



Department of the Environment and Heritage

COMPUTER & PERIPHERALS MATERIAL PROJECT

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for
ENVIRONMENT AUSTRALIA**

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EXECUTIVE SUMMARY

The information and communication technology (ICT) industry is one of the fastest growing industries in the world. Australia is one of the top ten countries per capita using ICT, however the Australian market accounts for only a small percentage (approximately 1.9%) of total worldwide shipments of computers and peripheral equipment. The industry has grown by nearly 12% in Australia over the past 5 years.

The companies which dominate the Australian ICT market are subsidiaries of global companies, mostly of American or Japanese origin. Most companies do not manufacture components in Australia, but undertake assembly of equipment using components produced to their specifications by companies that manufacture specific components (such as printed circuit boards, modems, etc) overseas.

The Australian computer market is dominated by 5 manufacturers (viz. Compaq, Dell, Hewlett-Packard, IBM and Toshiba) who account for approximately 50% of the market. The printer market is dominated by 3 manufacturers (Canon, Epson and Hewlett-Packard) who account for approximately 80% of the market. Printer and toner cartridges are supplied by the latter 3 manufacturers, as well as local re-inking and re-filling companies.

Structured data cabling of the type used in networked environments is produced and imported by a number of companies as part of their overall cabling supply business. Cabling for computers represents only a small percentage of the overall cable market, which is dominated by supply to telecommunications businesses.

Computers and peripherals amount to approximately 6.9% of Australia's total imports, with these predominantly sourced from Hong Kong, Malaysia, Singapore and the USA. The quantity and value of imports for all individual components is significantly higher than that of complete computer packages. The number of units exported from Australia is highly variable, although there has been a 30% increase in exports experienced over the past 5 years.

It is conservatively estimated that over 7.6 million computers, 5.3 million printers and 2.1 million scanners are in use in Australia. While there is a lack of definitive data on the geographic distribution of this equipment, various surveys conducted by the Australian Bureau of Statistics (ABS) show that the greatest use is in New South Wales, followed by Victoria, Queensland, Western Australia, South Australia, Australian Capital Territory, Tasmania and Northern Territory.

There is also a gap in data on the distribution of equipment across consumer sectors, however estimates suggest that in order of significance they are medium and small businesses, households, large corporations, Government and education. These estimates are based on new equipment sales; when including second-hand machines that are reused, the significance of education and domestic households increases.

Current disposal pathways for obsolete equipment include:

- **Storage** (~69%): Both corporate and domestic household users retain significant volumes of obsolete equipment. This is often from a perception that the equipment retains value past its productive life or lack of awareness of disposal options.
- **Reuse** (~26%): Extending the productive life of the equipment may involve being reused within the same organisation or household, or transfer of ownership for reuse by someone else. The latter is facilitated by both non-profit organisations (often refurbishing equipment and providing it to people or institutions who might otherwise not have computers) and by

commercial organisations (such as auction houses and second-hand retailers) whose business is based on distribution of second-hand equipment.

- **Recycle** (~1.5%): Only a small amount of equipment is recycled, either through recovery of components for use in other equipment or recovery of materials (such as metals) for use in other processes.
- **Landfill** (~3.5%): There is widespread disposal of equipment to landfills, often due to lack of alternatives. In some instances (particularly Government departments), landfill disposal is seen as the only alternative due to concerns about destruction of confidential data which may remain on the hard disk.

Modelling of industry figures has derived estimated figures for disposal pathways of obsolete equipment. The number of computers disposed of in Australia over the next 10 years is estimated in Table ES1.

Table ES1 Estimates of PCs Disposed in Australia

Disposal Option	2001	2006	2011
Recycled	281,700	494,000	509,600
Landfilled	926,500	1,632,800	1,694,700
Sent to storage	1,331,000	1,792,800	1,839,800
Total already in storage	3,618,200	5,260,400	5,479,700

Disposal rates for printers are likely to be over 1.5 million per year; given the approximate product life of 5 years and its relatively recent market penetration, scanners are unlikely to have been disposed in large numbers to date, although this is likely to change in the future.

Waste toner and printer cartridges are being generated in the order of 2.1 million to 8.7 million per year, depending on usage rates. It is estimated that nearly 38,000 km of cabling of various types enters the waste stream each year.

However it is noted that the estimates for all computer and peripheral equipment are conservatively based on inadequate data, and that the real volumes of waste equipment are likely to be much higher.

Computers are comprised of a range of plastics, metals and other material. Metals include both precious metals in small quantities (e.g. gold, platinum and silver) and heavy metals which may contribute to environmental harm (e.g. arsenic, cadmium, chromium, lead, mercury and zinc).

There are a range of different plastic resins used in computer manufacture, with the majority consisting of Acrylonitrile Butadiene Styrene (ABS) and High Impact Polystyrene (HIPS). Flame retardants (such as tetrabromobisphenol-A) are also used in manufacture of printed circuit boards.

Many of these materials are hazardous materials, and may cause harm to the environment. Substitution of some hazardous materials has been investigated, with replacement at different stages of development and implementation for various materials. The use of lead-free solders and substitution of halogenated flame retardants is more advanced than other efforts.

There are Commonwealth regulations in place which control the export and import of waste electrical equipment. While there are State-based regulations dealing with hazardous material contained in computers, confusion remains about the classification of the equipment itself as a hazardous waste.

Significant international initiatives have been implemented dealing with waste computer and peripheral equipment. The Organisation for Economic Cooperation and Development (OECD), of which Australia is a member, has issued guidelines on the management of used personal

computers. Relevant legislation has been established in a number of European countries, and other countries (such as the USA) have initiated programs oriented towards minimising the environmental risks arising from both the manufacture and disposal of computer equipment. Many of the leading international manufacturers have also undertaken voluntary initiatives, particularly focused on Design for Environment (DfE) principles or take-back schemes. A number of these initiatives have been conducted in alliance with government bodies and have included a range of collection trials.

Opportunities for environmental improvement in Australia could be implemented in 3 areas.

- **Manufacture:**
 - Implementation of consistently understood DfE principles by Australian manufacturers.

- **End of Life:**
 - Establishment of take-back schemes by manufacturers, either through direct return to manufacturers or by arrangement with retailers. This may be funded through imposition of a fee at time of purchase.
 - Further component reuse and equipment refurbishment activities by manufacturers.
 - Addressing concerns about retention of confidential data on obsolete hard disks that inhibit computer reuse options (particularly at Government level).
 - Improve recycling of component materials through investigation of alternative products and markets.
 - Increase automation of disassembly (and decrease labour costs) through use of appropriate technology.

- **User Education:**
 - Educate users on the scope of the waste problem, including the nature of hazardous materials used in manufacture and disposal requirements.
 - Encourage Australian manufacturers to implement initiatives already in place in some international parent companies.
 - Establish environmental performance criteria, either through existing international eco-marks (e.g. Blue Angel) or through establishment of an Australian label.
 - Encourage the consideration of environmental criteria when purchasing computer equipment, especially by Government and large corporate users.

Additional opportunities include:

- coordinated industry programs, including product stewardship of manufacturers, standards on reused and refurbished equipment and best practice for recyclers;
- further research and development of alternative products and markets;
- determining optimum collection systems in Australia; and
- banning landfill disposal of computer and peripheral equipment.

Based on these opportunities and the current structure of waste management and recycling in Australia, a number of pilot projects have been identified which offer potential for environmental improvement. These projects are included in Table ES2 below.

Table ES2 Possible Pilot Projects

Recommendation	Description
Trade- In Scheme	Actively encourage industry to establish a voluntary Trade-in Scheme whereby obsolete equipment is returned on purchase of new equipment. The mechanisms for this scheme would need to be established by the industry in conjunction with retailers and reuse or recycling organisations.
Collection Program	Investigate optimising collection programs through a trial of various collection strategies under a national umbrella program. This would test the suitability of various collection systems for maximum regional and sectoral coverage.
Product Labelling and Certification	Develop industry criteria to standardise reporting of environmental product parameters; this will allow consumers to make educated purchasing decisions in regard to environmental considerations. Product information could be made available to consumers via the manufacturers' web sites.
	Develop Government purchasing guidelines to assist all levels of Government to incorporate consideration of environmental performance in development of new contracts and leasing arrangements for ICT equipment.
	Develop an Australian Eco-mark, building upon existing international programs and criteria developed under the above projects. Maintenance of the scheme could be facilitated by an independent accreditation body. A scheme may initially be established as a product review then built up to an accreditation scheme.
Alternative Uses for Recovered Plastic	Research and development of alternative products for recovered plastic from computer and peripheral equipment should be undertaken in conjunction with industry groups (such as PACIA) to help establish viable end markets for materials.
Awareness Raising	Establish a program for data gathering to help overcome gaps in information for key computer and peripheral equipment markets of Government, health and education.
	Encourage information sharing through providing information on reuse and recycling companies on the Internet. In addition, a web-site could offer other environmental information and promote the pilot programs.

1. INTRODUCTION

The Australian electrical and electronic industry is one of the largest components of Australia's material consumption, with the turnover of products increasing dramatically in recent years. Rapid advances in information technology mean that the life of many computers and peripheral materials is limited. These advances are accompanied by decreases in the cost of both purchasing new equipment and upgrading to higher performance equipment. This contributes not only to an overall growth in the number of computers purchased, but also to many units reaching the end of their productive use within a short number of years. The disposal of obsolete machines and peripheral materials is therefore expected to become more of a problem in the short to medium term, with disposed volumes likely to grow as exponentially as has the growth in use of computers.

The environmental impacts of this have been recognised by the electrical and electronic industry, which has initiated development of a national electrical and electronic product stewardship agreement. The four peak electrical associations, the Australian Electrical and Electronic Manufacturers Association (AEEMA), the Australian Information Industry Association (AIIA), the Australian Mobile Telecommunications Association (AMTA) and the Consumer Electronics Suppliers Association (CESA), guided by an Australian and New Zealand Environment Conservation Council (ANZECC) working group comprised of Commonwealth and State/Territory Governments and wider industry organisations, are currently developing a Product Stewardship Strategy for Electrical and Electronic Equipment. It is intended that this strategy will address all environmental loads incurred during the life of the product, including material efficiencies and recovery at end-of-life.

The National Product Stewardship Strategy is expected to include a Computer and Peripherals Annexe, focused on issues specific to computers and peripheral materials. This project has been initiated by Environment Australia, in conjunction with the AIIA, in order to provide information upon which the framework of the Computer and Peripherals Annexe can be built.

For this project, computers and peripherals are defined as:

- personal and laptop computers, including central processing unit (CPU), mouse, screen and keyboard;
- servers;
- printers;
- scanners;
- toners and printer cartridges;
- ethernet and coaxial cable;
- fibre optic cable; and
- other similar equipment.

There are numerous types of equipment that may be considered similar to computer equipment, such as those used in conjunction with computer equipment in networked environments (e.g. dumb terminals, hubs, routers, switchers, uninterrupted power supplies). For the purposes of this project, this equipment has been considered to be distinct from computers and as such not included in the study. Consumable items (such as removable storage disks and mouse pads) are also excluded from this study.

It is important to note that packaging materials encasing computer and peripheral materials are not addressed in this project. Significant volumes of cardboard, polystyrene foam and plastic are used to supply computers, printers, scanners and peripheral equipment, and this should be addressed by manufacturers as part of their product stewardship responsibilities. However the issue of used packaging materials is the subject of the National Packaging Covenant and special regulation, viz. the *National Environment Protection (Used Packaging Material) Measure*, and does not form part of the scope of this project.

The objective of this project is to identify opportunities for improved material use, recovery and reuse of computers and peripherals. A clear understanding of the nature and likely quantities of materials that could be available for reuse and reprocessing will provide a basis for the planning of infrastructure and program development.

This report details the outcomes of research and consultation undertaken to identify:

- the volumes of computers, peripherals and product components being imported and/or manufactured in Australia;
- whether materials can be recovered, their recyclability and feasibility to do so;
- the life expectancy of computers and peripherals, their current disposal pathways and issues with disposal;
- the source and spatial distribution of computers, where information is available;
- the nature of materials used in manufacturing computers, including alternatives for hazardous material;
- international product stewardship activities; and
- feasible options for recovery, dismantling and re-use, including cost, logistical and technical issues.

Stakeholders consulted during this project are detailed in Appendix E.

2. BACKGROUND

2.1 Industry Status

The information and communication technology industry is one of the fastest growing industries in the world. Worldwide the industry has nearly doubled in size over the past 10 years, with total spending in 1992 of US\$1.3 trillion expected to exceed US\$2.4 trillion by 2002 (WITSA 2000). Australia is one of the top ten countries using information and communication technology (ICT), ranking tenth in the world for spending per capita and fifth in the world for spending as a percentage of gross domestic product (WITSA 2000).

In Australia the ICT industry has grown by nearly 12% over the past 5 years, accounting for approximately \$50 billion in sales and \$4 billion in exports on an annual basis (AIIA 2000). However the Australian ICT market is only a small percentage of total worldwide shipments. In 1999, Australia accounted for only 1.9% of a global market of around 113 million units per annum (IDC Australia 2000).

Following its rapid growth in recent times, the ICT industry has now entered a phase of consolidation. This has been evidenced by the withdrawal of Gateway from the Australian market in August 2001, and the merger of Compaq and Hewlett-Packard in September 2001. Market forecasts suggest that the Australian market for computer equipment is likely to shrink by approximately 2.7% in 2001 over the previous year (Braue 2001), although there is some optimism that new technology and software will continue to maintain sales at current levels.

There are approximately 18,500 businesses involved in the industry, including manufacturers, software developers, consultants, and other specialist businesses. This includes approximately 1,400 computer wholesalers (including manufacturers and distributors). The majority of ICT businesses (43%) are located in New South Wales, with the second largest representation in Victoria (AIIA 2000).

The companies which dominate the Australian ICT market are subsidiaries of global companies, mostly of American or Japanese origin. Other Australian manufacturers have developed a niche export market for computers designed for specialist applications, including defence applications and use in hazardous environments (e.g. refineries).

Some companies undertake assembly in Australia from parts manufactured overseas. However most computer hardware is imported from overseas rather than manufactured or assembled locally. In many cases the international parent company does not manufacture their own computer components, but assembles products (i.e. computers) using components produced to their specifications by companies that manufacture specific components (i.e. printed circuit boards, modems, etc.). Often there is little input from the Australian subsidiary into design features or the manufacturing process carried out overseas.

The Australian computer market is dominated by five manufacturers, which account for approximately 50% of shipments (IDC Australia 2000). These manufacturers are (in alphabetical order):

- Compaq;
- Dell;
- Hewlett-Packard;
- IBM; and
- Toshiba.

This list is expected to change in the future following the recent merger of Compaq and Hewlett-Packard.

The Australian printer market is dominated by three manufacturers, which account for approximately 80% of shipments (IDC Australia 2000). These manufacturers are (in alphabetical order):

- Canon;
- Epson; and
- Hewlett-Packard.

Printer and toner cartridges are supplied by these same three manufacturers, as well as local re-inking and re-filling companies.

Structured data cabling of the type used in networked environments is produced and imported by a number of companies as part of their overall cabling supply business. Cabling for computers represents only a small percentage of the overall cable market, which is dominated by supply to telecommunications businesses.

2.2 Equipment

A typical computer system can be described by breaking the system into three distinct sections: inputs, processing and outputs.

Inputs are information conveyed to the computer through devices for either manual entry (e.g. game controllers, keyboard, mouse) or digital entry (e.g. imaging equipment such as scanners and digital cameras). Many devices are in general use, however others are developed for more specialised applications (e.g. graphics tablet or magnetic card-reader).

Processing includes executing software program instructions and mathematical processing, which is undertaken by a central processing unit (CPU) that is linked to ancillary processors, memory modules, input and output devices.

Outputs are the means by which processed information is communicated to users (e.g. monitor or printer). Some components fulfil both an input and output role (e.g. network interface cards and either fixed or removable storage devices).

Computers, monitors, printers, scanners and other equipment are described separately in the following sections. Whilst these sections are not intended to form a primer for the manufacture and construction of computer equipment, a number of industry terms and acronyms have been included to facilitate identification of key components, and to provide examples of their use.

2.2.1 Computers

Computers are made in a variety of forms to cater for different applications, with the most common forms being desktop computers, laptop or notebook computers, and servers.

Desktop computers are generally comprised of several components connected together to provide inputs, processing and output (e.g. case, keyboard, monitor and mouse).

Laptop computers have integrated input, processing and output devices to allow for ease of transport, and as such are much smaller than desktop computers (i.e. smaller than a briefcase).

Servers are specialised computers that are used to coordinate inter-operation by a number of computers and output devices over a network.

Common components of all three forms include those outlined below.

- A **case** that encloses the key components of a computer (including the CPU, memory power supply and storage devices), and provides protection from dust or damage. Cases are generally comprised of a metal frame and cover with a moulded plastic faceplate. Some laptop cases are high-impact plastic, whereas others are made of high-grade, lightweight metals like titanium.
- **Integrated Circuits (ICs):** ICs are the chips that perform the logical and computational functions within a computer. The ICs that are present within a computer include the Basic Input/Output System (BIOS), which is used to control fundamental operations; Random Access Memory (RAM), which is used to temporarily store information during processing; and Read-Only Memory (ROM), which is used to permanently store essential instructions. An IC is made of a silicon wafer and may be housed inside a flat plastic case with metal interface pins, or directly wired to a printed circuit.
- The **Central Processing Unit (CPU)** is also an IC. The term CPU is often used to describe the case and internal components, however it more correctly refers to the main processor that executes program instructions and performs mathematical calculations.
- **Printed Circuit Board (PCB):** PCBs are the principal material that contains the computer's basic circuitry and components. The largest PCB is the motherboard, which connects the components of the computer (e.g. CPU, input and output devices, RAM and storage devices) to one another. Expansion slots on the motherboard allow for the insertion of daughter boards that provide further input and output connections (e.g. sound, modem, networking, video). Circuitry is imprinted or affixed to the surface of the board; this involves the use of metals (primarily copper, with gold-plated connectors) to provide the circuit, embedded in a fibreglass board using either glue or solder. Fire retardants are usually incorporated into the manufacture of PCBs.
- **Storage:** Information can be stored on fixed devices (e.g. magnetic "hard" drive) or removable devices that use any one of a range of consumable media (e.g. 3.5" magnetic disks, CD-ROM, digital tape, flash memory cards and Zip disks)
- **Power Supply:** The power supply takes mains power and transforms it to the voltages required by the CPU, motherboard and input/output devices. Metal and some plastic components are used in their construction.

- A **battery**, either as a main source of power supply (e.g. laptops) or as a backup to enable basic functions (e.g. saving times and dates) when the main power is switched off. In the past, nickel cadmium (NiCd) or nickel metal hydride (NiMH) batteries were used; however computers manufactured today generally utilise lithium ion (Li) batteries.
- Two or more **fans** to cool the CPU, power supply and other heat-generating components. These are generally manufactured from plastic with metal connections.
- **Cables** to convey power to individual components (e.g. from the power supply to the motherboard) and data from one component to another (e.g. bus cables connecting the motherboard to storage devices). All of these cables are made of metal wires (principally copper) surrounded by plastic.

The location of these components in a typical desktop computer is shown in Figure 2.1.

Figure 2.1 Computer Components

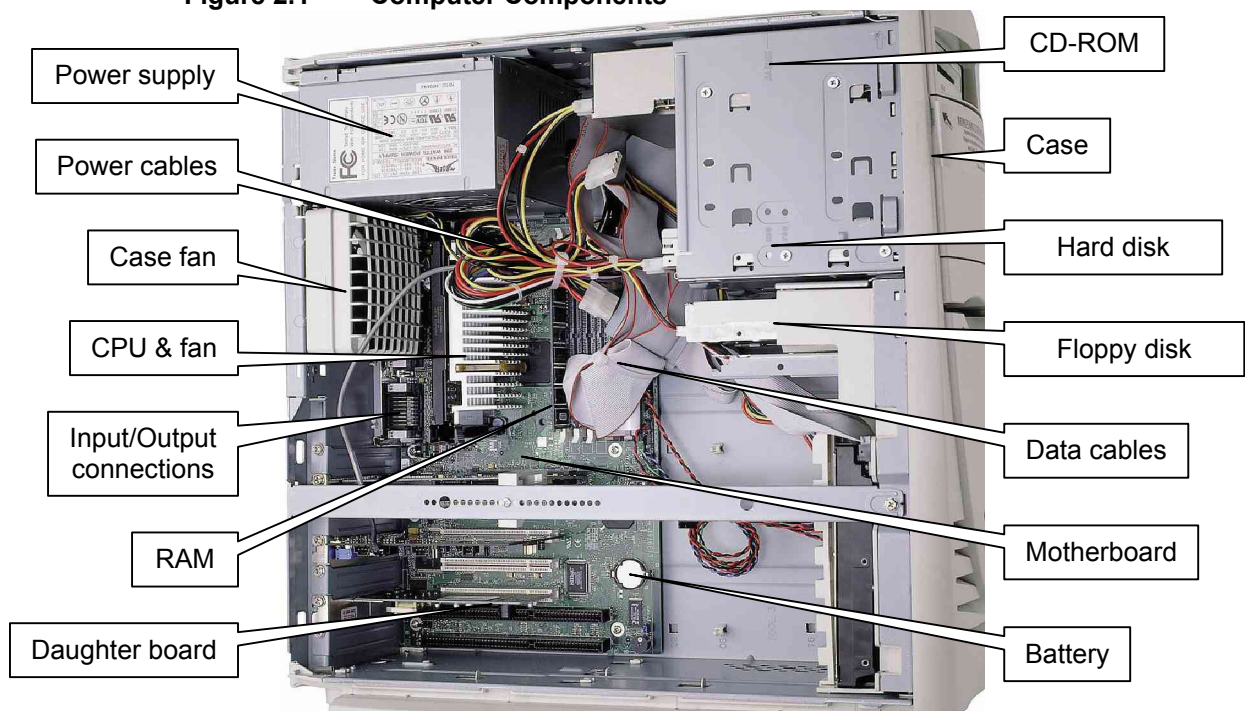


Image courtesy of <http://www.kids-online.net/>

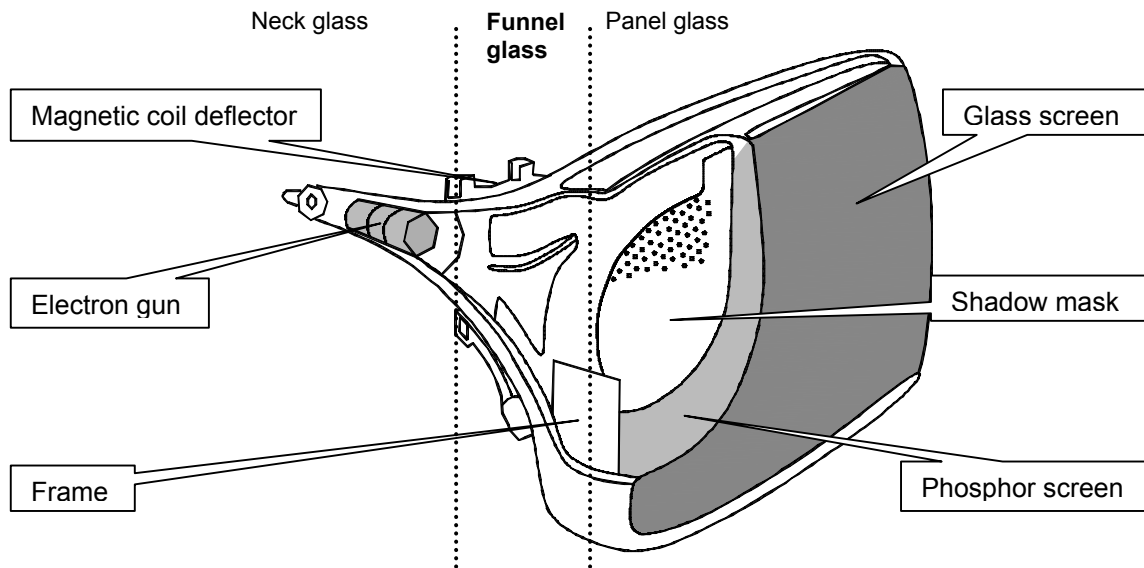
2.2.2 Monitors

Cathode ray tube displays (CRTs) are the predominant display technology currently used in computer monitors. A CRT is generally comprised of a glass panel screen, a plastic casing (often with a swivel base), various connecting wires, magnetic and radiation shielding, and the cathode ray tube itself.

The cathode ray tube holds electron guns and deflection yoke coils, which create an electric field that directs a flow of electrons from the guns through small holes in a shadow mask to illuminate phosphors on the back of the glass panel screen. This tube's glass funnel contains lead for radiation shielding, and is joined to the

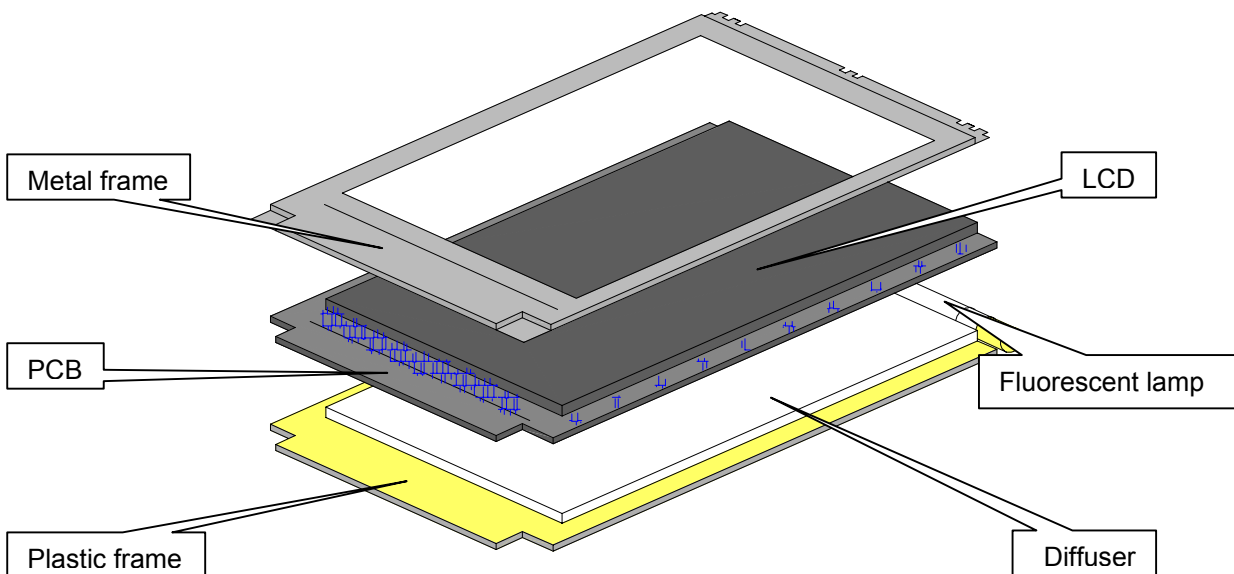
glass panel screen and shadow mask using a 70-80% lead-content solder. The location of these components is shown in Figure 2.2.

Figure 2.2 Internal Components of a Typical CRT Monitor



Flat panel displays are an alternate display technology to CRTs that is predominantly used in applications where portability (i.e. weight, size) and energy consumption are important (e.g. laptops). Liquid crystal displays (LCDs) are a type of flat panel display where the monitor produces an electric field to trigger a grid filled with crystals, with the resulting arrangement of crystals forming the desired image on the screen. Figure 2.3 indicates the principal parts of an LCD screen.

Figure 2.3 Internal Components of a Typical LCD Monitor



An LCD screen is comprised of electrodes on two glass substrates with liquid crystals sealed into the narrow gap between them. There are approximately 300 different liquid crystal compounds used, comprised of non-hazardous organic

chemicals. The common LCD technology used in computer monitors uses separate and independent Thin Film Transistors as a switch for each pixel. Turning these switches on or off will align the liquid crystal molecules so that light from the screen's backlight is allowed to shine through to a coloured filter and then to the front of the display. Up to four fluorescent lamps and a thin light diffuser are used to provide light so the screens may be seen in the dark. This assembly is sandwiched within a metal frame for protection and ease of mounting.

2.2.3 Printers and Cartridges

Printers download digital information from a computer onto paper, generally through one of three processes, namely dot matrix, inkjet and laser printing.

The dot matrix or impact system is akin to a typewriter, with a printhead impressing a combination of tiny pins onto an inked ribbon to form characters and images. Machines of this type were historically the least expensive option to purchase, however the comparatively low quality of the printed material and the decline in cost of inkjet printers has led to a considerable decline in use over recent years.

Inkjet printers use cartridges that are comprised of a supply of ink and a printhead of tiny jets embedded with electronic heating elements that force the ink onto the page. The quality of images that these printers are capable of delivering, combined with the relatively low cost compared to laser printers, have led to this printer becoming the dominant type for low-volume users.

Laser printers use a laser to describe an image onto a drum, which induces a negative electrical charge on the drum surface that causes the positively-charged toner particles to adhere to it. The toner is transferred to paper as it passes over the drum, and a heat roller then fuses the toner to the paper. The rapid delivery of printed material that this process allows has led to laser printers becoming the dominant printer for high-volume users.

Printers and their cartridges are predominantly made from moulded plastic with metal parts. Laser toner cartridges also contain a glass drum that has been chemically coated to impart particular charge and thermal related properties.

2.2.4 Scanners

A scanner is a device that takes in an optical image and digitises it into an electronic image. This can be used to create a computerised version of a photo or illustration. It may also be linked to optical character recognition software allowing printed documents to be converted to electronic text without keyboard entry. There are a number of different forms of scanner, including handheld and 'flatbed' readers. They are generally comprised of a moulded plastic housing with a glass copy plate, a bright scanning light and PCBs with control ICs.

2.2.5 Cabling

In addition to the cables present within a computer case, there are cables for the transmission of power (e.g. from the mains electrical socket to a computer power supply, monitor, printer, etc.) and data (e.g. from the printer port of the computer case to the printer, or from the video output to the monitor). These cables tend to

be in short lengths and are generally comprised of copper wires with a sheath of plastic insulation.

Copper cabling is also used in the interconnection of two or more computers to form a network. Alloys used in copper cable vary greatly, with the percentage of copper used proportional to the distance between connections and the quantity of current that the cable is expected to carry.

Fibre optic cabling, where the glass conducts data as pulses of light, is also used in the creation of large networks. The majority of applications for optical fibres lie in the telecommunications sector and, whilst there are specialised adapter cards available to network PCs using optical fibre, it is rare for cabling of this sort to be directly connected to desktop computers, laptops or servers.

2.2.6 Other Devices

Handheld computers are compact integrated devices designed for portability and usually for inter-operability with desktop or laptop computers. They are generally sized to fit within the palm of one hand. A variety of forms exist, however the common components are a battery, ICs, LCD and a PCB within a high-impact plastic case.

2.3 Technology Trends

Moore's Law, first observed by Gordon Moore in 1965, indicates that new chips contain roughly twice as much capacity as their predecessor, and that chips are released within 18-24 months of the previous chip. The number of transistors on a chip has increased from 29,000 on the 8086 in 1978 to 7.5 million on the Pentium II processor. This trend in the increase of processing speed and memory capacity has been accompanied by a subordinate trend for the cost of new chips to decrease, bringing the latest technology within financial reach of many computer users within a short period of time following their release.

