovered materials to avoid stockpiling of E-waste.

As per an online review and survey conducted in WA (ABC, 2018), the cost and effort for transport and logistics within a large jurisdiction can have major impact on the ability of local councils to successfully participate in NTCRS. This is an important consideration while comparing management of waste (including E-waste) in Australia to other countries of higher population densities and smaller areas. Individual units such as Total Green Recycling in Kewdale, Perth (UN DESA, 2017) focus on high-value materials such as gold in WEEE and are pushing forward the implementation of NTCRS in improving the recycling rate. As per available data, 35% of end-of-life televisions and computers were recycled in 2014–15.

The European Union adopted a law in 2003 named the EU WEEE Directive, which was adopted by all member states by 2007 (Sthiannopkao and Wong,

2013). This law has influenced the introduction of legislation in countries such as Australia, Canada, Japan, Korea, and the United States.

The Australian Government reports that to date over 1800 collection services have been made available to the consumers resulting in over 130,000 tonnes of television and computer waste collected and recycled. An estimated total of 122,000 tonnes of televisions and computers reached their end-of-life in Australia in 2014–15, out of which around 43,000 tonnes were recycled (35%) under this scheme. This a significant improvement from only 9% recycling rate in 2008. Full details about the scheme and copies of publications can be accessed through www.environment.gov.au/ewaste (Baldé et al., 2017; Australian Government, 2012, 2014, 2017; Bigum et al., 2013).

An operational review of the scheme was announced in 2014 to consider what further adjustments could keep the scheme operating efficiently. Following extensive consultation with scheme stakeholders on proposed changes, the Australian Government is going ahead with the proposals which received strong public support. These changes improve the operation of the scheme and ensure its ongoing success.

Scheme recycling targets are increasing to better meet strong public demand for recycling services and ensure stability and ongoing capacity in the E-waste recycling industry. From 1 July 2015, the target trajectory for industry-funded recycling was to 50% of available E-waste for the 2015–16 financial year reaching 80% in 2026–27. This target will enable the scheme to deal with legacy waste sooner.

From 1 July 2016, the Australian Government required coregulatory arrangements to only contract with recycling service providers that are certified to AS 5377: the Australian Standard for the collection, storage, transport and treatment of end-of-life electrical and electronic equipment. This will ensure a consistent industry standard for scheme recycling providers and ensure positive work health and safety outcomes. This start date reflects requests from industry to allow adequate transition time.

A recent survey among local councils across Australia indicated strong preference for federal (national) legislation to manage E-waste among the responders. Both consumers and producers were most commonly suggested to bear the cost of E-waste end-of-life disposal while the survey also indicated the key barriers such as limited access to local reprocessing facilities and inadequate public awareness (Davis and Herat, 2010). In Victoria, the Regional Implementation Plans (waste infrastructure) identified adequate infrastructure for collection, storage, and processing for the recovery of E-waste (SWRRIP, 2018).

Many urban councils have their electronic waste collection schemes where residents can drop off their old computers, batteries, fluorescent lamps, and other electronic waste. With the recent surge in urban residential development, all new multilevel urban developments are required to have specific space allocated for residents to keep electronic waste for pickup by waste management companies (Council of the City of Sydney, 2017).

Notwithstanding the introduction of collection/management schemes and legislation, cooperation from specific E-waste generators is of paramount importance. Institutions and industries that deal with large number of computer stations and other electronic devices generally produce a large quantity of obsolete equipment that will be classified as E-waste. Institutions such as higher education will have specific solutions to managing this resource sustainably, an example being the E-waste program implemented by Griffith University (Davis and Wolski, 2008). Researchers have assessed that the implementation of legislation in Australia on E-waste management, despite being one of the top 10 countries in terms of electronics consumption (thus generation of E-waste), is inadequate with quantities and types of materials prescribed not meeting the actual waste generation (Morris and Metternicht, 2016; Davis and Herat, 2010). Lack of adequate auditing, compliance review, and reporting has also been pointed out in comparison to other countries of similar technological advancement.

### 3.1 Comparison With Oceania Region

On the regulatory management of E-waste in Oceania region, the National Television and Computer Recycling Scheme is one of the most significant producer responsibility schemes to be implemented in Australia under the Australian Government's Product Stewardship Act 2011. The Act came into effect on 8 August 2011. Under this Act, the Product Stewardship (Televisions and Computers) Regulations 2011 came into effect on 8 November 2011. This scheme provides Australian households and small businesses with access to industry-funded collection and recycling services for televisions and computers. The television and computer industries are required to fund collection and recycling of a proportion of the televisions and computers disposed of in Australia each year, with the aim to increase the rate of recycling of televisions and computers in Australia from an estimated 17% in 2010–11 to 80% by 2021–22 (Australian Government, 2012, 2014).

