Poison PCs and Toxic TVs

"Computers may represent an even bigger problem. Some 300 million to 600 million personal computers in the US could be headed to dumps in the next few years – many of them overseas," says Ted Smith, executive director of the Silicon Valley Toxics Coalition. The group estimates that up to 80 percent of old computers end up being exported to places like China or Vietnam, where children and peasants pick apart the toxic innards for $1 a day."

– "Gadgets to Garbage"
Christian Science Monitor
January 2, 2004

CONTENTS

Executive Summary

Electronic waste (E-waste) encompasses a broad and growing range of electronic devices ranging from personal computers and televisions, to handheld PDAs, VCRs, and cellular phones. Where once consumers purchased a stereo console or television set with the expectation that it would last for a decade or more, the increasingly rapid evolution of technology has effectively rendered everything disposable. Consumers no longer take a malfunctioning television, VCR or telephone to a repair shop. Replacement is often easier and cheaper than repair. And while these ever-improving gadgets – faster, smaller, and cheaper – provide many benefits, they also carry a legacy of waste.

Electronic waste already constitutes from 2% to 5% of the US municipal solid waste stream and is growing rapidly. European studies estimate that the volume of electronic waste is rising by 3% to 5% per year – almost three times faster than the municipal waste stream. [1]

According to the US Environmental Protection Agency (EPA), in 1997 more than 3.2 million tons of E-waste ended up in US landfills. In a report for the EPA, analysts warned that the amount of E-waste in US landfills would grow fourfold in the next few years. [2]

Over the last several years, no product so epitomizes the problems posed by obsolete electronics as the personal computer. Televisions with cathode ray tubes present the same problems. Due to their growing waste volume, toxicity and management cost, both computers and televisions are the focus of this report. How US policy makers – at the national, state and local level – choose to address the problems posed by obsolete computers and televisions is likely to set the tone for the broader spectrum of E-waste. Our laws and regulations are beginning to slowly – and imperfectly – address these concerns.

Today's computer industry innovates very rapidly, bringing new technologies and 'upgrades' to market every couple of years. According to industry sales figures, US purchasers bought more than 45 million new computer systems in 2002.[3] Currently over 50% of US households own a computer. [3]

Should every consumer attempt to throw out their obsolete computer at once, the nation would face a "tsunami" of e-scrap, presenting a major budgetary and environmental crisis that, depending on policy decisions now, could unfairly burden state and local governments with the cost of handling this crisis. By 2006, some 163,420 computers and televisions will become obsolete in the US every day – weighing in at almost 3,513 tons. [5] These units have been used, reused, and stored – and will then be either recycled or tossed out with the trash and subsequently landfilled by trash collectors. Consumers have, on average, 2 to 3 obsolete computers in their garages, closets or storage spaces. US government researchers estimated that three-quarters of all computers ever sold in the United States remain stockpiled, awaiting disposal. [6]

The crisis continues to grow. Other studies estimate that the number of obsolete computers in the United States will soon be as high as 315 to 680 million units. [7, 8]

Recycling rates for computers are low, and opportunities are challenging for most consumers – limited to occasional drop-off programs, or complex mail-back programs offered by a few manufacturers. Options that do exist typically come with a price tag of $10 to $60 per unit, require waiting for infrequent one-day voluntary programs at remote locations. [9] One example: IBM sold more than 3 million computers in the United States in 2000, and was the first manufacturer to establish a pay-as-you-go system for recycling obsolete computers. Results were under-whelming. According to the company, less than 1,000 computers (0.03% of annual sales) were recycled during this period.

The National Safety Council reported in 1999 that only 11% of discarded computers were recycled, compared with 28% of overall municipal solid waste. [10] Other estimates of computer recycling range from 5% to 15%, compared to a 42% rate for overall solid waste and a 70% rate for major appliances like refrigerators, washing machines, and dryers. [11] For large commercial customers, computer system distributors may negotiate for the collection and management of obsolete computer systems.

While there remains limited information on where and if these computers and televisions are recycled, some studies tracking E-waste shipped overseas find that lax practices pose serious environmental and human health threats. (See Exporting Harm, page 19.)

Computers and televisions are toxic traps:

Discarded computers and televisions are hazardous wastes – and when dumped into landfills or improperly recycled, pose a hazard to the environment and human health. The cathode ray tubes (CRTs) in computer monitors, television sets, and other video display devices contain significant concentrations of lead and other heavy metals. The State of California affirmed that:

"...when discarded, CRTs are identified as hazardous waste under both federal and State law and are required to be managed in accordance with all applicable requirements, including generator, transporter and facility requirements." [12]

Source: California Department of Toxic Substances Control
March 21, 2001, Letter to Materials for the Future Foundation

As a hazardous waste, the disposal of CRTs in California municipal solid waste landfills is prohibited. Additionally, collection, whether for recycling or disposal, must be regulated and permitted as a hazardous waste activity. Other states, including Massachusetts, Minnesota and Maine, have taken similar steps. In those states without specific landfill bans for CRTs, any non-residential CRT containing hazardous waste is banned from landfilling under national hazardous waste laws.

Each computer or television display contains an average of 4 to 8 pounds of lead. [13] The 315 million computers that became obsolete between 1997 and 2004 contain a total of more than 1.2 billion pounds of lead. [14] Monitor glass contains about 20% lead by weight. [15] When these components are illegally disposed and crushed in landfills, the lead is released into the environment, posing a hazardous legacy for current and future generations. Consumer electronics already constitute 40% of lead found in landfills. [16] About 70% of the heavy metals (including mercury and cadmium) found in landfills comes from electronic equipment discards. These heavy metals and other hazardous substances found in electronics can contaminate groundwater and pose other environmental and public health risks. [17] (See: Computers and Televisions are Toxic Traps, page 10)

As bans on disposal and other partial responses (such as bottle-bill type deposits on sales of new computers or TVs, similar to a recently adopted California law) [18] begin to take effect, the large volumes of obsolete computers being reused or stored in homes and businesses will begin to show up in local waste collection and recycling programs. If a proposal being circulated in the winter of 2004 at an EPA-created stakeholder consensus group called the National Electronics Product Stewardship Initiative (NEPSI) is adopted, a tsunami of E-waste will swamp our existing programs, starting in 2007 and peaking around 2009-10. (See: Chart "E-waste Tsunami" on page 5.)

How much will this cost?

Recycling of computer and television materials and components – when properly implemented – represents the safest and most cost-effective strategy for addressing the problems posed by these units when inoperative or outdated. Recycling TV and computer materials and components and removing and/or reducing and treating the hazardous components conserves resources, reduces environmental and public health threats, and protects worker safety, while substantially reducing the high cost of permanently storing and disposing of hazardous wastes in permitted hazardous waste facilities.