The decline in the cost of new technology has also affected other computer components. The average unit price for LCD screens has decreased from approximately five times the price of a CRT monitor to approximately double. Decline in cost of inkjet printers has led to their increased uptake as an entry-level printer, resulting in a considerable decline in use of dot matrix printers over the last 5-10 years. The low cost of production is also demonstrated by the packaging of printers and other peripherals as bonus items when a PC is purchased.

The resolution of printers and scanners, through improvements in hardware and software design, has increased significantly over time. In the case of printers, this has resulted in the demise of dot-matrix printers as the quality of output from ink-jet printers rendered them largely uncompetitive. In the case of scanners, improvements in resolution have been accompanied by an increase in demand as use of the Internet to electronically transfer images and text increases.

As the technological capability of chips (and other components) has increased, software developers have written programs to exploit the capabilities of the newer technology. As a result, the minimum operating requirements for new software has steadily increased over the past 10 years.

The performance of CRTs has undergone continual improvement, in response to a demand for larger screen sizes and better resolution. Whereas 12"-14" diagonal screen widths were once commonplace, CRTs available for sale are

presently between 17"-21". Reduced dot pitch (i.e. better resolution), colour matching, and flatter and more lightweight design are features becoming readily present in standard rather than premium products.

Advances in telecommunications engineering yield continued increases in the quantity and quality of signal able to be carried over computer networks. As a result of these advances, standards for the design of cabling and their connection systems are changed, as illustrated by the replacement of Thinnet (characterised by black co-axial cable) by Un-Twisted Pair or UTP (characterised by blue cabling with large telephone-style connectors) as the standard networking cable.

The dynamic nature of the ICT industry cautions against making detailed predictions for the future, however there are several key trends that will affect the nature and quantity of computer and peripheral equipment manufactured in the future.

New devices are being developed that will provide a choice of products for activities that have traditionally been the domain of PCs. These range from TV set-top Internet access and dedicated console gaming devices (e.g. Playstations) to appliances integrated within other electrical and electronic equipment. As these devices are unlikely to replace the role of the PC for productivity and fundamental computation, it is more likely that this will result in an increase in the number of devices used within certain sectors, as opposed to the replacement of PCs.

The technology used in computers and peripheral equipment is continually being improved, and the physical limits to the size and capability of equipment are being stretched. Opportunities will become available to produce units using less materials and at smaller overall size. It is also likely that the performance of components will continue to follow Moore's Law for the near future, and as such there will be continued incentive to replace existing equipment.

The choice of individual components by consumers is likely to reflect both their capabilities and their cost. The perceived benefits of LCDs, including less radiation emissions than CRTs, lower energy use, lower incidence of eye strain among users, together with the reducing price differential compared to CRTs, are expected to provide LCDs with an increasing market share over CRTs in the near future. Integrated devices that provide multiple functions within the one product (e.g. faxing, photocopying, printing and scanning) may also increase in use, particularly when the cost of purchasing such devices is competitive with that for separate components.

3. PRODUCTION

3.1 Manufacturing

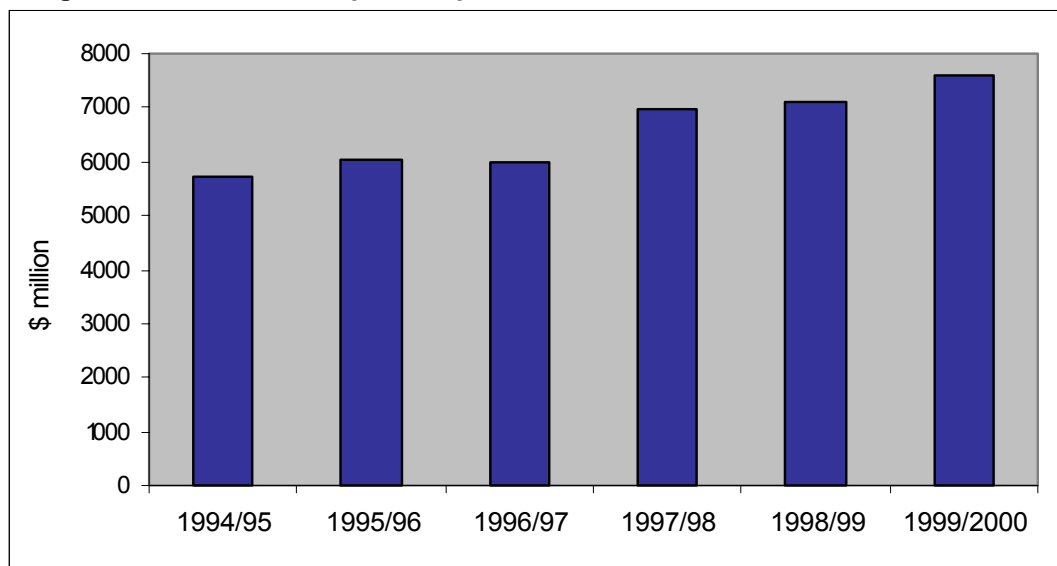
The manufacture of computers and peripheral equipment involves the production of separate components by different companies. In most cases, computer and peripheral equipment companies will assemble their product by combining parts sourced from manufacturers of individual components. The chain of supply may involve several companies (e.g. company A assembles a desktop computer using a motherboard built by company B using ICs from companies C and D, plus PCBs from company E, etc.).

Given the small percentage of the global ICT market occupied by Australia, it is generally less expensive to import basic materials (e.g. ICs, PCBs) than to manufacture them locally. Some companies undertake assembly in Australia from parts manufactured overseas, however most computer hardware is imported from overseas rather than manufactured or assembled locally. Some Australian manufacturers have developed niche export markets for specialised equipment (e.g. point-of-sale keyboards) or commonly required components (e.g. memory chips), however these will usually still be manufactured utilising imported materials.

3.1.1 Imports

Data recorded by the Australian Bureau of Statistics (ABS) shows that computer imports have risen significantly over the past 5 years. Figure 3.1 shows total computer imports for the past 6 financial years.

Figure 3.1 Total Computer Imports



Source: ABS

In 2000, imports of personal computers (PCs), disk drives and monitors amounted to \$5,498 million, representing 4.7% of Australia's total imports. An additional \$2,518 million of computer parts (such as motherboards and memory) was imported into Australia in the same year. In total, computers and peripherals amounted to 6.9% of Australia's total imports in 2000 or \$8,016 million (ABS 2000).

Table 3.1 indicates that over half of the average quantity of computer and peripheral equipment imported between 1996 and 2000 came from four countries, these being (in alphabetical order) Hong Kong (Semi-Autonomous Region of China), Malaysia, Singapore and the United States of America. There have been significant increases in the quantity of imports from Malaysia and Singapore during this period, as well as significant increases in the value of imports arriving from Japan, Malaysia and Taiwan. The latter observation may indicate a shift in the types of materials being imported from these countries towards higher-value components and finished products. Less than 1% of imports are “re-imported” (i.e. they were originally exported from Australia and are now being re-imported, usually following processing overseas).

Table 3.1 Country of Origin for Computer and Peripheral Imports (1996-2000)

Country of Origin	Average Quantity 1996-2000 ^{1,2}	Share ² %	Growth in Quantity %	Average Value 1996-2000 (\$) ²	Growth in Value %
United States of America	36,651,800	17	37	1,207,003,400	0
Singapore	35,506,200	16	62	928,195,200	14
Hong Kong (SAR of China)	24,446,100	11	16	150,760,300	-17
Malaysia	24,173,000	11	34	745,296,600	78
Taiwan	17,842,600	8	29	573,296,600	45
Japan	14,106,800	7	100	646,388,800	100
Thailand	13,537,300	6	69	118,642,200	23
All other countries	50,001,100	23	52	1,085,600,000	51
Total	216,264,800	100	43	5,455,231,800	34

Source: ABS

- Notes: 1. Data is based on imports recorded in number of units (kilograms, metres or not recorded). Imports recorded in number of units represent 99% of total value of imports 1996-2000.
2. Values for individual countries may not equal the total due to rounding.

Data obtained from ABS lists the quantity and value of computer related commodities imported between 1996 and 2000. The data has been aggregated into categories of commodity that reflect the scope of this report. Data has also been separated according to destination states or territories. Summary tables are provided in Appendix A of this report.

The ABS data shows that, in broad terms, the quantity and value of imports for all individual components was significantly higher than that of complete PC packages. These components may either be destined for assembly of complete PCs within Australia or for individual sale as parts for repair and upgrade of existing machines.

It is important to note that materials imported under some of these categories (e.g. co-axial cables, insulated wires and integrated circuits) may not be exclusively destined for use in computers and peripheral equipment.

The average annual quantity and value of computers and peripheral equipment imported between 1996 and 2000 is provided in Table 3.2. Integrated circuits represent the largest quantity of commodities imported, whereas computers represent the highest value. Monitors and printers are imported in slightly greater quantities than computers, whereas keyboards are imported in lesser quantity. Storage devices are imported in significant quantity, and represent approximately double the quantity of otherwise unclassified input/output units. Data for cabling has been recorded in kilograms or metres rather than number of units and, as such, care must be taken when comparing cabling to other commodities. It is possible to identify an overall low value for cabling despite significant quantities being imported, which is consistent with information received from stakeholders.

Table 3.2 Average Annual Quantity and Value of Computer and Peripheral Imports (1996-2000)

	Unit	Average Annual Quantity	Average Annual Value (\$)
Accessories	no	6,455,228	481,833,309
Co-axial cables	kg	655,402	7,341,014
Co-axial cables	m	64,106,131	35,851,368
Computers	no	1,244,053	1,967,224,022
CRT monitors	no	1,470,293	453,056,132
Drives, storage units	no	4,634,107	931,767,807
Input/output units	no	2,467,753	445,829,210
Insulated cables, wires ¹	kg	2,679,936	34,094,630
Insulated cables, wires ¹	m	3,031,967	2,047,433
Integrated circuits	no	196,407,747	1,048,718,508
Keyboards	no	853,667	19,407,745
Optical fibres	kg	No data	30,870,542
Printers	no	1,367,528	417,033,063
Ribbons	no	1,364,385	12,620,604

Source: ABS

Note: 1. Different measures of cables and wires are not equivalent, i.e. kilograms of cables imported is not equal to metres imported, but the total of both amounts represents all cabling imported.

Table 3.3 presents a summary of the average annual quantity and value of commodities imported to each State and Territory between 1996 and 2000. However it is important to note that the State of destination for an imported commodity does not necessarily equate to the State where that commodity will be sold, let alone used.

This is particularly the case where companies import materials through one port and then distribute them nationally from that location. However the domestic distribution is likely to occur where it is most cost-effective (e.g. intrastate and to neighbouring States, but not between locations at opposite ends of the country). The data may therefore be employed as only an indicative measure of the geographic distribution of computer sales and use.

Table 3.3 indicates that the greatest proportion of commodities within each category are imported to New South Wales, with the exception of co-axial cable, insulated cables and ICs, for which the greatest proportion are imported to Victoria. In general terms the majority of imported goods arrive in Victoria and New South Wales, with significantly smaller amounts being received within other States. Western Australia receives a significant, if comparatively low, proportion of printers, and Western Australia and Queensland received a significant if comparatively low quantity of computers in 2000.

Table 3.3 Imports of Computers (1996-2000)

Commodity	State	Average Annual Quantity	Average Annual Value (\$)
Computers	ACT	14	410,274
	NSW	962,426	1,649,658,021
	NT	32	667,574
	Qld	58,387	28,554,183
	SA	4,980	6,901,554
	Tas	12	174,995
	Vic	112,197	191,240,640
	WA	106,004	89,616,782
	Total	1,244,053	1,967,224,022
CRT monitors	ACT	1	4,705
	NSW	1,116,804	347,529,175
	NT	1,421	329,878
	Qld	36,199	8,852,241
	SA	24,464	6,880,751
	Tas	1	2,063
	Vic	230,992	71,123,520
	WA	60,409	18,333,799
	Total	1,470,293	453,056,132
Printers	ACT	1	616
	NSW	952,153	228,210,335
	NT	134	65,791
	Qld	4,206	2,372,970
	SA	10,862	481,852
	Tas	2	6,791
	Vic	29,515	14,821,251
	WA	370,656	171,073,459
	Total	1,367,528	417,033,063
Ribbons	ACT	0	0
	NSW	1,117,194	6,460,322
	NT	35	579
	Qld	55,011	504,823
	SA	1,849	10,053
	Tas	3	100
	Vic	150,074	5,377,340
	WA	40,219	267,388
	Total	1,364,385	12,620,604

Table 3.3 Imports of Computers (1996-2000) – continued

Commodity	State	Average annual quantity	Average annual value (\$)
Integrated circuits	ACT	70	1,114
	NSW	88,817,752	653,288,258
	NT	85	4,273
	Qld	2,204,348	9,263,333
	SA	6,998,283	29,345,702
	Tas	84	5,161
	Vic	95,065,543	340,716,438
	WA	3,321,583	16,094,227
	Total	196,407,747	1,048,718,508
Accessories	ACT	415	24,102
	NSW	4,213,909	432,470,293
	NT	91	28,946
	Qld	293,530	7,284,565
	SA	45,339	2,738,234
	Tas	236	9,962
	Vic	1,627,637	34,346,750
	WA	274,071	4,930,458
	Total	6,455,228	481,833,309
Drives, storage units	ACT	3	3,136
	NSW	3,483,026	719,406,463
	NT	25	49,433
	Qld	32,720	6,680,127
	SA	3,190	609,032
	Tas	6	11,583
	Vic	979,463	164,695,586
	WA	135,673	40,312,448
	Total	4,634,107	931,767,807
Input/output units	ACT	68	84,482
	NSW	1,931,268	348,580,758
	NT	78	65,745
	Qld	25,560	4,839,680
	SA	19,031	1,706,039
	Tas	5	7,164
	Vic	347,618	57,554,933
	WA	144,125	32,990,409
	Total	2,467,753	445,829,210
Keyboards	ACT	0	39
	NSW	642,501	15,352,211
	NT	1	1,364
	Qld	17,536	281,801
	SA	3,252	223,712
	Tas	1	918
	Vic	159,782	2,918,532
	WA	30,593	629,169
	Total	853,667	19,407,745

Table 3.3 Imports of Computers (1996-2000) – continued

Commodity	State	Average annual quantity	Average annual value (\$)
Co-axial cables ¹ (kg)	ACT	0	0
	NSW	337,919	3,019,762
	NT	30	1,955
	Qld	44,456	543,016
	SA	24,963	474,545
	Tas	7,065	29,131
	Vic	209,055	1,743,800
	WA	31,915	1,528,806
	Total	655,402	7,341,014
Co-axial cables ¹ (m)	ACT	0	0
	NSW	24,832,819	9,222,413
	NT	166,446	204,245
	Qld	2,816,560	949,917
	SA	5,208,636	1,486,556
	Tas	141	2,735
	Vic	30,874,322	23,367,809
	WA	207,207	617,691
	Total	64,106,131	35,851,368
Insulated cables, wires ¹ (kg)	ACT	40	7,086
	NSW	1,505,008	22,730,898
	NT	298	12,735
	Qld	96,857	999,197
	SA	67,462	516,506
	Tas	758	41,455
	Vic	977,018	8,917,735
	WA	32,494	869,018
	Total	2,679,936	34,094,630
Insulated cables, wires ¹ (m)	ACT	3,646	8,800
	NSW	1,077,350	1,223,409
	NT	4	119
	Qld	640,707	93,775
	SA	10,824	4,731
	Tas	0	0
	Vic	1,173,887	689,296
	WA	125,549	27,303
	Total	3,031,967	2,047,433
Optical fibres	ACT	No data	0
	NSW	No data	21,757,955
	NT	No data	338
	Qld	No data	691,090
	SA	No data	13,598
	Tas	No data	0
	Vic	No data	8,240,717
	WA	No data	166,845
	Total	No data	30,870,542

Source: ABS

Note: 1. Different measures of cabling are not equivalent, i.e. kilograms of cables imported is not equal to metres imported, but the total of both amounts represents all cabling imported.

The quantity of particular materials also provides an indication of the geographic distribution of companies involved in manufacturing and assembly for computers and peripheral equipment.

3.1.2 Exports

Australia also exports computer equipment, with data from 1997/98 recording the total value of computer exports at \$1,065 million (ABS 1999). This indicates that exports are significantly lower than imports. Data from both ABS and information from individual companies indicates that the principal export destinations for PCs are (in alphabetical order) Hong Kong, Singapore and New Zealand.

Table 3.4 indicates that the annual number of units exported is highly variable, however there was a 30% increase in the quantity of computers exported between 1996 and 2000, and overall increases of varying magnitudes in all other categories.

It remains unclear as to whether the optical fibres and co-axial cabling exported from Australia is destined for use in computer networking applications or in telecommunications and other electrical and electronic applications. Similarly, integrated circuits may be used in a range of electrical and electronic applications, including but not limited to computers and peripheral equipment. If exported cables and integrated circuits were excluded from comparison, the largest segment of exported materials is comprised of PCs, which is consistent with information from individual companies. Input and output devices are also exported but printers and scanners are not.

Table 3.4 Quantity of Components Exported from Australia (1996-2000)

Component	Year				
	1996	1997	1998	1999	2000
Optical fibres	1,726,289	144,146	2,047,248	4,640,901	29,580,413
Co-axial cables	5,300,034	7,925,068	4,123,036	4,634,394	28,481,570
Computers	104,628	116,227	116,018	89,323	149,807
Integrated circuits	1,090,430	927,458	895,428	2,942,015	11,113,897
Input-output units	89,846	52,684	110,709	95,222	97,680

Source: ABS

Table 3.5 indicates that the highest export value (cabling excepted) is in computers, which is again consistent with advice from stakeholders. The value of exports is highly variable across all sectors, however the table indicates a decrease in the per-unit value of computers, integrated circuits and input-output units. This may indicate a shift towards manufacturing and assembly of less sophisticated products with a lower market value.

Table 3.5 Value of Components Exported from Australia (1996-2000)

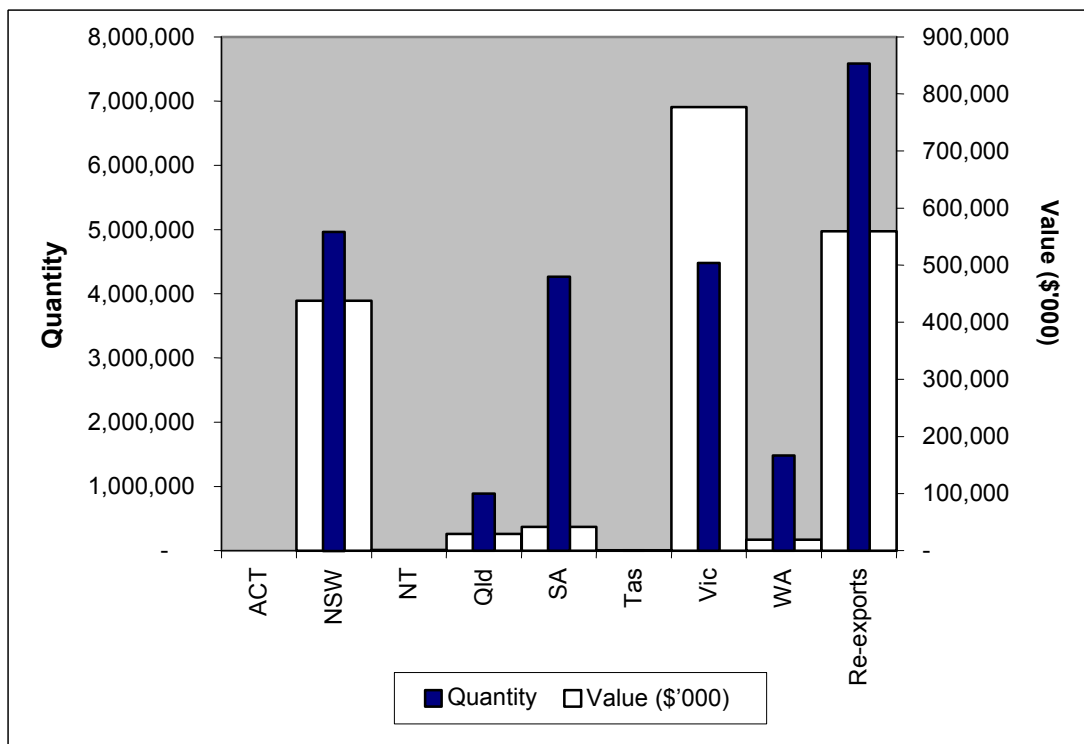
Component	Value (\$'000)				
	1996	1997	1998	1999	2000
Optical fibres	39,096	16,842	82,424	134,542	292,694
Co-axial cables	10,041	9,613	3,910	5,117	27,199
Computers	169,642	274,500	266,375	168,513	147,264
Integrated circuits	16,313	13,109	17,484	25,789	54,029
Input-output units	73,812	23,234	36,965	34,092	32,518

Source: ABS

Figure 3.2 indicates that significant quantities of exports are “re-exported” (i.e. the material has originated overseas, and is being sent back after processing within Australia). The principal commodities being re-exported are various ICs, and principal destinations are Hong Kong, New Zealand, Singapore, UK and USA.

Re-exported materials excluded, Figure 3.2 illustrates that New South Wales, South Australia and Victoria are the principal places of origin for exported goods, with significant yet lesser shares in Queensland and Western Australia. Comparison of quantity and value of goods exported indicates that goods with the highest unit value are being produced in New South Wales and Victoria.

Figure 3.2 Quantity and Value of Exports by State/Territory, 1996-2000



Whilst exported goods are limited indicators of geographic distribution of manufacturers (due to the same distribution characteristics that affect import data), it may be inferred that the principal manufacturing centres lie in New South Wales, South Australia and Victoria.

3.1.3 Total Domestic Shipments

According to IDC Australia, computer shipments in Australia grew from 2,098,001 in 1999 to 2,219,425 in 2000 (refer Table 3.6 below). These figures indicate the total number of new computers sold in each year, and as such includes computers that have been imported as well as those assembled or manufactured within Australia.

Table 3.6 Computer Shipments in Australia

Year	Shipments
1998	1,791,632
1999	2,098,001
2000	2,219,425

Source: IDC Australia

The market is highly variable, as indicated by the 17.1% growth experienced between 1998 and 1999 being followed by 5.8% growth between 1999 and 2000. This reduction is thought to be tied to worldwide economic factors, rather than saturation of the Australian computer market. In fact there are suggestions that some companies have been constrained by a lack of supply of some computer components (e.g. hard drives, motherboards) and historically have experienced difficulty in meeting the market demand for their products in Australia.

The approximate split of shipments between different forms of computer is provided in Table 3.7 below.

Table 3.7 Shipment Composition (1999)

Type	%
Commercial Desktop	57.4
Consumer Desktop	24.7
Portables	15.2
PC Servers	2.7
TOTAL	100

Source: IDC Australia

Based on IDC Australia data for sales of printers in selected quarters of 1999 and 2000, approximately 705,000 printers were sold in 1999. Higher sales in the first quarter of 2000 indicate that actual sales are currently higher than this estimate suggests. Data from IDC Australia allocates 74% of sales in the second quarter of 1999 to inkjet printers. If it is assumed that this proportion remained relatively stable during 1999, the number of inkjet printers sold can be estimated to be approximately 530,000 whilst the number of laser printers sold is approximately 175,000.

Comparable figures for cabling, scanners and other peripherals are not available.

3.2 Usage Patterns

Data relating to the geographical distribution of computer and peripheral equipment use is limited, as is data on the proportion of use in various market segments. This is due in part to the nature of the manufacturing and sales industry, whereby many different companies are involved at separate points in the chain from original equipment manufacturers (OEMs), new equipment distributors (NEDs) to end users. However some quantitative analysis can be undertaken based on the limited data available; this is discussed in the following sections.

3.2.1 Computers

Market segmentation for PC sales in Australia was estimated by the Australian Greenhouse Office in 1993; this is shown in Table 3.8 below. However sales figures can be expected to vary from year to year, and market segmentation for individual forms of computer may differ considerably.

Table 3.8 Computer Sales by Community Sector

Sector	%
--------	---

Households	17
Government	18
Education	14
Medium and small business	28
Large corporations	23

Source: AGO

Despite the age of the data, these figures provide not only an indication of purchasing by sector but also indicate the source of equipment that is likely to have recently been replaced and disposed.

A quarterly survey of household computer ownership indicates an increase from 4,174,000 computers in 1998 to 5,416,000 computers in 2000 (ABS 2001). Table 3.9 indicates continued growth over the past three years, with a marked increase between 1999 and 2000. This table also indicates that the number of computers owned by home users is higher in metropolitan areas than in other areas, with 3,764,000 computers in metropolitan areas compared to 1,652,000 computers in other areas in 2000 (ABS 2001).

Table 3.9 Households with Access to a Computer at Home

Region	Nov 1998 (%)	Nov 1999 (%)	Nov 2000 (%)
Metropolitan areas	50	53	59
Other areas	43	44	52
Total	47	50	56

Source: ABS

Percentages of households provide an indication of ownership, however there will be some households that own more than one computer, so the relationship is not linear.

A smaller study conducted in South Australia in 2000 found that computers were present in 65 out of 100 households surveyed, which indicates that the percentage of households owning a computer varies between States (EPA 2000). This is borne out by ABS data provided in Table 3.10, which shows the largest quantities can be found in New South Wales and Victoria.

Table 3.10 Computers Owned by Households by Location (2000)

Location	No of Computers
STATE:	
ACT	131,000
NSW	1,825,000
NT	37,000
Qld	942,000
SA	400,000
Tas	112,000
Vic	1,442,000
WA	527,000
Total	5,416,000
REGION:	
Metropolitan areas	3,764,000
Other areas	1,652,000

Source: ABS

A survey of business use of computers conducted by ABS in June 2000 showed significant use amongst a range of industry sectors. Across all sectors, computer

use has grown from 49% of businesses in 1993/94 to 63% in 1997/98 and 76% in 1999/2000.

However the survey did not include government administration and defence (including the Reserve Bank of Australia), education, religious organisations, or agriculture, forestry and fishing. These missing sectors are likely to be significant users of computers. Nevertheless the survey data does provide an overview of use amongst private industry as outlined in Table 3.11 below.

Table 3.11 Business Use of Computers

Industry Sector	No of Businesses ('000)	Businesses with Computers (%)	No of Computers ('000)
Mining	2	82	33
Manufacturing	54	79	288
Electricity, gas & water supply	-	85	38
Construction	90	68	121
Wholesale trade	45	83	208
Retail trade	112	68	198
Accommodation, cafes & restaurants	32	61	44
Transport & storage	32	64	105
Communication services	4	77	97
Finance & insurance	23	81	262
Property & business services	149	88	473
Health & community services	51	83	117
Cultural & recreational services	17	81	46
Personal & other services	30	60	59

Source: ABS

The table shows that while there was a widespread use of computers across all sectors, the most extensive use was in property and business services, followed by manufacturing, finance and insurance, wholesale trade, retail trade, health and community services, and transport and storage.

One of the missing areas (agriculture) was the subject of a separate survey. A survey of computer use on farms found that an estimated 49% of the 147,160 farms in Australia owned or used a computer at the end of March 1999 (ABS 1999). The highest proportion of farms using a computer were located in Northern Territory (65%), the Australian Capital Territory (62%) and Western Australia (59%), while Queensland (45%) and New South Wales (48%) had the lowest proportion of farms using a computer (ABS 1999).

The government sector was also the subject of a previous survey. The principal sector of PC ownership by Government in 1998 was State and Territory departments and agencies, as indicated by Table 3.12.

Table 3.12 Estimated Computer Ownership by Government Type

Government Type	No of
-----------------	-------

	Computers (‘000)
Federal departments and agencies	164
State/Territory departments and agencies	231
Local Government	60
Other government organisation	51

Source: ABS

Survey data from ABS (2000) also indicates that the extent of computer use is related to the size of the business. Table 3.13 shows that the extent of computer use increases in accordance with increasing business size, with computers being used in all businesses that employ over 100 people. These figures are slightly higher than those estimated by IDC Australia, which indicate that approximately 67% of Australian businesses employing less than 100 employees in the non-agricultural private sector use personal computers and information technology to some degree (IDC Australia).

Table 3.13 Business Computer Use by Size

Size	No of Businesses (‘000)	Businesses with Computers (%)
EMPLOYMENT		
1 - 4 persons	415	69
5 - 19 persons	184	85
20 - 99 persons	36	97
100 or more persons	6	100
ANNUAL SALES		
Less than \$100,000	158	63
\$100,000 - \$999,999	365	76
\$1m - \$4.9m	92	91
\$5m or more	26	99

Source: ABS

Businesses using computers within each State/Territory and within capital and regional areas are shown in Table 3.14. Whilst the values indicate a comparatively low use of computers by businesses in the Northern Territory, there is a relatively even percentage of businesses using computers throughout Australia.

It is particularly important to note the relatively small difference in the percentage of businesses with computers in capital cities compared to other areas.

Table 3.14 Business Computer Use by Location

Location	No of Businesses ('000)	Businesses with Computers (%)
STATE:		
Australian Capital Territory	12	80
New South Wales	233	74
Northern Territory	4	68
Queensland	112	79
South Australia	42	78
Tasmania	12	70
Victoria	169	77
Western Australia	57	75
REGION:		
Capital cities	430	77
Other areas	211	74

Source: ABS

If the data on household and business use of computers is compared to sales data in Section 3.1, it may be argued that the market share for home consumers has increased to approximately one-quarter of the overall new computer market. The impact of this increased market share on business, Government and education sectors is not clear, however it can be assumed that the business sector has retained its proportional share of the remaining market share. Advice from leasing companies suggests that 70% of leased equipment lies within corporate and institutional sectors, with education being the largest sector, followed by health, other Government departments and large corporate companies.

If these assumptions are applied to a revised market share based on the home consumer market accounting for 25% of annual sales, and if it is assumed that these sales patterns remain relatively stable between successive years, then the percentage of computer sales by sector (as established in Table 3.8) can be updated as estimated in Table 3.15.

Table 3.15 Estimated Computer Sales by Sector (2001)

Sector	%
Households	25
Government	16
Education	13
Medium and small businesses	25
Large corporations	21

It should be noted that these estimates are based on new equipment sales, and do not incorporate second-hand machines that are being re-used in these sectors. As discussed in Section 3.3, the education sector and domestic households are major recipients of reused and/or refurbished equipment. Consequently the share of computer usage and the total number of computer equipment in these sectors is likely to differ from sales figures in Table 3.15.

3.2.2 Peripheral Equipment

The quantity and quality of data on the use of peripheral equipment (including cables, printers and cartridges, and scanners) is more limited than it is for computers. ABS surveys of household computer ownership have identified high ownership of printers but a low percentage of scanners, as indicated by Table 3.16.

Table 3.16 Household Ownership of Printers & Scanners (2000)

Location	Printer		Scanner	
	% of Households	No	% of Households	No
STATE:				
ACT	88	115,280	31	40,610
NSW	87	1,587,750	27	492,750
NT	90	33,300	29	10,730
Qld	85	800,700	32	301,440
SA	87	348,000	33	132,000
Tas	87	97,440	26	29,120
Vic	86	1,240,120	26	374,920
WA	86	453,220	24	126,480
Total		4,675,810		1,508,050
REGION:				
Metropolitan areas	88	3,312,320	30	1,129,200
Other areas	88	1,453,760	30	495,600

Source: ABS

The table also indicates that ownership of peripheral equipment is independent of the number of computers owned, with the largest percentage of printers owned in Northern Territory, and the largest percentage of scanners owned in South Australia. The ABS survey did not identify any significant differences in ownership between metropolitan areas and other areas. The survey also identified internal components such as CD burners, CD-ROM drives, DVD drives, modems and webcams, however these items are not considered as separate items within the scope of this report.

