E-Waste Think Tank

Review and Synthesis

May/June 2008
Canberra, Australia

Elizabeth Noble
Project Officer
Canberra Environment and Sustainability Resource Centre

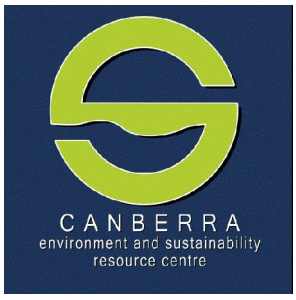


Table of Contents

List Of Tables

List of Figures

List of Boxes

Acronyms

ABS	Australian Bureau of Statistics
AIIA	Australian Information Industry Association
AMTA	Australian Mobile Telecommunication Association
ANU	The Australian National University
ARF	Advance Recycling Fee
BAN	Basel Action Network
CESA	Consumer Electronics Suppliers Association
CESRC	Canberra Environment and Sustainability Resource Centre
CUA	Clean Up Australia
DCITA	Department of Communications, Information Technology and the Arts
DEH	Department of the Environment and Heritage
EIA	Electronics Industries Alliance
EIONET	The European Environment Information and Observation Network
EEE	Electrical and Electronic Equipment
EPA	Environment Protection Authority
EPHC	Environment Protection and Heritage Council
EPR	Extended Producer Responsibility
ETC/RWM	The European Topic Centre on Resource and Waste Management
EU	European Union
GAO	The United States Government Accountability Office
IT	Information and technology
NEPM	National Environment Protection Measure
OECD	Organisation for Economic Cooperation and Development
OEM	Original Electronics Manufacturer
PC	Personal computer
PDA	Portable digital assistants
PROs	Producer Responsibility Organisations
PWBs	Printed Wiring Boards
RoHS	Restriction of Hazardous Substances
SENS	Swiss Foundation for Waste Management
StEP	Solving the E-Waste Problem
SWICO	Swiss Association for Information, Communication and Organisation Technology
TAMS	Territory and Municipal Services
US	United States
WEEE	Wasted electrical and electronic equipment

Foreword

Mobile telephones, microwaves, MP3 players, video and audio equipment, computers and many other electronic devices are now very much part of our daily life. They have transformed how we live, do business and engage socially. While offering advantages such as increasing our access to information and each other, and giving us more flexibility in communicating, there are disadvantages, particularly in the waste that is generated. This waste is called E-Waste and it has toxic components such as heavy metals. With increasing electronic products available to us, how best to manage this waste is an increasing challenge.

As reported in this paper:

- There is a trend for some electronic devices to have a decreasing lifespan - in 1992 the average life of a computer was around 4.5 years yet some 14 years later it is 2 years.
- Australians are amongst the highest users of new technology and rank fifth in the world for spending on IT equipment as a percentage of gross domestic product.
- The increasing demand by consumers to own the latest products creates inevitable wastage of the "old" items, which are superseded. Consequently, E-Waste in Australia is growing at over three times the rate of general municipal waste.
- Very little of the increasing amount of E-Waste being generated in Australia is being recycled, with most of it ending up in landfill, representing a loss of non-renewable resources.

This paper reflects the strong cooperative efforts of a very diverse range of stakeholders and also provides a strategic and practical approach towards managing E-Waste. While specific actions are recommended, the paper should also be used as a basis for discussions aimed at fostering further ideas on how best to manage E-Waste.

Australia, and in particular the ACT, is a generally affluent and technologically savvy. There is an opportunity and a responsibility to be leaders in E-Waste management and to develop innovative ways of re-using and recycling our E-Waste to benefit both our society and our environment.

While there are obvious environmental advantages in recycling E-Waste, there are also social and economic advantages such as the creation of new industries and employment opportunities. Reuse of computers for training and to provide to low-socioeconomic people with skills and access to technology is happening in some jurisdictions and shows how valuable reuse of our E-Waste can be. E-Waste is a practical example of how we can advance sustainability (i.e. achieve environmental, economic and social gains).

Dr Maxine Cooper,
Commissioner for Sustainability and the Environment

Executive Summary

The Canberra Environment and Sustainability Resource Centre (CESRC), with the support of the Australian National University (ANU) and the ACT Commissioner for Sustainability and the Environment, organised an E-Waste Think Tank in May 2008 to help establish a more strategic response to the growing problem of E-Waste in Australia. The primary aims of the event were to:

- Articulate the best realistic future for a sustainable E-Industry
- Understand issues, options and challenges for sustainable E-Industry
- Identify actions needed by different sectors
- Build partnerships among stakeholders

The event was well attended and representatives from the following organisations, institutions and departments were present:

ACT Government
ANU*green*
Australian Industry Group (AiG)
Australian Information Industry Assoc. (AIIA)
Australian Mobile Telecommunications Assoc. (AMTA)
The Australian National University (ANU)
Charity Computers
Clean Up Australia
Consumer Electronics Suppliers Assoc. (CESA)
Commission for Sustainability and the Environment Office
Dell Computers
Department of the Environment, Water, Heritage and the Arts (DEWHA)
Dick Smith Electronics Holdings
Kyocera
MRI
SEE-Change
Surveyor Resources
Theiss Services

The event was facilitated by Dr Su Wild-River from ANU*green* who began the day with a *future search process* that enabled participants to work together to identify a positive, realistic future for the E-Industry. The outcome of this was:

- Design for longevity, reusability and recyclability
- Cradle-to-cradle product cycles and closed loop systems
- IT service provision and remote data storage/'Cloud Computing'

Participants then delivered presentations in the sectors of Manufacturing and Marketing and Use, Reuse and Recycling, and Responses and Policy Actions. The issues, options and challenges for sustainability in these sectors were explored using *force field* analysis technique. Stakeholders then voted to identify priorities. The most important being:

- The Australian Government to design and implement a National framework to sustainably manage E-Waste
- Education of consumers and users of electrical and electronic equipment (EEE)

Other related priorities identified were:

- Extended warrantees and guarantees
- The introduction of full-take-back programs and/or Extender Producer Responsibility (EPR)
- Research and development (R&D) in reprocessing, reuse and recycling

Partnerships were built between representatives throughout the day and the consensus was reached that Government leadership is now needed to develop a nationwide strategy to sustainably manage E-Waste.

Introduction

This report is divided into two sections. The first section addresses what E-Waste is and why it is a problem, along with the underlying factors of E-Waste and the domestic and global responses to its management. This is approached through a review of current literature. This section is not a representation of the thoughts or opinions of either speakers or participants of the E-Waste Think Tank.

The second section of the report acts as a review of the E-Waste Think Tank. It outlines the purpose of the event and synthesises the presentations given on the day. It also lists the prioirites relating to E-Waste management that were identified by stakeholders and presents recommendations and conclusions based on these priorities.

Section One: What is E-Waste?

Electronic waste or E-Waste, as it is becoming more commonly referred to, is a generic term embracing various forms of electric and electronic equipment that have ceased to be of any use to their owners. This term can apply to a broad range of goods, including large and small household appliances; Information and technology **(**IT) equipment including computers, computer games and peripherals; cellular telephones and other telecommunication equipment; portable electronic devices such as portable digital assistants (PDAs), video and audio equipment, including MP3 players and peripherals; and electrical tools. Furthermore, many everyday commodities that were formerly considered electrical equipment, such as refrigerators, household appliances and toys, are becoming 'electronic' objects through the addition of programmable microprocessors (Hilty *et al.,* 2005, Oertel *et al.,* 2005).

Once these products reach the end of their useful life, they become E-Waste or WEEE, wasted electrical and electronic equipment. WEEE and E-Waste are terms that are often used synonymously, however, in this report; the term E-Waste will be predominantly used in reference to these products. E-Waste has been defined by Schafer *et al.* (2003) as any equipment that is dependent on electric currents or electromagnetic fields in order to work properly, including equipment for the generation, transfer, and measurement of current. However, at this point in time, there is no standard definition of what constitutes E-Waste. Table 1 lists other selected definitions.

Table 1: Overview of Selected Definitions of E-Waste

Reference	Definition
EU E-WASTE Directive (EU, 2002a)	"Electrical or electronic equipment which is waste. . . including all components, sub-assemblies and consumables, which are part of the product at the time of discarding." Directive 75/442/EEC, Article 1(a) defines "waste" as "any substance or object, which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force."
Basel Action Network - BAN (Puckett and Smith, 2002)	"E-Waste encompasses a broad and growing range of electronic devices ranging from large household devices such as refrigerators, air conditioners, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users."
Organisation for Economic Cooperation and Development - OECD (2001)	"Any appliance using an electric power supply that has reached its end-of-life."
Sinha (2004)	"An electrically powered appliance that no longer satisfies the current owner for its original purpose."
Solving the E-Waste Problem - StEP (2005)	E-Waste refers to " . . .the reverse supply chain which collects products no longer desired by a given consumer and refurbishes for other consumers, recycles, or otherwise processes wastes."

Source: Widmer *et al.,* 2005.

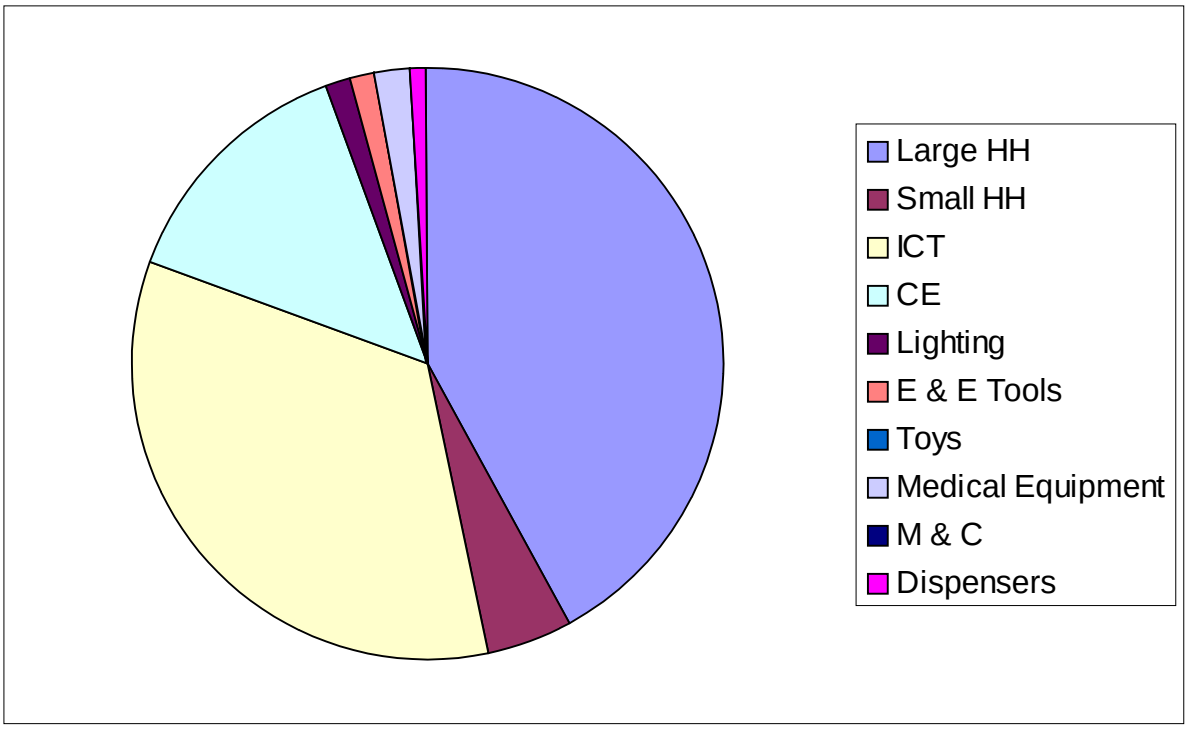
Table 2: E-Waste Categories According to the EU Directive on E-WASTE

No.	Category	Label
1	Large Household Appliances	Large HH
2	Small Household Appliances	Small HH
3	IT and Telecommunications Appliances	ICT
4	Consumer Equipment	CE
5	Lighting Equipment	Lighting
6	Electrical and Electronic Tools	E & E Tools
7	Toys, Leisure and Sports Equipment	Toys
8	Medical Devices	Medical Equipment
9	Monitoring and Control Instruments	M & C
10	Automatic Dispensers	Dispensers

Source: Widmer *et al.*, 2005.