Computers, televisions and other E-waste contain valuable materials and components that are technically recyclable. The problem is the lack of collection incentives and the newly emerging recycling infrastructure, as well as the high cost of materials collection, handling and processing.

Estimates for the cost of recycling computers range from $10 to $60 per unit. While this can be less expensive than the estimated $25 to $50 per unit cost for safe and disposal as hazardous waste, someone must still pay these costs. And, as we know from experience with other hazardous waste issues, costs for later cleanup of toxic contamination from poorly handled E-waste, of course, will reach much higher.

Based on conservative, best-case estimates, the minimum costs for recycling and proper disposal of E-waste in the US will reach some $10.8 billion dollars between 2006 and 2015. (See: Chart entitled Best Case: National Cost of E-waste Collected on Page 23). If costs for recycling rise above the lowest and best-case $10 estimate, the overall price tag will also climb. Clearly, consumers and local governments have neither the technical ability nor financial resources to address this problem on their own.

A better approach than a small advance fee is to internalize the cost of proper waste management into the price of electronic devices at the time of purchase. Requiring consumers and small business generators to pay the cost of recycling and/or disposal on the back end has proven to be a shortsighted and ultimately ineffective approach. As we have seen firsthand, reliance on back-end disposal fees – such as those currently in place for used tires in many states – reduces incentives for proper recycling, encourages 'sham' recycling, and results in improper and often illegal disposal which ultimately requires cleanup at a substantial cost to taxpayers.

The State of California took an important first step in 2001, by recognizing that electronics scrap and junk computers are hazardous wastes that must be kept out of landfills. In 2003, responding to local solid waste managers facing a huge and costly influx of disposed CRTs, California adopted a $6 to $10 consumer-paid advance recycling fee (similar to bottle-bill schemes).

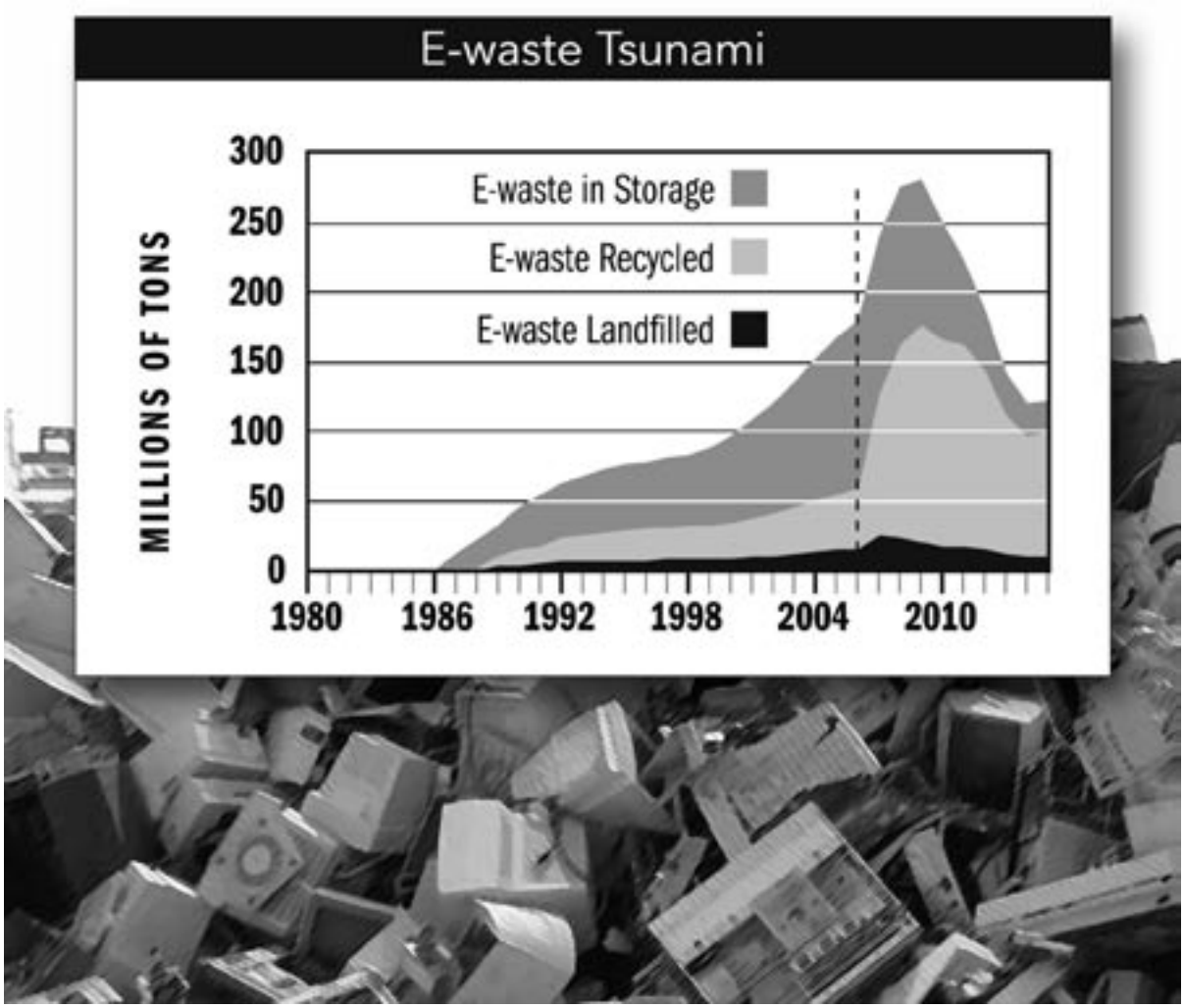
If the California or NEPSI models are adopted, and are successful at a national scale, there will be a shortfall of funds from the nationally-collected monies to pay for recycling E-waste. This is based on the following assumptions (see Chart "Best Case: National Cost of E-waste Collected 2006-2015 on page 23):

- Recycling up to 90% of all televisions and computers from both residential and non-residential sources that have reached the end of their useful life and are coming from use, reuse, or storage,
- Recycling costs $10 per unit,
- A minimal $5 per unit "advance recovery fee" or ARF to be paid by everyone who purchases a new television or computer.

Under this scenario, there is a $7.5 billion shortfall in ARF monies to handle the "tsunami" of E-waste that will come out of storage and reuse cycles between 2006 and 2015. Local agencies, taxpayers and/or fee payers across the nation will inevitably pick up this huge difference in costs. As well, the funding shortfall could lead to increased illegal dumping of unwanted electronics. Note that if actual recycling costs are greater than $10 per unit, the costs of this unfunded mandate will grow dramatically.

Front-end fees collected in the future will pay for handling costs for IBM's past large market share as that two-decade legacy of past IBM PC sales moves out of storage. But IBM, now shifting its business model away from selling PCs to providing services, will only collect fees in the future on their estimated 5% of share of the PC market, and thus escape collecting fees that would pay for the whole of their historic sales now moving out of storage and finding its way into solid waste collection programs. Estimates of the anticipated tax or rate payer subsidy to IBM range as high as a $430 million.