Table 3.16 outlines the estimated number of printers and scanners in use in 2000 in the household sector at 4,675,810 and 1,508,050 respectively. There is no baseline data on the numbers in use in other sectors. If printer and scanner sales are consistent with the percentages for computer sales outlined in Table 3.8 (which shows that the household sector accounts for approximately 17% of total sales), then the total number of printers and scanners in use is in the order of 27,505,000 and 8,871,000 respectively. However these figures would indicate more printers in use than computers, a situation not reflected in actual use. The figures also do not reflect the business use of one printer linked via a local area network to a large number of computers.

The best estimate of printer and scanner use in non-household sectors may be based on the number of businesses that use a computer (as provided in Table 3.11). This table shows that there are approximately 641,000 businesses using computers (excluding government, education, religious organisations, agriculture, forestry and fishing). If it is assumed that each of these businesses has a printer and a scanner, then the total numbers of printers and scanners in use is at least 5,317,000 and 2,149,000 respectively. This is expected to be a conservative figure, as it does not allow for the possibility of multiple pieces of equipment in corporate situations.

Industry figures provided to Environment Australia (2001) suggest that 1.3 million printer toner cartridges were in use in Australia in 1999. If the estimates of printers in use given above are accurate, then the number of inkjet cartridges in use may be more than double the suggested figure even before considering the percentage of users consuming more than one ink cartridge per year.

If estimates by ACF (1996) that laser printer cartridges have a 1-4 month lifespan (based on 300 gm of toner per cartridge, and 3,000-5,000 pages printed) are considered accurate, then the approximate number of toner cartridges used in Australia in 2001 will fall within the range of 2,625,000 to 10,500,000. While this range is quite large, it is dependent on the number of toner cartridges used with each laser printer. This relies on the print volume of each user, which may vary significantly with the nature of the print run and the type of user.

This figure is comparable to estimates from a leading cartridge recycling company that approximately 5 to 6 million toner cartridges are purchased each year in Australia.

3.3 Waste Equipment

3.3.1 Computers

The annual quantity of computers disposed of is directly related to the number of years for which the equipment is used before disposal. Approximately 70% of small to medium businesses retain their PCs for longer than 3 years (ABS 2000), and anecdotal evidence from Australian computer manufacturers suggests that the retention period of the domestic user is approximately 5 years. The retention period may vary significantly between users.

A limited survey of 100 South Australian households by Göl et al. (EPA 2000) indicated that 46% had yet to replace their first computer and, out of those that had replaced their first computer, approximately 40% had done so within five years after their original purchase. The majority of replaced household computers identified in the study were either placed into storage (34%) or had been passed on for reuse (26%), generally within the family.

Leasing of equipment is well established in Australia, particularly in the institutional and corporate sector. Industry participants estimate that approximately 600,000 computers are currently leased in Australia. Approximately 240,000 computers are disposed of in this sector every year. Leasing of scanners and printers is also established, although at a much lower rate. Approximately 15,000 units would be disposed of each year.

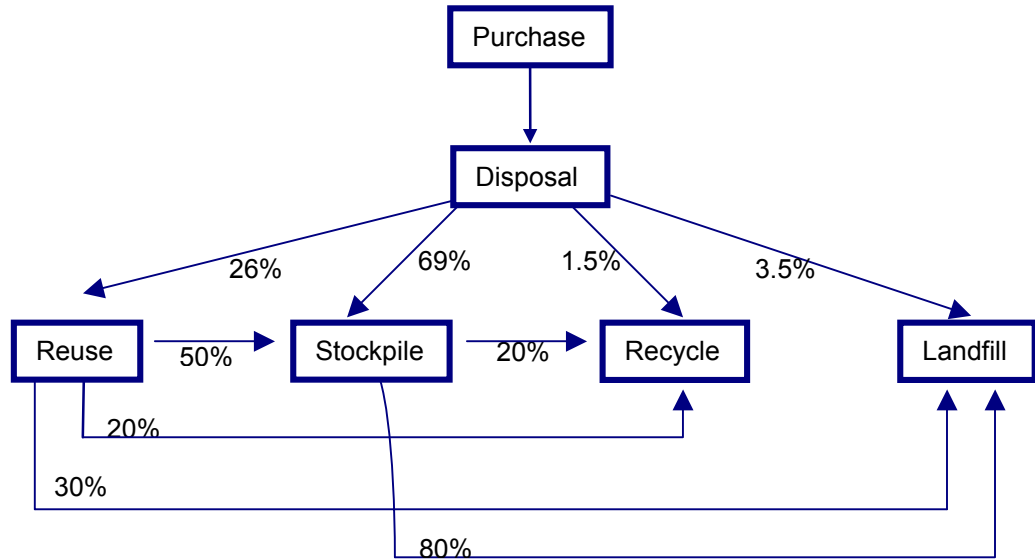
Leasing is also likely to become much more prevalent in the future as the lifespan of future generations of computers become shorter and users (especially commercial users) wish to minimise technology costs. Industry participants suggest that the average lease in the USA runs for approximately 18 months, before the machines are scrapped and new ones provided. In Australia, the average lease period is approximately 3 years, although this is decreasing. Industry surveys by IDC Australia indicate that over 30% of Australian small-to-medium enterprises upgrade their PCs every 2 years.

The earlier ABS surveys of household computer use identified a clear trend to acquire greater computer capacity, with a general decline in numbers of computers owned or being paid for with processing capacity below a 486 and memory capacity below 16 megabytes (ABS 1998).

A model for the disposition and end-of-life of desktop and notebook computers was developed by Matthews et al (1997). The model utilised assumptions regarding the lifespan of computers and the proportions of obsolete computers being disposed of through reuse, storage, recycling or landfilling to estimate the number of computers disposed of through each pathway. The Matthews model has been adapted to reflect the disposal patterns in Australia, based on

information provided by industry participants and a survey of corporate and individual computer users in South Australia (EPA 2000). The adapted model is provided in Appendix B. The model is based on flowpaths as indicated in Figure 3.3.

Figure 3.3 Flowpath of Disposed Computers



After Matthews et al. (1997)

It is important to recognise that these percentages are both approximate and homogenous (i.e. they do not reflect differences in disposal patterns for different sectors of the community). Limited evidence from South Australia indicates that private users store fewer machines than corporate users (EPA 2000).

These percentages may also vary between geographic regions, most likely due to the degree of access to particular options that are available in each region. The percentages will also differ to, but are generally consistent with, those identified overseas, as illustrated by estimates from studies in Florida (Price 1999), which indicate that of the total obsolete computers in the State, approximately 8% are landfilled, 21% recycled and over 71% are in storage awaiting disposal.

The model in Appendix B yields an estimate of approximately 7,677,300 computers in use in Australia in 2001. This number includes the cumulative total of computers that have been purchased new between 1999 and 2001 (being 6,477,800 computers) and the cumulative total of computers that have been passed on for reuse between 1999 and 2001 (being 1,199,500 computers).

A summary of the total number of computers sent through each disposal pathway (other than reuse) is provided in Table 3.17. As computers are held in storage for an approximate average of 3 years, values for both the annual quantity sent to storage and the quantity of computers already in storage have been provided.

Table 3.17 Estimates of PCs Disposed in Australia

Disposal Option	2001	2006	2011
Recycled	281,700	494,000	509,600
Landfilled	926,500	1,632,800	1,694,700
Sent to storage	1,331,000	1,792,800	1,839,800
Total already in storage	3,618,200	5,260,400	5,479,700

Based on an average landfill compaction rate, it is estimated that over 77,000 m³ of landfill airspace will be taken up by computers in 2001. This is estimated to nearly double within 10 years, to approximately 141,000 m³ per year by 2011.

The model in Appendix B extrapolates data from 1985 (when computer ownership began to be widespread) to 2011 (to predict movements over the next 10 years). The model shows that during this period approximately 2,011,000 m³ of landfill airspace will be taken up by waste computers by 2011.

It is important to acknowledge that there are a number of shortcomings in the model's applicability to the Australian situation. Of particular importance is the volume of equipment in use (and subsequently the amount disposed of). The model shows that approximately 7,091,200 computers were in use in Australia in 2000. However data from ABS surveys (Table 3.10) shows that household ownership of computers in 2000 was approximately 5,416,000, indicating a domestic market share of almost 77%. This comparatively large domestic market share is inconsistent with advice from a range of stakeholders and contrary to information from a range of other Australian reports which shows a much larger market share by the corporate / commercial sector than the 23% which these figures indicate. It is possible that the sample households surveyed by the ABS skewed the results of the total domestic ownership of computer and peripheral equipment. It is more likely that the model underestimates the number of computers in use in Australia.

The model remains the best representation of computer circulation that has been developed. However the number of assumptions required affect its sensitivity. Therefore, while model figures included in Table 3.17 above indicate that waste computer equipment is a very large problem in Australia, it is possible that the real problem is in fact much worse.

3.3.2 Printers & Scanners

Anecdotal evidence suggests that the lifespan of peripheral equipment can be considerably longer than that of PCs and is determined more by equipment operability and the availability of replacement parts and consumables (e.g. ink and toner cartridges) than by obsolescence.

Given the relatively recent market penetration of scanners and the anticipated lifespan of around 5 years, it is unlikely that significant numbers of scanners have been disposed of into the waste stream. However this is not likely to be the same case for printers.

Information from stakeholders indicates that laser printers may last up to 5 or 6 years depending on the intensity of use. However leasing of printers is likely to increase and as such the period of use for individual machines is likely to decrease.

Stakeholder advice is that few printers are reused, in part due to their longer product life and the relatively low purchase price of a new printer. It may therefore be assumed that all printers reaching the end of their product life are disposed of. With a conservative estimate of 5,317,000 printers currently in use and an approximate product life of 5 to 6 years, it is possible that disposal rates are upwards of 1,500,000 printers per year. However this figure should be treated with caution given the uncertainty of actual printer use.

3.3.3 Cartridges

Industry stakeholders advise that approximately 17% of an estimated 6 million cartridges are recovered, leaving 83% potentially being disposed of.

Based on the estimated range of 2,625,000 to 10,500,000 cartridges being sold each year, this equates to an annual waste stream of between 2,179,000 and 8,715,000 cartridges.

3.3.4 Cabling

It is difficult to approximate the quantity of cabling being disposed of per year in Australia, however there are some observations that can be made. It is likely that the adoption of UTP as standard networking cable has led to the disposal of significant quantities of Thinnet cabling in the past 5 years. This material is likely to be predominantly comprised of shorter lengths of cable that have been used to connect PCs to in-wall cabling.

Inside each CPU there may be up to 5 m of cable length, of various types and sizes. Additionally there may be up to 10 m of cable externally, connecting input and output units, and the PC to power supply. Based on these assumptions the following quantities of cables could potentially be entering the waste stream. For 2001 figures, 12,660 km of internal cabling and 25,319 km of input and output cables is estimated. This is in addition to 18,071 km of internal and 36,142 km of input and output cabling potentially already in storage.

In situations where cables have been installed within wall cavities it is unlikely that effort will be expended to remove surplus cabling, and as such this material may be regarded as "stored" until significant structural alterations are made to their surroundings and they are disposed of with other demolition material.

4. MATERIAL COMPOSITION

4.1 Materials

Computers and peripheral equipment are comprised of a range of different materials, including different types and blends of plastic, ferrous and non-ferrous metals (including precious metals and heavy metals), glass, foam, rubber, carbon powder and additives (such as paints, coatings and fire retardants). The types and quantities of materials used in each unit will differ according to the type of equipment (e.g. PC, printer, scanner, etc), manufacturer, model and when it was made.

The materials described within this chapter are limited to those that are physically present within computers and peripheral equipment. A number of other materials, including some materials that pose environmental and health risks, will have been used in the manufacture and packaging of these finished products. These materials are outside the scope of this current project, however it is important to note that they are covered under separate arrangements with manufacturers. The manufacture of computers and peripheral equipment may be addressed through cleaner production initiatives between industry and Commonwealth or State authorities. The packaging of computers and peripheral equipment should be addressed through the National Packaging Covenant and the *National Environment Protection (Used Packaging Materials) Measure*.

The composition of a typical desktop computer has been determined in 1996 US studies; the results are outlined in Table 4.1. While laptop computers and LCD monitors have not been examined, their constituent materials are similar to those detailed in Table 4.1. These components are discussed in further detail in the following sections.

Table 4.1 Material Composition of PC

Material	% Weight	Material	% Weight
Silica	24.8803	Bismuth	0.0063
Plastics	22.9907	Chromium	0.0063
Iron	20.4712	Mercury	0.0022
Aluminium	14.1723	Germanium	0.0016
Copper	6.9287	Gold	0.0016
Lead	6.2988	Indium	0.0016
Zinc	2.2046	Ruthenium	0.0016
Tin	1.0078	Selenium	0.0016
Nickel	0.8503	Arsenic	0.0013
Barium	0.0315	Gallium	0.0013
Manganese	0.0315	Palladium	0.0003
Silver	0.0189	Europium	0.0002
Beryllium	0.0157	Niobium	0.0002
Cobalt	0.0157	Vanadium	0.0002
Tantalum	0.0157	Yttrium	0.0002
Titanium	0.0157	Platinum	Trace
Antimony	0.0094	Rhodium	Trace
Cadmium	0.0094	Terbium	Trace

Source: Microelectronics and Computer Technology Corporation

4.1.1 Metals

It can be seen from Table 4.1 that many different base and precious metals are used in the construction of computer components. The likely form and use of metals that are of particular environmental concern are outlined below.

- A small quantity of **antimony** is present in some inorganic flame retardants, in the form of either antimony trioxide or antimony chloride.
- A small quantity of **arsenic**, in the form of gallium arsenide, is contained within light emitting diodes (LEDs).
- **Base metals** including aluminium and iron, are used for structural purposes such as component cases and frames, as well as moving parts.
- A small amount of **beryllium**, in the form of a copper-beryllium alloy (typically 98% copper and 2% beryllium), may be present in the connection slots on older motherboards used for connecting to daughterboards. Small amounts may also be found in “finger clips” used to maintain electrical conductivity in metal housings.
- **Cadmium** occurs in some components of PCBs, such as surface-mounted chip resistors, infrared detectors and semiconductors. There is a small amount of cadmium in plated contacts and switches, and a very small amount of cadmium may have been used as a stabiliser in PVC insulation for wires of the type used in PCs. Rechargeable nickel cadmium (NiCd) batteries have been used in laptop PCs. Newer laptops are likely to contain batteries made from nickel metal hydride (NiMH) or lithium ion (Li) rather than NiCd. Cadmium sulphide has also been used as a phosphor in older CRTs.
- **Copper** is used as the principal conducting element within electronic equipment, and can be found in PCBs, cables, and electromagnets in CRTs and storage devices. The percentage of copper used in data cabling varies from approximately 20% to 45%, and use of particular grades generally follows the rule of higher percentages being used where higher capacities or longer run cable lengths are required.
- **Chromium** is used as a hardener or corrosion resistor in steel housings, and as a decorative finish. It is more correctly known as hexavalent chromium or chromium VI.
- **Lead** may be found in a number of components. There is approximately 2-3 kg of insoluble lead encapsulated in the glass matrix of the funnel and faceplate in each CRT (representing approximately 27% of content of the glass screen). There is an additional 15-100 gm of lead present as soluble lead oxide in the ‘frit’, which is a type of glass solder used to join the faceplate and funnel sections of CRTs. A small quantity of lead is present in the solder used to bond ICs and other small components to PCBs and wiring connections. Lead sulphate may also be used in small amounts as a stabiliser in PVC sheathing for cables and wires. Some early models of laptop computers may contain a sealed lead acid battery.
- **Lithium** is present in backup batteries on the PC motherboard, as well as in some newer laptop batteries.
- **Mercury** is found in the small lamps that provide backlighting in LCDs, however xenon is now being used as a replacement. The average amount of mercury contained in a laptop computer is 0.12 to 5 mg of mercury (approximately one-fifth the amount of mercury in a single household

fluorescent light). Mercury switches and relays were traditionally used in large mainframe computers, however it is unlikely that the older mainframe computers are either still in circulation in Australia or represent a significant portion of computer waste currently being sent to landfill. Mercury may also be found in small quantities within batteries and PCBs.

- **Precious metals** including gold, platinum and silver are used to create conductive materials, particularly connectors.
- **Zinc**, in the form of zinc sulphide, is mixed with rare earth metals to create a phosphor coating used on the interior of a CRT screen to convert the kinetic energy of an electron beam to light.

Other metals are often found in small quantities, usually in alloy form. Aluminium is often used in alloy with titanium, and iron is alloyed with nickel, cobalt and manganese in steel housings. Small or trace amounts of particular materials may be found in components that are bonded to PCBs (e.g. antimony in diodes, germanium and gallium in semiconductors, indium and selenium in rectifiers, ruthenium in resistors, and tantalum in capacitors). Phosphor activators and emitters within CRTs (in addition to the zinc or cadmium compounds mentioned above) include europium, terbium, vanadium and yttrium. Additional quantities of particular materials may be found within many different components (e.g. cobalt may be found in NiMH rechargeable batteries).

4.1.2 Plastic

The plastics referred to in Table 4.1 consist of the following resin types:

- Acrylonitrile Butadiene Styrene (ABS);
- Polyphenylene Oxide (PPO);
- High Impact Polystyrene (HIPS);
- Polycarbonate/Acrylonitrile Butadiene Styrene (PC/ABS); and
- Polyvinylchloride (PVC).

The amount of each of these plastics has been determined in studies by the American Plastics Council. These figures are provided in Table 4.2.

Table 4.2 Plastics in Computers

Plastic	%
ABS	57
HIPS	5
PC/ABS	2
PPO	36
PVC	Trace

Source: American Plastics Council

Other plastics may also be present in computers and peripheral equipment (e.g. cross-linked polyethylene [XLPE] may be used in place of PVC as an insulating coating for cables).

Plastic is used as a housing or surface material for electronic parts, or as mechanical parts (e.g. gears, levers and rods). A component made of one type of plastic may be attached to components made from other types of plastic (e.g. trays in CD-ROM drives), and as such an item of equipment may comprise a number of different plastics.

Some types of plastic may include metals and other elemental additives. For example, PVC sheaths for cabling include cadmium and lead stabilisers (i.e. additives to prevent the plastic from breaking down during use) and chloroparaffins have been used as softeners (i.e. additives to allow the plastic to remain flexible). Plastic housings made from ABS plastic may contain tetrabromobisphenol-A (TBBA), which is a brominated flame retardant.

4.1.3 Silica

Silica is the principal material used in the glass present in both CRTs and LCDs, and is also the basic material used to manufacture the majority of solid-state ICs (as exemplified by the term "silicon chip"). Glass of varying size and grade is used for copying plates within scanners, and the glass drums in toner cartridges for laser printers.

4.1.4 Other

Flame retardants, including organic halogenated or brominated compounds (e.g. TBBA) and inorganic compounds (e.g. antimony compounds), are used in the epoxy resin of PCBs to prevent fires. Polybrominated biphenyls (PBBs) have also been used as flame retardants, however sources indicate that their use in computer housings was discontinued between 7 and 10 years ago.

Antimony trioxide is commonly used with halogenated flame retardants as a synergist to achieve a high flame retardancy (EEB 2001).

There is some uncertainty (and argument) about the use of polychlorinated biphenyls in PCs. A principal use of polychlorinated biphenyls was for cooling and lubrication within older capacitors and power transformers. Whilst the OECD (2001) has indicated that capacitors containing polychlorinated biphenyls have been used in larger items of equipment (e.g. mainframe computers and large printers), their historic use in computers is less clear. This is illustrated by opposing statements made by the Electronic Industries Alliance (2000) and Silicon Valley Toxics Coalition (2001) regarding the presence or absence of polychlorinated biphenyls in computer equipment.

Trace amounts of liquid crystals are present in flat panel displays (e.g. approximately 0.42 gm are found in a 15" LCD monitor).

Inks are comprised of a pigment dissolved in an oil base with various additives to control the rate of drying, spreading and stickiness. Pigments have historically contained heavy metals (e.g. lead chromate or cadmium compounds) but have more recently contained organic and synthetic pigments. Black ink will normally be carbon-based. Toner is normally a powdered mixture of carbon black and plastic resin, and often includes waxes and a mineral carrier.

The list of materials given above is by no means exhaustive. Mechanical parts within individual PC components or peripheral equipment may include materials not specified in the previous sections, in order to carry out specific functions (e.g. rubber rollers that are used to feed paper through printers, and foam insulation). The materials specified above do represent the most common materials found in computers and peripheral equipment, and more importantly include those materials that have been commonly identified as posing environmental or health risks.

4.2 Environmental Impacts

It is important to note that the environmental and health risk of computer waste materials may be much larger than the quantities indicated by Table 4.1 might suggest. This is due to the overall volume of waste computer equipment disposed of each year, which compounds the small amount present in individual units into a total amount that may pose significant risks. Particular materials may also be of concern due to the manner in which they accumulate within the environment.

The materials that are of principal concern with regard to environmental and health risks include:

- brominated flame retardants;
- cadmium;
- chromium VI;
- lead;
- mercury; and
- PVC plastic.

Other materials pose lesser risks that are specific to their handling in recycling operations (e.g. beryllium may be released into the air through the preparation of material samples for testing and will be harmful if inhaled, and lithium ion batteries pose a fire risk if shredded).

The adverse impacts of these materials upon both the environment and human health have been well documented by previous reports (EIA 2000, EEB 2001, EPA 2000, OECD 2001, SVTC 2001). Lead can damage the nervous system, accumulates in the environment and has high acute and chronic toxic effects on plants, animals and microorganisms. Cadmium and cadmium compounds are persistent, bioaccumulative and toxic with possible risk of irreversible effects on human health and the environment. It may cause cancer with prolonged exposure.

Inorganic mercury in water (e.g. landfill leachate) is transformed into methylated mercury in sediments. It is bioaccumulative and persistent, and can cause damage to the brain. Mercury alkyls and inorganic compounds are very toxic when inhaled, and can cause significant damage to health through cumulative impacts.

Chromium (VI) is easily absorbed and can produce various toxic effects within cells. It can cause severe allergic reactions, asthmatic bronchitis and potential damage to deoxyribonucleic acid (DNA) in cells.

Brominated flame retardants can be soluble in landfill leachate and are bioaccumulative and persistent. Nearly all flame retardants containing bromine and chlorine migrate and are volatile to a certain extent. They have been found in indoor dust and air through migration and evaporation from plastics.

Antimony trioxide (commonly used with halogenated flame retardants) decomposes when heated, producing toxic fumes (antimony) and can react under certain circumstances with hydrogen to produce a poisonous gas (stibine). Stibine affects the lungs, eyes, skin and respiratory tract; it is possibly carcinogenic and may affect the reproductive system.

Landfilling of computers and peripheral materials poses significant environmental and health risks, particularly through specific substances leaching into soil and groundwater. Soluble materials (e.g. the lead oxide solder in CRT frit, cadmium-based phosphors and the residual ink and toner from printer cartridges) may

migrate into leachate. The leachate in landfills can be highly acidic and can dissolve materials that might otherwise remain stable (e.g. lead ions from broken CRT glass, or TBBA).

Documentation regarding the environmental and health risks associated with the disposal of computer and peripheral equipment often considers the effects of incineration. While incineration of the municipal waste stream is not established in Australia, the trend towards use of alternative waste technologies includes options for processing under high temperature. Combustion or high temperature processing may also occur during recovery of materials from waste computer and peripheral equipment. High temperature processing (e.g. smelting) may result in the release of dust containing oxides of beryllium, cadmium or lead. Lead fumes may also be released through heat treatment. Plastics extrusion may release bromine (from PBB and TBBA flame retarded plastics and PCBs) and chlorine (from PVC plastics), which are converted to chlorinated or brominated dibenzo dioxins and furans.

Plastic poses significant environmental risk for reasons other than toxicity, most notably due to the durability and longevity of material. This results in plastic materials remaining in landfill for very long periods of time. Considerable effort has been invested by many organisations worldwide to reduce the impact of plastic use on declining oil reserves and rapidly filling landfill space. Whilst many different types of plastic are produced to suit a wide range of applications, computers and peripheral equipment are a small yet significant part of the total product stream where recycling or recovery of materials will reduce current impacts.

It is noted that there will be additional environmental impacts arising from other parts of the total life cycle of computers and peripheral equipment (e.g. the extraction of natural resources for the production of materials and energy). However these aspects are outside the scope of this project.

4.3 Substitution of Hazardous Materials

The substitution of hazardous materials used in the manufacture of computers and peripheral equipment with more benign material has been investigated, with replacement at different stages of development and implementation for various materials.

Lead-free solders have been under development for over 10 years and some alternatives are available. Lead-free alloys generally have higher value, which may also encourage recovery of metals from end-of-life products. Alternatives for lead in solders are based on alloys of tin, silver, copper, bismuth and zinc, and are specific to the application. These include:

- tin – bismuth – copper (main solder alternative);
- tin – bismuth – silver (solder for surface mount reflow);
- tin – copper and tin – silver (for wave soldering);
- tin – bismuth (for low temperature soldering); and
- tin – zinc – bismuth.

The latter solder (tin – zinc – bismuth) requires more development but is already in use by NEC in certain applications. A number of other companies involved in manufacture of computers or peripheral equipment have also instigated voluntary plans for elimination of lead-based solder (EEB 2001). These voluntary measures are detailed in Table 4.3 below.

Table 4.3 Voluntary Plans for Use of Lead-Free Solder

Company	Details
Fujitsu	High-end servers (step soldering): tin-silver-copper and tin-bismuth-silver (PCBs) used from 1999 Lead-free finishing components required from October 2001 Use of tin-silver-copper and tin-bismuth-silver solders in all new products from December 2002
Hitachi	Use of tin-silver-copper and tin-bismuth-silver solders in all products by March 2002
Matsushita	Use of tin-silver-bismuth solders in optical disc drivers and mini-discs by September 1998 Use of tin-silver-copper and tin-silver-bismuth solders in all new products by March 2003
NEC	Notebook PCs: tin-zinc-bismuth solder used from 1999 Full adoption of lead-free solder in all products by 2002 (substitution of tin-silver-copper and tin-silver-bismuth-copper solders)
Panasonic	Full adoption of lead-free solder in 2001
Sony	Lead-free finishing components required from January 2001 Use of lead-free solder in at least one model at each business unit from March 2001 Elimination of lead solders in all products, electronic components and maintenance services by March 2006

Source: EEB 2001

There are also some computer companies involved in the European Improved Design Life and Environmentally Aware Manufacturing of Electronic Assemblies by Lead-Free Soldering (IDEALS) project, including Philips and Siemens. This project initiated changes in 1999 in the use of lead solder by some European companies, although it is yet to be fully implemented across all participants.

Other alternatives to the use of solder may also exist. Cornell University announced in 2000 the development of a new epoxy (Alpha-Terp) which, while very strong at room temperature, starts to fall apart at approximately 190° C and can be dissolved with a common industrial solvent. Its use in PCBs as a replacement for solder has been promoted (Krause 2001).

Substitution of halogenated flame retardants has also been initiated in some areas. Aluminium trihydrate (ATH) and magnesium dihydrate (MDH) are two main substitutes used. They are mostly inert in landfills; ATH is insoluble and MDH has a very low solubility (EEB 2001). Industry initiatives include:

- Siemens banned the use of PBB and PBDE in its products in 1994, although the company noted in 2000 there were still some problems with substitutes for certain halogen-containing components;
- Sony planned to phase out halogenated flame retardants in European models by March 2001, and in all products sold worldwide by March 2003; and
- Toshiba introduced a notebook with halogen-free motherboard in 1999.

Sony also uses a phosphorous-nitrogen based flame retardant system for PCBs used in other types of electrical equipment that they manufacture (EEB 2001).

Material substitution initiatives within the CRT manufacturing sector include the removal of lead from CRT panel glass by the majority of CRT glass manufacturers within the USA, replacement of arsenic with sodium antimony in CRT glass, and the withdrawal of cadmium sulphide from use as a phosphor.

Some alternatives to the use of mercury have also been established. Hewlett Packard has chosen to use light emitting diodes (LEDs) instead of mercury lamps for their scanners. The company has also eliminated batteries by using flash memory technology (Krause 2001).

PVC is another problematic material which is being phased out in some computer and peripheral material applications. Sony has committed to reducing PVC use in wiring by 50% in all Japanese products by March 2001, and by March 2003 in all models made worldwide (EEB 2001). Alternatives to PVC include an ethene or ethene/propene co-polymer, and a polypropylene / styrene-ethylene-butene-styrene (PP/SEBS) blend.

5. WASTE EQUIPMENT PATHWAYS

5.1 Australian Manufacturers

Extended producer responsibility for waste computer and peripheral equipment has not yet been incorporated into the ethos of Australian computer manufacturers. While the international parent companies of many Australian manufacturers have implemented a number of environmental initiatives, product stewardship in the Australian computer industry is currently in its infancy.

International manufacturers' initiatives are outlined in Section 7.2, and include a range of features such as design initiatives, take-back schemes and refurbishment of used equipment, however many of these have not been implemented in Australia.

Design of computer equipment is undertaken by international parent companies, often with little input from Australian subsidiaries. Consequently the Australian computer industry benefits from environmental features incorporated into the design of the equipment initiated overseas; conversely, the ability of local subsidiaries to influence design features is limited.

Refurbishment and remanufacture of computer and peripheral equipment is also limited in Australia. As mentioned in Section 2.1, most computer hardware is imported from overseas rather than produced locally; at best it may be assembled locally from imported components. The lack of remanufacturing in Australia is a feature of the lack of computer manufacturing generally.

Recycling and take-back schemes are also limited in scope. The only collection scheme for obsolete computers currently in place is that established by Compaq Computer Australia with funding assistance from the NSW Environment Protection Authority. This scheme (known as the Computer Asset Recovery Service) commenced in January 2000 and focused on large corporations. It does not accept obsolete computers from domestic sources, and has limited geographical coverage of Australia. The NSW EPA advised that over a period of 15 months the service collected approximately 200 tonnes of computers, monitors and related equipment, including items such as fax machines which are outside the scope of this project.

Hewlett Packard also currently has a trade-in program in Australia, whereby old printers are taken back by the manufacturer when customers purchase a new laser printer. The old printers are either recycled or refurbished and resold. However the program is limited to certain models of printers, including limitations on the model of old printer accepted and new model purchased. The extent of participation in this program is not known.

Fuji Xerox Australia has a program for return of printer cartridges. Customers are provided with a recovery box which is collected by arrangement with Fuji Xerox when full. Ricoh Australia has also recently introduced a service for take-back and recycling of toner cartridges. While recovery of cartridges in Australia is more widespread than these two programs, these services are offered by recycling companies rather than the manufacturers. Recycling and disposal pathways are discussed in more detail in the following section.