A notable feature of the above scheme is that it is coregulatory, where the Australian Government, through the Regulations, set the outcomes to be achieved by industry, along with the procedures to be implemented. The television and computer industries, operating through the approved coregulatory arrangements (Producer Responsibility Organization), will determine how to implement the procedures efficiently to deliver these outcomes.

In comparison to Australia, New Zealand is still in the process of developing a national scheme to deal with the E-waste issue. It is estimated that around 95 kt of E-waste is produced in New Zealand annually, however no information is available on the amount of E-waste recycled, which is likely to go into landfills.

## 4 Current End-of-Life Management of E-waste in Australia

In general, end-of-life (EOL) management of used computers could be achieved using one of the following methods:

- Storage at home or offices pending future management options.
- Reuse by giving used computers to friends and family, selling to employees or donation to schools and charity organizations.
- Disposal to commercial used computer recyclers.
- Disposal through computer take back schemes.
- Disposal through channels provided by local municipalities.

Reuse involves the transfer of ownership of the used computer for continued use by someone else. Reuse could take various forms including a "closed system" where computers are transferred to an immediate circle of influence or "open system" where ownership is transferred via commercial or nonprofit organizations. This is a viable option given that different people have different needs as far as the computing is concerned. Several nonprofit organisations are involved in delivering the "open" reuse of computers in Australia. For example, Computer Bank operates in several states around Australia delivering computers to disadvantaged groups. WorkVentures is a similar organization where computers are made available to low income communities. All these organizations rely upon volunteers and several organizations employ "work-for-the-dole" staff providing additional benefit to the society.

As per the United Nations University Global E-waste Monitor (Baldé et al., 2015), approximately 1% of Australia's E-waste is collected by designated organizations, producers, and/or by government for recovery in state-of-the-art waste treatment facilities. Australia tops the nations in the Oceania region with a generation of E-waste of approximately 0.5 Mt per year. The majority of E-waste generated in Australia ends up in landfill with fewer than 1% of TVs and 10% of discarded computers being recycled [(Clean Up Australia Fact Sheet, n.d.), 2015 data]. It has been identified and accepted that a major challenge facing management of landfills in Australia relate to the receipt of recoverable materials including E-waste, that should not be landfilled (Pickin and Randell, 2017). Some areas in Australia have placed a ban on E-waste from going into landfill (Zaman and Lehmann, 2011; Pickin and Randell, 2017).

Recycling E-waste is undertaken manually (for resale and reuse of components) or by mechanical means such as crushing and shredding followed by magnetic/density/optical or X-ray sorting for material recovery. Recycling and recovery of used computers involve disassembly of computers into constituent parts in order to recover raw materials such as metals and plastics that have been used in their manufacture. To date, Australia has not recycled much of its computers mainly due to lack of infrastructure due to not enough incentives to invest in reprocessing facilities. However, within last 2 years there is significant interest from major international companies to set up business in Australia. Sims E-Recycling (Sims-E) and MRI are two major companies currently operating in Australia.

Sims-E joint venture is designed to complement the international resource recovery capacity and infrastructure of the Sims-E Group and the collection

capacity of Collex with the purpose of implementing a broadly-based fee-for-service electronics recycling business. Sims-E officially began operations in Melbourne in July 2005 and has since established recycling stations in Sydney and Brisbane. Sims-E is the recycler appointed to support the Sustainability Victoria and HP pilot collection programme in Melbourne. MRI (Australia) Pty Ltd is the second major recycler in Australia. The company operates plants in both Melbourne and Sydney with Melbourne being the major center for the company. MRI is the recycler for the national cell phone take-back scheme and holds the recycling contract for Dell's Australian computer take-back scheme. MRI is also a remarketer and is said to export refurbished equipment to South East Asia. This is understood to include product from Dell's computer take-back scheme. MRI engages in a combination of both a manual and mechanical recycling operation. Plastics and wire are shredded; plastics granulated and recycled in-country. Specific technology is required for the separation of brominated flame-retardant plastic and it is only the larger recyclers that possess such capabilities. This plastic is demanufactured into hybrid pallets and fence posts and stakes for agriculture.

MobileMuster is the official national recycling program of the cell phone industry in Australia. The program collects and recycles cell phone handsets, batteries, and accessories from a network of over 1400 mobile phone retailers, local council, government agencies, and businesses drop-off points across Australia. The program is fully funded by the Australian Mobile Telecommunications Association (AMTA) through its members which include handset manufacturers such as LG Electronics, Motorola, Nokia, NEC, Panasonic, Sagem, Samsung, Sharp and Sony Ericsson, carriers such as Optus, Telstra and Vodafone and service providers such as AAPT and Virgin. This take-back scheme is free to consumers and retailers. Customers can also post in their old cell phones using a free reply-paid recycling satchel available from Australia Post outlets. As part of leading product stewardship program, MobileMuster has launched an Australian-first educational program, called Mobile Connections, targeting students and their interconnections with technology/cell phones and assisting them with sustainable choices. AMTA Recycler MRI in Melbourne dismantles, sorts, stores and processes the equipment collected by Mobilemuster (http://www.mobilemuster.com.au/).