According to the definitions in the European Union Directive on Waste Electrical and Electronic Equipment (EU, 2002a), E-Waste consists of the ten categories listed in Table 2 (Widmer *et al.*, 2005). Of the ten categories listed in Table 2, Categories 1–4 account for almost 95% of the E-Waste generated in the EU (see Fig. 1).

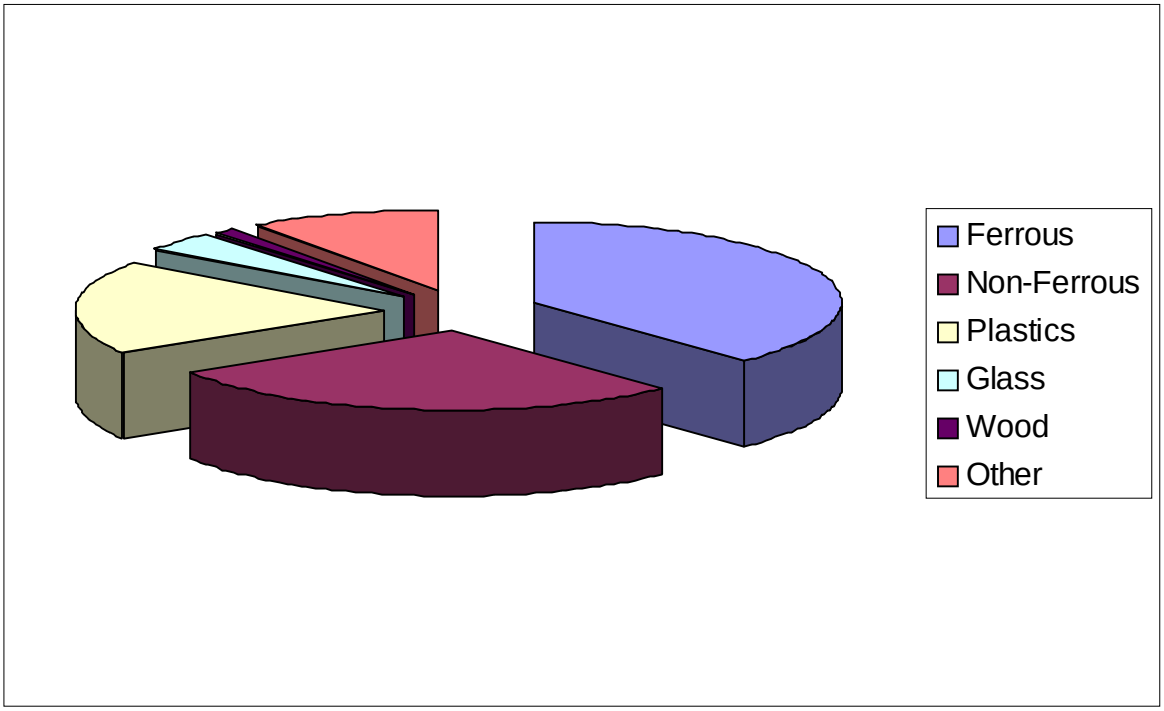
Figure 1: Composition of E-Waste in the EU



Source: Widmer *et al.*, 2005.

E-Waste is made up of a diverse range of materials, making it difficult to give a generalized material composition for the entire waste stream. However, most studies examine five categories of materials: ferrous metals, non-ferrous metals, glass, plastics and "other". These various elements found in E-Waste are represented in Figure 2.

Figure 2: Materials Found in Electronic Equipment



Source: Zhang and Forssberg, 1997.

It is estimated that about 66% of E-Waste by weight consists of metals such as iron, copper, aluminium and gold (Babu *et al.*, 2007). According to The European Topic Centre on Resource and Waste Management (ETC/RWM, 2003) iron and steel are the most common materials found in electrical and electronic equipment and account for almost half of the total weight of E-Waste in Europe. Nonferrous metals such as aluminium, copper and some precious metals make up about 13% of the European E-Waste stream (Babu *et al.*, 2007). Plastics are the second largest component by weight representing approximately 21% of E-Waste (Wilkinson *et al.*, 2001, ETC/RWM, 2003). Glass accounts for an estimated 5.4% of the total weight of waste from electric and electronic equipment every year in Europe (Theisen, 2002).

Why is E-Waste a Problem?

Toxicity

When E-Waste is disposed of or recycled without strict controls, there are negative impacts on the environment and human health. Over time, the ferrous and non-ferrous metal content has remained the dominant fraction of E-Waste, representing well over 50%; however, electronic waste still also contains pollutants and hazardous components. E-Waste should not be combined with unsorted municipal waste that is disposed of in landfill because electronic waste can contain more than 1000 different substances, many of which are toxic, such as lead, cadmium, mercury and hexavalent chromium (Babu *et al.,* 2007). Some of the harmful effects of these heavy metals on human health are given below.

Lead
The negative effects of lead have been well documented for many years and the risks associated with lead poisoning are both established and recognised. Lead causes damage to the central and peripheral nervous systems, blood systems, kidney and reproductive system in humans. The main applications of lead in computers are in glass panels and gaskets in computer monitors (1.5 – 3.5kgs per monitor), and solder in printed circuit boards and other components.

Cadmium
Cadmium compounds pose a risk of irreversible effects on human health due to their toxicity and ability to bioaccumulate (Jarup & Vonkema, 1995). Cadmium occurs in components including surface mount devices, chip resistors, infrared detectors, and semiconductor chips.

Mercury
Mercury is used in thermostats, sensors, relays, switches (e.g. on printed circuit boards and in measuring equipment), medical equipment, lamps, mobile phones and in batteries. Mercury can cause serious damage to organs including the brain and kidneys. Most importantly, the developing foetus is highly susceptible through maternal exposure to mercury (EU Explanatory Memorandum, 1999 cited in Babu *et al.*, 2007).

Hexavalent Chromium/Chromium VI
Chromium VI is used for corrosion protection of untreated and galvanized steel plates and as a hardener for steel housings. It easily passes through cell membranes and is absorbed by the body, producing various toxic effects (EU Explanatory Memorandum, 1999 cited in Babu *et al.,* 2007).

Other harmful substances in E-Waste include arsenic, polychlorinated biphenyls (PCBs), chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), nickel, and asbestos (Ogilvie, 2004). When these chemicals are present in E-Waste, even in small amounts, they can act as potent pollutants and contribute to toxic landfill leachate and

vapours, such as the vapourisation of metallic and dimethylene mercury. In addition, fires may also begin and burn uncontrollably in landfills, releasing extremely toxic dioxins and furans (dioxin-like compounds) into the atmosphere.

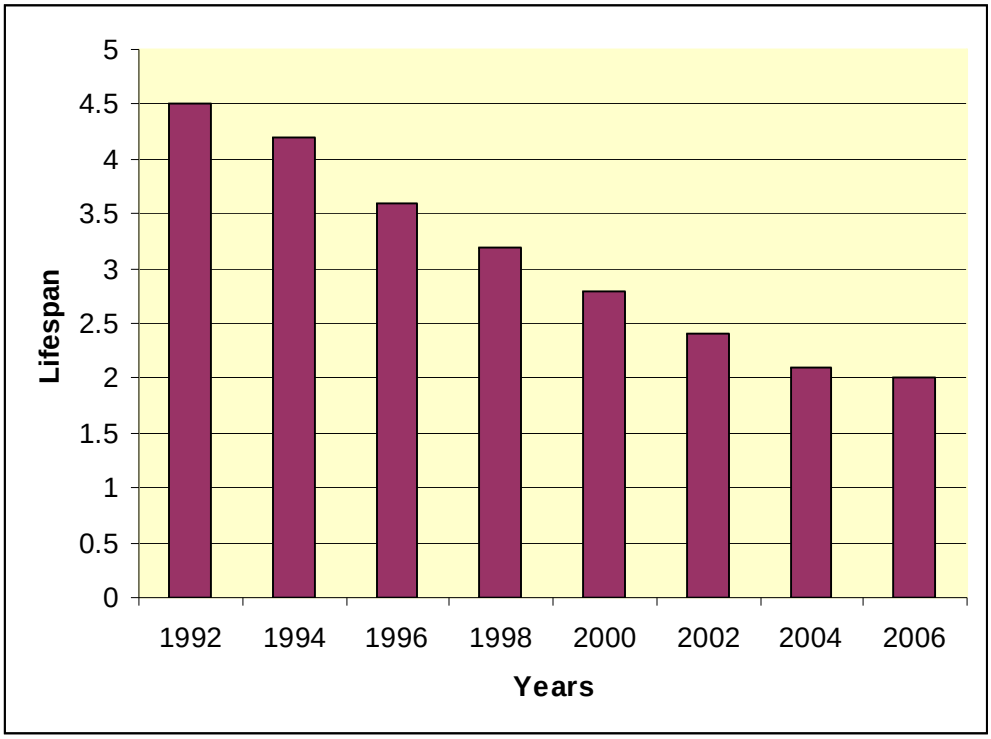
Growth of the E-Industry and Obsolescence

Another major problem associated with E-Waste is the speed with which it is generated. E-Waste is one of the fastest growing areas of the international waste stream and is increasing at a much higher rate than all other waste streams (Herat, 2007). It was reported in the Economist, that E-Waste accounts for 8 % of all municipal waste (The Economist, 2005).

Computers, a huge contributor to E-Waste, have delivered a revolution in information and communication technology and transformed life in the second half of the 20_{th} century. With the rapid growth of the electronics industry internationally, the IT sector is growing exponentially. Computers, which are the major component of IT, are seen as a basic necessity for business, government and the individual consumer for the purposes of accessing the broad spectrum of information now available through the Internet. They have increased significantly in terms of numbers, as well as speed, memory and power, leading to rapid product obsolescence (Herat, 2007). Software companies constantly generate new programs that fuel the demand for more speed, more memory and higher power. Today, it is frequently much cheaper and more convenient to buy a new machine to accommodate a newer generation of technology than it is to upgrade the old instrument. As a result of technology, development and higher standards for personal computers (PCs), the average lifespan of a PC was 4.5 years in 1992, but this value was estimated to decrease to only 3 years in 1999 and to further decrease to 2 years in 2005 (National Safety Council, 1999, Widmer *et al.*, 2005). Figure 3 shows this change in PC lifespan.