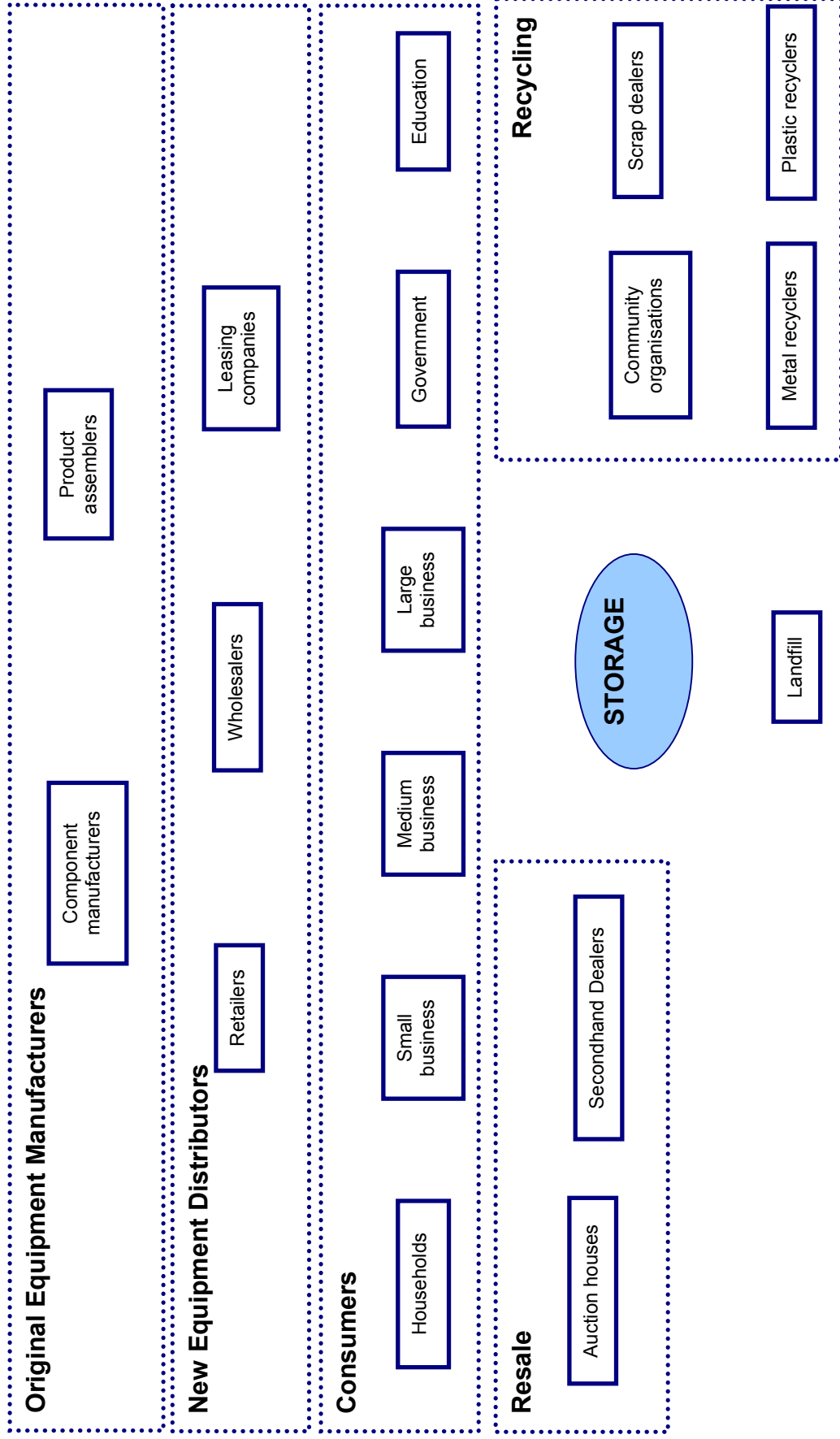
5.2 Disposal & Recovery Pathways

The fate of waste computers and peripheral equipment following obsolescence will depend upon a number of factors. The use of particular disposal options varies both geographically and between sectors of the community, which is generally equivalent to the level of service provided by commercial, Government or non-Government entities.

Use of particular options also reflects the value placed on the equipment by the owner as well as the wider community. For example, there is often an expectation by an owner of the obsolete equipment that disposal involves further use of the item or its component materials as they ascribe a high value to the purchase and ownership of that equipment. Decisions by the owner of a particular item of equipment made according to these criteria (among others) will result in the computer being reused, stored for future disposal, disposal for recycling, and disposal to landfill.

Figure 5.1 overleaf indicates that each of the disposal options mentioned above is administered by a variety of distinct entities, each providing a service for either commercial or charitable purposes. The disposal path interactions between the various entities are complex, with a web of pathways resulting from overall flow of material.

Figure 5.1 Computer Equipment Segmentation



5.2.1 Storage

Storage is undertaken by consumers within all sectors, and is also prevalent within certain sectors of the disposal system (e.g. second-hand equipment retailers and non-profit refurbishers). Retention and storage of used equipment is principally related to the perceived or actual value of the equipment, either in fiscal terms or in opportunities for further usefulness.

Users may hold an item in storage out of a sense that the full value of their purchase was not realised before a replacement item was required. This may be influenced by the trend of rapid improvement of computer performance (and therefore premature obsolescence of purchased equipment) or by a company's asset management system. This latter factor may result in the retention of broken or obsolete computer equipment until its value has been fully depreciated. Anecdotal evidence suggests that some organisations continue to store material for considerable periods of time, despite having to pay storage fees for this reason and because of lack of awareness of appropriate disposal options.

Users may also retain equipment as a contingency, in case it may 'come in handy' later. Spare equipment and its constituent components may allow users to replace faulty equipment, either permanently or temporarily. This is particularly the case in organisations with dedicated information technology management units where maintenance and repairs are oriented towards minimising disruption to productivity by faulty equipment.

Second-hand retailers and refurbishers will stockpile materials to facilitate the repair and upgrade of equipment, particularly older components for which new replacements may not be readily available. Non-working equipment, particularly CRTs, may also be stored by refurbishers in response to the environmental and health risks associated with their disposal to landfill, in case economically viable alternatives to landfilling arise in future.

Equipment that has been placed in storage may either be sent for reuse, recycling or disposal. This may occur with or without the equipment being used in the interim. The period of time that may elapse before an item is taken from storage for further disposal will depend principally on the user's decision that it is no longer worthwhile to store the item; the decision to release the equipment from storage may be triggered by a number of factors including the value of the item or availability of storage space. Storage is rarely a viable medium- to long-term option.

The retention period and value of equipment usually follow an inverse relationship, with the value decreasing as the time in storage increases. This in turn will have a subsidiary effect upon the opportunity to dispose of equipment to particular pathways, particularly for reuse.

5.2.2 Re-Use

Re-use involves the reassignment or transfer of ownership for an item of equipment that results in its continued productive use. In many cases, re-use entails the provision of technology to individuals and organisations with lower technology needs or fewer resources than the original owners. Decisions as to the destination of reused computers may rely as much upon the ease and expediency of a particular option as it will on the perceived benefit to be gained by both the disposer and recipient. Re-use may take various forms, and may involve a 'closed' system operating within a user's immediate circle of influence,

or an 'open' system involving other consumer sectors and either commercial or non-profit organisations.

Closed systems include household owners passing surplus equipment on to family members (e.g. to children for study and recreational use), and organisations selling surplus equipment to employees. Reassignment of computer equipment is also a closed activity, and occurs within organisations (e.g. computers are allocated to staff depending on their information technology needs, as well as their position within the organisation). Industry sectors may also operate closed re-use operations (e.g. the education sector transfers used computers that are surplus at well-resourced schools to those that are less well-resourced).

Open re-use activities entail the donation, return or sale of used equipment to a separate entity. This transfer of ownership may result in direct re-use (e.g. private sales or donation to local schools and community groups) or preparation and distribution for re-use to third parties by an intermediary organisation operating on a charitable (non-profit) or commercial (profit) basis. Both types of intermediary organisations are described in more detail below.

- **Non-Profit Organisations**

Nationally, there are a number of non-profit and community organisations involved in recovering waste computers. The activities of these groups generally focus on three things:

- recovery of waste computer and other electrical equipment as a social service;
- refurbishment of equipment as a way to provide job-creation and/or employment-related services for their local community; and
- distribution of computers to people or institutions (such as schools, community groups, disability groups, low-income families) who might otherwise not have computers due to financial constraints.

It is important to note that the social benefits provided by these groups are significant, and range beyond solely a function of waste computer management.

These organisations may be involved in both re-use and recycling of equipment, however the principal objective of those organisations consulted was the preparation of equipment for re-use, with the recovery of raw materials seen as a subsidiary yet important stage of processing.

Organisations often rely upon volunteer labour or in-kind support from a range of committed bodies and individuals in the community. Several organisations employ 'work-for-the-dole' staff, providing an additional social benefit to the community.

The age of equipment received can vary considerably, however the average standard of computers received is well below that of current 'entry-level' models, indicating an average age of 5 to 10 years. Principal materials received by non-profit organisations are monitors (usually no longer serviceable) and desktop PCs, with peripherals (e.g. printers and cabling) comprising a relatively low fraction of total stock.

Equipment is sourced from a mixture of consumer sectors, and many organisations operate their own drop-off facility or collection system to facilitate

this. Other organisations operate out of landfill facilities to separate materials upon their arrival at the landfill, obviating the need for a collection program.

Organisations may send refurbished equipment to identified markets (e.g. disadvantaged children or overseas aid). The quantity of refurbished and dispatched equipment is influenced by the age and condition of received equipment, with one operation reporting that 647 complete PCs (including CPU/case, keyboard and monitor) were shipped using materials from 2,650 received PCs and equivalent components. Another organisation reported that 1,500 out of the 7,000 CRT monitors collected since 1999 had been serviceable.

The high proportion of non-functioning computers and peripheral equipment received by these organisations means that they often become responsible for disposal of large volumes of unusable parts. Since many of these charitable organisations rely solely on donations and small grants, the disposal cost may be beyond the resources of some of these groups. As mentioned in the previous section, re-use organisations frequently stockpile materials, including non-working equipment, particularly if an alternative to landfilling is not immediately available. However, this is dependent on space availability and throughput of materials. Some materials are recycled. There is anecdotal evidence to suggest that some organisations transport unusable parts to overseas countries for further processing and/or reuse.

The financial issue of disposal is further highlighted by the fact that some of these groups receive used equipment donated by large corporations. The corporations may receive some taxation benefits due to the donation to a non-profit organisation. However if the community groups are bearing the cost of ultimate disposal of large volumes of scrap computers, it could be argued that there is some abrogation of financial responsibility by the donor corporations for the (waste) equipment they generated.

The usefulness of reconditioned computers depends greatly on the ability to use particular software, not only in the sense of the hardware being of a sufficient standard to run a particular operating system or application, but also on the ability to afford the purchase of this software. This impacts on the ability to transfer data and to operate computers effectively by users having access to consistent software (i.e. either the same or similar enough to be compatible).

Often software licences purchased by large organisations may be for the whole company rather than each installation, resulting in the donated computers being without a license for the software that they contain breaching licensing laws. One Victorian non-profit refurbishing operation advised that they had recently been instructed by Microsoft to refrain from installing operating system and applications without paying license fees, despite the fact that the software being installed is so old as to no longer be supported by the manufacturer. As recipients of computers from non-profit organisations most often do so out of a lack of funds to purchase equipment, the cost of commonly used software is likely to be unaffordable and as such presents a significant barrier to equipment reuse.

Donation of computers and peripheral equipment directly to schools and other community education groups occurs particularly in regional centres. This pathway bypasses third parties (such as second-hand dealers) and relies on knowledge within the community of the need for this equipment by such groups. Conversely, schools may also be a source of equipment to the domestic market through notices in school newsletters, etc.

It should also be recognised that these groups can be in potential competition with businesses involved in the refurbishment and resale of computers for profit.

- **Commercial Organisations**

There are many companies selling second-hand computers and peripheral equipment within Australia, with the majority concentrated in the Eastern states (Table 5.1). The geographic distribution of individual businesses (e.g. in capital cities compared to regional centres) has not been determined, however it may be assumed that companies will be located where the concentrations of available computers and buyers are highest.

Table 5.1 Second-hand Computer Retailers by State/Territory

State / Territory	No of Second-hand Computer Retailers
NSW	53
QLD	44
Vic	40
SA	19
WA	14
ACT	11
Tas	6
NT	2
Total	189

Source: Yellow Pages

The age of equipment depends greatly upon both the source and market for equipment (e.g. one company may market its products to buyers seeking affordable but recent equipment, while another may serve buyers seeking replacement parts for old yet still-functioning equipment). Equipment is generally much younger than that destined for non-profit organisations, with an average age of 2 to 4 years and a range of up to 7 years.

The principal equipment received is desktop and laptop PCs, followed by printers, then other peripherals such as cabling and scanners. Equipment is primarily sourced from the corporate sector, and may include computer retailers and leasing firms. Materials purchased for resale rarely include unusable material and those items not sold immediately will often be stored; as such, few materials are sent to landfill from this sector.

Companies employ a range of sales methods to suit both the origins of their equipment and the principal markets. Auction houses provide a vehicle through which used computers and some peripheral equipment from large corporations are made available for sale to individuals and businesses. This is particularly important for organisations needing to dispose of equipment still considered as assets. Between 250,000 to 300,000 units per year can move through the larger ICT auction houses. The more ICT-focussed auction houses may offer other services such as collection, testing and secure removal of old (and possible confidential) data. In addition, companies may use the services of an auction house for convenience, despite the items having little or no value (older equipment) and incurring costs to do so.

Manufacturers may either operate or be in partnership with factory outlets to dispose of recently superseded models, as well as remanufactured returns (e.g. equipment returned under replacement warranty that has subsequently been repaired). These outlets wholesale to re-sellers and large companies, and retail to individuals and small offices. Retailers may purchase used equipment to re-

sell whole computers or to provide spare parts for individual sale and repair stock. Commercial remanufacturers may also be involved in the recycling of equipment for their constituent materials.

Markets for second-hand or reassembled equipment exist overseas, however it is unclear what quantities are being exported. While this outlet was previously a commercially viable reuse option, the enactment of Commonwealth legislation requiring export permits for waste computer equipment (refer Section 6.1) has seen a reduction in this activity. The current extent is not known.

Reuse of cabling has been undertaken by some operations with attempts to sell cable back to electrical companies involved in data wiring. However, this outlet for cabling is limited due to the average length of cable being 20 metres, which is well below the preferred length of 100 metres. As a result, cabling is often stockpiled and sold in small lengths.

Several companies operate collection and re-use schemes for ink and toner cartridges, providing a cost-effective source of packaging for their principal product (the ink and toner). As the returned cartridges contain residual amounts of ink or toner, a significant issue for the re-manufacturing industry is the disposal of residue.

The quality and reliability of re-used cartridges has been a matter of some discussion, and the economic impact on sales by original cartridge manufacturers (which are usually printer manufacturers as well) has resulted in competitive schemes to induce customers to avoid purchasing re-filled cartridges in favour of new cartridges. However, some companies are moving to provide product guarantees after quality testing in order to address this issue.

5.2.3 Recovery

Recovery encompasses activities involving the disassembly of equipment into constituent parts, principally to recover the raw materials that have been used in their manufacture. The industry is comprised of a chain of different companies, from the originators of the source material to specialised commercial and charitable remanufacturers, to scrap metal processors and plastics granulators, to agents and finally to the purchasers of the recovered materials.

Recovery facilities may be operated by organisations that also re-sell and remanufacture equipment on a commercial basis. As a higher market value will be realised from resale of complete equipment, recovery operations are supplied principally with non-working equipment. Non-profit remanufacturers will often provide non-working material to recovery centres as their facilities, skills and financial resources are too limited to undertake substantial recovery operations themselves.

Advice from stakeholders indicates that higher volumes of material are processed by scrap facilities in Eastern states than in the rest of the country, however the quantity of waste computers and peripheral equipment processed is marginal in comparison to the total quantity of scrap from all sources.

The principal material recycled from waste computers and peripheral equipment is metal. Whilst some recovery operations separate PCBs, metals and plastics, others shred all equipment together and add it to piles of mixed metal, which is exported in significant quantities as well as being sold to domestic metal consumers. Purchasers may choose to sort this mixed metal to separate PCBs and other materials and recover the precious metals and copper. Separated

materials are usually exported (e.g. PCBs are exported overseas to precious metal recyclers in Asia, and low-grade copper cable is sold to Canadian copper smelters as a refining agent).

Until recently, PCBs typically contained enough precious metals to allow for cost-effective recovery. The average computer contains approximately 0.25 – 1.0 gm of gold, with other metals recovered including platinum, silver, copper, steel and aluminium. However over the last several years, computer manufacturers have cut costs by reducing the use of precious metals by as much as 90% (MACREDO 2000). This makes it more difficult for computer recyclers to operate on a financially viable basis.

Plastic has the potential to be a significant commodity, however there are barriers to the provision of acceptable materials to agents and their buyers. Larger computer recovery operations sell plastics to other companies who granulate and sell it as 're-grind' (indicative value of \$0.90/kg) or as 're-extruded' when additives such as colour are used (indicative value of \$1.60 - 1.70/kg).

Other recovery operators, and a number of non-profit remanufacturers, currently stockpile plastics or send it to landfill because they are unable to grade and sort it in the manner required by plastic recyclers. This barrier is the result of a mixture of plastics being used in computers and peripheral equipment, both historically and across product types. Becoming more common is the clear labelling of plastic components to identify the type of plastic used, however this is not the case for older products and those made by some smaller manufacturers.

There is interest within the recycling sector to expand into the computer and peripheral equipment market. For example, a CRT crushing facility is being established in Albury-Wodonga, with a view to transporting CRTs to the facility from across Australia. Such a facility is likely to require fees being charged by the recycling company, rather than present payment of a purchase cost for the material.

Recycling of electronics is a very labour-intensive industry, particularly as some components must be manually disassembled to recover valuable materials. Concerns regarding the confidentiality of data on waste PCs held by originators of equipment in the Government and corporate sectors compounds the issue, requiring additional effort to remove sensitive data through erasure (and in some cases physical destruction) of storage drives. The industry must continually address occupational health and safety (OH&S) issues related to materials like lead solder and phosphors in CRT monitors. Insurances and costs associated with conforming to regulations on hazardous materials can be significant.

A small yet diverse section of the recovery industry involves the use of computers and peripheral equipment for artistic uses. Whilst these may provide a novel and entertaining use of waste computer and peripheral equipment (e.g. use of PCBs in jewellery making and old CRT monitor housings as a decorative surrounding for fish tanks), they are unlikely to result in the diversion of significant quantities of material from landfill.

In addition to companies providing collection and re-use services for ink and toner cartridges, a range of companies provide collection and recycling services. These companies collect the empty cartridges to recover the plastics for a variety of products such as furniture (e.g. stools, side tables), outdoor furniture (e.g. street benches, garden table settings, letterboxes), promotional products (e.g. rulers), and road and walkway products (e.g. ramps, signs).

Processing of empty cartridges can entail disassembly, cleaning and sorting into the different polymer types. The plastics are then granulated ready for moulding into new products. Many companies on-sell the granulated polymers but some also undertake the plastics moulding processes as well.

5.2.4 Landfill

Disposal of computers and peripheral equipment at landfills is widespread throughout Australia. The volume of space occupied by items of equipment can be considerable, particularly in the case of CRT monitors. Landfilling is undertaken due to lack of alternatives and the cost implications despite landfill fees.

In addition, certain groups often see landfilling as a preferable and secure means of disposing of waste computers that contain confidential information. This decision may often be made due to lack of awareness or confidence in the ability to remove stored information by the data security services offered by a number of commercial re-use and recovery operations. This is a particular concern for financial institutions and some Government departments. Anecdotal evidence from landfill operators around Australia has indicated that various Government departments continue to demand on a regular basis secure cells dedicated to deposition of computer equipment. This includes equipment such as CRTs which contain no data and cannot be considered as a security risk.

At many landfills, area has been set aside for recovery of waste material (including computer equipment), making the material available to the public via this mechanism. However, the area is not managed to optimise the reusability of equipment (e.g. uncovered areas allowing electrical equipment to get water damaged) and there may be no testing of equipment. Consultation with computer recyclers and landfill operators has shown that this practice can negatively impact on the reuse market, with equipment of little value finding its way back to the landfill after being returned. Availability of poor quality equipment can damage the credibility of remanufactured equipment.

6. REGULATIONS & STANDARDS

The storage, transportation and disposal of computer components becomes subject to regulatory control when the materials that comprise these components are considered to pose an environmental or health hazard. Hazardous wastes are controlled through various State and Commonwealth Acts and Regulations.

In general terms the transportation of hazardous materials both between States and either imported or exported is controlled by the Commonwealth Government, whereas intrastate movement and handling of Controlled/ Hazardous materials is subject to the specific State or Territory requirements. The disposal requirements of specific waste materials are similarly dependent on individual legislation and guidelines set by the State or Territory receiving the waste.

A table listing the relevant Commonwealth and State or Territory legislation and policies is provided in Appendix C.

There is also a number of relevant Australian and international standards which provide an industry benchmark with respect to design characteristics of computer and peripheral equipment.

Regulations and standards applicable to computer components and equipment are discussed in the following sections.

6.1 Regulations

6.1.1 Commonwealth

The *Hazardous Waste (Regulation of Exports and Imports) Act 1989* implements Australia's obligations under the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal*. This Act defines waste as anything to be disposed of, including computers destined for disassembly followed by re-use, recycling, recovery or disposal.

Under this legislation, exports and imports of waste electrical equipment or scrap (e.g. nickel cadmium batteries, CRT glass or mercury) which contain less than 0.5% (weight for weight) of lead or generate less than 1.0 mg/L of lead during a Toxicity Characteristics Leaching Procedure (TCLP) test will be considered non-hazardous. A TCLP test is a laboratory test that estimates the potential for both organic and inorganic constituents to leach from a physically solid waste type when it is deposited within a landfill. The test results indicate the environmental acceptability of disposal to landfill of the waste type being tested (recommended procedures for TCLP Tests are provided in the Australian Standard AS4439 *Wastes, Sediments and Contaminated Soils*). If waste electrical equipment or scrap does not meet the above conditions, then a Basel permit is required for their import and export from certain countries.

Waste electrical equipment or scrap may be exported without a permit if it is destined for recovery operations in a member country of the Organisation for Economic Co-operation and Development (OECD), or if printed circuit boards are only a minor component of the overall material. Export and import of used computers for sale and on-going use as a computer does not require a permit if machines are in working order or require only minor repairs (e.g. replacement of broken parts or upgrading of chips), however a permit is required if re-construction of single units from multiple units is involved.

No permits have yet been granted to Australian companies under the *Hazardous Waste (Regulation of Exports and Imports) Act 1989* to export or import computer and electrical scrap under a Basel permit. One company has breached this legislative requirement with the cargo seized in Hong Kong and returned to Australia.

The *National Environment Protection Measure - Movement of Controlled Waste Between States and Territories* (Movement of Controlled Waste NEPM) establishes a nationwide tracking system for the interstate transport of controlled wastes. The Movement of Controlled Waste NEPM defines 'waste' as any matter that is discarded, rejected, unwanted, surplus or abandoned whether the material is for disposal, recycling, reprocessing, recovery, reuse, purification or sale whether of any value or not.

The Movement of Controlled Waste NEPM provides lists of waste streams, specific constituents and hazardous characteristics to identify whether specific materials are hazardous waste. This is similar to how the Basel Convention defines hazardous wastes. Comparison of listed wastes to the materials listed in Table 4.1 indicates that computers are controlled wastes if the following materials are present and have hazard characteristics such as toxicity, ecotoxicity or are capable of yielding another material which possesses a listed hazard characteristic (as in a TCLP test):

- antimony;
- arsenic;
- beryllium;
- cadmium;
- inks and pigments;
- lead;
- mercury;
- polybrominated biphenyls; and
- selenium.

The Movement of Controlled Waste NEPM does not quantify these materials or any associated hazard characteristic. The decision on whether a waste is a controlled waste, in practice, rests with the destination jurisdiction. Exemption from some requirement of the Movement of Controlled Waste NEPM may be given based on the direct reuse of some controlled waste.

6.1.2 States and Territories

It is important to recognise that most if not all of the hazardous constituents listed under Commonwealth legislation will also be listed as controlled wastes by individual States and Territories, either through direct reference to the Movement of Controlled Waste NEPM or a similar schedule of materials. It must therefore be assumed that waste computer equipment may be classified as hazardous material and therefore subject to control within each State and Territory. Despite this basic similarity, each State or Territory has a different approach to the control of these wastes, and may also place controls on particular activities relating to waste production, transportation and disposal.

The regulatory framework for each State and Territory is discussed below.

▪ Australian Capital Territory

The ACT's *Environmental Standards: Assessment and Classification of Liquid and Non-Liquid Wastes* provides directives for the generation, storage and disposal of waste materials created through the processing of computer components. All materials must be classified as either inert, solid, industrial or hazardous waste, however the tables provided to assist with classification cannot be applied to electronic scrap. Case-by-case testing is therefore required, using TCLP and Specific Contaminant Concentration (SCC) tests and the differing levels of maximum concentrations documented in the standard, to classify tested materials as inert, solid, industrial or hazardous waste. Tests may not be required if the production process and the maximum level of contaminants within the material is known, and the waste can be classified without testing.

Generators or owners of waste materials are responsible for producing documentation that conveys the waste classification to transporters and receiving facilities. As the commercial collection of waste from commercial premises requires an environmental authorisation under the *Environment Protection Act 1997*, certain activities relating to the collection of used PCs may require formal approval.

- **New South Wales**

The *New South Wales EPA Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes* form the basis of the State's waste classification standard, and is similar to that adopted by the ACT Government. Computer waste and scrap is subject to control when the materials tested contain more than 1% (weight for weight) lead and leach more than 5mg/L of lead in a TCLP test. The guideline also defines the waste industry operators who are required to hold an environment protection licence. Waste and recycling operators who transport, treat, process, reprocess or dispose of material that is classified as either hazardous or industrial wastes require licences. Licences are also required for the manufacture or reprocessing of batteries, production of carbon black, and either manufacture or reprocessing of plastics. Operators may be exempt from licensing if they are small in scale (e.g. generating less than 10 tonnes per year and on site storage of less than 2 tonnes). Transporters of hazardous or industrial waste will require licensing if loads are greater than 200kg.

The *Protection of the Environment Operations Act 1997* requires that waste facilities (other than those used strictly for re-use, recycling or reprocessing operations) pay a levy to the EPA, which provides a financial mechanism to ensure that users of waste facilities pay a contribution to the environmental costs of waste disposal. This in turn influences the cost of landfilling within NSW, as well as providing funds for waste minimisation projects that are administered by the Authority. Changes to this levy to provide the most effective incentive for waste minimisation and resource conservation have been implemented as part of the recent enactment of the *Waste Avoidance and Resource Recovery Act 2001*.

The *Waste Avoidance and Resource Recovery Act 2001* contains provisions which allow the Minister to make regulations establishing an extended producer responsibility scheme and product stewardship scheme, in which the producer's responsibility is extended to the post-consumer stage of the product's life cycle. The implementation of any schemes would have regard to any national scheme which may be in place and which adequately addresses waste issues in NSW.

- **Northern Territory**

The Northern Territory currently does not have any licensed landfill site in operation, requiring all Listed Wastes to be disposed in neighbouring States under the Movement of Controlled Waste NEPM. Works are currently being undertaken by the Department of Lands, Planning and Environment, documenting licensing requirements for handlers, transporters and disposers of Listed Wastes.

- **Queensland**

The *Environmental Protection Regulation 1998* defines certain activities as Environmentally Relevant Activities, requiring site operators to be licensed under the regulation. The licensing requirements are based on the nature of site activities rather than specific quantities or concentrations of regulated wastes. Activities that are likely to affect operators in the computer recycling/reprocessing industry include battery recycling, as well as recycling, reprocessing, storage, transport or treatment of regulated waste. Transport of less than 250 kg in one load would not require a permit.

The *Environmental Protection (Waste Management) Policy 2000* defines principles such as the waste minimisation hierarchy, 'polluter pays', 'user pays' and product stewardship. This policy also establishes a framework for waste management planning by those involved in authorised activities, as well as industry waste reduction programs and strategic waste management planning by Local Governments. The spirit of this policy indicates that the ICT industry within Queensland would benefit from the adoption of a formal set of measurable objectives for minimising waste.

The transportation of waste computer equipment or scrap within Queensland may require a permit under the *Environmental Protection (Waste Management) Regulation 2000*, as it is likely to contain materials that are considered Trackable Wastes.

- **South Australia**

South Australian legislation, viz. the *Environment Protection Act 1993* and *Environment Protection (General) Regulations 1994*, is similar to Queensland in that it indicates activities which require a licence rather than classifying any particular material as listed or controlled waste by quantity or concentration. Prescribed Activities of Environmental Significance likely to be applicable to the computer industry include depots for the reception, storage, treatment or disposal of waste, commercial collection or transport of waste substances, and activities producing listed wastes. Exemptions apply for temporary storage at the place where waste has been produced, handling of quantities less than 100 tonnes per year, or an activity that the State is satisfied will involve the production of waste in such quantities or circumstances that an environmental authorisation is not required.

- **Tasmania**

The *Environmental Management and Pollution Control (Waste Management) Regulations 2000* uses several acts and regulations, including the Movement of Controlled Waste NEPM, to define controlled substances. Any manufacturing, installation, servicing or decommissioning involving a controlled substance is a controlled activity under the regulations unless it is shown that the state of the waste does not possess the hazardous characteristics described by the Movement of Controlled Waste NEPM. It has been indicated that computer components would not demonstrate these characteristics when in their solid form,

and only those stages of waste processing where materials are separated (e.g. recovery of precious metals) may be classified as a controlled activity.

A license is required for the commercial transportation of controlled wastes, as well as storage, treatment and disposal at sites receiving more than 100 tonnes of waste per year. This excludes temporary storage at the place where the waste has been produced. Environmental approvals may be sought to reuse, reprocess, recycle, treat, recover energy or dispose of controlled waste; the information required when seeking an approval is listed in the *Environmental Management and Pollution Control (Waste Management) Regulations 2000*.

Fines apply to persons who permit or cause a controlled substance to be produced, treated or stored in a manner that is reasonably likely to result in a leak or spill into the environment or cause environmental harm.

The landfilling of waste material in Tasmania will have to comply with the Draft Landfill Code of Practice, which broadly adopts ANZECC levels likely to result from the breakdown of materials within a landfill.

▪ **Victoria**

The overarching principles of the *Environment Protection Act 1970* include both product stewardship and the waste management hierarchy. In a manner akin to Commonwealth legislation, the Act defines 'waste' as discarded, rejected, unwanted, surplus or abandoned matter, including that intended for recycling, reprocessing, recovery or sale.

As computer equipment contains a mixture of the wastes listed in Schedule 1 of the *Environment Protection (Prescribed Waste) Regulations 1998* it is likely to be classified as "prescribed industrial waste". The *Industrial Waste Management Policy (Prescribed Industrial Waste)* applies the waste hierarchy within a decision framework to assess opportunities for reuse, recycling, energy recovery or treatment of this waste.

A permit is required to transport prescribed industrial waste under both the Act and the *Environment Protection (Transport) Regulations 1987*. Obligations are placed upon both producers of waste and consignors of waste shipments, including identification of the waste, recording details about the waste or the movement of the waste, and reporting requirements. Exemptions apply if a vehicle or combination of vehicles with a gross load carrying capacity of less than 1000 kilograms transports prescribed waste on a non-commercial basis less than twice in any calendar month.