Clearly, electronics manufacturers will have to come up with more money than is currently proposed, or we must pursue some other system.



What we are proposing:

There's much more that must be done. Europe has taken the lead in addressing the E-waste problem by proposing an ambitious system of "Extended Producer Responsibility" (EPR or sometimes "producer takeback," for short). In May of 2001, the European Union (EU) Parliament adopted a directive that requires producers of electronics to take responsibility – financial and otherwise – for the recovery and recycling of E-waste. A second directive requires manufacturers to phase out the use of hazardous materials. US policy should follow the EU's lead.

1 Manufacturers of electronic devices sold in the US should be required to phase down – and where feasible, phase out – the use of hazardous materials in their products.

2 Manufacturers should be responsible for meeting specified recovery and recycling goals for electronic devices in the US. Such goals will provide manufacturers with an incentive to help finance the development of a convenient and effective collection infrastructure.

3 Manufacturers should be required to pay the net cost of recycling electronic materials (or the cost of proper disposal for devices that are not recyclable). This approach (proven in Europe) will provide manufacturers with an incentive to design products for recyclability, as well as to develop markets for recycling.

4 Taxpayer-funded local solid waste programs are already overburdened and underfunded and should not be financially responsible for the new task of E-waste management. In the short term – in areas where no other collection opportunity exists – programs should be authorized to charge-back manufacturers for the costs of managing their electronic devices.

5 State and federal policy makers must establish a workable regulatory framework for the management of electronics waste that encourages recycling while protecting public health, worker safety and the environment.

6 Manufacturers of computer monitors, television sets and other electronic devices containing hazardous materials must be responsible for educating consumers and the general public regarding the potential threat to public health and the environment posed by their products, and for raising awareness of the proper waste management protocol. At minimum, all computer monitors, television sets and other electronic devices containing hazardous materials must be clearly labeled to identify environmental hazards and proper materials management.

Acknowledgments:

Much of the research contained here was released in 2001 by Californians Against Waste (CAW) in a report entitled *Poison PCs and Toxic TVs: California's Biggest Environmental Crisis That You've Never Heard Of.* Established in 1977, CAW is a nonprofit grassroots organization that has grown to represent the interests of more than 24,000 Californians. CAW is the only environmental group in California with full-time staff lobbying exclusively in support of a recycling economy. CAW advocates policy initiatives at the local, state, and federal levels.

We would like to thank the CAW and the author of the original report, Keirsten Scanlon, for her hard work and diligent research – and Michael Picker of Lincoln Crow for his oversight of the project. In addition, we thank Anne Peters and Carolyn Dunmire of Gracestone, Inc. for the use of its model and data regarding costs for managing E-waste at its end of life (page 23) (which in turn, is derived from the Carnegie-Mellon/Matheson model 1997). Any errata resulting from the adaptation of these earlier works are the responsibility of the Computer TakeBack Campaign.

Overview

Over the last two decades, a technological revolution has taken place. Driven primarily by faster, smaller and cheaper microchip technology, society is experiencing an exponential evolution in the capability of electronic appliances and the growing sales category of personal electronics. And while the media has provided extensive coverage of this wave of technological innovation, scant attention is being paid to what is left in its wake.

Electronic waste (E-waste) encompasses a broad and growing range of electronic devices, ranging from personal computers, laptops and televisions, to handheld PDAs, VCRs, and cellular phones, and more. Once built to be repairable, consumer electronics are now designed to be replaced when broken – and then discarded.

E-waste – and in particular the cathode ray tubes (CRTs) contained in computer monitors and television sets – represents an enormous and growing solid and hazardous waste problem. And, the E-waste problem will continue to grow at an accelerated rate. US consumers (all sectors) are expected to buy more than 57,848,558 million new computer systems in 2006 (with increased growth in sales in future years), [19] rendering their older systems 'obsolete.' Current proposals advanced at the EPA-initiated National Electronic Product Stewardship Initiative (NEPSI) will leave much of the cost to taxpayers and local governments for their collection, processing and cleanup. This cost could easily exceed $7.5 billion between 2006 and 2015. [20]

The purpose of this report is to raise awareness of the large and growing scope of the E-waste problem. Specifically, this report attempts to educate the public and policy makers regarding the volume and

hazards posed by E-waste, the growing financial impact on local governments and taxpayers for its cleanup, and the consequences of continued inaction. Finally, the report offers a blueprint for action: a market-based policy approach that encourages waste reduction and minimizes taxpayer responsibility while increasing producer responsibility.

What exactly is E-waste?

Electronic waste, or E-waste, is the by-product of an extraordinary technological revolution. Whether generated in your home or office, E-waste includes the broad spectrum of electronic appliances, products, components, and accessories that – due to malfunction (the broken PDA or the television that's cheaper to replace than repair), exhaustion (batteries, light bulbs and fluorescent tubes), or obsolescence (that old 286 computer you've been meaning to donate to Goodwill, or the Playstation your kid begged you to buy five years ago, but hasn't been touched since the introduction of the latest X-Box) – have been discarded. When disposed of in a landfill, E-waste becomes a conglomeration of plastic and steel casings, circuit boards, glass tubes, wires, resistors, capacitors, fluorescent tubes from flat panel displays, and other assorted parts and materials.

Cleaned and sorted, the precious metals and other materials that make up E-waste have considerable value on the recycling market. The root problem is a lack of incentives for recycling, and the relatively high cost of dismantling, cleaning and sorting.

A single component of E-waste – cathode ray tubes (CRTs) – has emerged as the leading edge of a hazardous waste crisis at the local, state, national and international level. CRTs are the glass 'picture tubes' in television sets, computer monitors and other video display devices that amplify and focus high-energy electron beams to create the images we ultimately see on our screens. In order to protect consumers from radiation dangers, the glass in CRTs contains lead. Lead composes approximately 20% of each CRT; about 4 to 8 pounds per unit.

Lead is an extremely toxic heavy metal, exposure to which poses serious public health risks. Human and animal exposure to lead can cause damage to the central nervous system and blood system and is demonstrated to have serious negative effects on the brain development of children.

High Tech: A short life-cycle from helpful to harmful

The keystone of our high tech revolution is rapid innovation which now brings new technologies to market every couple of years. For all its benefits, our renaissance of innovation brings with it the interrelated consequences of rapid obsolescence.

The creative genius of high tech entrepreneurs and marketing moguls has created astonishing wealth and growth in our economy. However, the same entrepreneurs and companies that benefit so dramatically from this technological revolution utterly fail to apply their brilliance to one of humankind's oldest issues – waste resulting from shortsighted thinking and design. Corporate decision-makers pass along the indirect costs to the public and the environment in the form of delayed cleanup, health consequences that will last for generations, destruction of natural resources and environmental contamination.