According to Matthews *et al*., (1997) estimations, approximately 500 million PCs reached the end of their service lives between 1994 and 2003. Based on these figures, 2 872 000 tonnes of plastics, 718 000 tonnes of lead, 1363 tonnes of cadmium and 287 tonnes of mercury entered landfill during this time. In the 2002, a report from the Basel Action Network concluded that the obsolescence of 315 million computers left approximately 1.2 billion pounds of lead, 2 millions pounds of cadmium, and 4 billion pounds of plastics in the waste stream (Puckett & Smith, 2002). Realff *et al.,* (2004) confirm such reports, claiming that consumer electronics are responsible for up to 40% of the lead in landfills, and about 70% of heavy metals (such as mercury and cadmium) in US landfills come from electronic waste. These toxins can cause brain damage, allergic reactions and cancer (Puckett & Smith, 2002).

Figure 3: Decreasing Lifespan of Computers



Source: National Safety Council, 1999.

The Underlying Factors of E-Waste

Manufacturing and Design

The growth of the E-Industry and in turn the shortened lifespans of Electrical and Electronic Equipment (EEE) can be seen in close connection with manufacturing and design processes. The current design of EEE and particularly computers is a significant problem because the manufacturing processes of the E-Industry are linear in nature and adhere to the standard "profit" focused approach (Herat, 2007). Doppelt (2003) refers to this approach in his book *Leading Change Toward Sustainability: A Change-Management Guide for Business, Government and Civil Society*, as "take-make and waste". Herat (2007) refers to the products we develop as messengers between the acts of production and consumption and suggests that they provide a possible key to the progression of sustainability. However, this progression depends on ensuring design is integrated and circular and that the linear approach to manufacturing is abandoned.

Consumer Culture

Is it possible for the E-Industry to design and manufacture products that are made to last and which support the idea of reuse in such a consumerist culture? The issue of consumerism is one that cannot be dealt with in detail here. However, it is important to at least consider the cultural aspects that contribute to E-Waste generation.

In recent history material wealth has increased, particularly in the developed world. This accumulation has reduced time to money and potential leisure is often sacrificed to work in order to earn the resources to pile up still more goods (Cross, 1993). Dominant social values have become organised through consumption practices, leading to contemporary society as described as materialistic, hedonistic, or more positively, as a society of choice. This consumerist bias has been acquired over a long period. It has emerged out of complex cultural, political and economic contexts.

Economist Victor Lebow's famous quote from 1955 –

> "Our enormously productive economy ... demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we seek our spiritual satisfaction, our ego satisfaction, in consumption.... we need things consumed, burned up, replaced, and discarded at an ever-accelerating rate."

makes it difficult to decipher if this culture of consumption has been prescribed by economics or whether it has been a societal choice (Suzuki, 2003). Debating whether consumerism has lead to the increase of obsolescence or the other way around, is however, not the question that needs considering. What is of more importance is to recognise the underlaying factors of consumerism and disposability that greatly the affect the situation of E-Waste domestically and globally.

The International Situation of E-Waste

As E-Waste extends across a number of industry sectors and is a relatively new focus of environmental concern, it is difficult to ascertain accurate data and trends regarding its generation, reuse, recycling and disposal. This difficulty is largely due to the lack of a uniformly accepted definition of E-Waste, which has made record keeping and accounting problematic (Babu et al., 2007).

As previously mentioned, E-Waste constitutes the fastest growing waste fractions generated worldwide. The disposal rate of this waste stream is consequently also accelerating because the global market for electronics is far from saturated, and the lifespan of electronic goods is becoming shorter, so that obsolete equipment disposal is increasing. Whilst the countries of the OECD have highly saturated markets for EEE and generate the majority of E-Waste, the market penetration of EEE in industrialising countries is not very high. Despite this, developing countries show the fastest growing consumption rates for EEE, and thus large quantities of domestically generated E-Waste will soon become a major part of their waste stream in the near future (Widmer et al., 2005).

In Europe, the production of EEE is a hugely expanding business sector (Cui & Forssberg 2003) and it is expected the growth rate of E-Waste will increase by at least 3 to 5% per year (Hischier *et al*., 2005). E-Waste is already recognised as the fastest growing waste stream in the European Union (EU), with estimates of up to 20 kg per person per annum (Darby & Obara, 2005). Although the per capita waste production in populous industrialising countries such as China and India is still relatively small and estimated to be less than 1kg of E-Waste per person per year, the total absolute volume of E-Waste generated in these countries is huge (Widmer *et al.*, 2005). Additionally, some developing and industrialising countries import considerable quantities of E-Waste, even though the Basel Convention (Box 1) restricts transboundary trade of such waste. Figure. 4 illustrates the main E-Waste traffic routes in Asia. There are, however, no confirmed figures available on how substantial these transboundary E-Waste streams are. According to BAN, non-ratifying countries, such as the USA, ship 50–80% of their collected domestic E-Waste to destinations such as China (Puckett and Smith, 2002).

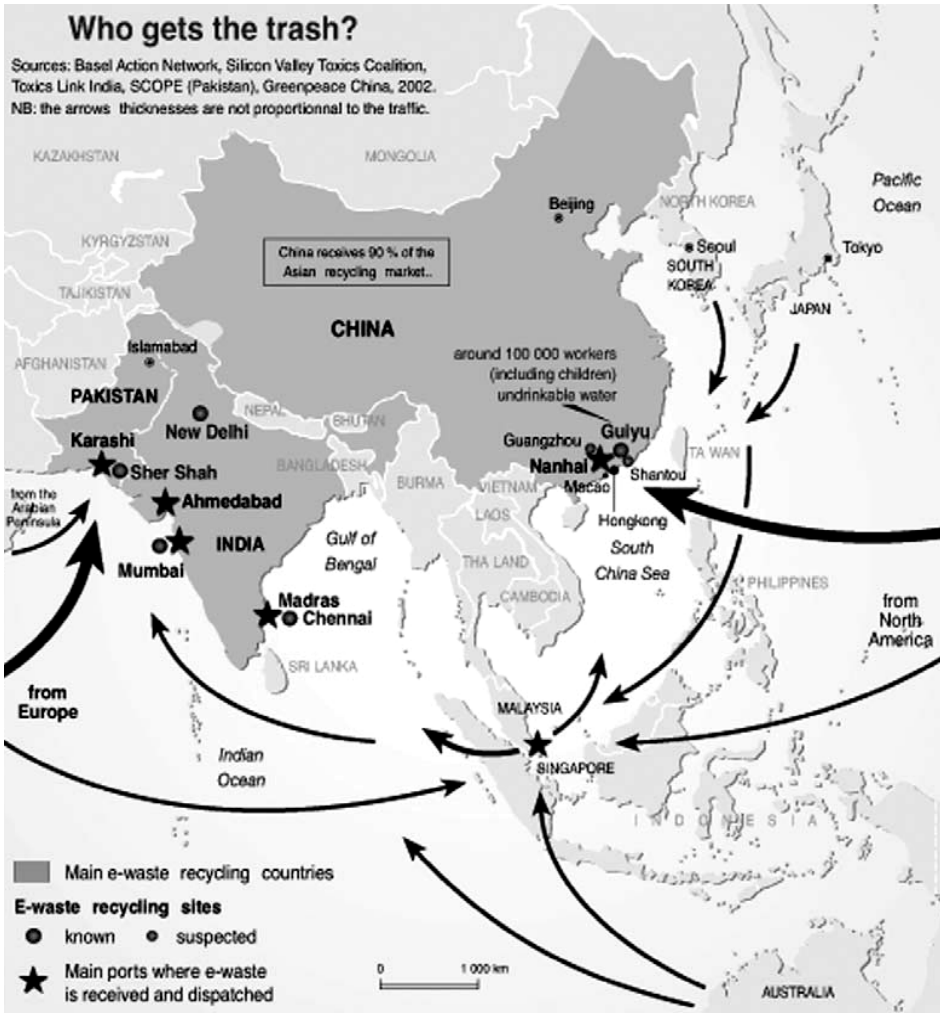
A variety of collection systems exist in different countries to manage E-Waste. In some cases, collection is conducted via local municipalities with the support of the original electronics manufacturers (OEMs), who in many countries are already responsible for the collection of E-Waste (Babu *et al.*, 2007). Considering the amount of metal, glass and plastic in such waste, its recycling and reuse seems logical. However, the success of E-Waste recycling depends on the cost of labour, the structure of the economy, the existing regulatory framework, and the possibilities and limits of law enforcement. These factors must be considered in order to find solutions that can improve the situation with regard to environmental impacts, occupational hazards and economic revenue (Babu *et al.*, 2007). This report will now consider current collection and recycling practices around the world to give a brief overview of the international situation of E-Waste management.

Box 1: The Basel Convention

The most prominent example of an international initiative aimed at controlling the management of E-Waste is the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (in force since 1992). The Convention puts an onus on exporting countries to ensure that hazardous wastes are managed in an environmentally sound manner in the country of import. Article 2 of the Convention defines waste as 'substances or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law'. Apart from Afghanistan, Haiti, and the United States of America, all 164 signatory countries have ratified the convention (Secretariat of the Basel Convention, 1999). The transboundary movement of E-Waste is regulated by the Basel Convention as it is considered to be dangerous to humans and the environment under the List A of Annex VIII of the Convention (UNEP, 1989).

Source: Widmer *et al.*, 2005, Babu *et al.*, 2007.

Figure 4: Asian E-Waste Traffic



Source: Schwarzer *et al.*, 2005.

Europe

Traditionally in Europe (and elsewhere), the legislative approach toward environmental problems has been one of 'command and control', aimed at solving 'end-of-pipe' pollution problems (Bailey, 2002; Darby and Obara, 2005). Now, the emphasis is changing towards producer responsibility whereby those who produce goods are responsible for the environmental impacts throughout the whole of their life cycle, from resource extraction to recycling, reuse and disposal (Nnorom & Osibanjo, 2008). The primary example of this came about in January 2003, with the European Commission-WEEE Directive (2003), which adopted regulations relating to five categories:

1. EEE product design
2. E-Waste collection
3. E-Waste recovery
4. E-Waste treatment and treatment financing
5. EEE user awareness.

The principal aim of the directive is to raise awareness of end-of-life factors during product design. These factors include dismantling of parts and recyclability of materials, appropriate collection systems that support separate collection of E-Waste to reduce disposal in common municipal waste streams, and best practices for management, recovery and recycling of E-Waste (Nnorom & Osibanjo, 2008). In addition, according to the type of E-Waste, producers should conform with the minimum recovery rates (70–80% by weight) and "component, material and substances reuse and recycling" rates (50–80% by weight) (European Commission -WEEE Directive, 2003). Distinctions are also made in relation to the source of the E-Waste: private/non-private, historical/new (European Commission-WEEE Directive, 2003).

Implementation has proved difficult, although some EU countries such as the Netherlands and Greece are already employing the regulation. Countries with no previous experience of E-Waste management have sought extensions to comply with the directive (Magalini and Huisman, 2007). Two major causes delaying the implementation of the directive are:

1. The complications of transferring/integrating previous regulations (e.g., Austria, Belgium, Denmark, Sweden and Luxembourg)
2. Negotiations with stakeholders regarding responsibilities in the process (e.g., France)

(Magalini and Huisman, 2007).

The European Union Restriction of Hazardous Substances (RoHS) Directive restricts (beginning July 2006) the use of six hazardous compounds: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers, commonly found in EEE (European Commission-RoHS Directive, 2003).