The costs of sending waste to landfill in Victoria are influenced by the Landfill Levy paid by landfill operators to EPA, which ranges from \$2-3/tonne for general wastes to \$10/tonne for prescribed industrial wastes. A rebate applies if waste is removed from a licensed landfill or waste storage facility within 12 months of being deposited to enable it to be recycled, reprocessed, recovered or purified by an operation separate from that which produced it. If computers are classified as prescribed industrial waste, then these provisions provide incentive to avoid landfilling of unwanted computer equipment.

▪ **Western Australia**

Controlled wastes within Western Australia are listed by the *Environmental Protection (Controlled Waste) Regulations 2001*. Controlled wastes must be transported and disposed of only by licensed companies. Operations involved in

the reprocessing of waste computer components are not likely to require permits, however the Department of Environmental Protection in Western Australia has indicated that individual approvals should be clarified in writing on a case-by-case basis.

Irrespective of classification as controlled waste, scrap materials destined for landfill must meet landfill acceptance criteria requirements based on Concentrations and Leachable Limits. These limits are documented in the Department of Environmental Protection *Guidelines for Acceptance of Solid Waste to Landfill (2001)* and *Landfill Waste Classification and Waste Definitions 1996 (as amended)*. Waste material must be tested in accordance with Australian Standard Testing Procedures (AS4439 - 1997) and directed for disposal based on the concentration of contaminants.

6.2 Standards

The physical characteristics of computer equipment are influenced by a variety of design standards produced by a number of organisations including but not limited to Standards Australia, the International Standards Organisation, the International Electrotechnical Commission and the Institute for Electrical and Electronic Engineering. Standards of particular relevance to the ICT industry relate primarily to PCBs, including Australian Standards as follows:

- AS1795 *Sheets and Boards for Electrical Purposes*;
- AS2546 *Printed Boards*; and
- AS3508 *Printed Board Assemblies*.

Whilst the majority of standards refer to the minimum acceptable performance of a particular component rather than specifying the materials used in their construction, some standards provide an opportunity to improve the choice of materials. For example, ISO11469 *Standardised Material Marking System* provides a framework for identifying plastics used in the construction of a product and is used by several major computer companies to facilitate identification of parts for recovery.

Some standards mention environmental considerations within design (e.g. Standards Australia HB98 - 1997 *Guidance on Environmental Aspects in Specifications and Design Briefs for Electrotechnical Products*, or IEC60249 *Base Materials for Printed Circuits*, which instructs designers of PCBs to consider the risk of emission of hazardous substances arising from combustion or incineration).

Information from stakeholders suggests that the current structure of some standards does not reflect environmental best practice, however no specific examples could be identified. It may, however, be argued that the inclusion of more specific references to design-for-environment within relevant standards would assist in the minimisation of hazardous waste from computers and peripheral equipment.

6.3 Summary

Commonwealth regulations dealing with the transport of waste computer equipment are in place. However traditionally there has been some confusion about the classification of waste computers or scrap in State regulations despite there being regulatory framework and guidelines. Nevertheless, as the size of the waste stream becomes more significant there is greater scrutiny being given to this material and the necessary controls for hazardous computer materials.

The diversion of waste computer and peripheral equipment from landfill to other recovery and disposal operations is therefore likely to require approval and licensing by the appropriate Commonwealth and State or Territory authorities. Liaison with the relevant authorities is necessary in order to clarify the requirements for tracking and appropriate disposal of these materials. Testing may be required to clarify whether a material will be subject to regulatory control.

If waste computers and peripheral equipment are deemed to be hazardous waste, disposal to landfill will not only be limited to specifically engineered facilities but will also involve considerable cost. This will present a significant incentive to divert waste material to reuse, recycling and recovery operations. Transportation of bulk quantities of waste computer and peripheral equipment will also require tracking, which can impose additional costs.

Frameworks and defined principles relating to industrial waste management plans and product stewardship have been instituted in a number of States, indicating that authorities in those States will be receptive to action on the part of the ICT industry to establish a formal strategy for minimising waste.

7. INTERNATIONAL APPROACHES

There have been few regulations implemented by international governments which deal specifically with computer and peripheral materials, although some have been established which deal with generic waste electrical and electronic equipment. However there are some voluntary programs which have been initiated by statutory authorities working in conjunction with industry alliances. A number of ICT manufacturers (many of which have Australian subsidiaries) have also implemented activities in response to the environmental impact of their products.

These initiatives range from product stewardship and extended producer responsibility activities through to waste management and recycling issues. These are discussed in the following sections.

7.1 Regulations, Policies & Programs

7.1.1 OECD

The OECD has issued guidelines entitled *Environmentally Sound Management of Used and Scrap Personal Computers (PCs)* for use by OECD member countries (including Australia). The guidelines focus on reuse and recovery of used PCs and their constituent materials, but do not address other environmental issues such as product design, choice of materials and energy efficiency. The guidelines highlight areas such as substances of concern in reuse/recovery and disposal activities, facility requirements (including energy recovery) and transport.

The movement of materials found in computers and peripheral equipment between OECD countries is controlled under Council Decision C(92)39/FINAL, *Decision of the Council concerning the Control of Transfrontier Movements of Wastes Destined for Recovery Operations*. Metal and metal-alloy wastes (including electronic scrap) and solid plastic wastes are classified as "Green" tier items, and movement of materials is not subject to additional OECD controls above those existing controls normally applied in commercial transactions. Glass from CRTs and used batteries are classified as "Amber" tier materials, and require that written consent is provided by responsible authorities before movement of materials may occur.

7.1.2 Europe

In June 2000 the Commission of European Communities proposed establishment of a *Directive of the European Parliament and of the Council on Waste Electrical and Electronic Equipment* and a *Directive of the European Parliament and of the Council on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment*.

The Directives are currently waiting on development of a common position by the European Council, and will soon be read for a second time in the European Parliament. The Directives incorporate the following objectives:

- manufacturers to take responsibility for recycling of WEEE (purchasers can return equipment at end of life, free of charge);
- establish separate collection facilities for WEEE, including setting of targets for collection, reuse and recycling (Of the material collected under the

separate collection scheme, the Directive sets minimum targets that must be reused or recycled, ranging from 65% to 80%, depending on the category of electronic/electrical goods);

- establishment of treatment systems by manufacturers, with plants certified by member Governments;
- provide users with relevant information, including labelling of equipment components for easy identification; and
- restriction of the use of certain hazardous substances in electrical and electronic equipment, with substitution of lead, mercury, cadmium, hexavalent chromium and brominated fire retardants to be effected by 1 January 2008.

The Directives have provided impetus for some European countries to initiate activities within their own national jurisdiction. Those countries with legislation on WEEE include Austria, Belgium, Denmark, Italy, Netherlands and Sweden. Finland and Germany are expected to introduce legislation soon.

Much of this European legislation deals with white goods, brown goods and lighting, with less focus on computers. Those countries with existing regulations which also encompass computer waste include the following:

- 1997 Italian waste management decree setting out take back and recovery obligations for certain ICT equipment;
- 1998 regulation in the Flemish Region of Belgium, requiring manufacturers, importers, distributors and retailers to take back all ICT equipment free of charge;
- 1998 ordinance in Switzerland on the take back and disposal of WEEE;
- 1998 regulation in Norway on the acceptance, collection, recycling and disposal of WEEE;
- 1999 order in Denmark making local authorities responsible for collection and recovery of ICT equipment (funded by local taxes or collection fees); and
- producer responsibility obligations in Sweden which (effective from 1st July, 2001) allow customers buying a new product to return an old product of the same type free of charge. Producers are also obliged to provide information on the content of the equipment when requested by pre-treatment operators.

The Directives have also provided impetus for industry bodies to liaise with Government on implementation issues. The Industry Council for Electronic Equipment Recycling (ICER) is liaising with UK Government agencies on issues such as recovery targets, the scope of the Directive, pre-treatment procedures, financing options, collection mechanisms and implications for electronic commerce. ICER has also established voluntary accreditation schemes for WEEE recyclers and refurbishers in anticipation of changing requirements under the Directives.

A system of endorsement of environmentally responsible products has been established in some European countries, with relevant products receiving labels which allow marketing of environmental credentials. Some PCs have received endorsement under the schemes outlined below.

- The Swedish Confederation of Professional Employees' TCO '95 and TCO '99 Certification for personal computers (including the CPU/case, monitor and keyboard), which covers ergonomic qualities and environmental impact in addition to emissions (electric and magnetic fields, noise and heat), energy efficiency and ecology.
- The Nordic Environmental Label (or Swan label), which is a multinational environmental labelling scheme operating in Sweden, Finland, Denmark,

Iceland and Norway. The label criteria apply to the CPU/case, monitors and keyboard, and the main requirements are ergonomics, energy efficiency, low electric- and magnetic emissions, ecological requirements concerning choice of materials and construction, and electrical safety and fire risk.

- The German Blue Angel Eco-mark (or Umweltzeichen). A non-profit company created by German manufacturers as part of a product stewardship strategy developed this mark. It licences use of the Blue Angel logo to companies meeting specific environmental criteria. Of all European environmental labels, Blue Angel has greatest recognition and penetration within the computer industry.

The Blue Angel mark has established criteria for a range of computer and peripheral equipment, including:

- portable computers;
- workstation computers;
- printers;
- reprocessed photoconductor drums for laser printers;
- reusable ribbon and toner cartridges; and
- lithium batteries.

The criteria differs for each type of equipment but addresses issues including the following:

- longevity of the appliances;
- return / acceptance of used appliances;
- recyclable design;
- reduction of number of plastics used;
- marking of plastics;
- material requirements for plastics, PCBs, etc.;
- use of hazardous substances;
- display requirements;
- batteries;
- noise emission;
- pollutant emissions;
- energy consumption;
- appliance safety / electromagnetic compatibility;
- recyclable design of consumables;
- packaging; and
- user manual.

The Blue Angel mark is cited by a number of international computer manufacturers on their web-sites as an environmental benchmark that a number of their products meet. The importance placed on this in the purchasing decisions of their customers is not known, however industry feedback suggests that it is well-regarded. The Blue Angel criteria are provided in Appendix D.

In the UK, ICER has initiated a number of programs in its role as a voluntary industry association. One of its major initiatives is the establishment of best practice guidelines for recyclers of electronic and electrical equipment. This is intended to lead to an accreditation scheme for recyclers. The broad guidelines being developed by ICER for this scheme are outlined below.

ICER: Requirements for Best Practice

- Appropriate licences or exemption certificates for all sites in accordance with waste regulations. Use of waste transfer notes and authorised transport operators.
- An audit trail which shows what happens to products, their components and materials throughout the recycling process. This will require detailed records and must be supported by a mass balance (i.e. a total weight of products in =

Source: ICER 2001

7.1.3 Asia

▪ Japan

While there are no regulations in Japan which specifically address computers and peripheral materials, other affiliated legislation addressing electrical appliances and recycling has been established.

An overarching *Law for the Promotion of Utilisation of Recycled Resources* was enacted in 1991 to indicate a standard for both the use of recycled materials by domestic manufacturers and provision for ease of recycling in product design (e.g. removal of NiCd batteries from PCs). A *Basic Law for Establishing a Recycling-based Society* was approved by Cabinet in June 2000 as an overarching framework for more specific laws.

The *Law for Recycling of Specified Kinds of Home Appliances* (effective as of April 2001) obligates Japanese manufacturers, retailers and consumers to share the cost of disposing of televisions, refrigerators, washing machines and air conditioners. Manufacturers are required to meet designated recycling rates for each product, and to safely dispose of any hazardous materials.

Larger manufacturers have set consistent prices for take-back of goods, and established recycling plants to handle both materials covered by the Act and other electronic goods. Retailers are obliged to pick up discarded appliances and

return them to manufacturers, with consumers contributing towards the cost of transportation and recycling.

Whilst previous arrangements allowed consumers to dispose of equipment for free or for a small fee, whereas reported costs range from ¥500 up to ¥7,000 depending on prices set by retailers and local governments. Anecdotal evidence suggests that the change in post-use product flows has resulted in a short-term impact on the viability of existing recycling firms, and a decline in purchasing after the law came into effect. There is a risk of illegal dumping to avoid paying additional costs. The law has also been criticised for a lack of mechanisms to motivate consumers to obey the law. The law does not specify PCs, however some manufacturers anticipate the expansion of the law to include them in future.

The Japan Environment Association (JEA) administers the Eco-Mark labelling program under the authority of the Environment Agency. Certification criteria for computers were released in 2000 and include design for recycling, take-back and recycling provision, elimination of hazardous substances, and energy conservation. There have been 7 personal computer products from 3 manufacturers certified since the criteria were introduced.

▪ **Taiwan**

Similar requirements came into force in Taiwan in 1998, where product take-back of personal computer equipment from business and consumer customers is handled through the government-created Environmental Protection Administration Recycling Management Fund. The fund consists of recycling fees paid by computer manufacturers (e.g. IBM Korea).

7.1.4 North America

▪ **United States of America**

The United States Environmental Protection Agency (US EPA) administers a raft of programs oriented towards minimising the environmental risks arising from both the manufacture and disposal of computers and peripheral equipment, through the Common Sense Initiative, Design for Environment (DfE) and Waste Wise programs. Projects related specifically to computers include the following.

- The DfE Printed Wiring Board project, which involves 10 representatives from community, Government, industry and research sectors to examine alternative technologies to reduce the volume of hazardous waste from PCBs.
- The DfE Computer Display Project, which is a partnership with members of the display industry (e.g. Apple, Sharp, Sony and the Electronics Industry Association) and the community sector to evaluate the life cycle environmental impacts of CRT and LCD displays.
- The Waste Wise program, which is a voluntary scheme to promote and encourage pollution prevention and recycling. The program includes 32 partners from the computer and office equipment industry sector, and has produced an update regarding electronics reuse and recycling within the USA.
- The Computer & Electronics Sector Subcommittee of the Common Sense Initiative, which has 25 members representing Government, industry (e.g. Intel and Continental Circuits) and health and community organisations. The

subcommittee has initiated pilot residential recycling projects for electronic products, investigating regulatory barriers to CRT recycling, and hosted a conference on electronic product recovery and recycling.

- The Electronics Recycling Initiative run in conjunction with the National Recycling Coalition and the US Postal Service. Its goal is to promote the recovery and reuse of obsolete electronic equipment and to encourage the design, manufacture and purchase of responsible electronic equipment. It provides a clearinghouse of information, conducts educational sessions and workshops and holds an annual congress and exposition.

Disposal of some computer materials (e.g. Ni-Cd batteries) is regulated under the *Universal Waste Rule* issued by the US Environmental Protection Agency in 1995. This rule is designed to reduce the amount of hazardous waste items in the municipal solid waste stream, encourage recycling and proper disposal of certain common hazardous wastes, and reduce the regulatory burden on businesses that generate these wastes.

Individual States have adopted their own directions on the management of waste computers and peripheral material. Massachusetts declared by State rule that unbroken CRTs are not hazardous waste, however the US EPA disagree with this interpretation for being less stringent than federal legislation requirements. Florida's stance is that CRTs are and remain hazardous wastes when deposited to landfill or combusted in waste incinerators; they are not hazardous wastes when reused as a substitute for commercial products (e.g. glass for new CRTs or as a fluxing agent in secondary lead smelters). California has determined that only hazardous waste disposal facilities should legally accept CRTs, and that disposal by existing collection and recycling facilities is illegal; it has therefore introduced emergency regulations to address CRT disposal. Other States are expected to introduce laws, policies or programs for the management of waste computers and peripheral material soon.

The US EPA is expected to publish another regulation shortly, entitled *CRT Glass-to-Glass Rulemaking* (the Glass-to-Glass Rule). This is expected to reduce some of the controls on CRTs that are transported for recycling into new CRT glass. Its purpose is to reduce the cost of CRT recycling and encourage the recycling of used CRT glass.

▪ **Canada**

While there are no Canadian regulations currently in place which deal with waste computer equipment, Environment Canada has commissioned a study to investigate the issue. The report, *Information Technology and Telecommunication Waste in Canada* (Environment Canada 2000), includes baseline estimates of the scope of the problem, existing Canadian recycling activities and initiatives taken around the world to address information technology waste.

A number of municipalities, particularly within Ontario, accept waste computers and peripheral equipment at their waste recovery operations. The majority of these operations are drop-off centres, however regional take-back programs have been established in two Ontario municipalities.

The Canadian Environmental Choice program has certified some printers and printing cartridges as eligible to display the Environmental Choice label (www.environmentalchoice.com). Criteria for certification includes requirements with regard to:

- energy consumption;
- elimination of use of CFCs in manufacturing process;
- ozone concentration;
- dust concentration;
- recycling of waste;
- compliance with safety and performance standards; and
- educational material.

7.2 *Industry Initiatives*

7.2.1 International Manufacturers

Key international manufacturers producing computers and peripheral equipment have implemented a range of programs to reduce the environmental impact of their products. These programs vary between geographic regions due to differences in local regulatory requirements, customer demand and opportunities for diversion.

Product stewardship initiatives instigated by the top manufacturers of computers and peripheral equipment are outlined below. This includes the top ten manufacturers of computer equipment on a worldwide basis (as identified by IDC Australia), together with an additional four companies who are market leaders in peripheral equipment (viz. printers, cartridges). Initiatives outlined below are based on information provided by the manufacturer or available in the public arena.

Apple

Apple has shown an early interest in the environmental performance of their products, commencing with an internal review of a particular model of computer (the Power Macintosh 7200) in 1995-96. Performance of the computer was assessed against the criteria of energy conservation, ease of disassembly, separability, recyclability, upgradability, hazardous constituents, material conservation, common components, ease of assembly, ease of service and product economics. This review found that enhancement of environmental performance was consistent with improvements in cost and functional performance, resulting in a higher quality product. It identified potential design improvements which could be incorporated into all Apple computers, incorporating Design for Environment features along with the company's Design for Reliability focus.

Apple engineers now design products to be upgradable to extend their life and to have components and parts that are recyclable at their end of life. Other Design for Environment features established by Apple include:

- increased utilisation of materials that are easily recycled into other products;
- labelling of materials with international recycling codes, facilitating their identification at product end-of-life (in some products the resin code is also included to further identify the grade of plastic);
- utilisation of modules, snap-fit designs and connections and minimisation of the number of screws and screw types being used; this makes products easier to upgrade, service and disassemble;
- reducing or avoiding the use of hazardous materials wherever possible;
- standardising designs and components to facilitate material use among product lines;

- reducing the weight and the amount of materials utilised in products, generating less material to be dealt with at end-of-life;
- favouring rechargeable batteries to reduce the resource consumption required in the production of new batteries;
- utilising more environmentally responsible battery chemistries, including new technologies as they become available;
- labelling batteries with their battery chemistry to help identify constituents and facilitate recycling and safe disposal; and
- avoiding batteries that contain lead, cadmium and/or mercury.

In the US, Apple printer toner cartridges can be returned to a collection centre free of charge using a pre-paid mailing label. The mailing label is part of the brochure that is contained within the toner cartridge packaging. In Europe toner cartridges for 2 models of printer can be returned to a collection centre in selected countries free of charge using a pre-paid mailing label for that country. For other printer models, toner cartridges may be returned to a local Apple dealer; the dealer then forwards the used cartridges to a collection centre. The used cartridges received at the collection centres are returned to the original suppliers for recycling. Apple estimates that 95% (by weight) of the cartridge can be recycled and utilised.

Apple provides an education focus for clients on its website (www.apple.com), outlining what consumers can do with products at the end of their useful life. Information includes suggestions for donation/recycling of scrap computers, recycling of toner cartridges and safe handling and disposal of batteries.

Canon

Canon Inc adheres to 8 action items as part of developing products with a minimal impact on the environment. These action items are as follows:

- strictly comply with the law;
- conserve energy;
- conserve resources;
- facilitate disassembly and collection;
- facilitate reuse and recycling;
- minimise final waste after disposal;
- develop products with long lives; and
- develop products that last in the marketplace.

It assesses products at three stages (viz. product planning, prototype completion, and production testing) based on the concept of life cycle analysis (LCA). This has allowed the company to shorten disassembly times and raise the recoverability ratio of their products.

One model of bubble jet printer (the BJC-620) incorporates a number of environmental features including:

- labelling of all plastic parts weighing more than 20 gm;
- parts and materials selected through green procurement system;
- 63% energy consumption reduction in standby mode;
- no use of PBB or PBDE brominated flame retardants;
- installation of holes under product nameplates to facilitate removal;
- thinner plastic housing which is 100% recyclable;
- introduction of snap-fit couplings; and
- ink tanks that can be replaced individually.

Most of Canon's laser printers have achieved certification under the Blue Angel label.

Canon incorporates sandwich moulding of plastics in production of their equipment. This process involves putting recycled plastic material in between virgin material. The process allows maximisation of use of recycled plastic without affecting the outer appearance; because the recycled plastic is not mixed or heated in the process, the strength and flame resistance of the used material is also not affected. This method is currently being used by Canon in production of copying machines, but is also planned for laser and bubble jet printers.

Collection of used toner cartridges began in 1990 in the US, Germany and Japan and recycling began the following year. In 1999 over 12,350 tonnes of toner cartridges were collected worldwide, an increase of 21% over the previous year.

Collection and recycling of bubble jet ink cartridges began in 1996 in Japan, with approximately 9 tonnes collected in 1999. Cartridges are collected via collection boxes placed in approximately 2,000 Canon retail outlets and service centres throughout Japan. The cartridges are separated into material groups for reuse as plastic or metal parts. Specialty resins used with the cartridge ink tanks are reused in new cartridges; additional resins, metals and other materials are also recycled. One outlet for the latter material is as an alternative to coke used as a reducing agent for blast furnaces. The recoverability ratio of bubble jet ink cartridges exceeds 97% by weight.

Compaq

Compaq Computer Corporation incorporates a Design for Environment approach, focusing on environmental stewardship during the lifecycle of their products. Guidelines followed by Compaq are detailed below.

- **Energy Conservation:** Products which minimize energy consumption during both active and inactive periods facilitate preservation of worldwide energy resources. A focus on energy conservation also reduces customer operating costs.
- **Disassembly:** Concepts learned from network of recycling partners have been integrated into mechanical design practices. Product designers plan for recycling of materials at the end of product life.
- **Reuse and Recyclability:** Use of materials that can be easily identified and recycled, employing available recycling infrastructures.
- **Packaging:** Packaging is kept to a minimum, is composed of recycled materials and uses no heavy metal inks. Compaq require at least 35% recycled materials in all corrugated papers for packaging. Packaging is made of materials that can be easily identified and recycled.
- **Upgradability:** Incorporation of design features that aid in extending the life of a computer, including features such as microprocessors, memory, internal storage and other subsystems that can be upgraded.

Compaq products have earned Germany's Blue Angel and Sweden's TCO '95 monitor certification. Commercial desktop product families are certified with the Blue Angel label and the complete range of commercial monitors are certified to carry the TCO '95 emblem.

Dell

Dell Computer Corporation established its Design for Environment program in 2000, incorporating the following design concepts:

- modular, upgradable design – parts can be removed without use of special tools, allowing easy repair and upgrades and lengthening the useful life of the computer;
- designed for ease of assembly and disassembly – most parts snap together, no glue and minimal use of screws used as fasteners;
- no ozone-depleting chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs) used in manufacturing processes;
- large plastic parts are marked to aid recycling;
- internal chassis is made of recyclable steel;
- meet stringent acoustic standards;
- meet low emissions requirements; and
- meet low energy consumption requirements.

These concepts have been incorporated into commercial desktop PCs, encompassing a model range which includes a 100% recyclable chassis with an internal metal frame with a plastic shell. Few screws are used and materials are labelled for ease of recycling.

Dell has product take-back programs in Germany, Sweden, Norway and the Netherlands. The returned systems are reused, recycled or disposed of (as appropriate) in accordance with local environmental guidelines. In 2001 Dell Europe introduced eCycle, a technology retirement service that included logistics management and data security provisions, as well as compliant environmental disposal. Under the eCycle program, redundant equipment (regardless of brand) is collected from customers, resold, refurbished, recycled or disposed of in an environmentally responsible manner.

Dell also participates in a government-run, fee-based take-back program in Taiwan. In 1999 in Singapore, Dell teamed up with the National Computer Board to refurbish, upgrade and provide a year's worth of Internet access for used PCs to be donated to lower income families and charities.

Dell offers an Internet auction site for used computer equipment which has been refurbished. In the US, an online exchange system allows consumers to trade-in, auction or donate old PCs to charitable organisations.

Dell also offers an asset recovery program to large corporate customers in over 30 countries. This system has been showcased by the US Minnesota Office of Environmental Assistance as a case study for extended producer responsibility (refer Case Study below).

CASE STUDY**Dell Computer Corporation's Leasing Program**

Dell Computer Corporation, the 2nd largest computer company in the United States, is leasing to increase their sales and build long-term relationships with their customers. They have been leasing computers to large corporate customers for 5 years as a way to provide a service their clients were demanding. Because of rapidly developing technology, many corporate customers had 2-3 obsolete computers per desk and wanted Dell to take them back.

These companies knew they had to manage the computers in a responsible way but didn't want to take the expense and staff time to figure it out. The leasing programme, where a company's computers are updated every 2-3 years, assures customers that they do not have to worry about finding the best way to handle the old computers.

Customers pay for the service as part of the leasing agreement. They get record-keeping information from Dell, and do not incur additional staff time and effort to handle disposal issues. In turn, Dell makes sure that the old machines are managed in an environmentally responsible way and is able to provide their customers with service that keeps them coming back to Dell.

Dell uses a modular computer chassis that is built for disassembly, using connectors like snap-together hooks and latches. This design also allows for simple replacement of memory or storage devices during upgrades.

For easier recycling at end-of-life, Dell now uses fewer types of plastics, and marks them with internationally recognised codes for easy identification. The company also avoids using coatings or composite materials that are difficult to recycle.

Source: Minnesota Office of Environmental Assistance

As part of the company's environmental performance communication program, products are accompanied by Environmental Data Sheets, containing information on seals of approval (e.g. Blue Angel), electromagnetic compatibility compliance, material composition, recyclability, packaging material, acoustic performance and energy consumption.

Dell's website (www.dell.com) also includes extensive information on the company's environmental initiatives. Information on the website includes local recycling options and also addresses options for extending the life of PCs.

 **eMachines Inc**

eMachines Inc does not operate in Australia but is one of the top five computer manufacturers in the USA. It does not provide any information on the environmental impact of its equipment or measures taken to ameliorate it.

 **Epson**

One of the key design features of equipment produced by the Seiko Epson Corporation is resource saving, including savings in power, space and time. This results in equipment of smaller size, lighter weight and lower power consumption, however there is no evidence that this results from an environmental focus. There is no company information to show that any product stewardship initiatives have been undertaken.

 **Fujitsu Siemens**

In 1997 Fujitsu assessed the environmental performance of over 200 products manufactured in Japan, including computers and printers. The assessment criteria included:

- compliance with environmental laws;
- ozone layer protection;
- natural resources conservation;
- energy saving;
- recycling;
- ease of processing and disposal;
- ease of collection and transportation;
- disclosure of information; and
- packaging.

From this assessment an *Environmental Consciousness Product Evaluation Standard* was developed. This standard formed the basis for the development of some of their products to conform to the principles encompassed in the standard, viz.:

- recyclable rate of 75% or more;
- compliance with *Energy Saving Law*;
- compliance and registration with the Energy Star computers program;
- capable of 100% separation or disassembly into component materials or units;
- any plastic part weighing at least 25 gm has an indication of its component materials; and
- no hazardous substances are used.

The Fujitsu Recycle System was also established in Japan in 1997. The system consists of a series of 13 collection terminals and 4 recycling centres which accept waste electronic products from Fujitsu sales offices throughout Japan. The recycling centres undertake disassembly and separation of waste products, including crushing of CRT glass and extraction of precious metals.

Gateway

Gateway has not yet incorporated product stewardship into company operations.

It has a limited program in place in the US for recycling of old computers. The company has a trade-in program whereby a discount on the purchase of a new Gateway PC is provided to individuals who donate or recycle their old PC (regardless of manufacturer). The discount allowable is based on an agreed value of the particular equipment, up to a maximum of US\$50.

By preference Gateway leaves the logistics of disposal to customers but will accept PCs if customers pack up equipment and send it to the company. It recommends donation of old PCs to Goodwill or the Salvation Army, although acknowledging that some outlets may not accept them. Alternatively the company refers customers to local recycling companies via web-sites which provide lists of US recyclers.

Hewlett Packard

Hewlett Packard has established Design for Environment guidelines for its product designers. These are detailed below:

- place environmental stewards on every design team to identify design changes that may reduce environmental impact throughout the product's life cycle;
- eliminate the use of polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants where applicable;
- reduce the number and types of materials used and standardise on the types of plastic resins used;
- use moulded-in colours and finishes instead of paint, coatings or plating whenever possible;
- help customers use resources responsibly by minimising the energy consumption of printing, imaging and computing products;
- increase the use of pre- and post-consumer recycled materials in product packaging;
- minimise customer waste burdens by using fewer product or packaging materials overall; and
- design for disassembly and recyclability by implementing solutions such as the ISO 11469 plastics labelling standard, minimising the number of fasteners and the number of tools necessary for disassembly.

The company has PC product end-of-life return programs in place in a number of countries, with equipment donated to charitable organisations or recycled. Approximately 19,200 tonnes is reused or recycled worldwide each year through these programs, representing approximately 98% of all returned material. Product refurbishing centres are established in the US, Germany and Australia.

In the US, the recycling service costs consumers between US\$13 and US\$34 per item (depending on the type of hardware returned). This requires customers to package old equipment and arrange for collection by Hewlett Packard. This collection service is limited to 10 pieces of equipment, although larger orders may be taken by special arrangement. A similar service is provided in Japan at a cost of approximately ¥ 3,000 (or less than \$50).

Approximately 39 million toner cartridges have been recycled worldwide by Hewlett Packard since 1992. The recyclability of printer cartridges has been increased through a reduction in the average use of plastic resins (44% decrease since 1992), a reduction in the number of parts used (22% decrease) and the marking of plastic parts weighing over 25 gm with identification symbols.

IBM

IBM encompasses 15 environmental attributes as part of its Design for Environment guidelines. These are detailed by IBM as follows:

- **Labels/Marking of Plastic Parts:** Moulded-in marking of plastic parts is preferable to adhesive backed labels.
- **Use of Regulated Materials:** Resins and paints used on PC products must not contain polybrominated biphenyls (PBBs), polybrominated biphenyl ethers (PBDEs), lead, cadmium or mercury metal.
- **Upgradability, Expandability and Commonality:** Products designed for modularity and expandability can conserve resources by extending product life and delaying the need for replacement.
- **Assembly and Disassembly:** Products are reviewed for ease of disassembly, whether any special tools are required, numbers and types of fasteners, and other factors.

- **Electromagnetic Emissions:** Products must meet standards set by government agencies, so that they do not interfere with other electronic equipment or personal devices.
- **Batteries:** The number, composition, ease of removal and disposal of product batteries are assessed, as well as rechargability and life expectancy.
- **Acoustics:** Products must meet allowable noise limits set in IBM standards worldwide.
- **Power Management:** Machine should power down when not in use and power use should be less than 30 watts after a period of inactivity.
- **Fewer Materials:** Using fewer plastic materials eases sorting at disassembly.
- **Coding of Plastic Parts (>25 gm):** Plastic parts must have full identification marks, including the generic polymer acronym, commercial name and grade in accordance with IBM standards.
- **Use of Materials with Recycled Content:** The percentage of recycled content of plastics purchased is calculated, plus the amount of recycled content in packaging, printed materials and other elements.
- **Recyclability and Reutilisation of Parts:** Products must have no hard-to-remove metal inserts and few or no labels. New products must be coded properly as to their materials.
- **Finishing of Parts:** Products can be more easily recycled if they have moulded-in finishes instead of painted decoration.
- **Electromagnetic Shielding:** Conductive gaskets, clips and other shielding components are used to meet the emission requirements. Use of metal sub-packaging or foils is preferred to metal painting or coating; choice of components and method of attachment can affect Design for Environment.
- **Supplier Compliance:** IBM's goal is to have OEM product and sub-assembly suppliers meet IBM standards and practices, including pollution prevention programs, Design for Environment practices and manufacturing free of chlorofluorocarbons (CFCs).