How big is the problem?

Electronic waste generally – and CRTs specifically – are a growing toxic waste problem. Nationally, million of tons of computers, televisions, stereos, cell phones, electronic appliances and toys and other electronic gadgets become obsolete every year. [22] A small fraction of this E-waste is recycled. While

a sizeable portion remains in E-waste purgatory (unused but stockpiled in closets, garages, basements and office storerooms), the majority is currently placed into garbage and dumpsters, and landfilled.

According to the EPA, in 1997 more than 3.2 million tons of E-waste ended up in US landfills. European studies estimate that the volume of electronic waste is rising by 3% to 5% per year – almost three times faster than the municipal waste stream. [23] Today, E-waste could represent as much as 5% of municipal solid waste disposal. That's more than beverage containers, more than disposable diapers, and about the same level as all plastic packaging.

The CRTs in computer monitors and television sets, as well as other video display devices, are in the eye of the E-waste storm. According to data compiled by Stanford Research, Inc. (SRI), US sales of CRTs used for computer monitors, terminals and workstations equaled 28.4 million units in 2000 and industry analysts IDC (www.idc.com) estimate personal computer shipments of 47.5 million in 2004, rising to 58.85 million in 2006. Since 1980, an estimated 280 to 330 million computer CRTs were sold in the United States. Between 2006 and 2015, another 670 million computers and laptops will be sold in the US. [24]

Approximately 25 million television sets are sold in the United States annually. [25] Yearly sales equaled or exceeded 20 million units during the last decade. The number of televisions in use may be double that of computer monitors. Household penetration of televisions is over 95% in the United States, compared to about 50% for computers – but the rate of sales growth (and obsolescence) is slower in televisions than in computers.

While no data is available on the average life of televisions or the annual volume of TVs discarded, with less than 20,000 units annually being recycled, the volume of TVs making their way into the waste stream is considerable. Additionally, it is anticipated that there will be a significant spike in the numbers of televisions purchased and subsequently discarded when new federal rules for high-definition broadcasts (HDTV) become effective, and as sales of new digital TVs take off.

Many consumers, unwilling to accept that the latest and greatest computer system they paid top dollar for just two or three years ago is already obsolete, hang on to it in hopes that it will be worth something to someone. Research conducted for the EPA estimates that three-quarters of all computers sold in the United States remain stockpiled [26] in garages, closets, or storage. Other studies estimate that the number of these unused computers in US will soon be as high as 315 to 680 million units. [27]

These statistics quite simply mean that if every consumer decided to throw out their obsolete computers at once, the entire United States would face a major budgetary and environmental catastrophe.

The world according to Moore: "Moore's Law" [21]

This chart shows the link between increased computing power and the rate at which computers will be dumped.

Transistor counts that double every 18 months enable new chips to do more work per clock cycle.

Year	1971	1974	1976	1982	1986	1989	1993	1995
Chip	4004	8080	8086	80286	386DX	486	Pentium	Pentium Pro
Transistors	2,300	6,000	29,000	134,000	275,000	1.2 million	3.1 million	5.5 million

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Computers and televisions are toxic traps

The increasing volume of E-waste is a huge problem. It is not the only issue, however; computers and other electronic and electrical equipment pose significant environmental and health hazards to our communities. Electronic waste components contain lead, cadmium, mercury, and brominated flame retardants – compounds known to be hazardous to humans and to the environment.

"Printed Circuit Boards contain heavy metals such as Antimony, Silver, Chromium, Zinc, Lead, Tin and Copper. According to some estimates, there is hardly any other product for which the sum of the environmental impacts of raw material, extraction, industrial refining and production, use and disposal is as extensive as for printed circuit boards."

– CARE conference, Vienna, 1994

"The product developers of electronic products are introducing chemicals on a scale which is totally incompatible with the scant knowledge of their environmental or biological characteristics."

– Mans Lonnroth, Swedish Secretary of State , 1997

The list of toxic components in computers includes:

- Computer circuit boards containing heavy metals such as lead & cadmium
- Computer batteries containing cadmium
- Cathode ray tubes with lead oxide and barium
- Brominated flame-retardants used in printed circuit boards, cables and plastic casing
- Polyvinyl Chloride (PVC) coated copper cables and plastic computer casings that release highly toxic dioxins & furans when burned
- Mercury switches
- Mercury in flat panel screens
- Poly Chlorinated Biphenyls (PCBs) present in older capacitors & transformers

Discarded computers and televisions are hazardous waste.

When these items are dumped into landfills or improperly recycled, they pose a significant hazard to the environment and human health. In 2001, the California Department of Toxic Substances Control confirmed that the cathode ray tubes (CRTs) in computer monitors, television sets and other devices contain concentrations of lead that classify them as hazardous waste when they are discarded. [28]
The State of California recently affirmed that:

"...when discarded, CRTs are identified as hazardous waste under both federal and State law and are required to be managed in accordance with all applicable requirements, including generator, transporter and facility requirements." [29]

Source: California Department of Toxic Substances Control
March 21, 2001, Letter to Materials for the Future Foundation
See website: www.ciwmb.ca.gov

Under these laws, disposal in municipal landfills in prohibited. In other states without specific landfill bans for CRTs, any non-residential CRT containing hazardous waste is banned from landfilling under national hazardous waste laws.

Each computer or television display, as noted above and in the chart on the next page, contains an average of 4 to 8 pounds of lead. [30] The total amount of lead in the 315 million computers that became obsolete between 1997 and 2004 is estimated to be more than 1.2 billion pounds. [31] Monitor glass contains about 20% lead by weight. [32] The diagram on page 15 illustrates the construction of a CRT and highlights areas within the CRT that hold concentrations of lead.

Poisons in E-waste and their effects on us

CRTs, computer towers, televisions and other electronic equipment contain toxic substances. Knowing the health and environmental effects these substances lends additional urgency to solving the E-waste crisis.