Switzerland and Extended Producer Responsibility (EPR)

Other European nations outside of the EU have also been addressing the handling of E-Waste. Switzerland was the first country to implement an industry-wide organised system for the collection and recycling of E-Waste. The effective collection of E-Waste in Switzerland is primarily due to the efficient management of the waste stream by two Producer Responsibility Organisations (PROs): the Swiss Association for Information, Communication and Organisation Technology (SWICO) for office, dental, graphic and telecommunication equipment and Swiss Foundation for Waste Management (SENS) for household appliances (Hischier *et al.,* 2005). Both SWICO and SENS have extensive experience in managing E-Waste and began their programs based on the principle of Extended Producer Responsibility (EPR). Lindhqvist (2000) defines EPR as:

> "An environmental protection strategy to reach an environmental objective of a decreased total impact from a product, by making the Manufacturer of the product responsible for the entire life cycle of the product and especially for the take back, recycling and final disposal of the product"

The system rests on secured financing of the collection and recycling by way of the Advance Recycling Fee (ARF) charged on new products. This fee is used to fund the collection, transport and recycling of products at their end-of-life. Various levels of independent controls that monitor free riding ensure that the recyclers maintain quality and environmental standards (Sinha-Khetriwal *et al.,* 2005), making certain retailers and consumers participate in the system. As a signatory to the Basel Convention, Switzerland does not authorize the export of e-waste to non-OECD countries (Sinha-Khetriwal *et al.,* 2005). Controls prevent the illegal import and export of E-Waste to and from Switzerland and require documentary evidence that disposal is environmentally appropriate and in line with policies of the importing country.

The introduction of legal frameworks by several OECD countries such as Switzerland and notably by the EU is not only intended to forward E-Waste management systems but also better product designs (Widmer *et al.,* 2005). These frameworks are working to raise awareness and revolutionise production in non- OECD countries. Exports to the EU are at stake both due the restrictions on hazardous substances (RoHS Directive) and the required compliance with the WEEE Directive, foremost due to the financial implications it brings with it of guaranteeing that all EEE imported into the EU is recycled (Widmer *et al.,* 2005).

America

The United States (US) is one of the largest producers of E-Waste in the world (Davis & Herat, 2008). Gibson and Tierney (2006) estimate 2.2 million tonnes of E-Waste was generated in the US during 2000. The majority of this waste was exported to developing countries such as China and India. By 2002, such practice began raising concerns amongst environmental groups and although it appears that the situation has improved since then The United States Government Accountability Office (GAO) claims recycling and re-use of EEE is not supported by economic incentives or enforced by federal regulations, which also allow hazardous used electronics to be disposed in landfills and exported to developing countries (GAO, 2005, cited in Davis & Herat, 2008).

In the absence of national legislation, individual States are addressing the E-Waste issue by developing and implementing legislation covering areas such as landfill disposal bans and comprehensive recycling legislation (Davis & Herat, 2008). Davis and Herat (2008) report that as of April 2007, seven States (Arkansas, California, Maine, Massachusetts, Minnesota, New Hampshire and Rhode Island) have banned the landfill disposal of various types of electronic waste and four States (California, Maine, Maryland and Washington) have passed comprehensive e-recycling legislation. California is implementing an ARF, while the other States are putting an EPR system in place.

Additionally, in May 2007 the Electronics Industries Alliance (EIA) released a framework that has laid the foundation for Federal legislation, which aims to put a national program in place for recycling televisions and IT products. It proposes separating televisions from computers to reflect their divergent business models, market composition and consumer base. Televisions are to be collected and recycled by an industry-sponsored third party and supported by a nominal fee paid by consumers at the point of purchase, which would eventually expire, once a significant number of "legacy" sets are recovered (Davis & Herat, 2008). The manufacturers of IT products would have to implement a collection and recycling program that is convenient and free for household consumers as a condition of conducting business (EIA, 2007).

China and India

Some developing and industrialising countries import considerable quantities of E-Waste. Some imports arrive as donations meant to help "the poor", while others are simply mislabeled (Widmer *et al.,* 2005). In certain countries such conditions are worsened by a lack of regulations and/or enforcement in the recycling and disposal sector. This allows a profitable E-Waste recycling sector to develop which relies on risky low-cost techniques and low-income labour (Figure 5). In China and India, purely business-driven E-Waste recycling systems have emerged without any government intervention. These complex systems are executed by a very entrepreneurial informal sector, reflecting a long tradition in waste recycling. Rag pickers and waste dealers have adapted to the influx of E-Waste and a large number of new businesses have been created in re-using components or extracting secondary raw materials. Most of the people employed in such informal

sectors do not realise the potential environmental and health risks such work poses and are either unaware of better practices or are without capital to finance improvements or implement safety measures (He *et.al*, 2006).

Figure 5: The extraction of copper from printed wiring boards (PWBs)

(1) Manually removing varnish, (2) Recovering copper-sulphate after submerging PWBs for 12 h in sulphuric acid followed by boiling off H2O using PWB residues as a fuel, (3) Manually segregating the copper layer and glass fibres after burning multi layer PWBs which are resistant to acid.
Source: Empa Survey 2004 cited in Widmer et al., 2005

In India, waste collectors pay consumers a positive price for their obsolete appliances who in turn sell to traders who aggregate and sort different kinds of waste and sell it to recyclers who recover the metals (Sinha-Khetriwal *et al.,* 2005). According to Baud et al., (2001), these trade and recycling alliances provide employment to many groups of people (Baud et al., 2001). Unfortunately, given that most businesses operate out of backyard workshops (Empa, 2004), there are no figures available regarding the scale of the business or the number of people it employs. Empa (2004) reports that in Delhi the number of unskilled workers in recycling and recovering operations to be at least 10,000. Sinha-Khetriwal *et al.* (2005) maintain that the biggest drawback of the current Indian system is the uncontrolled emission of hazardous substances into the air, water and soil which not only affect the workers who come into contact with the waste, but also the environment.

Chinese domestic E-Waste is becoming an important waste stream in terms of toxicity and quantity, with stockpiles approaching a peak. China is also the destination for a large proportion of E-Waste shipments from developed countries, although actual figures are unavailable (Liu *et al.,* 2006). In response to the inflow of E-Waste, the Chinese government announced a ban on the importation of E-Waste, which came into force on 15 August 2002 (SEPA, 2002). However, some reports claim that E-Waste imports are still an increasing problem and are spreading from the primary Guangdong Province to other regions (Liu *et al.,* 2006). This is exacerbated by the fact that legislation to regulate domestic E-Waste recycling has not yet been finalised and individual collectors form the main channel for such waste. Approximately 60% of the total discarded E-Waste is collected by individual peddlers (Beijing Morning News, 2005 cited in Liu *et al.,* 2006).

As in India, consumers are paid for their obsolete appliances by traders who then sell these products to small backyard workshops where they are processed primarily through manual disassembly and open burning.

The development of small-scale and informal recycling processes has had serious adverse impacts on the environment and human health in some regions of China (Liu et al., 2006). This impact has forced stakeholders to recognise how important the establishment of a regulated E-Waste management framework is, however, as in India, progress with regard to legislation, the collection system and the construction of formal recycling facilities is slow.

In the expectation of having the WEEE and RoHS Directives transposed and enforced soon, China and India are moving towards solving their domestic E-Waste issues (Widmer *et al.,* 2005). The Chinese government has designated Zhejiang province to enforce the WEEE legislation as a pilot for later replication in other provinces (Liu *et al.*, 2006). India has set up WEEE Strategy Groups to develop a comprehensive WEEE management system. These strategy groups consist of key delegates such as government agencies, EEE producers' and importers' associations, recyclers and NGOs. These groups focus on the specifics of policy and legislation formulation, the creation of a national E-Waste baseline, the restructuring of the E-Waste recycling sector, the implementation of EPR and the creation of public awareness (Widmer *et al.,* 2005).

E-Waste in Australia

Australians are amongst the highest users of new technology and rank fifth in the world for spending on IT equipment as a percentage of gross domestic product (ABS, 2006b). However, the increasing demand by consumers to own the latest products creates inevitable wastage of the "old" items, which are superseded. Consequently, E-Waste in Australia is growing at over three times the rate of general municipal waste (ABS, 2006a). Very little of the increasing amount of E-Waste being generated in Australia is being recycled, with most of it ending up in landfill, representing a loss of non-renewable resources (ABS, 2006a). It has been estimated that in 2006 there was around 1.6 million computers disposed of in landfill, 1.8 million in storage (in addition to the 5.3 million already gathering dust in garages and other storage areas) and only 0.5 million recycled in Australia (DCITA, 2002).

At this point there is no national regulatory framework to deal with E-Waste in Australia. The absence of any Federal regulations regarding E-Waste often places the responsibility of developing strategies to deal with this issue on individual local councils (Davis & Herat, 2008). Consequently, the current disassembly and recycling of such waste in Australia is very piecemeal, with each State or Territory taking a different approach to the problem (Environment Victoria, 2005).

The ACT is the only jurisdiction that bans computer waste to municipal landfill. Since January 2004, the ACT's policy has been to divert computers from landfill to be recycled (TAMS, 2006). However, these end-of-use computers, along with those accumulated in other States and Territories, can be exported for reuse in developing and industrialising countries if the consignment complies with the relevant Federal statutes (Environment Victoria, 2005). The *Hazardous Waste (Regulation of Exports and Imports) Act 1989* regulates the transboundary movement of hazardous wastes to and from Australia as required under the Basel Convention (Box 1), to which Australia is a signatory. Under the *Hazardous Waste Act* and the Basel Convention, material that is going to be re-used for its original purpose is not regulated as waste. The onus then rests on exporters (or importers) to verify the status of waste before its export. This self-assessment process would be far more rigorous if E-Waste was classified as hazardous and its transport tracked as required under the National Environment Protection Measure – Movement of Controlled waste between States and Territories (NEPM) (Environment Victoria, 2005).

Australia has had little capacity to recycle E-Waste, nor any incentives to invest in reprocessing facilities (Environment Victoria, 2005). Current E-Waste recycling initiatives are largely driven by brandowners that have undertaken their own schemes, such as Dell Computers. In 2006(a), the ABS reported that Australian governments have been working with the EEE industry to facilitate the establishment by industry of product stewardship schemes to collect and recycle used equipment. The Recycle IT pilot undertaken in NSW in 2002/2003 for the recycling of computers is an example of this. The more recent Byteback program is another. Byteback claims to be "an Australian first as government and industry are sharing responsibility for disposing of computer waste safely. Sustainability Victoria is running Byteback in partnership with the Australian Information Industry Association (AIIA) and founding partners Apple, Canon, Dell, Epson, Fujitsu, Fuji-Xerox, HP, IBM, Lenovo, and Lexmark."(2008). However, some still argue that Australia is lagging far behind the rest of the world in combating the E-Waste problem.

Jane Castle, a resource conservation campaigner for a Sydney-based Environmental Non-Government Organisation (ENGO) claims that whilst initiatives such as Byteback are worthwhile, they detract attention from the more important step of achieving significant government intervention (Castle in Henty, 2007). It has been reported that within the next few years, 30 countries will have implemented take-back laws for electronics (Environment Victoria, 2008). "Europe, Canada, the US, Japan and many other countries have mandated extended producer responsibility which requires computer producers to collect and recycle, but Australia has stalled for a decade" (Castle quoted in Henty, 2007). Federal Environment Minister Peter Garrett was recently quoted in the Epoch Times (2008) stating a solution to Australia's E-Waste problem is currently being sought. 'The Australian government and Environment Protection and Heritage Council are actively working with industry on a range of product stewardship options such as voluntary codes of conduct and recycling schemes."