IBM details incorporation of these environmental attributes into some specific models of keyboards, servers, monitors and commercial desktop computers. These products feature the use of recycled plastic for structural and decorative parts. Plastic parts have integral finishes wherever possible, eliminating the need for paints as well as facilitating end-of-life processing and metal parts have powder coatings, eliminating the use of volatile organic compounds (VOCs) found in paints. Thermoplastic parts over 50 gm are coded for ease of identification and the number of fasteners and screws minimised for ease of disassembly.

IBM has embraced these initiatives for both environmental and financial reasons. The company has found that the use of recycled plastics in PC housings and keyboard bases can reduce raw material costs by approximately 22%. This led to the development of one model (the IntelliStation E Pro CPU) that is composed of 100% recycled plastic resin from discarded computer parts. The IntelliStation E Pro is the subject of a case study showcased by the US Minnesota Office of Environmental Assistance for extended producer responsibility (refer Case Study overleaf).

CASE STUDY**IBM's Recycled Resin Personal Computer**

In March 1999, IBM introduced the IntelliStation E Pro, the first personal computer (PC) in the world that has all of its major plastic parts made of 100-percent recycled resins. According to Inder Wadhera, an IBM senior plastics engineer who helped develop the new PC, using all recycled resins "hasn't cost one extra cent." In fact, switching from virgin to recycled plastics made one part in the new unit 20 percent less expensive to manufacture.

The IntelliStation is the first of many IBM products that will incorporate recycled plastics. IBM's Austin facility is developing two models that each contain about 25 percent recycled plastic. "Eventually every division will use recycled resins," Wadhera said.

Because these highly engineered recycled plastics are new, IBM must carefully test each resin for long-term performance and safety. Also, it is harder to use recycled resins in parts of the computer that are visible, or "appearance parts," since people expect their computers to look evenly colored and unblemished. To address the issue of color irregularities, IBM's new 100-percent recycled resin PC is completely black. While IBM is the industry leader in using recycled resins, the company's overall goal for using recycled content plastic is just six percent for 1999. That goal increases to eight percent next year, and 10 percent in two years.

The main barrier to using recycled resins is limited supply. Debbie Horn, lead engineer of the Environmentally Conscious Products team for the IBM Server Group in Rochester, Minnesota, explained that for plastic parts, IBM always specifies a recycled-content resin and a virgin resin, so that manufacturing is not delayed if a resin is unavailable.

Right now, the recycled plastics come from four main sources: one is pre-consumer and three are post-consumer. The pre-consumer source is IBM's own manufacturing process. When plastics are poured into molds, the leftovers are broken off and sent to be reground by an IBM supplier into new resins.

One of the resins that IBM needs for its new PC is polycarbonate. Post-consumer sources for this resin include the large, refillable water bottles that are used in office water coolers, and the shatter-resistant window panes, the type often found in schools. Once the metals are stripped, the plastic from old compact discs and CD-ROMs can also be recycled.

IBM is beginning to explore another source of recycled resins — old computers that have been returned under warranty or through collection programs established in response to government requirements in Europe and Asia. IBM has Materials Recovery Centers worldwide, including one in Endicott, New York, that disassemble old computers and process millions of pounds of plastic. The company is trying to use some of the recovered resins to produce new computers, but they have encountered several problems.

For example, the products that are returned to the Materials Recovery Centers vary in age, and contain an assortment of plastics types. Some of the plastics are no longer used by IBM since the company instituted its Environmentally Conscious Product Design protocols.

Despite the obstacles, the company is committed to using more recycled plastic in its

In the US, IBM's PC recycling service allows consumers and small businesses to recycle the PC of any manufacturer (including peripherals). For a cost of US\$29.99, the customer receives a pre-paid mailing label to allow shipment of the PC to an electronics recycler in Pennsylvania. Depending on its age and capability, the PC will either be recycled or refurbished for donation. If the computer can be donated, the customer receives a receipt which can be used for tax deduction purposes (US EPA 2001).

IBM collects used computer materials at Materials Recovery Centres around the world, with large centres in Germany, the Netherlands, Italy, Japan and USA. In 1996 over 85% of this returned equipment was either reused or recycled, with less than 7% disposed of in landfills. Reusable PCs are donated to non-profit organisations. Some products are refurbished and resold; other parts and components are recovered and resold to secondary markets, with the residue (such as chips and precious metals) recycled.

Lexmark

Lexmark International's corporate environmental policy includes a commitment to:

- be an environmentally responsible neighbour in the communities where it operates;
- maintain respect for natural resources by practicing conservation and seeking to recycle materials, purchase recycled materials and use recyclable packaging; and
- develop environmentally conscious and energy-efficient products through environmentally sound processes.

Lexmark's laser printers incorporate a power-saving mode, cutting energy consumption by up to 70%, and comply with Energy Star specifications. Printing configurations allow users to print on both sides of paper or multiple pages on one side, reducing total paper consumption. New laser printers also allow use of paper with recycled content and have cartridges with long life. Lexmark printers have achieved Blue Angel certification.

In the US Lexmark has a cartridge return program in place called Operation ReSource which takes back cartridges manufactured by Lexmark, IBM, Hewlett Packard, Canon and Apple. Empty cartridges can be placed in replacement cartridge cartons and returned to Lexmark at no cost; additional mailing labels can also be obtained from Lexmark.

NEC Packard Bell

In 1998 NEC established *PC Standards for Environmental Soundness*. These standards provided the basis for awarding an internal environmental mark (the NEC Eco-symbol) used in consumer information programs. The standards are as follows:

- **Prevention of Global Warming:** Low electric power consumption; observe the Energy Saving Law; meet the standards of the US EPA's Energy Star program; reduce the product's electric power consumption when the product is in sleep mode.
- **Easy Recycling and Resource Conservation:** Use cardboard as much as possible for padding; use recycled plastic in the main units of the product and use easily recyclable materials, such as NuCycle or magnesium alloy, in its casings; make the product's mass and/or weight less than that of previous NEC products or similar products from competitors; make the recyclable ratio

of all components 75% for desktop PCs and 50% for laptop PCs; make disassembly using a screwdriver possible.

- **Avoidance of Hazardous Substances:** Do not use PVC in the product's casings; do not use mercury or NiCd batteries; obtain a firm grasp of the product's lead content.
- **Low Noise Level:** Keep noise level at 30 deciBels or less.
- **Adaptability:** Include extension slots and PC card slots.
- **Development of a Recovery and Recycling System:** Implement the recovery and recycling of products sold to corporate clients.
- **Information Release:** In manuals, include any environment-related information for the disposal of used products.

Five models of PCs manufactured by NEC currently meet these standards.

NEC has been recovering and recycling used rental and lease computers in Japan since 1969. In 1999 the company started using plastics from reclaimed PCs in the manufacture of new PCs. Since 1993 the company has also been collecting NiCd batteries via collection boxes at NEC sales outlets. Company statistics show that in 1999 recovered materials from computers in Japan included:

- 1,150 kg NiCd batteries;
- over 81,000 printer cartridges;
- 2,000 computer components; and
- over 9,070 tonnes reclaimed products.

NEC Germany collects computers and other equipment from corporate clients in conjunction with a local recycling company. In conjunction with an industry specialist, it is also conducting research into disposal methods for LCD monitors.

Toshiba

Toshiba has established voluntary environmental standards for personal computers for the Japanese market. The standards include criteria on:

- energy savings;
- resource conservation;
- recyclability;
- long-term use;
- green procurement;
- use of recycled materials; and
- disposal at end of use.

Two models of notebook computers produced by Toshiba currently comply with these standards.

In 1996 Toshiba changed from using sheet metal and moulded parts for main computer units, to polypropylene steel plate which does not require painting or use of ozone-depleting substances. More recently this material was superseded by HIPS plastic resin.

Toshiba has established a collection network for the take-back of televisions, refrigerators, washing machines and air conditioners, as required by Japanese law. Some recycling of PCs is also carried out in conjunction with this system.

Xerox

Xerox incorporates the concepts of easy disassembly, durability, reuse and recycling into their equipment design, with over 90% of equipment designed to be remanufacturable. The company estimates the financial benefit of equipment remanufacture and parts reuse (through reductions in the use of raw materials and energy needed for manufacture of new equipment) to amount to several hundred million dollars each year.

The company's asset recycling program is encouraging customers to return a wide range of products, including printers and toner cartridges. Employees disassemble and sort parts from returned equipment for re-manufacturing wherever possible; re-manufactured parts are incorporated into new products. Parts that do not meet re-manufacturing criteria and cannot be repaired are ground, melted or converted into basic raw materials. Xerox integrates re-manufacturing into the same assembly lines that produce new products. The company has set a zero waste goal, with eventual recycling of products to be incorporated in product design (US EPA 2001).

Xerox introduced their cartridge return program in the US in 1991 for the collection, return and remanufacture of toner and printer cartridges. Prepaid postage labels and the packaging from new cartridges enable customers to return old products for reuse and recycling. Returned cartridges are cleaned, inspected and then remanufactured or recycled.

Xerox notes that a barrier to the success of their programs has been the perception of consumers that products with recycled content are inferior to those built from new parts. The company sees it as important to educate customers about the quality and reliability of reused parts.

They have established a number of technologies that enable all products regardless of recycled content to meet the same specifications for performance, quality and reliability. Signature analysis is one such technology used by Xerox. It tests new parts to determine its 'signature', an acceptable range for the noise, heat or vibration produced by the parts while in operation. The same characteristics in parts from returned equipment are tested; only those parts whose signatures match those of new parts are approved and processed for reuse. All Xerox products, new and re-manufactured, carry the same guarantee.

7.2.2 Australian Comparison

Comparison of international initiatives outlined above with the actions of Australian manufacturers (detailed in Section 5.1) shows some disparity in the level of product stewardship activities implemented.

The majority of major international manufacturers are moving towards Design for Environment practices at the initial production stage. While there is some difference between manufacturers in what the Design for Environment practices incorporate, they are generally addressing at least some of the criteria. As product design is addressed by the international parent companies rather than Australian subsidiaries, this criteria is also incorporated into their products imported into Australia. It is therefore likely that many of the models on the Australian market have been designed with a view to environmental issues, however this is not made clear to consumers by Australian manufacturers.

Similarly, the practice of component manufacturing occurring mainly overseas rather than in Australia, impacts on the use of recycled material or equipment refurbishment that is undertaken by Australian companies. Initiatives such as the

use of recycled plastic in manufacturing equipment (as implemented by IBM and Canon) are not currently the pathway for obsolete Australian equipment; the recycled material utilised is likely to be sourced from international locations where manufacturing of computer components occurs. While some refurbishment and re-sale of equipment is undertaken in Australia, this is limited to certain models of Hewlett Packard laser printers: this is not widespread in the Australian industry.

Take-back and collection schemes are also much more evident internationally than in Australia. The Computer Asset Recovery Service initiated by Compaq Computer Australia, Hewlett Packard's laser printer trade-in program and the recovery of printer cartridges by Fuji Xerox (refer Section 5.1) are the only Australian take-back programs currently in place. International take-back and collection programs appear to be much more extensive; these have often been driven by legislative requirements such as various European legislation (refer Section 7.1.2).

There is also evidence that internationally the computer industry has worked more closely with other stakeholders with regard to the issue of waste computer equipment. This includes sponsoring programs in conjunction with statutory authorities (e.g. US EPA and Minnesota Office of Environmental Assistance) and developing best practice guidelines for recyclers (e.g. ICER). The only Australian partnership project to date (Compaq Computer Australia and the NSW Environment Protection Authority) involved government funding assistance to industry, rather than industry sponsorship.

7.3 Recycling Projects

In addition to programs established by manufacturers, a number of international trials for collection and recycling of computers have been established, including programs sponsored by Government, schools and non-profit organisations. The experiences and outcomes of some key programs are discussed below.

▪ Netherlands

Stichting Computerbemiddeling Onderwijs (SCBO or Computers for Classrooms) receives donated computer equipment that is commercially redundant and supplies it to primary and secondary schools and tertiary institutes for vocational education and adult training. Its mission is to be able to supply reliable machines, in sufficient numbers and at an acceptable price. It follows on from a number of other schemes which have attempted to provide the same service and have failed.

The organisation has identified 3 key elements of its success:

- the scheme must take responsibility for after-sales service (SCBO therefore offers a 3 year warranty on equipment and a 24-hour help line);
- schools have small budgets, therefore the cost of equipment must be kept low; and
- the end-of-life environmental problem should be addressed (SCBO are responsible for product take-back and ensure that it is recycled or disposed of in an environmentally responsible manner).

This approach has ensured ongoing success of the program, with few problems encountered. Calls to the help desk average around 14% of PCs installed, and less than 3% of PCs installed have required return for repair (Environment Canada 2000).

▪ Spain

A take-back collection trial for corporate computers and office equipment and domestic brown goods (televisions, video recorders, etc.) was conducted in Bilbao between October 1994 and December 1996. The trial was sponsored by the Basque Government and participants were the Municipality of Bilbao, a supermarket chain, the city's waste management contractor, a recycler and a number of other companies financing the storage, classification, shipment and treatment of their end-of-life appliances (Environment Canada 2000).

The trial tested the feasibility of collection of WEEE via municipal recycling centres and established the quantities likely to be received in any ongoing program. The conclusions of the trial were as follows:

- it was important to have a range of recycling sites to collect, classify and consolidate sufficient volumes of domestic equipment to make it economically viable to transport to recyclers;
- location of the recycling sites close to supermarkets encourages drop-off of equipment, especially small domestic appliances;
- community education was essential, although slow and costly;
- no special risk in the management or transportation of WEEE was observed; and
- the availability of good market access for secondary plastics would make it possible to achieve 90% recycling, and if recovery of the energy content was practicable this figure could rise to 98%.

▪ United Kingdom

At the request of the United Kingdom Government, a collection and recycling scheme for all electrical equipment was trialled by the Industry Council on Electrical and Electronic Equipment Recycling (ICER). The trial ran for approximately 2 years between October 1995 and April 1997, and involved two collection methods:

- specially marked skips at waste management facilities; and
- kerbside collection, where participating households placed equipment in grey plastic bags issued to them.

Full results of the trial are not publicly available, however initial results showed that amounts collected were much lower than anticipated (based on the number of participating households and estimated volumes of obsolete equipment), and that very few items (5% of total) were sourced from kerbside collection (Environment Canada 2000).

The average age of collected equipment (15 years) was also much older than anticipated by manufacturers' estimates of product life (Environment Canada 2000).

▪ United States of America

A number of trials for waste electrical and electronic equipment have been carried out at various locations around the US.

One study undertaken in San Jose, California under the US EPA's Common Sense Initiative modelled a corporate take-back program for collection of electronics through three retail outlets (MACREDO 2000). One of the retailers had significant corporate support for the program and provided funds for

advertising the drop-off scheme, hence ended up collecting more than 80% of the total 62,000 pounds of material recovered. It should be noted that the monitors which represented a substantial proportion of the material collected could not be resold.

The material collected is detailed in Table 7.1 below.

Table 7.1 San Jose Collection Trial

Component	Quantity (pounds)	% Received
CPUs	21,700	35
Monitors	20,460	33
Printers	9,300	15
Other	9,920	16
Laptops	620	>1

Source: MACREDO 2000

The project found in terms of overall costs as follows:

- transportation, processing, and recycling of the monitors came to approximately \$US23,000; and
- revenue from sale of materials contributed \$US5,000.

The net cost came to \$US18,000 or \$US584 per ton. Of the revenue returned, 38% was from resale of functioning equipment and the remaining 62% from sale of materials for scrap.

A comparative analysis was also undertaken to determine the difference in costs from recycling monitors locally in the United States (\$US15,000) or shipping them overseas for processing (\$US1,500). The overseas options were significantly less at \$US142 per ton.

Other findings from the project highlighted the need to support such schemes with awareness-raising and the other flow-on benefits that one retailer reported, with "increased sales due to the end-users' browsing following equipment drop-off".

Another US trial, which was unique in its development approach, was conducted by the Minnesota Office of Environmental Assistance (MOEA). The MOEA established a partnership with the American Plastics Council, Panasonic-Matsushita, Sony Electronics Inc and a waste management company, each of which provided funding for the trial. The MOEA called for and received participation by a range of organisations, including Local Government, electronics retailers and waste management contractors.

The final trial program encompassed a number of different collection events, each of which were focussed on the abilities of the participating organisations to undertake. The events ranged from one day to more than one month and were held across the State. Collection strategies included kerbside collection and various drop-off opportunities at household hazardous waste sites, recycling centres, transfer stations, neighbourhood clean-up events, and retail stores. The MOEA and its partners managed the transportation and disposal of the collected material from the 65 collection sites involved in the 3 month program. This method of trial enabled the MOEA to determine the relative success of a number of different collection methods. The trial provided drop-off facilities for electrical equipment to approximately 1.3 million people and collected around 700 tonnes of material.

7.4 International Summary

A framework for regulatory control of computer and peripheral materials has been established in many countries. This framework may not necessarily be directly focussed on computer and peripheral materials but have influence over this area via generic electronic and electrical equipment protocols.

The OECD guideline for *Environmentally Sound Management of Used and Scrap Personal Computers (PCs)* (2001) is the only internationally based policy and is applicable to Australia (as a member of the OECD). This is focussed on the reuse and recovery of materials and the transboundary movement of hazardous materials, rather than upstream issues.

Many of the existing regulations are also related to transportation of hazardous materials. However, increasingly policies and regulations are directed at ensuring greater responsibility for the recovery and recycling waste materials and that improving environmental performance of the product overall is adopted by producers.

In Europe, the overarching Directives provide a framework for environmental programs such as free-of-charge return of WEEE, reuse and recycling of equipment, labelling of materials and elimination of hazardous substances. The European Council is still developing these Directives, however, the framework has been adopted by a number of member countries that have made special criteria for ICT equipment. Again the focus of these policies is on managing the obsolete material.

In Asia, Japan recently implemented requirements for retailers to return selected electrical and electronic products to manufacturers, whereas in Taiwan the collection is facilitated via a government-created body.

In North America, there are a number of programs run in the USA, particularly in terms of alliances with industry. However, it is the individual States that have developed laws and policies addressing the issue in different degrees and are particularly focussed around whether or not materials (e.g. CRTs) are considered hazardous or not. The industry programs such as the Common Sense Initiative and the DfE have a greater focus on reducing environmental impacts of the overall product than just at end-of-life.

In addition to regulations, there are a number of eco-label accreditation programs in existence. These are primarily based in Europe but similar programs exist in Canada and Japan. The adoption of meeting the criteria specified under these schemes can be a non-regulating mechanism for encouraging improved environmental performance. Many of the programs have different degrees of standards required, with the German Blue Angel being the most comprehensive to date.

From an industry perspective, the most significant emphasis on overall environmental performance has been through voluntary programs adopted by many of the major companies to incorporate DfE into their business activities. Whilst DfE concepts have been established, these are often not consistent for all manufacturers. In addition to this, there are different degrees of incorporation throughout their operations, with many not having adopted these measures across the board with their products.

8. ENVIRONMENTAL IMPROVEMENT

There are a range of possible options that could be implemented in Australia to achieve environmental gains with respect to computers and peripheral equipment. Opportunities for environmental improvement can be examined in 3 main areas:

- actions initiated at manufacturing stage, which are focused on reducing the environmental footprint of production of the equipment;
- activities at the end of product life, involving extending product life and recovery of material resources; and
- education of users to encourage improvement across all stages of equipment life.

These opportunities, both those currently implemented and options for the future, are discussed in the following sections.

8.1 Product Manufacture

Incorporation of the principles of Design for Environment (DfE) has the ability to significantly reduce the environmental impacts of waste computer and peripheral equipment at the initial design and manufacturing stage. DfE can be implemented by computer manufacturers to reduce the types and quantities of waste arising from both the disposal of their products and other elements of the product life cycle (e.g. their manufacture and use).

As discussed in Section 7.2, DfE initiatives have been developed by a number of major equipment manufacturers. However while the majority have adopted some principles, there is a lack of uniformity in adoption of various features of DfE.

The essential components of DfE in the ICT industry are discussed below.

- **Use of easily identified materials:** One of the major problems identified by stakeholders in the recovery of computers was the lack of identification of the wide range of materials comprising computer and peripheral equipment. This can be overcome by labelling of each component with the type of material used in manufacture. It is important that the labelling is permanent and does not reduce recyclability (e.g. through contamination by labels made of other materials such as paper or plastic). The optimum method of labelling is by etching of components during manufacture with an internationally recognised code (e.g. in accordance with *ISO11469 Standardised Material Marking System*).
- **Use of materials with recycled content:** A fundamental premise of environmental sustainability is the use of recovered material in the manufacture of new products. A good example of this is the use by IBM of recycled plastic resins to manufacture their IntelliStation E Pro model. As well as providing a viable market for recovered materials (encouraging on-going recycling), it reduces the amount of virgin material and natural resources used in manufacturing. It can also offer significant financial savings to the manufacturer (e.g. 22% savings in raw material costs identified by IBM).
- **Reduction in the number of individual components used:** Reducing the number of components in computer equipment can reduce the time involved

in disassembly (and therefore increase the financial viability of recycling). It can lead to savings in raw material costs, as well as encouraging interchangeability of parts between computer models.

- **Reduction of resource use:** Reduction in the use of resources should be encouraged during both manufacture and operation of computer and peripheral equipment. This includes the amount of resources comprising each machine and the amount wasted during the manufacturing process. Other resources are involved in the operation of the equipment; consideration should therefore be given to reducing consumables such as paper and toner. Further consideration should also be given to the energy consumption and emissions of each piece of equipment.
- **Elimination of hazardous materials:** There are a number of hazardous materials currently being used in computer manufacture (especially CRTs). These should be eliminated through substitution with more benign materials. This can reduce the risk of environmental harm upon disposal. Elimination also allows manufacturers to reduce the lag in time-to-market of their products, avoiding the labour and resources needed to obtain necessary permits. Given that some waste of raw materials is inevitable in the manufacturing process, the company can achieve cost savings in disposing of manufacturing waste which is hazardous and requires special handling and management procedures.
- **Ease of disassembly and separation:** Another problem in recovery of computer equipment is the time and difficulty involved in disassembling equipment and separating different material types for recycling. This can be addressed at manufacture by designing components for ease of removal, through the use of a lesser number of fasteners, and using fasteners of consistent size that are easily undone. A number of manufacturers have achieved this through replacement of screws with clips, or ensuring that all screws used are the same size and require only one tool to undo them.
- **Standardisation and modular design of components:** Historically there has been a lack of design consideration given to the interchangeability of components between models. This has meant that some components (such as PCBs) cannot be utilised in new models, despite being fully functional when recovered. This can be addressed by a range of design initiatives, such as ensuring compatible connections for PCBs across a range of models, or ensuring that the case housing has sufficient space to allow future upgrades (such as additional daughterboards). As well as promoting recyclability, this has the added benefit to manufacturers of allowing reductions in inventory; with less capital allocated to component inventory, manufacturers can invest in other sectors of their business.
- **Extending product life:** The longer the useful life of the product can be extended, the less resources are used in providing the service. This may be achieved through interchangeability of components, as discussed above. It may also be encouraged through initiatives such as providing information to users on serviceability, e.g. making repair manuals available for downloading from the Internet (instead of charging for issue).

Additional DfE features may include elements of production beyond the scope of this project, e.g. reduction of packaging waste, and the use of more environmentally responsible packaging material.

DfE innovations may lead to the development of products that are specifically labelled and marketed as being environmentally conscious (e.g. Kyocera Mita's laser printers that use long life parts as part of their cartridge-free technology, or IBM's PC with plastic components made entirely from recycled plastics).

It is evident that the major manufacturers in Australia have implemented many of these DfE features into design of equipment undertaken by their international parent company. The issue in Australia is to encourage all manufacturers to implement the full range of DfE criteria within an industry framework.

This may best be developed within an industry code of practice voluntarily agreed to by all manufacturers operating in the Australian market. The code may be developed by the AIIA as an industry program and continual improvement by all manufacturers encouraged.

An essential component of the code will be determining DfE features applicable for Australian conditions and forming arrangement on which should be adopted. This will help establish consistency in the DfE features across the industry as a whole. The code should be consistent with criteria specified in any eco-mark schemes (see Section 8.3.2).

The code of practice could be adopted across the industry in a staged approach with focus initially on the large manufacturers then a roll out to smaller operations.

8.2 End of Life

A wide range of initiatives can be taken at the end-of-life stage of computer and peripheral equipment, with areas of responsibility allocated to different sections of the industry. These initiatives are discussed below.

8.2.1 Take Back Scheme

Collection of printer cartridges is the only established take-back arrangement currently in place in Australia. Cartridge collection may be provided as a value-added service for equipment that is being provided under leasing arrangements. Other companies may be happy to accept returns but may not actively seek them.

International take-back schemes for electrical appliances may offer a model for establishment of a scheme in Australia for computer and peripheral equipment.

The collection of used products by manufacturers occurs in several countries within Europe, Asia and North America, with the majority of programs established within the past decade. These programs have generally been established to comply with local environmental regulations and as such the reuse, recycling and disposal of materials is carried out in accordance with these requirements.

Some programs have also been established voluntarily, both by individual manufacturers and collaborative enterprises involving either multiple manufacturers or manufacturers and Government authorities. International examples of the latter type include the Recycling Guarantee program sponsored by the Swiss Economic Association of Information, Communication and Organization Technology, Belgium's RECUPEL-ICT system that utilizes dealers and municipal container parks for the collection of ICT equipment, and the CONIBI collaborative enterprise established by printer manufacturers to recycle toner cartridges in France.

Arrangements for shipping and transportation vary from being entirely the responsibility of consumers to a fee-for-service arrangement. In the case of printer cartridges, purchased items often include information on the location of recycling centres, and pre-paid addressing information to facilitate shipment to an appropriate location. Costs also vary from free-of-charge to a pre-determined fee paid by consumers to meet transport and treatment costs. Incentives are also offered in some countries (e.g. discounts for the purchase of new equipment or free recycling services with the purchase of new equipment).

The Japanese take-back scheme for consumer electrical appliances incorporates shared responsibility between manufacturers, retailers and consumers. Manufacturers are required to dismantle and recycle components and materials from electrical products, with designated recycling rates for different types of appliances (e.g. 50% of refrigerators, 55% of televisions and 60% of air-conditioners). Recycling may be done at the manufacturer's plant or at a centralised processing centre operated by an independent company and shared by different manufacturers. Retailers are responsible for return and transportation of appliances from consumer to manufacturer. Consumer responsibility is incorporated into the recycling fee paid by them. One part of the fee (the manufacturers' cost) has been set, but additional costs charged by individual retailers and Local Governments are also applicable. The total cost is in the order of ¥ 6,000 – 7,000 (or \$95 - \$110) per appliance; however these are much heavier appliances than computer equipment, and the current fee for computer recycling charged by Hewlett Packard (Japan) of ¥ 3,000 (or less than \$50) is more relevant to ICT equipment.

Take-back schemes in Australia may therefore be developed along similar lines to international models, as discussed below.

- **Retailers:** Retailers could provide a collection point for end-of-life equipment. The obsolete equipment could be accepted by retailers upon purchase of a new computer or peripheral. The acceptance of obsolete equipment would need to be irrespective of the brand or type of equipment purchased (i.e. not tied to the manufacturer). It may also need to be separate from purchase, i.e. retailers may need to accept material regardless of whether a sale is made. The retailers would then on-send equipment either back to the manufacturer or to a centralised site as designated by the manufacturer. There are a number of issues with establishing such a scheme such as cost and logistic implications (e.g. storage, transport) which may need to be the subject of an industry agreement.

The retail collection avenue could also be incorporated into a trade-in program offered by manufacturers. This could operate on a similar basis to the trade-in program offered by Gateway (USA) and Hewlett Packard (Australia).

- **Manufacturers:** Direct return of equipment to manufacturers could also be undertaken. This could be facilitated through a centralised collection site or sites for all manufacturers. Alternatively manufacturers could negotiate arrangements with individual reuse or recycling companies (or a third party) to accept material on their behalf for a predetermined fee. These services may include pick-up at kerbside collection in response to arrangements made as part of an 'at call' service (for a fee which may vary with location). In addition, options to recover the material could be investigated through Local Government networks (e.g. transfer stations, drop-off facilities).

Costs for this service could be met through the imposition of a fee paid up front upon purchase of new equipment or a hidden fee met by manufacturers. This may be on a sliding scale for various equipment (e.g. computers, printers, scanners), related to the recovery cost and revenue return on recovered material. There are a number of issues related to the administration of this bond, e.g. government versus industry administration, responsibility for orphan equipment, fee review period, etc., which would require extensive negotiation prior to implementation. There may also be a need to explore licensing of retailers and other players to operate within the scheme.

Establishing a take-back program would need extensive commitment from the industry and the following areas would need to be addressed:

- maximising capture of all the market, i.e. household, corporate and Government, may require a combination of retail and manufacturing collection options;
- maximising capture of all products including parallel imports, i.e. inclusion of products imported by manufacturers and those imported directly by large retailers;
- ensuring that the material collected has an environmentally sound outlet, i.e. is reused or recycled over disposal;
- costs incurred for collection, storage and processing are not borne solely by one party (particularly if storage areas are not available in retail outlets); and
- ensuring that sustainable options are available for regional areas; this may not reflect the scheme in urban areas directly.

8.2.2 Reuse & Refurbishment

▪ Manufacturers

As part of take-back programs, manufacturers may collect used products and refurbish them for resale. This is currently undertaken by Hewlett Packard in Australia for limited models of laser printers. The limitation placed on certain models of printers reflects one of the major issues manufacturers face: the current lack of interchangeability of components between models, due to the dynamic nature of equipment design.

Re-use of parts in upgraded models can often be problematic due to different dimensions (particularly in laptop computers where the industry trend is to smaller models) or to advances in capabilities (e.g. increased resolution of printers). Options for refurbishment will therefore vary between manufacturers as a function of their existing model range and the degree of dynamism between past and current designs.

Refurbishment of equipment, where possible, will therefore be encouraged through incorporation of the features of Design for Environment (as outlined in Section 8.1) by manufacturers. This is facilitated through the DfE principles concerning ease of upgrading, standardisation and modular design of components.

However there have been some problems experienced in the US in the use of refurbished components in new equipment. A number of large US manufacturers have recently faced lawsuits for using recovered components in equipment sold as "new". Some companies have been challenged legally by competitors for reducing prices to an uncompetitive level through the use of recovered parts (MACREDO 2000).

The ICT industry in Australia therefore needs to establish a cooperative relationship to ensure that similar problems are not encountered here. This competition does not encourage environmental improvement at an industry level.

▪ **Government**

It was identified during the completion of this project that significant volumes of computer equipment were being deposited at landfills at the instigation of a number of Government departments. This was in response to concerns held on the risk of dissemination of confidential data held on the hard drives of computers, together with liability concerns should equipment such as monitors explode.