Hazardous Materials and their Effects on Humans and the Environment

Lead [1A]

The effects of lead are established and well recognized. Lead is known to cause damage to the central and peripheral nervous systems, blood system and kidneys in humans. Effects on the endocrine system have also been observed and its serious negative effects on children's brain development are well documented. Lead accumulates in the environment and has high acute and chronic toxic effects on plants, animals and microorganisms. [2A] Consumer electronics constitute 40% of lead found in landfills. The main concern in regard to the presence of lead in landfills is the potential for the lead to leach and contaminate drinking water supplies. The main applications of lead in computers are:

(1) Soldering of printed circuit boards and other electronic components
(2) Glass panels in computer monitors and TV's (cathode ray tubes)

Cadmium [3A]

Cadmium compounds are classified as toxic with a possible risk of irreversible effects on human health. Cadmium and cadmium compounds accumulate in the human body, in particular in kidneys. Cadmium is absorbed through respiration but is also taken up with food. Due to the long half-life (30 years), cadmium can easily be accumulated in amounts that cause symptoms of poisoning. Cadmium shows a danger of cumulative effects in the environment due to its acute and chronic toxicity. [4A]

In electrical and electronic equipment, cadmium occurs in certain components such as SMD chip resistors, infrared detectors and semiconductors. Older models of cathode ray tubes contain cadmium. Cadmium is also used as a plastic stabilizer. Between 1997 and 2004, over 315 million computers became obsolete, representing almost two million pounds of cadmium content. [5A]

Mercury [6A]

When inorganic mercury is introduced into natural water systems, it is transformed into methylated mercury

in bottom sediments. Methylated mercury easily accumulates in living organisms and concentrates through the food chain, particularly in fish. Methylated mercury causes chronic damage to the brain. It is estimated that 22% of the yearly world consumption of mercury is used in electrical and electronic equipment. It is primarily used in thermostats, (position) sensors, relays and switches (e.g. on printed circuit boards and in measuring equipment) and discharge lamps. It is also used in medical equipment, data transmission, telecommunications, and mobile phones.

Mercury is also used in batteries, switches/housing, and printed wiring boards. Although this amount is small for any single component, 315 million obsolete computers by the year 2004 represent more than 400,000 pounds of mercury in total.

Hexavalent Chromium (Chromium VI) [7A]

Some manufacturers still use this substance as corrosion protection of untreated and galvanized steel plates, and as a decorative or hardener for steel housings. Chromium VI easily passes through cell membranes and is then absorbed – producing various toxic effects within contaminated cells. It causes strong allergic reactions in even small concentrations. Asthmatic bronchitis is a typical allergic reaction linked to Chromium VI. Chromium VI may also cause DNA damage. In addition, hexavalent chromium compounds are toxic in the environment. It is well documented that contaminated wastes can leach from landfills. Incineration results in the generation of fly ash from which chromium is leachable, and there is widespread agreement among scientists that wastes containing chromium should not be incinerated. Of the more than 315 million computers that became obsolete between 1997 and 2004, about 1.2 million pounds of hexavalent chromium will be present.

Plastics

Based on the calculation that more than 315 million computers that became obsolete between 1997 and 2004 – and that plastics make up 13.8 pounds per computer on average – there are more than 4 billion pounds of plastic present in computer waste. [8A] An analysis commissioned by the Microelectronics and Computer Technology Corporation (MCC) estimates that total electronics plastic scrap amounts to more than 1 billion pounds per year (580,000 tons per year). This same study estimates that the largest volume of plastics used in electronics manufacturing (at 26%) is polyvinyl chloride (PVC), which creates more environmental and health hazards than most other types of plastic (see below). While many computer companies have recently reduced or phased out the use of PVC, there is still a huge volume of PVC in the computer scrap that continues to grow – potentially up to 250 million pounds per year. [9A]

PVC [10A]

The use of PVC in computers is mainly found in cabling and computer housings, although many computer moldings are now made from somewhat more benign ABS plastics. PVC cabling is used for its fire-retardant properties – but there are concerns that once alight, fumes from PVC cabling can be a major contributor to fatalities and hence there are pressures to switch to alternatives for safety reasons. Alternatives include low-density polyethylene and thermoplastic olefins. PVC is a difficult plastic to recycle. It contaminates other plastics in the recycling process. More importantly, the production and burning of PVC products generates dioxins and furans. PVC, commonly used in packaging and household products, is a major cause of dioxin formation in open burning and garbage incinerators.

Hospitals are now beginning to phase out the use of PVC products, such as disposable gloves and IV bags, because of the dangers inherent in the incineration of these products. Many authorities in Europe have PVC-free policies for municipal buildings, pipes, wallpaper, flooring, windows and packaging. Recent concerns about the use of softeners in PVC plastic toys leaching into children's mouths have prompted further restrictions on the use of PVC.

Brominated Flame Retardants

Brominated flame-retardants are a class of brominated chemicals commonly used in electronic products as a means of reducing flammability. In computers, they are mainly used in four applications: printed circuit boards, components such as connectors, plastic covers and cables. They are also used in furniture foam, plastic covers of TV sets and in domestic kitchen appliances.

Various scientific observations indicate that Polybrominated Diphenylethers (PBDE) might act as endocrine disrupters. Research reveals PBDEs in breast milk of every American woman tested [11A] and that levels of PBDEs in human breast milk are doubling every five years – and this has prompted concern because of the effect of these chemicals in young animals. [12A] A recent study found that newborn mice fed PBDEs show abnormal behavior when placed in new surroundings. Normal mice become very active when first transferred to a new environment, but gradually slow down as they complete their explorations. However, treated mice were less active at first but became more active after being in new surroundings for an hour. Researchers concluded that exposure to these chemicals in early life could induce neurotoxic effects similar to those caused by other toxic substances such as PCBs and some pesticides. [13A] Other studies have shown PBDE, like many halogenated organics, reduces levels of the hormone thyroxin in exposed animals and is shown to cross the blood brain barrier in the developing fetus. Thyroid is an essential hormone needed to regulate the normal development of all animal species, including humans. [14A]

EPA recently negotiated a phase-out of some PBDEs, but not the one used mainly in electronics. Legislation passed in Maine during 2003 (LD 743) requires electronics manufacturers to phase out all brominated fire retardants and other toxins such as lead, mercury and PVC by 2006, unless no feasible alternatives exist.

High tech companies produce equipment that allows greater productivity and faster access to information than ever before in human history. It does so with little regard for the long-term financial, environmental, or health impacts of these toxic traps.

Footnotes on hazardous materials and their effects on humans and the environment

[1A] EXPLANATORY MEMORANDUM, WEEE (Third Draft) July 1999, Brussels, 05.07.1999.

[2A] Compare Risk Reduction Monograph No. 1 Lead – Background and national experience with reducing risk, OECD Paris, 1993.

[3A] EXPLANATORY MEMORANDUM, WEEE (Third Draft) July 1999, Brussels, 05.07.1999.

[4A] This information is based on the risk reduction monograph no 5, "CADMIUM, Background and National Experience with Reducing Risk" (OEDC/GD894) 97; *Health effects of cadmium exposure – a review of the literature and a risk estimate* (Lars Jarup and others) Scand J Work Environ Health 98; *Environmental impacts of cadmium*, Gerrit H. Vonkeman 1995; *Cadmium in Sweden-environmental risks*, Helena Parman and others 1997 and other research on this issue.

[5A] National Safety Council Report, Washington DC May 1999. From report "Electronic Product Recovery and Recycling Baseline Report."

[6A] EXPLANATORY MEMORANDUM, WEEE (Third Draft) July 1999, Brussels, 05.07.1999.

[7A] EXPLANATORY MEMORANDUM, WEEE (Third Draft) July 1999, Brussels, 05.07.1999.