According to some, this is a flawed strategy, and mandating producer responsibility for E-Waste is the only way that Australia can drive better product design, production and

waste management (Environment Victoria, 2005). Australia's federalist system of government, the fragmented nature of the E-Industry and the lack of economic incentives make the development of voluntary industry schemes difficult and "have been used as excuses to procrastinate on reaching agreement on a national take-back and recycling scheme" (Environment Victoria, 2005). The Federal Government is being pressed to fast track a national scheme for managing Australia's E-Waste. Managing Director of Panasonic Australia, Steve Rust stated, "E-waste is one of the most significant environmental issues facing Australia and the time to begin implementing a national … recycling scheme is now. The more a national initiative is delayed, the more dire the consequences for the Australian environment" (Australian IT, 2008).

Section Two: E-Waste Think Tank

The Canberra Environment and Sustainability Resource Centre (CESRC), with the support of the Australian National University and the ACT Commissioner for Sustainability and the Environment, organised an E-Waste Think Tank on May 21, 2008.

The aim was to help establish a more strategic response to the growing problem of E-Waste in the ACT and Australia. Organisers envisaged that the event would promote positive thinking and action, help form partnerships, and provide a model for further action at a national or even international level, including further engagement with the full range of stakeholders in the future.

The event was by invitation only, and involved 23 people, each of who are connected in some way to the E-Waste issue. All participants were provided with an outline of the main aims and outcomes of the event, prior to the day. They were as follows:

1. Articulate the best realistic future for a sustainable E-Industry.

2. Develop a clear understanding of issues, options and challenges in building a sustainable E-Industry.

3. Identify actions needed by different industry sectors in moving towards a sustainable E-Industry.

4. Build partnerships amongst stakeholders to foster a more cooperative and holistic approach to creating a sustainable E-Industry.

5. Produce a brief synopsis of the event that will be delivered to all speakers and participants.

6. Produce an article that will be published.

The day was divided into four sections. The first section included a welcome and introduction by the Director of CESRC, Dr Robin Tennant-Wood, followed by a Future Scenarios Exercise, lead by Dr Su Wild-River, who also acted as facilitator on the day. This exercise introduced scenarios as a tool to plan creatively, tap into the imagination and anticipate the future of the E-Industry. These future scenarios and priorities then acted as reference points throughout the day (Appendix A). A summary of the main priorities, as identified through a voting system, is presented in Table 3.

Table 3: Priorities for the future of the E-Industry

1.	Emphasis on design for longevity, reusability and recyclability. Cradle-to-cradle product cycles, where components are broken down and raw materials are perpetually circulated in closed loops, maximising material value without damaging ecosystems.
2.	Wireless, digital and universal devices that are compact, portable, ergonomic and multi-functional. Such equipment should process and store data remotely ('cloud computing') and operate easily upgradeable software.
3.	IT services are purchased online rather than business owned products from retail outlets and all equipment requires low-power and runs on renewable energy, reducing greenhouse gas emissions.

Manufacturing and Marketing

The second section of the day aimed to address Manufacturing and Marketing within the E-Industry in Australia. There were five presentations delivered in this section by a range of speakers from industry groups, research institutes and the manufacturing industry. A brief synopsis of each presentation is given below.

Dr Royston Gustavson - ANU School of Management, Marketing, and International Business

'Demand and Design: Strategies for reducing the creation of E-Waste'

Dr Gustavson offered an interesting perspective of E-waste by considering the issue in terms of consumption and design for the environment. He believes that "consumption is embedded in social and cultural practices" and that it is through such practice that we construct our identities, make sense of our place in the world, and communicate that identity and status to others. Consumption is also fuelled by the desire that people have to possess *new* things. And it is consumption that is responsible for pollution, in the first instance.

Dr Gustavson stated that one way of reducing the E-Waste problem is through a shift from product sales to service delivery that will fulfil consumer demands with less impact on the environment (called Product-Service Systems by the UNEP; or a Service and Flow Economy by Hawken, Lovins, and Lovins). This encourages the manufacturer to make products that are designed to last as they will have an ongoing cash flow, rather than needing to seek repeat purchases.

Another way of minimising E-Waste that Dr Gustavson addressed was that of product design. He did this through highlighting three priorities used in Hewlett Packard's Design for Environment Program (1992):

- Energy efficiency
- Materials innovation
- Design for recyclability

These principles are difficult to incorporate into manufacturing processes given the competitive climate of the E-Industry, however, Dr Gustavson suggested that government regulation, or the threat of regulation, to encourage voluntary initiatives should be used to encourage change. Increasing both warranty periods and the income tax effective life of depreciating assets may increase the length of use of equipment, thereby reducing the amount of E-Waste produced.

David Finn - Managing Director Kyocera Mita

"Kyocera … believes in the concept of product stewardship. Manufacturer[s] should take responsibility for their products at the end of their life cycle… Kyocera believes Complete Take Back should be the policy for all manufacturers."

David Finn explained Kyocera's dedication to providing a Complete Take Back service to its customers. KyoCollect delivers a container to the participating business, in which they can put all printer waste products, which will then be collected and fully recycled by Kyocera. He claimed take back encourages the use of environmentally safer components and fewer materials in production and longer lasting design. Kyocera's cartridge-free printers and removal of lead from their processing supports this idea.

He also addressed Kyocera's consideration of the environmental costs associated with packaging and freight logistics by development of lighter products and smarter, 'cleaner' packaging. No chemical adhesives or toxins are used in packaging and Kyocera is a signatory to the National Packaging Covenant.

Catherine Dickson - Sustainability Director Dell Computers

In her presentation, Catherine Dickson gave an insight into Dell's approach to E-Waste recovery. She reported that Dell see equipment recovery and recycling as part of lifecycle management. Dell has been taking practical action with an Australian consumer recovery program that was launched in 2004, making them the first manufacturers to offer no-charge consumer recycling. Dell recycles unwanted Dell-branded products free of charge. In addition, they offer free recycling for orphaned and historical products if consumers buy new Dell products. They are also participants in the Byteback pilot that is currently partnering industry and government to share the responsibility for E-Waste management.

Considering Dell is a forerunner in the E-Industry, Catherine suggested a framework for future action on the issue of E-Waste and model legislation. These are outlined below:

Policy framework
1. Individual producer responsibility
2. Clear and achievable recycling standards
3. Consumer choice (convenience and education)
4. Accountability and Transparency (standards-based)
5. Enforcement that allows for equity
6. Simple, flexible and efficient collection and recovery systems

Model legislation
1. Manufacturers to provide recycling services to consumers without charge. These services must meet government standards.
2. Manufacturers have the flexibility and incentive to develop their own systems, partner with other manufacturers, non-profit groups, recyclers or other third parties, or adopt other innovative solutions.
3. Manufacturer cannot sell IT products unless a) its products carry the manufacturer's brand name; and b) it has a no charge recycling program.
4. Manufacturers incented by Government to recycle whitebox & orphaned waste i.e. via green procurement requirements.

Rhett Somers - Australian Information Industry Association (AIIA)

In his presentation Rhett Somers firstly addressed the focus areas for AIIA in environmental sustainability. These are connected to product stewardship and fall across three main areas.

- Smart design – life-cycle approach and end-of-life considerations
- Energy efficiency – regulations and compliance standards
- Waste management – collection reuse and recycling

Rhett also explained that the AIIA's focus in waste management has been on designing the best realistic waste management program that can be adopted across the industry on a national scale. This would require AIIA members to agree to pay for their own waste, but only through the creation of a level playing field.

This was followed an introduction to the Byteback program. Byteback is a free service, available to residents and small business owners in Victoria to dispose of end-of-life computers in an environmentally responsible way. AIIA's first priority is to encourage non-participating brands to join Byteback. Secondly, AIIA wants government at all levels to be actively selecting sustainable suppliers of ICT equipment. AIIA is also calling for the establishment of a fair and equitable legislative framework to ensure there are no free riders and that orphan and historic waste from whitebox products are disposed of in an environmentally responsible manner. AIIA are also prioritising partnerships between

industry, government and other stakeholders to take the findings from Byteback and develop a sustainable, fair and equitable national scheme in Australia.

A summary of the AIIA's proposed national industry scheme is as follows:

- Intellectual capital invested by the industry along with the sharing of research data and the use of international comparisons
- Proactive engagement of government through the EPHC
- Each manufacturer is responsible for its own products
- User pays (included in the product cost)
- The creation of National Register of participants and use of Customs data to monitor participation
- Advanced recycling certificates and registration at the point of import: up-front charge on importers to cover waste from 'whitebox' products
- A waste levy to pay for all waste regardless of brand and other variations on disposal fee at local council and through taxation
- Product stewardship agreements, strong legislative enforcement and a policy framework established to facilitate engagement with other stakeholders

Mark Amos - Technical/Regulatory Manager Australian Industry Group (AiG)

Mark Amos represented AiG, Australia's leading industry organisation. He began his presentation by explaining that whilst industry understands its environmental obligations, it is also conscious of the risks to competitiveness from associated higher costs. For E-waste to be minimised along with negative impacts on Australian industry, he stated that a nationally consistent approach that considers environmental, social and economic costs, benefits & impacts must be introduced.

He outlined the objectives that must now be prioritised:

- Reduction of E-Waste entering landfill
- Reduction or elimination of hazardous materials used in EEE
- Maximum re-use of materials and reduction of virgin material use
- Management of Waste – Collection, transport, storage
- "Mining for Value" - Separating valuable materials and costs of recovery vs. value of "recovereds"

Mark Amos also addressed some of the key issues affecting the future of the E-Industry such as: regulation (RoHS, WEEE, EPR) and potential levies, historical and orphaned products, consumer education and government support. He claims that Industry favours a future where a voluntary code supported by co-regulation is introduced. It is believed that this will achieve better quality regulation, minimise regulatory divergences, increase consumer confidence and facilitate commerce. Industry favours a shared responsibility approach rather than that proposed by WEEE or EPR. This will require government to communicate to consumers and enforce effective regulations that are nationally consistent, internationally harmonised and fairly and strongly enforced with no "free riders".

These presentations were followed by another voting exercise where speakers and participants were asked to list the drivers and constraints to the sustainable manufacture and marketing of EEE They were then asked to rank these in order of importance (Appendix B). The summarised results of this exercise can be found in Table 4.

Table 4: Drivers and Constraints to the Sustainable Manufacture and Marketing of EEE

	Drivers	**Constraints**
1.	Government's to mandate full take back programs	Government is the largest single purchaser and tenders do not take sustainability into consideration
2.	Introduce legislation to ensure that all are working together	• It is commercially unattractive for a few players to embark on sustainability programs • E-Waste is low on the policy agenda • Inconsistency of existing legislation and lack of commitment to the issue across all levels of government • Lack of a clear path forward, and no leader in that path. Inertia at the EPHC/National Waste Working Group. No model legislation.
3.	Pragmatically dealing with built up E-Waste	The issue of dealing with historical and orphaned EEE

Use, Reuse and Recycling

The third section of the day addressed issues around the use, reuse and recycling of EEE. Speakers in this section represented retailers and suppliers, recyclers and Territory Government.