Significant volumes of equipment could be diverted from landfill if alternate disposal procedures could be mandated for Government departments. This could include:

- development of standard government policy on disposal methods;
- in-house software development or investigation and approval of existing software, guaranteed to meet Government criteria for destruction of data (this may also entail removal of the hard disk for destruction only); and
- liaison within Government departments to allow re-allocation of computer equipment to areas in need, e.g. education and health sectors.

The latter could involve determining the volume of surplus requirements in certain sectors and matching it to the needs in particular sectors for second-hand computers, e.g. regional areas, primary or secondary schools, minimum capacity of equipment required. This will allow targeting areas of special need, and preclude provision of equipment that is not suitable (e.g. if 486 capacity is sufficient or not).

▪ **Other**

Non-profit organisations and commercial companies are heavily involved in reuse and refurbishment of computer equipment in Australia. However the low percentage of computer equipment reused (currently estimated at 26% of obsolete computers) could be further addressed.

Opportunities range from raising consumer awareness to increase participation in reuse programs, to diversion of stockpiled computers while there is still some value in the components for reuse rather than recycling. This could be addressed through a range of initiatives discussed in other sections, e.g. collection programs, industry take-back schemes, provision of infrastructure. Toner cartridges are an area where further participation to recover empties could be enhanced.

In addition, education programs would offer gains in making the reuse industry more robust. Areas that could be targeted include information on the need for consistency and standards (to prevent on-sellers that do not have testing requirements giving refurbished equipment a poor reputation for reliability), the liability for operations such as licensing requirements and other legal issues.

Specific programs to actively encourage pathways for sending equipment to overseas markets for aid (possibly in conjunction with AusAID) would also be beneficial.

8.2.3 Recycling

Studies in the US (MACREDO 2000) have estimated that further development of computer reuse and recycling projects can create approximately 30 jobs per 1,000 tonnes of reused and recycled equipment. This is in addition to the environmental benefit of increased recovery of computer resources. Options for improvement in recycling are related to the materials included in the equipment.

In 1996 a US study determined the typical composition of a PC (refer Table 4.1). The same study also estimated the type and amount of material that could potentially be recovered from a typical desktop PC; this is provided in Table 8.1 below.

Table 8.1 Recoverable Material in PC

Component	%
Plastic	23.0
Aluminium	6.3
Steel	20.5
Gold	0.001
Silver	0.02
Lead	6.3
Cadmium	0.01
Mercury	0.0022
Total	56.13

Source: Microelectronics and Computer Technology Corporation

The recoverability of these material types (and glass) is discussed below, including options for recycling not yet established in Australia.

It should be noted that the study did not specify glass as a recoverable material. Additives such as lead and barium to glass used in different sections of the CRT place limitations on the recovery of glass. This does not mean that glass cannot be recovered; however the hazardous nature of lead requires separation of leaded glass from other glass types, and limits the applications that leaded glass can be utilised for.

▪ Plastics

Table 8.1 shows that the largest single component material potentially recoverable is plastic. However the mix of resin types used and the lack of established markets and end uses has positioned plastic as one of the more challenging areas of computer recycling.

There is some usage in Australia of recycled-content plastic resins, but they are mostly from a single feedstock or from post-industrial (rather than post-consumer) sources. The existing markets for plastic recyclate are limited and are mostly for low-end, low-value applications.

Some potential uses for mixed recycled plastics from electrical and electronic equipment were identified as part of a US EPA project; these are outlined below in Figure 8.1 in order of resin quality required.

Figure 8.1 Plastic Resin Applications

Resin Quality
High Electronic products
 - housings

- internal parts
- Flooring products
- Electronic connects and wall plates
- Traffic products and construction applications
- Low-end household products
- Promotional items
- Low** Road aggregates

The use of mixed granulated plastic from waste electrical equipment for road aggregates is well established in the US. Granulated plastic less than 15 mm in diameter and with no significant metal or other contamination is accepted. It is blended with other aggregates and asphalt in a cold mix asphalt emulsion process, where plastic replaces gravel of a similar size in the process. A maximum of 10-20% of plastic is incorporated. The end products are asphalt products, as well as paving and landfill cover.

The Association of Plastics Manufacturers in Europe (APME) has also undertaken research into the use of plastic from waste computers as a reducing agent and a fuel for smelting of zinc and other non-ferrous metals (APME 2000). The research at a smelter in Sweden is on-going.

One furniture manufacturer in Australia has been using recycled ABS resin for an internal chair mould for almost 30 years. The internal mould provides strength and support to the chair; it is surrounded by padding and fabric, and the appearance of the plastic is not an issue. The appearance is often an issue, however, in a variety of other applications; virgin material can provide colour uniformity, however recycled plastics from a variety of ages and subject to different treatments in its first life are often irregular in colour. This can be overcome by colouring (e.g. IBM's black computer made from recycled plastic) or sandwiching of recyclate between virgin material (e.g. Canon copying machines), however this may not be suitable for all applications.

Some Australian companies are actively seeking recycled plastic for use in their processes (e.g. furniture manufacturing) because of the price benefit. Granulated and sorted plastic computer casings may fetch up to \$0.90/kg; re-extruded plastic (i.e. re-granulated and colour added) can fetch between \$1.60 - \$1.70 per kg. The price of virgin material is quite variable, but can at times be double this price.

Generally, however, the performance of recycled plastics in a range of applications is not well documented, and there is industry reluctance to use a material of unknown quality in preference to virgin material which is often cheaper. Further research and development therefore needs to be undertaken, both to determine alternate uses in Australia for plastic resins used in computers, and to disseminate information across the plastics industry to highlight opportunities for reuse of plastic recyclate. This may best be achieved on an industry-to-industry basis, e.g. liaison by the AIIA with the Plastics and Chemicals Industries Association (PACIA).

The lack of recycling of plastics is also a feature of the structure of the plastics market. Many recycling companies, when seeking a market for their recovered plastics, have directly approached users of plastic resins. However many of these latter companies require the assurance of quality and on-going supply that can only be facilitated through plastics brokers or compounders. Many recyclers (particularly non-profit organisations) therefore need to further develop their understanding of the plastics market, and develop the appropriate networks within the industry structure.

▪ Metals

Scrap metal, from computer equipment and a wide range of other applications, has long had a viable recycling market in Australia with well established infrastructure present. While PCBs are likely to be worth more than scrap metal (due to the presence of precious metals such as gold and silver), this additional value is reliant upon the processing of PCBs to extract these metals.

Industry participants advise that PCBs are generally processed overseas (not in Australia), where values received can range from \$0.10 to \$3.00 per kg. These markets may not be available to all recycling companies, e.g. non-profit organisations, or those companies without an export permit.

While maximum value may not be received through extraction of precious metals, the market for mixed scrap metal is robust (ranging from \$150 to \$200 per tonne, depending on quality). The maturity of the scrap metal market does not warrant further assistance under this project.

▪ Glass

CRT recycling has commonly been difficult and costly to due the presence of two differing types of glass, i.e. the front screen contains barium and the back cone consists of lead glass. The major process for CRT recycling is to wrap a hot wire around the CRT at the interface of the two glass types in order to snap them apart. An alternative method is to smash the cones underwater, which causes the glass types to fracture into different sized pieces which can be separated. However this technique is not as efficient as the hot wire technique, and tends to lead to cross contamination.

Glass from CRT monitors has a range of applications, some of which are at varying stages of development and market penetration. A review of existing and potential applications in the USA was undertaken on behalf of the State of Massachusetts (CCRED 1998); options identified in that study have been reviewed for applicability to the Australian situation and an overview provided in Table 8.2 below.

Table 8.2 CRT Glass Recycling Options

Use Category	Application	Glass Type	Market Status
Glass-to-glass remanufacturing	CRT glass manufacturing	Panel and funnel glass, lead and no-lead glass chemistries	Small Australian market potential
Glass-to-glass manufacturing	Decorative tiles	Co-mingled CRT glass	Demonstration phase
	Decorative glass products	No lead panel glass	Low potential
	Lighting products	No information	Unknown

Lead Reuse	X-ray shielding products	Co-mingled CRT glass	International R&D
	Industrial glass panels	Co-mingled CRT glass	Small potential market
	Borosilicate cells for nuclear waste encapsulation	Leaded glass or co-mingled glass	Unknown, likely to be small potential
	Lead smelting	Co-mingled CRT glass	Available market, moderate potential
Glass Aggregate	Smelters: lead and copper	Co-mingled CRT glass or whole monitors (copper smelter only)	Available market, moderate potential
	Fibreglass	No information	No information
	Highway reflective products	No information	No information
Export	Refurbishment & resale, glass bottles for pesticides	Variable	Available market, potential unknown

Adapted from CCRED (1998)

Many of these options are in the early research or developmental phase. Most glass reuse and recycling options used in other applications are limited by the high concentration of lead in CRTs.

It has been used as a fluxing agent in lead smelters overseas, and there have been preliminary trials undertaken by Pasminco in their Newcastle smelter (although the recent economic downturn experienced by Pasminco is likely to preclude any further efforts in this area). Further research in this area, as with other identified options in Table 8.3, needs to be undertaken to help establish on-going reuse and recycling avenues.

▪ Other Materials

Toner cartridge recyclers are often faced with disposal of large volumes of residue toner from cartridges. This material (a mixture of carbon black and plastic resin) is sometimes used as an energy source for industrial purposes. Other uses include as a carbon additive in steel-making.

The success of all of the above material recycling options depend on the viability of the recycling industry in general. While many companies express doubt over the financial viability of the recycling industry, it includes many successful companies recycling a range of materials. Their continued involvement in recycling of computers and peripheral materials should be encouraged. It is unclear what economy of scale is required to make recycling of computer equipment profitable, however it is acknowledged that viability would be increased if the percentage of equipment recycled was increased. The current low percentage (approximately 1.5% of obsolete equipment) is unlikely to maximise the economies of scale which could be attained given the large volumes of computer equipment circulating in the Australian market.

One method to encourage further recycling participation could be to provide incentive for use of this disposal outlet. This may be through establishment of an industry take-back scheme (which would harness large volumes of equipment) or through a ban on landfill disposal of computer equipment, either in part (e.g.

CRTs) or in full. This could also be accomplished through differentiation of landfill disposal costs for computer equipment, i.e. additional costs for landfill deposition versus cheaper costs for sorted, separated computer waste.

8.2.4 Technology

There is a lack of technology used in the separation of computer materials for recycling. Currently the disassembly of computers is very labour-intensive, adding to the costs involved and encouraging off-shore processing where labour costs are less.

There may be avenues for increasing the use of technology in disassembly, reducing the costs involved and helping to establish a more viable recycling industry in Australia. This is likely to involve long-term research and development into suitable technology. Increasing technology may also be best suited to recycling processes rather than at the reuse level. This is seen through the proposed development of two new recycling plants that will incorporate increased automated processing for CRT monitors. Two competing recycling companies have proposed development of these plants; detailed information is therefore subject to commercial sensitivity.

8.3 Market Influences

Consumer expectations play a major role in determining the viability of disposal options. The perceived value of both refurbished computer equipment (i.e. the price that customers are willing to pay for equipment below current entry-level specifications) and disassembled materials (e.g. CRTs and plastics) will directly influence the viability of particular reuse, recycling and remanufacturing processes.

Cost perceptions are also a major consideration, especially in purchase of new equipment. This often overrides purchasing of equipment that may provide better environmental performance. For example, LCDs do not contain as much hazardous material as CRT monitors (e.g. lead solder in the frit), however the additional cost of LCDs has been a major deterrent in uptake by the market. An additional example is printers which use a fewer number of consumables (such as paper or toner cartridges); from a review of the printer market, there is no evidence to suggest that environmentally responsible printers have a significant market share.

Nevertheless market research in other industries suggests that consumers are considering environmental criteria in purchasing decisions. This can be translated to the ICT industry through a whole-of-industry approach to environmental performance and improvement. Methods to assist this are discussed in the following sections.

8.3.1 User Education

The average computer user in Australia is unaware of the scope of the problem of disposal of waste computer equipment. While consumers may be aware of their individual difficulty in locating an appropriate recycling or disposal pathway for their equipment, many do not understand the nature of hazardous materials used in computer manufacture and the requirement for special disposal.

Some international manufacturers provide an assessment of materials used in selected models that they manufacture. On-going education of users on the nature of materials used (e.g. hazardous materials) can be addressed through

the provision of environmental information provided by manufacturers with all models. User scrutiny may provide a market incentive for manufacturers to reduce the amount of hazardous material in their products.

Users also lack awareness of the range of reuse and recycling options available to them. A number of international manufacturers of computers and printers provide information online on extending the life of purchased computers (e.g. through upgrades, donations of used PCs, reuse of components, and recycling through local collection programs or asset recovery programs), reducing environmental impacts during product use (eg. minimising printing and using efficiency options within specific printer models) and purchasing at lower environmental cost (e.g. upgrading existing machines and buying second-hand or refurbished machines). However this information is mostly targeted to the US market and generally does not incorporate Australian contacts.

There may be a role for the relevant industry association to facilitate provision of this type of information on an industry-wide basis. An on-line list of businesses and non-profit organisations that reuse and recycle computer equipment may be provided (e.g. on the AIIA web-site www.aiia.com.au or on a stand-alone web-site).

It should be highlighted that education for large volume users (such as the corporate and Government sectors) requires a different approach than consumers at a household level. This may include information at different levels such as:

- targeting of householder collection options not available to corporate sector, e.g. computers should not be placed into domestic garbage collection;
- collection schemes open to selected companies, e.g. large volume users may not necessarily be charged a collection fee where economies of scale are achievable; and
- promotion of use of refurbished equipment in appropriate applications, e.g. large volume purchases of refurbished equipment from non-profit organisations.

Consultation with some Australian manufacturers showed that there may be a lack of awareness of the achievements being made by international parent companies in the environmental arena. There may be promotional and market advantages to Australian manufacturers in translating those achievements to the Australian situation.

8.3.2 Environmental Assessment

A review of international manufacturers (Section 7.2) has shown that there is significant support for labelling of products which achieve environmental performance in line with accredited third party schemes. This includes eco-marks such as the Blue Angel and TCO labels. A similar certification scheme, setting environmental criteria for a range of products, could be implemented in Australia through a range of delivery mechanisms. These include:

- **Existing Eco-marks:** Existing labels could be adopted by the Australian industry. The most appropriate existing eco-mark is considered to be the Blue Angel label, as this has the most extensive range of equipment included in its environmental assessment (refer Appendix D).
- **New Label:** A new eco-mark could be developed for Australia. This may build upon existing international labels or establish criteria dedicated to Australian requirements.

The new label could be an extension of existing environmental awards in Australia, such as the Banksia Awards. Alternatively it may be established by a respected third party organisation, such as the Australian Consumers Association or an environmental grouping. While this option has not been explored with the Australian Consumers Association, assessment of products against a range of different criteria is already conducted by them as an integral part of the services they provide. They have previously investigated computer and peripheral equipment and are likely to have the systems in place to undertake this role.

Should such an Australian eco-mark be established, it should address the use of consumables, including energy and paper. Energy Star is a feature of many computers; in Australia this program is promoted by authorities such as the Sustainable Energy Development Authority (NSW) and Sustainable Energy Authority (Victoria). This criteria should be incorporated into any new Australian-based eco-mark.

Additional criteria focused on paper use has been floated among some State Government departments. This may potentially be regarded as the paper equivalent of Energy Star, e.g. 'Paper Star'.

8.3.3 Green Procurement

Purchasing policies and specifications which specify criteria that computer equipment must meet can have a significant influence in encouraging adoption of environmental objectives. Initially, these criteria can be set around improving the end-of-life management of products with inclusion of take-back programs requiring reuse and recycling of materials. In the longer term, more DfE criteria can be included with minimum standards for upgrade, etc. incorporated into contracts.

Asset management services are different to take-back programs in the sense that they are professional services offered by a company to manage the disposition of old and obsolete equipment, predominantly from large consumers. Such a service offers inventory management and environmentally responsible disposal of equipment where redundant equipment – often regardless of brand - is collected from customers, resold, refurbished, recycled or disposed of. Services also provide the benefit of resale of assets with marketable value (with a certain percentage of the proceeds retained by the asset management service) and secure procedures for removal of data from redundant equipment. A number of major manufacturers have introduced asset management services in recent years, as have some large auction houses.

Government purchasing power can expedite this due the large sector of the overall computer and peripheral markets. This is demonstrated by government expenditure, with the NSW Government spending \$750 million a year on ICT (Office of Information Technology 2001), including hardware, software and support services. It is understood that NSW Government contracts include spending of \$65 million on PCs, \$15 million on laptop computers, \$15 million on servers, \$6.25 million on printers, fax machines and toner cartridges, and \$5 million on peripherals such as scanners and cabling (Public Works and Services 2001). Similarly ICT is ranked seventh in Government spending in Victoria, at around \$90 million per year (Victorian Government Purchasing Board 2000).

In NSW a significant Government contract for supply of PC hardware is out for tender and highlights areas such as labelling components for recycling, energy

usage, life expectancy of equipment and take-back of products for recycling or appropriate disposal (Department of Public Works and Services 2001). This represents a significant move in incorporating environmental considerations in purchasing decisions.

8.4 Other

8.4.1 Industry Programs

Given the competitive nature of ICT manufacturers and the small size of the Australian market, there is a major role for the industry association to coordinate environmental improvement programs across the industry. In order to achieve industry-wide gains, initiatives would need to encompass all OEMs and NEDs, regardless of membership status with the industry association. Coverage of both industry sectors is needed in order to capture parallel import of equipment by major retail chains.

Programs which the industry association could address include:

- voluntary establishment and participation in a product stewardship strategy for computers and peripheral materials (as per the proposed Annexe);
- education and awareness programs delivered on-line;
- coordination of development of an Australian eco-mark;
- further research and development partnerships with other industry associations (e.g. PACIA); and
- on-going environmental improvement of their membership.

A further option initiated at an industry level could be the establishment of an accreditation scheme for recyclers of electrical and electronic equipment (as being developed by ICER in the UK). This would assist in:

- providing industry standards for reused and refurbished equipment;
- establishing best practice operating parameters for computer recycling;
- promoting market confidence in computer recycling;
- sharing of information between industry stakeholders; and
- developing the maturity of the recycling industry.

8.4.2 Research and Development

Further research and development into increasing the range of markets available for materials from computer and peripheral equipment is needed. This is particularly important in plastics and glass (especially CRT glass).

While it is acknowledged that CRTs are expected to be replaced by LCDs in market share, the extent of the equipment stockpile shows that disposal of CRTs will remain a challenge in the long-term until alternate markets are found.

There is also a lack of identified product uses and end markets for recovered LCDs. Given that these are expected to show significant growth in the future, research should be initiated in the short-term in order to develop a long-term solution for this material.

Some areas requiring further investigation include:

- feasibility of using mixed granulated plastics as road aggregate to suit Australian conditions;

- application of waste computer plastics as a reducing agent and/or fuel for Australian zinc and lead smelters;
- extended use of mixed plastic resins in furniture manufacture;
- applications for reuse of leaded glass;
- extended markets for reuse of barium glass;
- suitability of toner residue (carbon black) as fuel source for commercial applications;
- uses for recycled plastic consisting of a mix of resin types (particularly ABS, HIPS, PPO and PC/ABS);
- high-value applications for selected recycled plastics; and
- further development and penetration of markets for recycled plastics.

8.4.3 Collection Infrastructure

The lack of recognition of the size of the waste computer problem has provided few economic incentives to invest in collection systems or infrastructure. ICT manufacturers have been the only stakeholders with an understanding of the waste equipment volumes; however their focus has not traditionally been on disposal, and dissemination of information to players in the waste and/or recycling industry has not been undertaken. Conversely, recyclers and waste companies have considered infrastructure investment to be too risky without a greater certainty of equipment flows.

Because of this lack of data, there has been little analysis undertaken in determining the most suitable methods of collection needed. This should be investigated before the introduction of a take-back scheme or any other industry programs focussed on recovery of waste equipment.

While a number of collection trials have been undertaken overseas, Australia has unique issues (such as distance to recycling markets, small population and markets) which could not be extrapolated from international collections. Trials should be undertaken in Australia to determine the optimum collection method and infrastructure necessary.

Collection systems for different sectors may include:

- return by consumers to retailers or network of facilities (as may be established under a take-back scheme);
- specialised drop-off centres for electrical equipment (these may be affiliated with other waste facilities or be stand-alone centres located near large retail stores, e.g. home improvement/furnishing centres);
- allocation of dedicated electrical equipment areas within existing transfer stations and waste management facilities;
- Council kerbside collections for electrical equipment (e.g. once or twice per year);
- temporary drop-off areas or mobile collections rotated on a regional basis (similar to household hazardous waste collections established in a number of Australian states); and
- kerbside collection by private waste management/recycling contractors as arranged by third party (e.g. industry association, Government).

A combined collection trial similar to that undertaken by the MOEA in Minnesota (refer Section 7.3) may be the optimum method to test the success of different collection systems in a range of locations. This would involve a range of participants (including retailers, Local Governments, waste management contractors and recycling companies) contributing their services to a number of

collection events, ranging from one-day household hazardous waste collections to month-long drop-off collections, within a longer program.

8.4.4 Landfill Ban

Given the hazardous nature of computer equipment, the simplest way to keep waste equipment out of landfills and prevent possible contamination of the surrounding environment is to ban them from landfill deposition.

Some industry participants have raised the possibility of banning CRTs only from landfill deposition, on the basis that this component of computer equipment contains the greatest amount of lead (including lead oxide in soluble form, which is the most likely form to migrate into landfill leachate). This would also stop leaded glass from monitors also adding to the lead load of landfills.

It should not be forgotten, however, that other components of computer equipment contain lead and, in fact, many other heavy metals that can prove harmful to human health and the environment. A ban on disposal of CRTs would not preclude lead, mercury, cadmium, chromium and other hazardous materials contained in the CPU, PCBs and cabling from being deposited in landfills and posing an environmental risk.

Based on the amount of hazardous material in a typical computer (refer Section 4.1) and the estimates of equipment landfilled (refer Section 3.3), aggregate figures of hazardous materials likely to be entering Australian landfills in 2001 have been derived in Table 8.3 below. It is estimated that in 2001 over 77,000 m³ of landfill airspace will be utilised by waste computers.

Table 8.3 Hazardous Materials Landfilled 2001

Material	Tonnes/annum
Antimony	5.2
Arsenic	0.7
Barium	17.4
Beryllium	8.7
Cadmium	5.2
Chromium	3.5
Cobalt	8.7
Lead	3,479.2
Mercury	1.2
Nickel	469.7
Selenium	0.9
Silver	10.4
Vanadium	0.1
TOTAL	4,010.9

The total hazardous material of 4,010 tonnes is expected to increase to over 7,200 tonnes by 2006. However, as mentioned in Section 3.3 with regard to the estimates of volumes of computers landfilled, this is a baseline only and the actual volumes may be much higher.

Banning only CRTs would also not address the majority of computer and peripheral waste generated. Collection trials conducted in numerous locations around the world have shown that CRTs only represent an estimated one-third of the computer waste disposed of. This reflects the historic focus of manufacturers on upgrading attributes of the CPU (e.g. processing capacity, response time) rather than visual display. Monitors have generally been interchangeable when upgrading computer models.

There are also likely to be logistical problems at landfills in putting into practice such a differentiation between different components of computer equipment. There may also be issues of identification of the source of a CRT (e.g. computer or television), especially where scrap parts of equipment are presented for disposal. Identification would be especially problematic with relation to cabling; there is great similarity in the cables used for telecommunication and information technology purposes, and differences would not be readily apparent to landfill operators. Any ban on CRTs would therefore need to encompass CRTs not just from computers, but from all sources of electrical and electronic equipment, and there would also need to be distinct differentiation between which components are acceptable and those which are not.

To ban computer equipment (whether solely CRTs or all components) from landfills, would require it to be handled as a hazardous waste. Under current State and Territory regulations, this generally requires special handling, transport and management arrangements to be undertaken. This may require transportation to be carried out only by licensed operators and impose tracking requirements on the movement of computer equipment. Categorisation as a hazardous waste, in short, would impose significant expense across a number of layers of computer disposal.

Other issues of a possible landfill ban arise from where, barring landfill disposal, computer equipment could be disposed of. Unless alternative disposal options were in place, illegal dumping of large volumes of waste computer equipment is likely to occur. Such a ban would not be feasible without a mature computer recycling industry able to accept and process the significant volumes of equipment likely to be directed to them. That is not presently the case. There are currently gaps in markets for particular materials (e.g. plastics). Manual processing is still prevalent (due to the small volume of recycled equipment) and the industry is not sufficiently automated to be able to handle large volumes.

If a landfill ban was considered as the necessary impetus for development of computer recycling, all States would need to agree on a consistent structure for implementation. A phased implementation would help address the lack of recycling market maturity as a disposal outlet in the short term.

Financial incentives for diversion from landfill could be utilised instead of a regulatory ban on deposition. This may involve a price differential on gate fees where sorted and uncontaminated computer equipment is segregated for recycling at landfills and transfer stations. However the variety of gate fees across Australia (on both a State and regional basis) and the involvement of private industry in facility operation makes direct intervention by Government on gate fees a complex issue. Controlling gate fees would require establishment of an environmental levy; as with a regulated landfill ban, this would require the cooperation of all Governments at Local, State and Commonwealth level to implement.

9. PILOT PROGRAM

9.1 Existing Framework

Any activities undertaken for environmental improvement need to be set within the operational framework of the ICT industry, the waste management industry and the current status of recycling and recovery in Australia.

The proposed development of a National Product Stewardship Strategy for the Electrical and Electronic Product Industry sets alternative disposal methods for waste computer and peripheral material within a wider national framework. Government policy at all levels is increasingly incorporating the principles of extended producer responsibility and the “cradle-to-grave” accountability of manufacturers for their products. Legislation in Europe has already been passed to mandate this and legislation recently passed in NSW (the *Waste Avoidance and Resource Recovery Act 2001*) also incorporates a regulatory response in relation to extended producer responsibility and product stewardship. This is unlikely to be the only legislation passed in Australia to incorporate these principles; other States are likely to follow suit in the future.

Waste management of computer equipment at the end of its useful life has principally been undertaken at Local Government level through existing collection systems and waste infrastructure. The Australian recycling industry is relatively immature, and is constrained by a range of factors such as the small size of the Australian market, the economics of transport to collection centres and markets, the labour-intensive nature of material separation, and the commodity prices of competing virgin material. This has placed intense pressure on the viability of Local Government waste management and recycling services.

Additionally, the large (and increasing) volumes of waste computer and peripheral equipment have the potential to place waste disposal burdens on Local Government which cannot be met under current circumstances. The projected volumes of waste equipment may in certain locations require landfill facilities dedicated solely to computer equipment, unless significant inroads into the problem can be made. Most Local Governments do not have the financial resources needed to establish dedicated facilities, further underlining the necessity for environmental improvement.

Given the low base of recycled and disposed equipment and the large volumes estimated to be in storage, major changes need to be effected in order to achieve rapid increases in the reuse and recycling of computer equipment. This will require efforts to:

- increase the rate of reuse and recycling of computer equipment; and
- increase the diversion of equipment from storage.

Increasing the rate of recycling depends upon a number of factors, including additional investment in infrastructure and the establishment of effective collection systems that capture a significant portion of obsolete equipment.

The continuation of storage of obsolete computer equipment as the option of choice of most users also needs to be addressed. The longer the stockpile is allowed to grow, the worse the problem will be in attempting to find solutions. Forward planning for recycling and disposal facilities requires a better understanding of the volumes likely to be accepted and for such volumes to arrive in a relatively steady stream. However while stockpiling continues, it is likely that

at some stage saturation point will be reached, and that “the Great Australian Spring Clean” will lead to “the Great Australian Waste Computer Crisis”.

9.2 Pilot Projects

In order to achieve the large gains necessary, significant change needs to be effected across the wide range of industry participants. In order to assist such change, a number of pilot projects have been identified as offering potential for rapid environmental improvement. These are discussed below.

It should be noted that there are a range of avenues for environmental improvement (as discussed in Section 8), not all of which are considered appropriate as pilot projects. The options detailed below are those considered suitable as pilots for on-going improvement in the future.

9.2.1 Trade-in Scheme

One of the reasons why there is such a large stockpile is the consumer’s perception that their equipment retains value. While this is not necessarily the case, this perceived value can be used to good effect both as a marketing initiative to encourage new purchases and as a method of diversion from storage of obsolete equipment.

One Australian manufacturer (Hewlett Packard) has introduced a trade-in scheme for some laser printer models, whereby purchasers of new equipment can return their old equipment. The obsolete equipment is accepted at an agreed value as a deposit against the purchase. A similar trade-in scheme is operated by another manufacturer in the US (refer Section 7.2 Gateway), although the logistics of equipment return are much more detailed.

The widespread introduction of trade-in schemes by manufacturers and/or retailers in Australia offers the potential of:

- reducing the volume of stockpiled material;
- providing manufacturers with components which can be utilised in reuse and refurbishment initiatives;
- offering incentive to purchase new equipment which may be less environmentally harmful than old equipment (e.g. new model incorporating DfE principles, more energy efficient);
- better aggregated collection of potentially-hazardous material;
- addressing collection logistics problem contributing to low participation by consumers in recovery programs; and
- increasing sales of manufacturers involved in the scheme.

There are a number of methods by which such a trade-in scheme could be implemented.

It could be offered by selected manufacturers who have their own retail outlets; this would encourage consumers to trade direct with manufacturers rather than through secondary retail stores. Given that most manufacturers would already have in place a system for transport of machines returned under warranty, the trade-in scheme would require adjustment to existing services, rather than establishment of a new collection system in total.

Some manufacturers may identify the contribution of the trade-in scheme as such a market advantage for their products that they choose to extend the program

further. This may include extension to retail outlets where collection and transportation arrangements between manufacturer and retailer allow.

There would need to be suitable arrangements put in place by each manufacturer to address disposal of components that could not be utilised in refurbishment (e.g. equipment produced by other manufacturers, old components unsuitable for current models). This is more appropriately handled by a recycler of computer and peripheral equipment, and the manufacturer (or a group of manufacturers) may wish to enter into a contractual arrangement with an experienced recycler with facilities that are close to or compatible with their manufacturing plants. Such an arrangement would include the safe disposal of non-recovered material by the recycler.

It is difficult to quantify either the cost or revenue likely from implementing such a trade-in scheme. These figures would differ from one manufacturer to another, depending upon the success of the scheme related to their products, the network of direct outlets they may have, whether they extend the trade-in to selected retailers, and what arrangements they may put in place with recycling companies for recovery of material and components. A pilot trade-in scheme would also depend on the number of manufacturers involved and the length of the pilot undertaken. As an indication, however, it is expected that involvement of one manufacturer over say a 6 month trial period would involve total costs upwards of \$100,000; the amount of revenue that could be off-set against this cost is indeterminable.

It should be noted that participation of manufacturers in such a scheme would be on a voluntary basis, however the potential for new sales and retention of existing customers is likely to provide a significant market advantage to participating companies. Recognition of this advantage would encourage participation in the scheme.