[8A] Californians Against Waste, "Addressing the Environmental and Economic Costs of Obsolete Electronics (E-Scrap) in California."

[9A] Adherent Technologies.

[10A] See the report section at: www.greenpeace.org/~toxics/reports/reports.html

[11A] Diphenyl Ethers (PBDEs) in U.S. Mothers' Milk" by Arnold Schecter, M. Pakuk, O. Päpke, J.J. Ryan, L. Birnbaum, and R. Rosen. Environmental Health Perspectives: doi:10.1289 [Online August 7, 2003]

[12A] "Persistent Organic Pollutants," Swedish Environmental Protection Agency. See website: http://www.smn.environ.se/miljonat/english/sokning/sokning.htm

[13A] "Evidence mounts on risks of brominated flame retardants," ENDS report 283. August 1998, London, UK.

[14A] Hoque, A et al, 1998. *Epidemiology* Vol 9(4) P. 373-8.

What's in our PCs?

Materials used in desktop computers and the efficiency of current recycling processes
Composition of a desktop personal computer, based on a typical desktop computer weighing 60 lbs.

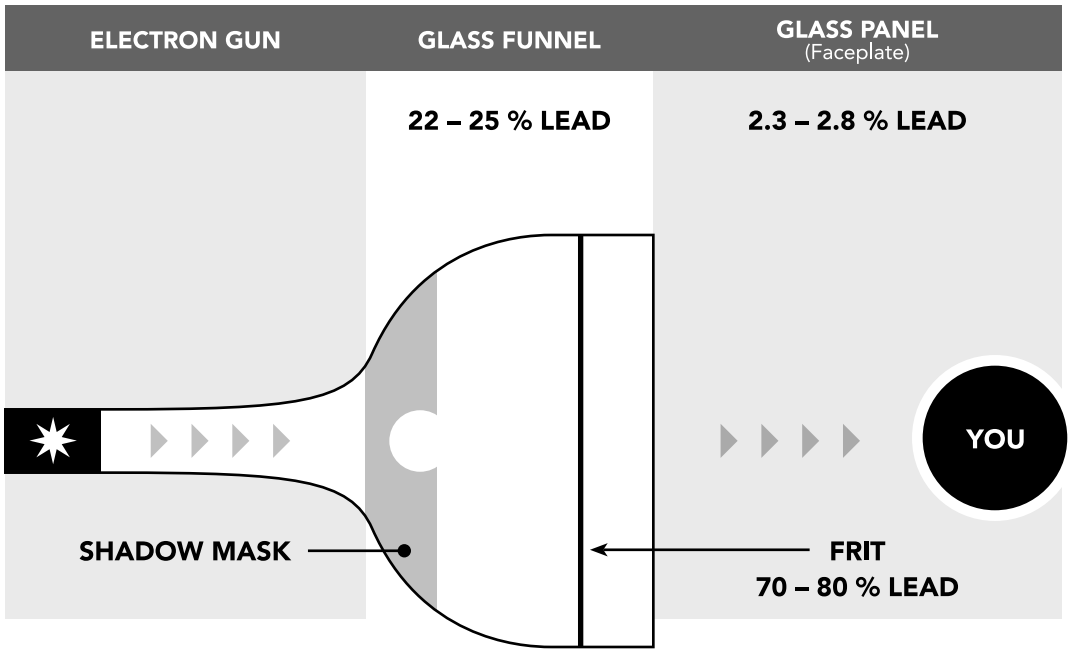
NAME	Content (% of total weight)	Weight of material (lbs.)	Recycling Efficiency (current recyclability)	Use/Location
Plastics*	22.9907	13.8	20%	Includes organics and oxides (other than silica)
Lead	6.2988	3.8	5%	Metal joining, radiation shield/CRT, PWB
Aluminum	14.1723	8.5	80%	Structural, conductivity/housing, CRT, PWB, connectors
Germanium	0.0016	< 0.1	0%	Semiconductor/PWB
Gallium	0.0013	< 0.1	0%	Semiconductor/PWB
Iron	20.4712	12.3	80%	Structural, magnetivity/(steel) housing, CRT, PWB
Tin	1.0078	0.6	70%	Metal joining/PWB, CRT
Copper	6.9287	4.2	90%	Conductivity/CRT, PWB, connectors
Barium	0.0315	< 0.1	0%	Vacuum tube/CRT
Nickel	0.8503	0.51	80%	Structural, magnetivity/(steel) housing, CRT, PWB
Zinc	2.2046	1.32	60%	Battery, phosphor emitter/PWB, CRT
Tantalum	0.0157	< 0.1	0%	Capacitors/PWB, power supply
Indium	0.0016	< 0.1	60%	Transistor, rectifiers/PWB
Vanadium	0.0002	< 0.1	0%	Red phosphor emitter/CRT
Terbium	< 0	< 0	0%	Green phosphor activator, dopant/CRT, PWB
Beryllium	0.0157	< 0.1	0%	Thermal conductivity/PWB, connectors
Gold	0.0016	< 0.1	99%	Connectivity, conductivity/PWB, connectors
Europium	0.0002	< 0.1	0%	Phosphor activator/PWB
Titanium	0.0157	< 0.1	0%	Pigment, alloying agent/(aluminum) housing
Ruthenium	0.0016	< 0.1	80%	Resistive circuit/PWB
Cobalt	0.0157	< 0.1	85%	Structural, magnetivity/(steel) housing, CRT, PWB
Palladium	0.0003	< 0.1	95%	Connectivity, conductivity/PWB, connectors
Manganese	0.0315	< 0.1	0%	structural, magnetivity/(steel) housing, CRT, PWB
Silver	0.0189	< 0.1	98%	Conductivity/PWB, connectors
Antinomy	0.0094	< 0.1	0%	Diodes/housing, PWB, CRT
Bismuth	0.0063	< 0.1	0%	Wetting agent in thick film/PWB
Chromium	0.0063	< 0.1	0%	Decorative, hardener/(steel) housing
Cadmium	0.0094	< 0.1	0%	Battery, blue-green phosphor emitter/housing, PWB, CRT
Selenium	0.0016	0.00096	70%	Rectifiers/PWB
Niobium	0.0002	< 0.1	0%	Welding alloy/housing
Yttrium	0.0002	< 0.1	0%	Red phosphor emitter/CRT
Rhodium	< 0	< 0	50%	Thick film conductor/PWB
Platinum	< 0	< 0	95%	Thick film conductor/PWB
Mercury	0.0022	< 0.1	0%	Batteries, switches/housing, PWB
Arsenic	0.0013	< 0.1	0%	Doping agents in transistors/PWB
Silica	24.8803	15	0%	Glass, solid state devices/CRT,PWB

Sources: Microelectronics and Computer Technology Corporation (MCC), 1996.
Electronics Industry Environmental Roadmap. Austin TX (MCC).