Pastor David Campbell - CEO Charity Computers

David Campbell, CEO of the not for profit organisation Charity Computers, explained that in the context of managing E Waste – there is a much deeper core driving Charity Computers excellent results for the environment, not just the bottom line. Pastor Campbell stated that we are producing too much E-Waste globally and that although the

ACT contributes a minute portion of this total, that local E-Waste still has a significant impact on the local environment and local landfills.

Charity Computers provides a three-fold strategic approach to management of E-Waste through:

- Reusing and recycling old computers
- Training people in IT
- Reselling and servicing computers to those in need

Charity Computers sees that there is a need to redefine its understanding of waste into categories of "Reuse" and "Recycle". Every product that enters a Charity Computers warehouse is assessed for its capacity for reuse. Reusable items are documented and stored to be built into refurbished computers. This process takes priority over Charity Computers recycling program, which is a last resort. Charity Computers engages volunteers and not only teach them about computers and IT but also give them a broader understanding of the value of reuse and recycling of IT equipment.

David claimed that one of the greatest challenges in the ACT is the cost of recycling. The limited metal recycling facilities in the region means equipment must be transported to Sydney or Melbourne. He stated that there is also a lack of recycling for monitor glass and computer plastics in Canberra. Pastor Campbell proposed that organisations like Charity Computers are perfectly positioned to work with the ACT Government and interested stakeholders to build a "No-Waste Industry" in the ACT. He identified three obstacles that need to be addressed to improve the situation of E-Waste in the ACT.

1. Local inability to recycle monitor glass
2. Local inability to recycle computer plastics
3. Individual, corporate and government desensitisation to the environmental issues.

Christopher Horsey - Manager ACT NOWaste ACT Government

Christopher Horsey is the manager of ACT NOWaste, the ACT Government's waste management agency. Christopher outlined the current state of play with E-Waste in the ACT. In 2003, the ACT Environment Protection Authority (EPA) restricted computers being disposed of in landfill, which resulted in ACT NOWaste introducing user pays charges on all computers and monitors and using this revenue to send computers for recycling. Chris explained that while the current arrangements are working, the estimated numbers of computers stored in people's homes remains high. Chris discussed his belief that the current disposal charges act as a barrier to the recycling of computers and monitors. This could be seen in connection with a rise in the number of computers being illegally dumped since the introduction of such charges.

Christopher went on to say that his preference was for a national approach that involved an end of life management fee charged at importation or sale point of computers, that then went into a central fund. Industry could initiate take back schemes and accredited E-Waste recyclers could be established in local jurisdictions, where the recycler claims

credit from the central fund. Recyclers could also provide data reports on products collected by brand name for reporting and financial purposes. This approach would remove disposal fees and therefore encourage E-Waste recycling. Any national scheme needs to avoid placing the costs of collection, transportation and recycling of E-Waste on local jurisdictions.

Chris was critical about the lack of progress made in establishing a national approach over the last 5 years. He believes that national legislation or regulation is required to mandate a scheme now, claiming there has been too much effort on trying to agree on a model rather than developing one that will deliver real outcomes.

Rose Read - Recycling Manager
Australian Mobile Telecommunications Association (AMTA)

Rose Read is the Recycling Manager for the AMTA. AMTA is the peak national body representing Australia's mobile telecommunications industry. AMTA's vision is to promote an environmentally, socially and economically responsible and successful mobile telecommunications industry in Australia.

In her presentation, Rose gave an overview of AMTA's Mobile Muster program which was initiated voluntarily by the telecommunications industry in 1999, to prevent mobile phones ending up in landfill. The program is industry managed, self-funded, free to consumers, visible and transparent. The three primary targets of the program are:

- Increased Collections
- Increased Awareness
- Reduced Landfill

As of the 31 March 2008 over 525 tonnes of mobile phone handsets, batteries and accessories had been collected. Mobile Muster recovers resources for reuse, minimises waste generation and better manages post-consumer waste. In the future the program hopes to diversify its collection methods and provide free recycling satchels and curbside recycling whilst maintaining whole of industry participation, increased awareness and decreased disposal to landfill.

Ian McAlister - Executive Director
Consumer Electronics Suppliers Association (CESA)

In his presentation the Executive Director of CESA, Ian McAlister, highlighted the association's commitment to product stewardship initiatives and EPR. He maintains that the most effective and sustainable E-Waste programs will result from sharing responsibility with appropriate stakeholders including producers, consumers, government bodies and retailers.

CESA's approach to electronics recycling is one of collaboration and joint responsibility and because of this they are working with sate and Federal Governments through the

EPHC, along with individual state and territory agencies to help to ensure a national uniform approach to the management of E-Waste. Any approach must be equitable however. CESA advocates safety net regulation as a top priority and believes all companies must fulfil their environmental responsibilities fairly.

CESA believes that companies and retailers have an important role to play in helping manage and minimise the environmental impacts associated with EEE. This belief is what inspired the creation of the Product Stewardship Australia (PSA) in June 2004, which manages end-of-life television's, with the scope to include other electronic waste. Ian claims that this kind of leadership is now required at the Federal level. There is a need for a competitive and equitable (no free riding) recycling infrastructure to be introduced nationally. States should not develop arrangements in isolation, but rather there must be positive direction at a national scale for the problem of E-Waste to be properly addressed.

Julian Purcell - Surveyor Resources

As a processor of E-Waste for some 15 years, Julian Purcell spoke about his understanding of and good practical grounding in the technologies that are used in processing and refining the valuable materials, mainly metals, that can be found in E-Waste.

Originally trained in the geosciences and with experience working for exploration and mining companies, Julian explained his interest in mineral befication, refining and its place in the reprocessing of E-Waste. He claimed that metals recovery/refining of some E-Waste is a profitable venture. As growing awareness about E-Waste is prompting governments to act on this issue, Julian is developing plans with his colleagues to process E-Waste locally. Unlike other companies currently dismantling E-Waste and exporting it, Surveyor Resources goal is to build up mini plants to recycle metal and plastic products in the ACT. Julian commented that there is a lack of research and development in this field and that it is partnerships and assistance from government that is what is now needed.

Dr Kamala Lahiri-Dutt - Research School of Pacific and Asian Studies

'Waste(d) Livelihoods: What can be done and who can do it?'

Dr Lahiri-Dutt began her presentation with a quote from Thomas Watson, chairman of IBM, in 1943 - "I think there is a world market for maybe five computers". Since this time there have been major changes in the E-Industry and it is predicted that of the 2 billion PCs purchased in 2015, 775 million will be in Russia, China, India and Brazil. Dr Lahiri-Dutt reported that in 2007, the number of PCs in China and India was 120 and 50 million, respectively. The problem of domestic E-Waste is therefore, only going to exponentially increase in these countries.

Unfortunately, the problem of international E-Waste is also a burden on these industrialising nations. Dr Lahiri-Dutt stated that although official figures are difficult to obtain due to the illegality of imports, close to 40,000 tonnes of E-Waste is dumped in India every month according to Greenpeace International. This waste ends up contaminating the environments of these countries with toxic organic compounds and metals. Whilst this waste provides lucrative business opportunities to the "developing world", the problem is that authorities pay no heed to the influx of tonnes of toxic E-Waste along with lax local laws, India is also turning into a deadly dumping ground that is threatening to be catastrophic over the next few years if left unaddressed.

These presentations were followed by a third voting exercise where speakers and participants were asked to list the drivers and constraints to the sustainable use, reuse and recycling of EEE. They were then asked to rank these in order of importance (Appendix C). The summarised results of this exercise can be found in Table 5.

Table 5: Drivers and Constraints to the Sustainable Use, Reuse and Recycling of EEE

	Drivers	**Constraints**
1.	Clear guidance regarding efficient use of resources – an Australian standard for E-Waste recycling	• Lack of legislation • Lack of Research and Development • High transport costs
2.	Consumer awareness	Lack of consumer awareness
3.	Sizeable reuse market	• Focus on recycling • Fragmented industry and groupings • Lack of economies of scale

Responses and Policy Actions

This was the final section of the day, which looked at the policy responses to the issue of E-Waste in Australia. This section included speakers from a national not for profit organisation, Federal Government and the Commission for Environment and Sustainability.

Terrie-Ann Johnson - Chief Executive Clean Up Australia (CUA)

Terrie-Ann Johnson, Chief Executive of CUA, explained in her presentation that CUA's focus is upon the role that technology can play in reducing the human impact on the environment. She stated that the organisation recognises that electronics are being

developed and produced at a faster rate than the disposal of preceding products can be managed. In response to this, CUA is:

- Encouraging the refusal of technology developments that are not needed, such as product enhancements for the sake of increased product sale versus any real usage value: REFUSE
- Encouraging multi-use to reduce product numbers and the purchase of quality products that are cost effectively repairable versus disposable: REDUCE
- Encouraging the reuse of technology through repair or refurbishment: RE-USE
- Encouraging whole of life-cycle responsibility; product stewardship and responsible disposal while capturing resources that can be returned to the manufacturing stream: RECYCLE

Terrie-Ann went on to say that CUA promotes:

- Better use of technology to reduce environmental impacts such as teleconferencing versus travel and increasing options of creative use of existing electronic tools.
- Community feedback and believes the community wants simple, cost effective and transparent solutions although few are prepared to pay for recycling at the time of disposal but will absorb a recycling fee at time of purchase.

Terrie-Ann believes that E-Waste is firmly on the national waste agenda. However, the reality is that industry has diminishing opportunity to influence this debate and therefore, CUA supports the need for regulation and accreditation within the E-Waste recycling industry. Terrie-Ann maintains that the timing is right, considering we have single party government right across the country and federally, providing an opportunity to have unity with firm decision-making. Terrie-Ann stated that elected officials have a responsibility to deliver what their constituents want – and that it is up to all of us to hold them accountable. “We live in a democracy – this is our chance to use our combined influence to secure more sustainable E-Waste management”.

Shaneen Coulson - Department of the Environment, Water, Heritage and the Arts
Product Stewardship Team, Environment Standards Branch

Shaneen represented the Federal Government during the Think Tank. Shaneen spoke about several items relating to the Government’s approach to product stewardship arrangements for E-Waste. She addressed the fact that end-of-life televisions and computers have been identified as a waste of national concern and that work is progressing through the Environment Protection and Heritage Council (EPHC). EPHC is the primary mechanism through which Australia’s environment minister’s work together on environment and heritage matters. New South Wales, Victoria and the Australian Government form the EPHC’s Electrical Equipment Product Stewardship sub group are developing with industry suitable arrangements for the sustainable management of end-of-life televisions and computers.

When proposing the introduction of any type of regulation, Council of Australia Governments (COAG) guidelines are followed to ensure that the benefits and costs of a range of options are assessed, that there is a net benefit to the community from the preferred option, and that any new regulation does not place an unnecessary burden on society. Formulating product stewardship arrangements can take a considerable amount of time, however there is significant work that is done behind the scenes to advise EPHC.

Dr Maxine Cooper - ACT Commissioner for Sustainability and Environment

Dr Maxine Cooper is the inaugural full-time Commissioner for Sustainability and the Environment. Her role is an expansion of the Office of the Commissioner for the Environment. Dr Cooper delivered a succinct and important message during the Think Tank.

The key point the Commissioner made was that whilst E-Waste is likely to be a significant issue in the ACT, "particularly given the profile of the ACT community; highly educated, wealthy and mainly employed in activities where electronic devices such as computers are a necessity, the people most concerned about it are in this room and we do not have any quantitative data about it."