9.2.2 Collection Program

While there have been a number of collection trials of computer and peripheral equipment conducted in various overseas countries, this has not yet been attempted systematically in Australia. Compaq established a collection trial in NSW, however this did not service all market segments as it was only available to business clients. Some computer equipment is collected via Local Government hard waste collection services; it may also be segregated with whitegoods and other scrap electrical equipment at landfills. However there remains a lack of diversion of computer equipment from the general waste stream, and a consequential lack of information on the quantity and type of equipment being disposed of and the type of collection system best suited to maximise recovery.

Establishment of a combination collection program is particularly suited to a pilot project. It can help raise awareness of the scale of the waste problem utilising existing infrastructure and systems, it can help establish statistical data on the volumes of waste equipment currently in circulation and/or storage, and it can provide direction in determining the most viable collection system in the long-term appropriate to a range of regional and logistic circumstances.

The type of project proposed is modelled on the collection program undertaken in Minnesota by the MOEA, adapted to suit the local Australian situation.

It is proposed that a lead body (such as Environment Australia or the industry association) coordinate funding for the collection project through a number of partners. The US trial involved funding of US\$25,000 each from four partners.

This translates to a total Australian cost of \$200,000, however the amount of funding required for a similar project in Australia may be subject to adjustment through incorporation of additional program partners, provision of in-kind support or changes to the scope of the project. This may reduce the total cost to between \$100,000 - \$200,000, spread across a number of different organisations.

Once financial support was addressed, the lead body would canvas support from a range of organisations to participate in the project. This may also involve in-kind support (particularly for State and Local Governments) or provision of services by private industry. The latter may be sought either through requests for Expressions of Interest, or through the tender process (where the need for specific services is identified).

The objective of the project would be to provide as many collection events as possible (within project funding), incorporating a range of collection methods and systems, under the banner of the same project. These events may include:

- one-off drop-off events at special locations (e.g. weekends at schools, community carparks, commercial centres);
- inclusion of computer and peripheral equipment as part of a regular program for collection of household hazardous waste (e.g. ChemCollect);
- provision of area for segregation of computer equipment at waste management facilities;
- kerbside collection of equipment (where feasible under existing service arrangements);
- take-back provision by participating manufacturers and retailers; and
- other collection projects which may be undertaken by State authorities (e.g. EcoRecycle Victoria, NSW Waste Boards/Resource NSW).

The length of these events may differ from one event to another, yet fall within an overarching program for the total pilot project (e.g. one day or one month within a total program period of 3 months).

The advantage of the total project umbrella lies in the momentum such a scheme could bring to the collection events, through economies of scale for recycling companies and promoting and encouraging participation of consumers. Participating events could be chosen to provide a wide coverage, both regionally and geographically. They could also be carefully selected to provide a range of different collection methods; analysis of the results could indicate the optimum collection systems to be established in the long-term to maximise recovery.

The lead body would need to liaise with and encourage participation with a range of organisations such as:

- State authorities (e.g. EPAs);
- Local Governments and waste management authorities;
- computer and peripheral equipment manufacturers;
- retail distribution companies;
- waste management companies;
- collection and/or recycling companies; and
- community groups (where appropriate).

Arrangements for processing of collected equipment would need to be put in place prior to the commencement of the program.

9.2.3 Product Labelling & Certification

Product labelling and certification could be addressed in a number of ways:

- provision of information by manufacturers to purchasers on the environmental impacts of the purchased equipment;
- certification of certain models as meeting requirements for Government purchasing; and
- establishment of an Australian eco-mark.

▪ Product Information

Provision of information to purchasers by manufacturers should be encouraged and a program to develop the criteria for reporting this information could be undertaken. Standard reporting criteria (i.e. key environmental performance areas to report against) would help the consumer compare different products against the same parameters. A lead body (such as Environment Australia or the industry association) could develop the broad criteria; this would need to be kept simple, e.g. limited to five key points. This could be an interim measure until a detailed assessment tool such as an eco-mark was adopted by industry. The program to develop the key performance areas for reporting would draw upon existing information such as energy use.

This would be a voluntary measure agreed to by the major manufacturers; consequently there would need to be consensus among the manufacturers on the criteria to be incorporated.

This may feature a phased program for implementation, applying to selected models of equipment in the first instance. The provision of environmental information could be expanded beyond the pilot stage to all models, as part of the features of DfE implemented by manufacturers.

It is not necessary to provide this information in hard copy to consumers; given that most equipment is manufactured and packaged overseas for subsequent import to Australia, the logistics involved in providing information with each unit would be difficult for the industry to implement. Rather, the information could be provided on each manufacturer's web-site in the area dealing with product specifications; many international manufacturers have pages dedicated to each country of operations, therefore this could be quarantined to Australian-specific information.

Provision of this information on an existing web-site would involve minimal cost on the manufacturer's part. The major cost would be from development of the criteria and gaining consensus on this by the manufacturers; this may be addressed as part of an industry-wide environmental responsibility overseen by the industry association. This cost is likely to be met via in-kind support from the industry association; this may be up to \$5,000 for labour and support costs.

▪ Government Purchasing Guidelines

The significant purchasing power of all levels of Government is evidenced by the spending on ICT mentioned in Section 8.3.3. The development of an Australia-wide Government purchasing guideline could provide encouragement for incorporating minimum environmental standards or requirements such as take-

back of end-of-equipment into Government contracts. This could also be developed for Government departments to build into leasing contracts.

Development of standard Government purchasing policies would help smaller departments adopt measures which they may not have the resources to develop in terms of environmental issues. This could be particularly beneficial at a Local Government level.

Contracts for the purchase of computer hardware by the NSW Government now incorporate a number of environmental criteria. These may form a basis for a whole-of-government guideline.

Establishment of the proposed guideline would require consensus between all levels of Government. This may be initiated through a body such as ANZECC.

No cost has been apportioned to this project due to the sole involvement of Government and its statutory role in environmental guideline development.

▪ **Australian Eco-mark**

The development of a voluntary Australian eco-mark program could build upon the criteria developed under the previous two projects. This would entail initial development of a body to facilitate the accreditation mechanisms. The program would need to be self-funding in the long term but establishment assistance would be warranted. To establish the program the following elements are required:

- accreditation criteria (building on other eco-mark programs and criteria identified for Australia under the above projects);
- establish a certification mark;
- develop certification processes (i.e. audit of information provided by manufacturers);
- develop structure for fee-based membership or licensing when accreditation received;
- review of members and new products; and
- awareness raising of the eco-mark to consumers.

It is important that the accreditation body has the necessary expertise and assessment systems in place. It also needs to be reputable from a consumer and environmental perspective. This role may be appropriately fulfilled by organisations such as the Australian Consumers Association (as an extension of assessment of computer and peripheral equipment currently undertaken under their 'Choice' program) or a similar respected organisation.

Linking of the program to existing environmentally-based schemes (e.g. Energy Star, Banksia Awards) in Australia may help promote its adoption and success.

There are significant marketing advantages gained by manufacturers who meet the environmental criteria and can advertise their certification in promotional material and programs. This is already undertaken by manufacturers who meet the necessary criteria for international programs (such as Blue Angel or TCO). The inclusion of an eco-mark focused on Australian criteria provides a local marketing feature to Australian consumers, as well as an additional advantage to international marketing drives.

Initial seed funding may be in the order of \$100,000 - \$150,000 to establish the criteria and testing regime, develop the certification label and establish trademark

rights, and develop the on-going organisational structure. On-going operating expenses may be required on an annual basis if the pilot develops further.

However this cost could be significantly reduced, depending upon the degree of incorporation of criteria already established under international programs or reliance upon existing international eco-marks (such as Blue Angel) for the Australian industry.

9.2.4 Alternative Uses for Recovered Plastic

The economic viability of managing waste PCs depends upon the value of the use for the products and materials. The challenge is therefore to identify and capitalise on the highest value commodities arising from the computer and peripherals waste stream.

Many of the high value alternative products require disassembly of components into their constituent materials (e.g. extraction of precious metals from PCBs); the high cost of doing this in Australia is a complex economic issue which cannot be adequately addressed through a pilot project. However there remain opportunities for proving the value of using some materials from waste computers and peripherals in low-end applications. This incremental approach of using recycled material in one application, and allowing market forces and innovation to expand uses to other applications, is the approach being used for a range of other recycled materials.

The lack of recognised end uses by industry can be addressed by undertaking trials with selected manufacturers to determine the applicability of the recovered material to their manufacturing process. The trial would test the material's properties, performance, quality, safety and other operating parameters, within the context of substitution of virgin material in each manufacturing process. Where it is demonstrated that recycled material can perform to the same criteria as virgin material, the deciding factor on selection is likely to be the price differential. For some materials (particularly plastics), the cheaper price of recycled material has already been identified by some manufacturers.

Given the preponderance of plastics used in manufacture of computers and peripheral equipment, the testing of plastic resin in other applications is an appropriate area for a pilot project. Discussions with a range of stakeholders have determined that there are a number of manufacturers in Australia who may be prepared to test various plastic resins for a range of applications. The plastics industry association, PACIA, advise that some of their members are investigating innovative ways of using recycled plastics, although specific companies have not been identified.

Selected companies, identified in conjunction with PACIA, could be approached to participate in a trial to test the properties of recycled plastics and their use in a range of applications. The plastics may be sourced from collection programs undertaken as part of a pilot project (refer Section 9.2.2) or sourced direct from computer manufacturers. Laboratory analysis of the properties of the material would be required by participating companies in order to check its suitability for replacement of plastics currently used in their process.

Similar trials undertaken by State EPAs for other types of recycled materials have cost in the order of \$25,000 - \$50,000. However the cost is dependent on the number of manufacturers involved in the trial, the extent to which the trial goes (e.g. the number of parameters tested) and the scope of promotion of the project outcomes to other manufacturers.

9.2.5 Awareness Raising

One of the major issues with waste computer and peripheral equipment is the lack of awareness of the problems surrounding disposal, recovery and recycling. This lack of awareness is spread across a range of stakeholders and in part stems from a lack of understanding of the size of the problem.

▪ Data Gathering

While this project has estimated volumes of computers from point of generation to point of disposal, some estimates include a high degree of uncertainty about their accurate reflection of real volumes. More work needs to be done in the area of gathering data, some of which could be undertaken as part of a pilot project.

While the ABS has undertaken a number of surveys on computer use, there are significant gaps in some sectors such as Government, education and health. These sectors have been identified by industry participants as significant users of computer and peripheral equipment, however there is a lack of information on the volumes of equipment purchased or disposed of by these sectors.

A pilot project could be undertaken to establish the volumes utilised in these three sectors (Government, education and health) and their current practices in reuse, recycling and disposal. This may best be facilitated by Environment Australia; the imprimatur of the Commonwealth Government may encourage participation by these sectors. Benchmarking of volumes and practices will assist in highlighting areas and practices inconsistent with environmentally responsible behaviour, and provide a focus for further action in the future to address identified issues.

The cooperation of State and Local Governments would be required to incorporate equipment used at all levels of Government. This would involve liaison with the various State EPAs (or other environmental authorities) and the Australian Local Government Association. It is expected that their cooperation would be forthcoming, given that the issue of waste computer and peripheral equipment is consistent with a number of existing reporting requirements (e.g. Waste Reduction and Purchasing Policy guidelines).

There is likely to be little extraneous cost for this pilot, with costs for time spent reporting and collating information borne by participating bodies.

▪ Information Sharing

Other education programs could be initiated as part of a pilot project, or in conjunction with other proposed pilots discussed above (e.g. promotion of project outcomes).

One area offering scope for establishment as a pilot is the proposed provision of information on reuse and recycling companies on an industry web-site. This information is currently available from a range of separate sources including EcoRecycle Victoria, NSW Waste Boards/Resource NSW and Yellow Pages. However this information has not been collated or established as a single source for information on reuse and recycling companies across Australia. The establishment of a single reference source on-line would provide simplicity of access to users (both domestic householders and corporate users) seeking this type of information.

However there are two additional issues which would need to be addressed in conjunction with establishment of the on-line resource:

- promotion of its use, so that equipment owners know the information is available and where to go to access it; and
- continual up-dating of information on the web-site.

At a preliminary stage, promotion of the web-site may be done in conjunction with the proposed collection program (outlined above in Section 9.2.2). Details of the site may be part of an information package provided to participants in the collection program. Costs may be minimised by highlighting its existence electronically, rather than providing printed material for each person with a piece of equipment dropped off or collected during the program.

Further promotion could be undertaken by the industry association through its membership (e.g. providing 'hotlinks' to the site from member companies' web-sites) and by advising appropriate statutory authorities (e.g. EcoRecycle Victoria, Resource NSW) of its existence.

Updating of information on the site could be part of a six monthly review system, the scope of which is beyond a pilot stage.

As much of this data is already available, establishment costs will be linked to data collation, establishment of a web-site or separate page on an existing industry web-site, and provision of 'hotlinks' on members' web-sites. It is possible that this will not involve external costs, but could be undertaken by the industry association and member companies' internal expertise. If external expertise was required, costs may be in the order of \$10,000 establishment costs, with annual management and updating expenses up to \$5,000 per year.

9.2.6 Pilot Summary

The proposed pilot projects discussed above are summarised in Table 9.1 below.

Table 9.1 Pilot Projects

Project	Stakeholders	Logistical Issues	Budget
Trade-in scheme	Manufacturers Retailers Recyclers	Requires coordinated approach between all stakeholders. Need for agreement re acceptance of alternate brands. Apportionment of cost and responsibility for acceptance and transportation requires consensus. Disposal of non-recovered material.	Varies with individual stakeholders & take-up rate by consumers. Will involve acceptance, storage, transport, recycling, refurbishment & residual disposal costs. Involvement of one manufacturer for 6 month trial upwards of \$100,000 (revenue off-set undetermined).
Collection Program	Commonwealth, State & Local Governments Manufacturers Retailers Recyclers Waste Management Contractors	Requires lead body accepting responsibility for overall program & development of funding arrangements. Complex administration and coordination of participating organisations. National awareness / publicity campaign involved. Recycling/disposal arrangements put in place for material collected.	Estimated budget range \$100,000 - \$200,000. May be subject to tender for elements of the program. Scope of program can be matched to funding, e.g. limited to certain regions (metropolitan, State) or reduced systems tested.
Product Information	Manufacturers Industry association	Australian manufacturers required to provide information on environmental performance of products. Industry association liaison required with manufacturers.	In-kind support up to \$5,000 for labour costs.
Government Purchasing Guidelines	Commonwealth, State & Local Governments	Consensus between all Government levels required. Lengthy period of liaison is likely.	No budget estimated – government role.
Australian Eco-mark	Independent accreditation body Manufacturers Industry association	Participation by manufacturers and support of AIIA is vital. Agreement necessary on role of accreditation body. Independence of accreditation body must be assured. Criteria for testing must be well regarded.	Initial seed funding \$100,000 - \$150,000 to establish criteria & testing regime, develop certification label, establish trademark rights & develop on-going organisational structure. Additional annual operating expenses required if pilot extended.

Project	Stakeholders	Logistical Issues	Budget
Alternative Uses for Recovered Plastic	Lead body (may be Commonwealth/State Government or AIIA) Recyclers or computer manufacturers (to source material) PACIA Alternate manufacturers using plastic resins	Identity of lead body (project may be sub-contracted). Sourcing of computer plastic for testing. Involvement of PACIA is essential. Identification and involvement of range of manufacturers to participate in the trial. Laboratory analysis of material properties required.	Cost dependent on number of trial participants & extent of testing; may be in the range of \$25,000 - \$50,000.
Data Gathering	Commonwealth, State and Local Governments	Cooperation required between different levels of Government and different sectors (e.g. education, health). Liaison between all participants may be lengthy.	No budget estimated – government involvement only.
Information Sharing	Industry association	Collation of information from existing sources. Web-site design expertise required (may be internal or external to industry association). Widespread publicising of availability of information on web-site. On-going updating required to keep information current.	May be undertaken by in-house expertise, however if external assistance required establishment costs approximately \$10,000. Annual updates up to \$5,000 per annum.

10. CONCLUSIONS & RECOMMENDATIONS

The contribution to the waste stream by ICT equipment has been little understood due to the lack of data and information on the disposal pathways. It is clear however, that the size of the issue has been largely hidden and confusion over the treatment of this material (e.g. whether it is considered hazardous material or not) has not assisted in highlighting the material as a priority.

In quantifying the amount of waste computer and peripheral material, the lack of data at disposal points across Australia was a consistent theme. This gap in information is inhibitive to reuse and recycling operations for assessing the potential to establish operations that may be capital intensive.

Ascertaining information on material flows from the amount of material entering the market place is also limited by the gaps in industry information on quantities being sold due to the competitive nature of the market place. The ABS data used also contained areas where further information is necessary to capture the complete equation. In addition, current data does not adequately reflect the regional distribution of end-of-life materials, which is necessary when determining collection and logistic strategies.

The material composition of the equipment differs from product type to product type, and from manufacturer to manufacturer. The basic composition of equipment does provide materials that have a value if recovered, such as metals (including precious metals) and plastics. However, many of these materials have a negative impact if allowed to enter the environment without proper treatment and handling. There have been good initiatives in reducing the hazardous materials within equipment by substitution and phasing out of certain technology; this should be encouraged further for equipment in the Australian market place where possible through emphasis on DfE principles.

Current disposal pathways for end-of-life equipment are dependent on factors such as (geographical) access to and awareness of reuse and recycling options. The perceived value of equipment at both a household and commercial (company asset value) level has resulted in a significant proportion of obsolete equipment being stored. The storage of equipment can impact on recovery options, with potential for reuse diminishing over time leaving a material value only. To promote the higher order reuse of equipment, it may be necessary to actively encourage users to look for reuse options over storage.

Reuse of equipment by non-profit and commercial organisations, whilst providing a major outlet for end-of-life equipment, could be further expanded. To achieve this, a number of issues need to be addressed such as improving the ability of machines to be re-manufactured through upgrades and ease of disassembly. Many of these features are considered in DfE principles and need to be adopted consistently across the industry. In addition to this, programs to raise awareness of re-manufactured equipment need to be undertaken at all levels, from the householder, commercial areas and Government. To help, ensuring that equipment entering the market is of high quality and reliable could be achieved through industry programs and standards (e.g. testing of equipment prior to resale, warranty periods).

Whilst some markets do exist for many of the materials in computer and peripheral equipment, the viability of recovering these materials is influenced by lack of infrastructure, and labour and transport costs. Again, it is important to

ensure that consistent products, both in quality and supply, are entering the market place (particularly for plastics). Industry standards and further research and development will help in raising the awareness of materials and potential uses.

Disposal of obsolete equipment or components to landfill is widespread throughout Australia. However, there is ambiguity about whether the appropriate level of management of these materials is being undertaken. Commonwealth regulations dealing with the transport of waste computer equipment are in place and it is likely that the States will have greater scrutiny over these materials in the future (e.g. licensing and testing requirements).

If waste computers and peripheral equipment are deemed to be hazardous waste, disposal to landfill will not only be limited to specifically engineered facilities but will also involve considerable cost. This will present a significant incentive to divert waste material to reuse, recycling and recovery operations. Transportation of bulk quantities of waste computer and peripheral equipment will also require tracking, which can impose additional costs.

Internationally, strong frameworks for regulatory control of computer and peripheral materials have been established in many countries. This has led to classification of equipment as hazardous materials, hence incurring the relevant regulatory controls. However, there are non-regulatory mechanisms (such as eco-label accreditation programs) in existence to promote better environmental practice. The most comprehensive of these concerning computer and peripheral equipment is the German Blue Angel label.

It is also evident from international analysis that good gains are being implemented by industry in regard to improving overall environmental performance, with many of the major companies incorporating DfE into their business activities. This is still a burgeoning area, with adoption of these principles across the board still to be achieved. Many gains through these programs have a filter-down effect for the Australian market place and should be encouraged. To achieve this consistently across industry in Australia, consensus on the key principles that should be adopted needs to be developed.

The need to set mechanisms in place now is important to ensure that sustainable pathways for material are established. The following recommendations for pilot programs may help to assist in developing a strategic approach to dealing with waste computer and peripheral equipment.

Recommendations

- ***Establish a trade-in scheme for manufacturers to accept old equipment when purchasing new equipment***

Manufacturers should be actively encouraged to establish a voluntary Trade-in Scheme whereby obsolete equipment is returned on purchase of new equipment. The pilot may involve one or more manufacturers in the program. The mechanisms for this scheme would need to be established by the industry in conjunction with retailers and reuse or recycling organisations.

Establishment of a trade-in scheme can assist in reducing the large stockpile by exploiting consumer perception of the retained value of computer equipment. It can better aggregate potentially hazardous material from computers and provide manufacturers with components for use in refurbished equipment.

It also offers incentives for consumers to purchase new equipment which may not be as environmentally harmful (e.g. more energy efficient, use of hazardous materials eliminated), as well as supporting participating manufacturers through increased sales.

- ***Undertake a pilot collection program combining a number of different collection systems***

There is a lack of systematic trialling of different collection methods to determine the optimum system or systems applicable to Australian situations. This may involve different systems for geographical areas, or systems targeted to user sectors. A combination collection program would provide the statistical data necessary to determine the most viable collection system in the long-term appropriate to a range of regional and logistical circumstances.

Different collection methods involving participation by stakeholders throughout Australia can be brought within a national umbrella program. Participating events could be chosen to provide maximum regional and sectoral coverage. A national program would provide momentum and promotional opportunities to maximise the participation of computer owners, as well as providing economies of scale for recycling companies involved in recovery of collected computer equipment. This also has the advantage of utilising the resources of organisations who have an interest in waste minimisation and resource recovery (e.g. State environmental agencies, Local Governments, waste management/recycling companies).

- ***Encourage industry to provide environmental information on their products***

There is a lack of information currently available to enable purchasing decisions to incorporate environmental considerations. A project could be undertaken to develop the environmental criteria against which manufacturers could report upon with regard to the performance of their products. Standard reporting criteria would help consumers compare different products against the same environmental parameters.

This could be a voluntary measure agreed to by major manufacturers, pending establishment of a detailed assessment tool (such as an Eco-mark)

- ***Develop Government purchasing guidelines incorporating environmental performance of ICT equipment***

Given the widespread use of computer and peripheral equipment in the government sector, all levels of Government (Commonwealth, State and Local) have significant purchasing power. This could be harnessed to provide encouragement for incorporation of minimum environmental standards or requirements for take-back of obsolete equipment by manufacturers and/or suppliers.

Guidelines could be developed through consensus by Commonwealth, State and Local Governments. This would assist all levels of Government to incorporate consideration of environmental performance in development of new contracts and leasing arrangements for ICT equipment.

- ***Develop an Australian Eco-mark***

An Australian Eco-mark could build upon the environmental criteria developed under the two previous recommended projects. This would entail detailed criteria

developed by an independent accreditation body, against which manufacturers can benchmark their products. A scheme may initially be established as a product review, then built up to an accreditation scheme.

The scheme would involve establishing a certification mark, development of certification processes, development of a structure for licensing of the Eco-mark, review of new products and awareness raising of the applicability of the Eco-mark to consumers.

A well-regarded environmental benchmark offers significant marketing advantages to manufacturers conforming with the Eco-mark, as well as providing instant recognition to purchasers of the environmental performance of a range of products.

International eco-marks (such as Blue Angel and TCO) are already widely acknowledged in the computer industry overseas. An Australian eco-mark may build upon such international programs or integrate with existing labels.

▪ ***Investigate alternative uses for recycled plastic***

A pilot project could be undertaken to test the applicability and suitability of recovered plastics to a range of alternate manufacturing processes. Selected companies, identified in conjunction with PACIA, could be approached to participate in a trial to test the properties of recycled plastics and their use in a range of applications.

If initial suitability was supported by more detailed research, success would help to establish viable end markets for recovered plastics.

▪ ***Gather data on computer equipment used by key Government sectors***

There is a lack of definitive data on the volumes of computer and peripheral equipment circulating and being disposed of in Australia, with some estimates including a high degree of uncertainty. There are significant gaps in ABS survey data on computer use in Government, education and health sectors. These sectors are estimated to be high volume users of computer equipment.

A pilot project to establish the volumes utilised in these three sectors and their current practices in reuse, recycling and disposal would add significantly to the body of data on computer volumes in Australia. Data could be used as a basis for influencing the disposal practices of these sectors. Given their role as significant users of computer and peripheral equipment, changes in practice could affect reuse and recycling of large volumes of equipment.

▪ ***Provide electronic information on reuse and recycling options***

Information on reuse and recycling opportunities can be hard to access on a national basis. While much of this information is available from a range of sources, it has not been collated or established within a single information reference source. The establishment of a national reference source on-line would provide simplicity of access to users seeking this type of information.

This could be provided on an existing industry web-site or a stand-alone web-site, promoting environmental best practice across the industry.

GLOSSARY

ABS	Acrylonitrile butadiene styrene Australian Bureau of Statistics
AEEMA	Australian Electrical and Electronic Manufacturers Association
AIIA	Australian Information Industry Association
ANZECC	Australian and New Zealand Environment Conservation Council
APME	Association of Plastics Manufacturers in Europe
ATH	Aluminium trihydrate
BIOS	Basic input/output system
CD	Compact disc
CD-ROM	Compact disc – read only memory
CFC	Chlorofluorocarbon
CPU	Central processing unit
CRT	Cathode ray tube
DfE	Design for Environment
Frit	Glass solder used to join the faceplate and funnel sections in a cathode ray tube
HCFC	Hydrochlorofluorocarbon
HDPE	High density polyethylene
HIPS	High impact polystyrene
IC	Integrated circuit
ICER	Industry Council on Electrical and Electronic Equipment Recycling
ICT	Information and communication technology
IDEALS	Improved Design Life and Environmentally Aware Manufacturing of Electronic Assemblies by Lead-Free Soldering
JEA	Japan Environment Association
LAN	Local area network
LCA	Life cycle analysis
LCD	Liquid crystal display
LED	Light emitting diodes

Li	Lithium ion
MDH	Magnesium dihydrate
MOEA	Minnesota Office of Environmental Assistance
NED	New equipment distributor
NEPM	National Environment Protection Measure
NiCd	Nickel cadmium
NiMH	Nickel metal hydride
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturer
OH&S	Occupational health and safety
PBB	Polybrominated biphenyl
PBBE	Polybrominated biphenyl ether
PBDE	Polybrominated diphenyl ether
PC	Personal computer Polycarbonate
PCB	Printed circuit board
PPE	Polyphenylene ether
PPO	Polyphenylene oxide (a PPE/HIPS blend)
PP/SEBS	Polypropylene / styrene-ethylene-butene-styrene
PVC	Polyvinylchloride
RAM	Random access memory
ROM	Read only memory
SCBO	Stichting Computerbemiddeling Onderwijs (Computers for Classrooms)
SCC	Specific Contaminant Concentration
TBBA	Tetrabromobisphenol-A
TCLP	Toxicity Characteristics Leaching Procedure
UTP	Un-twisted pair
VOCs	Volatile organic compounds

WEEE Waste electrical and electronic equipment
XLPE Cross-linked polyethylene

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Appendix A
Australian Bureau of Statistics Import/Export Data

Appendix B
Computer Waste Model

Appendix C
Australian Regulations & Guidelines

LIST OF RELEVANT AUSTRALIAN LEGISLATION, REGULATIONS & GUIDELINES

Jurisdiction	Legislation / Guideline
Commonwealth	Hazard Status of Waste Electrical and Electronic Assemblies or Scrap, October 1999 Hazardous Waste (Regulation of Exports and Imports) Act 1989 National Environment Protection Measure: Movement of Controlled Waste Between States and Territories 1998
Australian Capital Territory	Environmental Standards: Assessment and Classification of Liquid and Non Liquid Wastes Environment Protection Act 1997 Environment Protection Regulations 1997
New South Wales	Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes Protection of the Environment Operations Act 1997 Protection of the Environment Operations (General) Regulation 1998 Protection of the Environment Operations (Waste) Regulation 1996 Waste Avoidance and Resource Recovery Act 2001
Northern Territory	Waste Management & Pollution Control Act 1998
Queensland	Environmental Protection Regulation 1998 Environmental Protection (Waste Management) Policy 2000 Environmental Protection (Waste Management) Regulation 2000
South Australia	Environment Protection Act 1993 Environment Protection (General) Regulations 1994
Tasmania	Environmental Management & Pollution Control Act 1994 Environmental Management & Pollution Control (Waste Management) Regulations 2000
Victoria	Environment Protection Act 1970 Environment Protection (Prescribed Waste) Regulations 1998 Environment Protection (Transport) Regulations 1987 Industrial Waste Management Policy (Prescribed Industrial Waste)
Western Australia	Environment Protection Act 1986 Environment Protection (Controlled Waste) Regulations 2001 Guidelines for Acceptance of Solid Waste to Landfill 2001 Landfill Waste Classification and Waste Definitions 1996

Appendix D
Blue Angel Product Criteria

Appendix E
Stakeholders Consulted

STAKEHOLDERS CONSULTED

ABA Computer Pty Ltd
Acer
ACT Waste
Adelaide City Council
Air Road
Albury Computer Wreckers
Apple
Australian Cartridge Manufacturers Association
Australian Chamber of Commerce and Industry
Australian Electrical and Electronic Manufacturers Association Ltd
Australian Industry Group
Australian Information Industry Association
Australian Metal Company
Australian Retailers Association
Barwon Regional Waste Management Group
Brisbane City Council
Canon Australia Pty Ltd
CD Dodd
CitiSoft/Intelligent Machines Pty Ltd
Close the Loop
Compaq Computer Australia
Diamond Australia
Dell
Department for Environment and Heritage (SA)
Department of Environmental Protection (WA)
Department of Industry and Trade (SA)
Department of Lands, Planning, Environment and Heritage (NT)
Department of Primary Industry, Water and the Environment (Tasmania)
Department of Public Works and Services (NSW)
Department of Treasury and Finance (Victoria)
Eastern Metropolitan Regional Council
EcoRecycle Victoria
Electronics Industry Association
Ellipsis Solutions
Entech Integrated Technologies Pty Ltd
Environment Protection Authority (NSW)
Environment Protection Authority (Victoria)
Environmental Protection Agency (Queensland)
Epson Australia
Ericsson
Fire and Emergency Services Authority
Fuji Xerox
Fujitsu Siemens
Gateway
Gerard Industries
Getronics
Gippsland Regional Waste Management Group
Hallmark
Harvey Norman
Hewlett Packard
Hitechnology Metal Recyclers
Hobart City Council
Hymans Asset Management
IBM Australia Ltd
Inner Sydney Waste Board
Ipex

Kodak
Krone
Kyocera Mita Australia Pty Ltd
Legend
Lexmark
Macquarie Bank Ltd
MacRent/PC Rent Computer Hire Pty Ltd
MetalCorp
Mindarie Regional Council
Minolta-QMS
MRI (Australia) Pty Ltd
NCR
NDF
NEC Packard Bell
Next Best Computers
NSW Waste Boards
Oce
Office Equipment Industry Association
Olivetti
Optima
Parketronics Pty Ltd
Pasminco
PCs for Kids Inc
Perth City Council
Philips
Pirelli
Plastics and Chemicals Industries Association
PowerTel
Quest Electronic Developments
Rapier Electronics Pty Ltd
RecruitNet
Resource Work Cooperative
Roads and Traffic Authority
Salvation Army
Second Byte
Sims Metal
South Australian Centre for Manufacturing
Southern Cross Metals
South Western Regional Waste Management Group
State Library of New South Wales
State Library of Victoria
Sun Microsystems
Tandy
Theiss Environmental Services
Toshiba
Total Peripherals Group
Townsville Citiwaste
Tytronics
Waste Service NSW
Western Sydney Waste Board
Wharington International