* Plastics contain polybrominated flame retardants, and hundreds of additives and stabilizers not listed separately.

Lead in our PC and TV video displays

This diagram illustrates the lead content of typical PC and TV video displays.
Lead is toxic and hazardous. See chart at left for more detailed info on the toxic content of PCs and TVs.



Disposing of computers is hazardous

There are significant risks to handling the disposal of E-waste. Recycling E-waste poses many health hazards to workers. In addition to the evidence of worker exposure to flame retardants, the environmental risks posed by landfilling and burning are also significant. In particular, when computer waste is landfilled or incinerated, it poses contamination problems in leachate to water sources and toxic air emissions.

Past disposal of lead and heavy metals – a problem with high costs

All solid waste landfills leak. Even the best "state-of-the-art" landfills are not completely secure throughout their lifetimes, and a certain amount of chemical and metal leaching will occur. [33] The situation is far worse for older or less stringently maintained landfills.

Lead can enter drinking water by leaching from landfills, contaminating the clothes of workers at improperly regulated recycling plants, or can reach our homes from CRTs crushed in landfills. Significant amounts of lead ions are dissolved from broken glass containing lead, such as the cone glass of cathode ray tubes, when mixed with acid waters that commonly occur in landfills. [34]

About 70% of the heavy metals (including mercury and cadmium) found in landfills comes from electronic equipment discards. These heavy metals and other hazardous substances found in electronics can contaminate groundwater and pose environmental and public health risks. [35]

Mercury is released when certain electronic devices, such as the tubes found in flat panel screens, circuit breakers and switches, are destroyed. In a landfill, these components are easily crushed and broken, allowing mercury to enter the environment. The same is true for polychlorinated biphenyls (PCBs) from condensers. When plastics containing brominated flame retardants (BFRs) like Polybrominated Diphenylethers (PBDEs) or cadmium are landfilled, both PBDE and the cadmium may leach into the soil and groundwater.

The vaporization of metallic mercury and dimethylene mercury, both found in E-waste, is also of concern. In addition, uncontrolled fires may arise at a landfill, a frequent occurrence in many countries. Burning wastes can emit metals and other chemical substances, including extremely toxic dioxins and furans, combustion by-products from halogenated flame retardant products and PCB containing condensers.

The hazards of burning computer junk

The glut of E-waste is a primary source of heavy metals and halogenated substances contained in the municipal waste stream. [36] Due to the volume and variety of these substances, incineration or any burning of E-waste is particularly dangerous.

Municipal incineration is the largest point source of dioxins into the US and Canadian environments, and among the largest point source of heavy metal contamination into the atmosphere. Some producers send their E-waste to cement kilns for use as an alternative to fuel. Smelting can also present dangers similar to those found in incineration.

For instance, copper is a catalyst for dioxin formation when flame-retardants are incinerated. This is of particular concern, since the incineration of brominated flame retardants (BFRs) at relatively

low temperatures (600-800°C) may lead to the generation of extremely toxic polybrominated dioxins (PBDDs) and furans (PBDFs). [37]

Many plastics present in electronic products now in the waste stream were made of polyvinyl chloride (PVC). These toxic materials pose severe health threats. BFRs are linked to the disruption of the endocrine system and PVC – when burned – creates dioxins, among the most toxic substances known. Electronic waste contains significant quantities of PVC, [38] which makes the flue gas residues and air emissions particularly dangerous. [39]

The introduction of E-waste into incinerators results in high concentrations of metals, including heavy metals, in the slag, the fly ash, the flue gas and the filter cake. More than 90% of the cadmium put into an incinerator is found in the fly ash, and more than 70% of the mercury in the filter cake. [40] An estimated two million pounds of cadmium are contained in the 315 million computers that became obsolete between 1997 and 2004. [41]

The most dangerous form of burning E-waste is open-air burning of plastics in order to recover copper and other metals. These practices are well-documented at various Asian countries. The toxic fallout from open-air burning affects both the local environment and broader global air currents, depositing highly toxic by-products in many places throughout the world.

The hazards of recycling computer junk

While properly managed recycling may be the key to the management of E-waste, improper handling, weak regulation and 'sham' recycling may result in increased environmental, public, and worker exposure to hazardous materials.

In the past, poorly regulated recycling operations have resulted in toxic hazards and expensive cleanup costs. Recycling of hazardous materials has limited environmental benefit – it simply moves the hazards into secondary products that eventually require disposal. The primary goal should be to redesign products to reduce and ultimately eliminate hazardous materials.

Computers are difficult to recycle for several reasons. They contain toxic components that pose a significant risk to recycling employees. Computers have also been designed in a manner that makes disassembly difficult. Thus, policy should focus on manufacturer responsibility rather than government collection and contracting programs.

Both dioxins and furans are generated when electronic components are burned in order to recover the metal content of E-waste. Due to the risk of generating dioxins and furans, recyclers sometimes abstain from recycling flame-retarded plastics from E-waste. Because most computers lack proper identification of plastics containing flame-retardants, many recyclers do not process any plastic from E-waste. [42]

Hazardous emissions to the air can also result from the recycling of E-waste containing heavy metals such as lead and cadmium. [43] These emissions could be significantly reduced by means of pretreatment operations. Another problem with heavy metals and halogenated substances in untreated E-waste occurs during the shredding process. Hazardous substances, such as PCB contained in capacitors, may be dispersed into the recovered metals and the shredder waste. [44]

Halogenated substances contained in E-waste, in particular brominated flame-retardants, are also of concern during the extrusion of plastics, part of plastic recycling processes. These chemicals make computer recycling particularly hazardous to workers.

Polybrominated Diphenylethers (PBDEs) can form toxins called polybrominated dibenzo furans (PBDF) and polybrominated dibenzo dioxins (PBDD) during the extruding process. These chemicals are associated with increased risk of stomach, pancreas, liver, and lymph cancers, and are thought to act as endocrine disrupters. [45] As a consequence, the German chemical industry stopped the production of these chemicals in 1986. [46]

In an alarming discovery, high concentrations of PBDEs were found in the blood of workers in electronics recycling plants. [47] A recent Swedish study found that when computers, fax machines or other electronic equipment are recycled, dust containing toxic flame-retardants is spread in the air. Workers at dismantling facilities had 70 times the level of one form of flame retardant than are found in hospital janitorial workers. Because of their common presence in air, clerks working full-time at computer screens also had levels of flame-retardants in their blood – slightly higher than for cleaners. Humans may directly absorb BFRs when they are emitted from electronic circuit boards and plastic computer and TV cabinets.

In May, 1998 Sweden's National Chemicals Inspectorate called for a ban on PBB and PBDE while urging their government to work for a European-wide ban and for controls on the international trade in these chemicals.