She noted that the ACT, since early 2004, has banned computer waste to municipal landfill sites, and is the only jurisdiction that has such a policy. Given the importance and opportunities that are likely to emerge by effectively managing E-Waste, "there is an opportunity for building on this to develop the ACT as a place that showcases how to effectively manage E-Waste. The work undertaken by the ANU in managing its E-Waste is also to be noted in this regard. Given that Canberra is the nation's capital with Parliament House, and many very significant Commonwealth Departments located here, along with key Universities, CSIRO and other learning institutes, national bodies, businesses and other E-Waste generators, there is an opportunity for an ACT E-Waste group to be established to develop and implement E-Waste minimisation and management strategies. This could be done concurrently with developing a national approach. Local actions could be used to inform the national approach."

Dr Cooper impressed upon the audience that E-Waste and its sustainable management needs to be given priority in all jurisdictions, especially nationally. She made it very clear that she was willing to support this cause and open to advocating its importance.

Before the day concluded, facilitator Su Wild-River allocated speakers and participants time to consider what actions need to be taken across the entire E-industry and E-waste sector achieve sustainability. The results of this brainstorming session can be found in Box 2.

Box 2: Call to Action from the E-Waste Think Tank

The Australian Government is called on to:

- Act now to show leadership in putting a national framework in place to manage E-Waste. This will include standards for E-Waste recycling.
- Recognise the fast-moving nature of the E-Industry and ensure that poor practice is controlled, whilst being cautious of prescriptive legislative approaches that might constrain early adopters.
- Encourage innovation and seed on-shore solutions, especially in use, re-use and recycling.
- Endorse procurement policies that ensure that sustainable practices are rewarded.

Conclusion and Recommendations

Background

Electronic waste or E-Waste generally refers to household appliances, Information and technology (IT), telecommunication, video and audio equipment that have reached the end of their useful life. However, there is no standard definition of what actually constitutes this waste stream. E-Waste is made of a diverse range of materials including ferrous metals, non-ferrous metals, glass and plastics. It is estimated that about 66% of E-Waste consists of metals such as iron, copper, aluminium and gold (Babu *et al.*, 2007).

E-Waste creates serious problems when it is disposed of or recycled without strict controls, because it contains pollutants and hazardous components including lead, cadmium, mercury and hexavalent chromium. These substances have harmful effects on both human health (causing brain damage, allergic reactions and cancer) and the environment (Puckett & Smith, 2002).

Another major problem associated with E-Waste is the speed with which it is generated. E-Waste is one of the fastest growing areas of the international waste stream (Herat, 2007). Today, it is frequently much cheaper and more convenient to buy new electronic or electrical equipment (EEE) than it is to upgrade an old instrument. The growth of product obsolescence can be seen in close connection with current design and manufacturing processes, which often apply a “take-make-waste” approach (Doppelt, 2003). The dominant culture of affluence and consumption in which we live supports this profit driven approach and makes the problem of E-Waste even more complex.

In developed countries, the production of E-Waste is expected to grow by at least 3 to 5% per year (Hischier *et al*., 2005) and whilst the per capita waste production in developing countries is still relatively small, countries such as China and India import considerable quantities of E-Waste. Although the Basel Convention restricts transboundary trade of such waste, these imports continue to cause huge health and environmental risks due to the lack of controls over the disassembly and processing of this waste (Sinha-Khetriwal *et al.*, 2005).

A variety of collection, reuse and recycling systems have been designed and implemented in certain countries to deal with this growing problem. The European Union has put the Restriction of Hazardous Substances (RoHS) and Wasted Electrical and Electronic Equipment (WEEE) Directives in place to address the problem of E-Waste, however it is Switzerland that appears to be leading the way through its introduction of Extender Producer Responsibility (EPR) and Advance Recycling Fees (ARFs). Unfortunately, most E-waste generated in Australia is disposed of in landfill (ABS, 2006a).

There is currently no national regulatory framework to deal with E-Waste in Australia. Consequently, the disassembly and recycling of such waste in Australia is very piecemeal, with each State or Territory taking a different approach to the problem (Environment Victoria, 2005). The Federal Government is now being pressed to fast track a national scheme for managing Australia's E-Waste. The E-Waste Think Tank held in May 2008 is part of this call to action.

Future Actions

Assessing the problem of E-Waste and considering ways in which to approach it sustainably requires a comprehensive understanding of the current situation. The E-Industry includes a variety of actors, some which are small and informal, others that are multi-national and very powerful. Such a climate makes handling this complex waste stream and assessing quantities, job and business opportunities, along with risks to health and the environment, a very difficult task. For this task to be performed successfully, there needs to be a structured system that is put in place and which all actors and stakeholders conform to. But this system needs to be one that is tailored to the Australian situation.

Although there are systems that appear to be successful in European countries (see pgs 16-17), the success of one system does not necessarily portend success in another country (Kahhat *et al.,* 2008). Moreover, these systems may not be the most sustainable approach to E-Waste management in Australia. Developing a sustainable E-Waste system begins with understanding the culture within which the material flows take place. In order to be responsive, a sustainable system must address the physical flows, the ICT infrastructure, the incentives (Kahhat *et al.,* 2008) as well as the existing culture of purchasing and consumption. Many of these issues were debated during the E-Waste Think Tank that brought together many important stakeholders from the Australian E-Industry. During

this forum, they clearly articulated that the sustainable management of E-Waste depends upon several key priorities:

- *The design and implementation of a National framework*
- *Investment in and support for ecologically efficient design, manufacturing and reuse/recycling processes*
- *Education of consumers and users of EEE*

Through several exercises during the day, stakeholders highlighted a range of issues that relate to these key priorities and which must be considered when developing plans for future actions with respect to E-Waste.

- *Product design, manufacturing and marketing:*
    - Design for longevity, reusability and recyclability
    - Cradle-to-cradle product cycles, where components are circulated in closed loops
    - IT service provision and remote data storage/'Cloud Computing'
- *Use, reuse and recycling:*
    - Extended warrantees and guarantees
    - The introduction of full-take-back programs and/or Extender Producer Responsibility (EPR)
    - Research and development (R&D) in reprocessing, reuse and recycling

Stakeholders also acknowledged that developing a commercially and politically attractive framework would mean considering options that are compatible with market principles. This however, does not mean that stakeholders are calling for a voluntary market driven solution. On the contrary, those involved in the event agreed that regulation is desperately needed to control poor practice. Any regulations or legislation must however, be both flexible and equitable.

Numerous studies have already been undertaken on the subject of product stewardship and the recovery of EEE in Australia (DEH, 2004). The E-Waste Think Tank and its results are one example of an investigation to fuel future planning and policy actions. The issue of E-Waste has been long neglected and the time has arrived for Australia to begin putting into practice some of the strategies that have been identified to overcome the critical barriers to the sustainable management of E-Waste. For this to happen, the Australian Government must accept its responsibility and show leadership by developing a National framework to affect positive change within the E-Industry.

Appendix A: Key Features of a Future Sustainable E-Industry

#	Key Features	Votes
2	An emphasis on design for keeping, rather than disposability,	9
9	Wireless, digital, remote processing and 'cloud computing' with software and data storage somewhere else combined with excellent access from individual devices	9
12	A small, sleek, compact, portable, ergonomic, multi-functional, universal equipment with software that is easily upgradeable and fully recyclable hardware	8
17	Renewable power - for all of the devices with no greenhouse gas emissions.	8
3	Equipment that is no longer owned by businesses, but is treated as a service offered by suppliers	6
10	Cradle-to-cradle thinking in the design of the products, with the emphasis on the breaking down of components to be used as raw materials for recycling. Plastic bases and carbon compounds.	6
15	The initial purchase of IT equipment is done on line, with no stores or retail outlets - that's one saving, and packaging material is fully recycled. Products are well-protected for delivery, and products are transportable across home-work etc	5
23	Recycling driven by a scarcity and cost of resources	5
1	Small multi-functional low powered devices taking place of what we have now	4
4	Equipment that has been designed with the user in mind. A quantum shift in how we interact with technology. No screen, no keyboard.	4
6	Compatibility with parts across platforms, so it may have finished life in one sense, but its moved into another - including multi-functional devices	4
8	Whole of Canberra wired by a single network with international connectivity, that will be resistant to power cuts	4
16	People recycle their own electronic products, - they know what they are doing, and where to go to recycle	4
19	More elegant programming - reduce, reusing and recycling the hardware, while software gets better on the same device.	3
13	Not needing to travel to work because we can have virtual communities and virtual connections, flexibility and balance between home and work life	2
14	A greater reliance on devices by a broad cross-section of the community, in terms of age etc	2
20	Equipment is repairable, not disposable (eventually disposable, but not as a first option)	2
22	Passive devices with seamless interfaces so that you work with a very simple piece of equipment.	2
11	Compact portable computers with holographic screens and keyboard	1
21	a 'digital divide', based on class more so than country. A massive quantity of digital usage in developing countries, as well as people across the world without access to them.	1
24	IT design issues are influenced by health decisions. Eg using a mobile phone, wireless communication - knowing what it is doing to your health.	1

Appendix B: Sustainable Manufacture and Marketing of electronic equipment

#	Drivers	Constraints	Votes
10	Federal government and state governments mandate that tenderer's have a full take-back program. Weight this accordingly in allocating contracts.	Federal government is the largest single purchaser, and the tenders from federal and state governments don't take sustainability into consideration.	15
2	Legislation to ensure that all are working together.	Except in industries with a small number of players, its commercially unattractive for a few players to embark on sustainability programs	14
6	Pragmatically needing to come to terms with the built-up e-waste.	The issue of dealing with the historical computer stock that exists now.	8
1	Introduce a 'state of e-waste' report to inform industry and the community.	Lack of a clear path forward, and no leader in that path. Inertia at the EPHC/national Waste Working Group. No model.	6
3	All of the stakeholders need to get together to lobby the government and make this a strong policy agenda. Needs collaboration between groups.	Australia needs to lift the issue onto the policy agenda.	6
7	A national e-waste strategy - needed.	The inconsistency of legislation and lack of commitment/legislation across all levels of government. Particularly the lack of a national approach.	6
15	Federal government to make a start by ratifying the EU RoHS directive.	Take action now.	6
13	The need to address the big picture.	Government lacks the capacity to control corporations, implement the Basel Convention even though it puts up business costs	5
20	Accreditation for a benchmark standard for the products, recycling, distribution.	Establishing equity in the markets, between Australian-based manufacturers and importers. Especially if costs rise.	5
14	Awareness of issue and acceptance of responsibility at all levels of society.	Consumers lack education about the E-waste issues	4
4	Optimise the use of existing services - eg TNT that can move waste around.	Lack of a viable recycling infrastructure in Australia - not enough players to deliver. Mystification about what can be done through reprocessing.	3