In 2012/2013, MobileMuster collected 87 tonnes of cell phone components including an estimated 1 million handsets and batteries and 38,479 kg of accessories. This represents a collection rate of 53% of available cell phones. Since the program started in November 1998, 1014 tonnes of mobile phone components have been collected and recycled as at 30 June 2013, over 7 million batteries and handsets plus more than 518,000 kg of accessories. The current (2018) estimate includes 11 million batteries and handsets.

The recycling of collected items go through a 6-step process as below:

Step 1 (Sorting): First, phones are dismantled and sorted into the following components: batteries (NiCad, NiMetHyd, lithium ion), printed circuit

boards, handsets, chargers/accessories, plastics, metals and paper/cardboard packaging.
Step 2 (Batteries): Batteries are sorted into their chemical types. All lithium ion and nickel metal hydride (NiMetHyd) batteries are shipped to TES-AMM in Singapore where they are processed for cobalt, lithium, and nickel. All nickel cadmium (NiCad) batteries are shipped to KOBAR Ltd in South Korea where they are processed for nickel (to make stainless steel), cadmium (to make new batteries), and copper.
Step 3 (Circuits): Circuit boards are stored and then shipped to TES-AMM in Singapore where they are processed for precious metals including gold, silver, copper, and lead.
Step 4 (Casings): Pure plastic handset casings with are sent to local plastics manufacturers Australian Composite Technology, who shred them and use the plastic to produce composite plastic fence posts or to CloseTheLoop/EWood who shred and uses the plastics to make plastic wood planks for garden beds/furniture.
Step 5 (Accessories and Mixed Plastics): Accessories and mixed plastics are processed by TES-AMM in Singapore. Here, they are shredded and the plastics are separated from the ferrous and nonferrous metals for reuse. The plastics are used to make shipping pallets and the metals sold on to manufacturers.
Step 6 (Packaging): Packaging is separated into plastic and paper and sent to local recyclers for processing.

## 4.1 Comparison

In context, a comparison with similar initiatives in India is provided in this subsection. E-Parisaraa Pvt. Ltd., India's first Government authorized electronic waste recycler, started operations in September 2005 (Herat, 2018). The company is engaged in handling, recycling, and reusing E-waste in an environmentally-sound manner. The aim of the company is to reduce the accumulation of used and discarded electronic and electrical equipment which mostly end up in landfills or partly recycled in unhygienic conditions by backyard recyclers and then partly thrown into waste streams, damaging the environment. The objective of E-Parisaraa is to create an opportunity to transfer waste into socially and industrially beneficial raw materials such as valuable metals, plastics, and glass using simple, cost efficient, home grown, environmentally-friendly technologies suitable for Indian conditions. The company that started in Bangalore now has set up collection and dismantling facilities in or near Delhi, Mumbai, Chennai, and Kolkata.

Similar to MobileMuster in Australia, Karma Recycling is a leading trade-in operator and redistributor of mobile devices in India. Karma's consumer and enterprise software and services solutions help consumers, retailers, and OEMs manage large-scale buyback and trade-in programs.

## 5 Conclusions

Globally, it has been recognized that there is a lack of reliable data on the generation, collection, import, and exports, and management schemes in general. As a result, a number of countries are in the process of initiating surveys to better define the problem, to identify toxic constituents in end-of-life EEE, to develop pilot projects on successful collections, and develop infrastructure to be able to locally refurbish and recycle such used and end-of-life equipment. E-waste in Australia is growing at an alarming rate given the population's liking for information technology products. Widely known as the sleeping giant in solid waste sector, Australia's E-waste rate is set to climb to even higher levels compared most other countries around the world as the country is experiencing a steady and growing information technology-dependent economy. The recent past has seen the development of regulations to deal with this challenging problem. Although steady progress has been made, further improvement is necessary to maintain the momentum. For example, the current regulations are limited to portion of the E-waste generated in the country. As such there is an urgent need to add new categories to the legislation.

The private sector (EEE manufacturers) and public sector (national and local governments) must work closely in order to improve meeting the overall objectives of E-waste management. Governments require the assistance from the private sector to develop proper infrastructure to turn the growing E-waste problem into an opportunity. Environmentally-sound and economically-efficient resource recovery and recycling of E-waste cannot be achieved by public sector (national or local governments) alone. In this regard it is very useful to explore the strengths that the private sector can bring in to assist the public sector that is charged with solid waste collection responsibilities. Local governments need to explore opportunities to create shared value, where businesses and the community benefit from a product or service provided by the private sector. Private sector firms can derive economic benefits by reducing risk, enhancing productivity, and expanding markets, while making a substantive contribution to improved and equitable service delivery by local government.

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