11	Remove the words 'voluntary' and 'share' from the e-waste discussion. Be decisive.	The words 'voluntary' and 'share' from the e-waste discussion. Be decisive.	3
16	Create artificial values - private companies deliver all of these products, so government would need to create some value for the recycling.	Lack of value in the product makes it cost-negative. Computers need to work as computers more than they need to be recyclable.	3
21	A national waste levy needed to remove false costs.	False costs - the pricing is not right for the impacts we are having, the lack of a national waste levy to better align the costs and pricing.	2
22	We need to take a simple, flexible, market-driven and efficient approach. Could be co-regulation.	We are too focused on getting prescriptive solutions, but we need flexible solutions	2
5	Enhance demand for, and availability of innovative thinkers to develop business models.	Business models - not enough models of providing 'services' rather than 'products'. Current manufacturing not set up for sustainability.	1
8	market demand driven by government education and regulatory underpinning/regulatory base.	Lack of demand for sustainable manufacture and the recovery of e-waste.	1
19	Applying a minimum timeframe for taxation/warrantees (would have to be weighted along with other factors).	Not using products for their useable life - warrantees that effectively shorten the life of products.	1

Appendix C: Sustainable Use, Reuse and Recycling of electronic equipment

#	Drivers	Constraints	Votes
10	Clear guidance as to efficient use of resources - an Australian standard for recycling of e-waste is needed	Lack of legislative solutions	18
3	More consumer awareness	Lack of consumer awareness	16
1		Lack of investment in R&D	8
4		Transport costs	8
6	Sizeable reuse market	Not enough exploration of reuse, too much focus on recycling	7
2		Fragmented industry and industry groupings	6
7		Lack of economies of scale, lack of volume of throughput	5
5	Small-scale industries with the potential for expansion	No Australian-based processing of e-waste - only dismantling	4
8	Some initiatives making a difference - Mobile Muster	Poor understanding/analysis of the reuse, recovery potential	4
11	Companies potentially willing, if a legislative solution and better information are provided. Needs to be certainty to generate investment.	Lack of industry investment in refining from e-waste. Uncertainty among potential suppliers. No certainty of supply.	4
12	On-shore processing needs to be phased in.	We are licensing people to take materials offshore, and this is a barrier to on-shore processing.	2
9		Basel convention and other statutory constraints could be hampering a truly efficient use of resources	0

References

Australian IT (2008) Panasonic calls for e-waste scheme, May 13, http://www.australianit.news.com.au/story/0,,23686036-5013037,00.html?from=public_rss

Australian Bureau of Statistics (ABS) (2006a) Electrical Equipment Types 4613.0 - Australia's Environment: Issues and Trends. Canberra. http://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/CAFF6CD5744BB04CCA25723400206E4E?opendocument

Australian Bureau of Statistics (ABS) (2006b), Measures of Australia's Progress 1370.0 Canberra, 84.

Babu, B.R., Parande, A.K. & Basha, C.A. (2007) Electrical and electronic waste: a global environmental problem. *Waste Management Research* 25. 307-318.

Bailey, I. (2002) European environmental taxes and charges: economic theory and policy practice. *Applied Geography,* vol. 22. 235–51.

Baud, I., Grafakos, S., Hordjik, M., Post, J. (2001) Quality of life and alliances in solid waste management. *Cities* 18(1), 3–12.

Byteback (2008) http://www.bytebackaustralia.com.au/

Cross, G. (1993) Time and Money: The Making of Consumer Culture, Routledge Publishing.

Cui, J. & Forssberg, E. (2003) Mechanical recycling of waste electric and electronic equipment: a review. *Journal of Hazardous Materials*, B99, 243–263.

Darby, L. & Obara, L. (2005) Household recycling behaviour and attitudes towards the disposal of small electrical and electronic equipment. *Resources, Conservation and Recycling, 44, 17–35.*

Davis, G. & Herat, S. (2008) Electronic waste: The local government perspective in Queensland, Australia, *Resources, Conservation and Recycling*, doi:10.1016/j.resconrec.2008.04.001

Department of Environment and Heritage, (DEH, 2004) Electrical and Electronic Products Infrastructure Facilitation. Prepared in association with Centre for Design at *RMIT* and Product Ecology Pty Ltd. http://www.environment.gov.au/settlements/publications/waste/electricals/infrastructure/index.html

Department of Communications, Information Technology and the Arts, (DCITA, 2002) Advancing Australia – Highlights of the Information Economy Progress Report 2002, http://www.dcita.gov.au.

Doppelt, B., (2003) Leading Change Toward Sustainability: A Change-Management Guide for Business, Government and Civil Society, Greenleaf Publishing Limited, Sheffield, UK.

Electronic Industries Alliance (EIA) (2007) A legislative framework for electronics recycling: 4; http://findarticles.com/p/articles/mi_m0KWH/is_7_45/ai_n19394681

Empa. (2004) E-waste pilot study Delhi: knowledge partnerships with developing and transition countries. St. Gallen7 Empa. http://www.ewaste.ch/.

Environment Victoria (2008) Computer Waste Summary Sheet. http://www.envict.org.au/inform.php?menu=6&submenu=532&item=905

Environment Victoria (2005) Environmental Report Card on Computers: Computer Waste in Australia and The Case for Producer Responsibility. http://www.envict.org.au/file/Ewaste_report_card.pdf

Epoch Times (2008) Australia Drowning in Electronic Waste, May 14-20, 173, 10. http://epoch-archive.com/a1/en/au/nnn/2008/05-May/Edition%20173/Edition%20173_page10.pdf

European Topic Centre on Resource and Waste Management (ETC/RWM; Topic Centre of the European Environment Agency) (2003) part of the European Environment Information and Observation Network (EIONET). http://waste.eionet.eu.int/waste/6.

European Commission-RoHS Directive. (2003) Directive 2002/95/EC of the European Parliament and of the Council on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment. Brussels, Belgium: European Commission.

European Commission-WEEE Directive. (2003) Directive 2002/96/EC of the European Parliament and of the CouncilonWaste Electrical and Electronic Equipment (WEEE). Brussels, Belgium: European Commission.

Gibson, K. & Tierney, J..K. (2006) Electronic waste management and disposal issues and alternatives. *Environmental Claims Journal* 18(4) 321–32.

He, W., Li, G., Ma, X., Wang, H., Huang, J., Xu, M. & Huang, C. (2006) Review WEEE recovery strategies and the WEEE treatment status in China. *Journal of Hazardous Materials*, B136, 502–512.

Hendry, A. (2007) Australia stuck in e-waste dark ages. *CIO, Business, Technology, Leadership.* http://www.cio.com.au/index.php/id;151121279;pp;2

Herat, S. (2007) Sustainable Management of E-Waste. *Clean*, 35 (4), 305 – 310.

Hilty, L.M., Behrendt, S., Binswanger, M., Bruinink, A., Erdmann, L. & Froehlich, J. (2005) The Precautionary Principle in the Information Society – Effects of Pervasive Computing on Health and Environment. Second revised edition. Edited by the Swiss Center for Technology Assessment (TA-SWISS), Bern, Switzerland (TA46e/2005), and the Scientific Technology Options Assessment at the European Parliament (STOA 125 EN).

Hischier, R. Wa¨ger, P., Gauglhofer, J. (2005) Does WEEE recycling make sense from an environmental perspective? The environmental impacts of the Swiss take-back and recycling systems for waste electrical and electronic equipment (WEEE) *Environmental Impact Assessment Review* 25, 525– 539.

Jarup, L. & Vonkema, G.H. (1995) Health effects of cadmium exposure – a review of the literature and a risk estimate. *Scandinavian Journal of Work and Environmental Health*, 98.

Kahhat, R, Kima, J., Ming, X., Allenbya, B., Williams, E., Peng, Z. (2008) Exploring e-waste management systems in the United States. *Resources, Conservation and Recycling* 52, 955–964.

Lindhqvist T. (2000) Extended producer responsibility in cleaner production. Lund, Sweden7 The International Institute for Industrial Environmental Economics, Lund University. http://www.lub.lu.se/luft/diss/tec355.pdf

Liu, X., Tanaka, M., Matsui, Y. (2006) Electrical and electronic waste management in China: progress and the barriers to overcome. *Waste Management and Research*, 24, 92–101.

Magalini, F. & Huisman, J. (2007) Management of WEEE & costmodels across the EU: could the EPR principle lead US to a better environmental policy? In: Proceedings of the 2007 IEEE international symposium on electronics and the environment. 143–8. http://www.regconnect.com/content/isee/

National Safety Council. (1999) Electronic product recovery and recycling baseline report; May, 1999.

Nnorom, I. C. & Osibanjo, O. (2008) Overview of electronic waste (e-waste) management practices and legislations, and their poor applications in the developing countries. *Resources, Conservation and Recycling*, 52, 843–858.

OECD, (2001) Extended producer responsibility: a guidance manual for governments. Paris7 OECD.

Oertel, B., Wölk, M., Hilty, L.M. & Köhler, A. (2005) Risks and opportunities of the use of RFID systems. Bundesamt für Sicherheit in der In., Bonn.

Ogilvie, S.M. (2004) *WEEE and Hazardous Waste.* AEA Technology Environmental, Oxfordshire.

Puckett J, Smith T. (2002) Exporting harm: the high-tech trashing of Asia: The Basel Action Network. Seattle7 Silicon Valley Toxics Coalition.

Realff, M. J., Raymond M., Ammons, J. (2004) E-Waste: An Opportunity, *Mater* 7 (1), 40.

Schafer, T., van Looy, E., Weingart, A. & Pretz T. (2003) Automatic separation devices in mechanical recycling processes. In: Proc. International Electronics Recycling Congress, 13–15 January.

Secretariat of the Basel Convention (1999) Code of Practice for the Environmentally Sound Management of Asbestos Containing Materials in the Caribbean. Secretariat of the Basel Convention, Geneva, SBC No. 99:Asbestos:001.

SEPA (China State Environmental Protection Administration) (2002) Announcement No. 25 Announcement for Issuing the List of Prohibited Goods (Group 4 & 5). http://www.sepa.gov.cn.

Sinha, D. (2004) The management of electronic waste: a comparative study on India and Switzerland. St. Gallen, University of St. Gallen. Master Thesis.

Sinha-Khetriwal, D., Kraeuchi, P., Schwaninger, M. (2005) A comparison of electronic waste recycling in Switzerland and in India. *Environmental Impact Assessment Review*, 25, 492– 504.

StEP. (2005) Solving the E-Waste problem: a synthetic approach (StEP), Draft Project Document. http://step.ewaste.ch.

Suzuki, D., (2003) Consumer culture no accident, David Suzuki Foundation, http://www.davidsuzuki.org/about_us/Dr_David_Suzuki/Article_Archives/weekly 03070301.asp

Territory and Municipal Services (TAMS) (2006) Computer Recycling. http://www.tams.act.gov.au/live/Recycling_and_Waste/factsheets/computers

The Economist (2005) Berlin Economist Office, 29/01/05, p56.

Theisen, H. (2002) Collection of solid waste. In: Tchobanoglous, G. & Kreith, F., eds: *Handbook of Solid Waste Management*, 2nd edn. McGraw- Hill, New York.

UNEP (1989) Basel convention on the control of transboundary movements of hazardous wastes and their disposal, United Nations Environment Programme/Secretariat of the Basel Convention; 1989. http://www.basel.int/text/documents.html.

Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M. & Boüni, H. (2005) Global perspective on E-Waste. *Environmental Impact Assessment Review*, 25, 436–458.

Wilkinson, S., Duffy, N., Crowe, M. & Nolan, K. (2001) *Waste from Electrical & Electronic Equipment*. Environmental Protection Agency, Ireland, May 2001.

Zhang, S. & Forssberg, E. (1999) Intelligent liberation and classification of electronic scrap. *Powder Technology*, 105, 295–301.