Source: Sjodin, et.al. Flame Retardants Exposure – PBDEs in Blood from Swedish workers. *Environmental Health Perspectives*, Vol. 107, Number 8, August 1999.

This concern led to including of PBBs and PBDEs in the phaseout contained in recent the European-wide regulation regarding E-waste. [48]

A 2003 study entitled *A Tale of Two Systems* [49] compared two recycling operations, one of which is operated by the Federal Prisons Authority agency called UNICOR and a unionized facility (Micro-Metallics) that partners with Hewlett Packard. The study found severe deficiencies at the government facility. In the wake of this report – and under mounting public pressure – Dell Computers and the State of California both publicly repudiated their prison recycling partner.

Exporting harm: The high tech trashing of developing nations

"We've seen a growing number of dirty recycling and metal recovery options along the Mexican border. We already see elevated levels of lead, mercury and other heavy metals. Shipping millions of tons of unregulated E-waste across the border poses a serious threat to Tijuana and San Diego environmental quality and public health."

– Diane Takvorian, Environmental Health Coalition
A binational environmental organization based in San Diego & Tijuana

The overwhelming majority of the world's hazardous waste is generated by industrialized market economies. Exporting this waste to less developed countries has been one way in which the industrialized world has avoided having to deal with the problem of expensive disposal and close public scrutiny at home.

An alarming 50 to 80 per cent of American E-waste destined for "recycling" actually becomes global toxic trade. As documented in the report and video *Exporting Harm* (www.ban.org), many electronics turned in by U.S. consumers for recycling are actually shipped to China and other Asian nations for dismantling under horrific conditions, contaminating the land, air and water. [50] Residents of the Guiyu region in China have noted high levels of respiratory problems and BAN researchers found levels of lead, tin and chromium in the soil and water that were significantly higher that World Health Organization and U.S. recommended levels. [51] Furthermore, hair and sediment samples from the area found high levels of dioxins and furans. [52]

The export of scrap is profitable because the labor costs are cheap and regulations offshore are lax compared to US law. Managers of a pilot program collecting electronic scrap in San Jose, California, estimated that shipping monitors to China for reclamation was 10 times cheaper than recycling the same units in the US. [53]

Because of many diverse toxic components, E-waste, especially computers and televisions, are considered hazardous by the Basel Convention (of 1989) Technical Working Group (TWG). In 1994, parties to the Basel Convention, now over 60 countries, agreed to an immediate ban on exports of hazardous waste destined for final disposal in non-OECD countries. This action has not been adequate, however, to halt the transport of waste that industries claimed was being exported for recycling purposes.

Seventy-seven non-OECD countries, and China, pushed heavily for a ban on the shipping of waste for recycling. As a result, the Basel Ban was adopted, promising an end to the export of hazardous waste from rich OECD countries to poor non-OECD countries for recovery operations by December 31, 1997. The USA, however, has refused to ratify or participate in this ban.

The United States has lobbied governments in Asia to establish bilateral trade agreements to continue dumping hazardous waste after the Basel Ban came into effect on January 1, 1998. The amount of E-waste exported from the United States will continue to grow as product obsolescence increases, unless dramatic changes are adopted in the United States.

How does the US respond to the challenge?

Clearly, there is a growing and imminent waste crisis hitting the United States – computer junk and old televisions.

"The fundamental dynamism of computer manufacturing that transformed life in the second half of the 20th Century – especially the speed of innovation – also leads to rapid product obsolescence. The average computer platform has a life-span of less than two years, and hardware and software companies – especially Intel and Microsoft – constantly generate new hardware and software that fuel demand for more speed, memory and power.

Today, it is frequently cheaper and more convenient to buy a new machine to accommodate the newer generations of technology than it is to upgrade the old. This trend has rapidly escalated due to widespread Y2K concerns. Yet, we have no solution in North America for the rising quantities of computer junk that people are discarding.

We need to change the dominant paradigm that has prevailed over the past three decades – faster, smaller, and cheaper – into a new 21st Century paradigm of cleaner, greener, and more recyclable."

Ted Smith, Executive Director, Silicon Valley Toxics Coalition

The National Safety Council reported in 1999 that only 11% of discarded computers were recycled, compared with 28% of overall municipal solid waste. [54] Estimates of computer recycling range from 5% to 15%. The vast majority is landfilled, disposed of illegally, or simply stockpiled. This low computer recycle rate can be compared to a 42% recycle rate for overall solid waste and 70% recycle rate for major appliances like refrigerators, washing machines, and dryers.[55]

To put a number on these percentages, over 300 million computer monitors (CRTs) – not including TVs – were sold in the USA since 1980. Yet, in 1997 only about 1.7 million monitors in the US were 'recycled,' the majority of which – about 1 million monitors – were shipped abroad to countries such as China. [56]

Of the small amount of computers that are recycled, more than three-quarters come from large-scale users of the equipment. Individual users and small businesses contribute only a small fraction of the equipment that is recycled because almost no convenient, consistent, cost-effective collection or recycling programs are in place. [57]

Limited recycling in the United States

In the United States, growing public and government attention to the problems posed by E-waste has prompted a few manufacturers and retailers to announce plans for some small scale 'take-back' programs. Dell, HP, IBM and other market leaders all have programs of one type or another, mostly focused on their customers. But none claims to receive or recycle more that 10% of their annual sales. [58]

Several computer manufacturers, including Hewlett Packard (HP) and Dell, are beginning to include the take-back of old systems as part of a sales package for marketing new systems to commercial and government customers. And while most manufacturers rely on third parties to handle the collection,

processing and recycling of old PCs, HP has established three recycling facilities to handle waste reclaimed from the company's customers.

Some examples of small scale take-back programs for consumers include companies like Dell, IBM, HP and Lexmark. While some of these larger manufacturers are starting to provide take-back services, these services fall short of a suitable solution. A 2004 study of the options for recycling a desktop system found "high cost, relative lack of convenience and substantial time commitment." The average price was $68, far more than most consumers are willing to pay to recycle E-waste. [59] On average, it took nearly two hours to do the tasks involved in the recycling and 6.5 days of waiting for the recycling information or materials. The report concluded that these programs "do not offer the easy, low-cost options desired by consumers." Other than mail-back programs, there are infrequent one-day voluntary collection programs in scattered locations around the US.

Xerox and Pitney Bowes offer, for a variable fee, a take-back program on office equipment to their business leasing customers. These programs demonstrate that there is a significant cost associated with recycling or properly discarding E-waste.

Extended Producer Responsibility (EPR) in the European Union

The European Union (EU) Parliament has recognized the scope and urgency of the E-waste problem, recently approving two directives dealing with this important issue. The two main pieces of legislation are "Waste from Electrical and Electronic Equipment," (the WEEE Directive) and "A Directive on the Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronics Equipment" (ROHS). These directives show that the European continent's governing body understands the cost of cleaning up the legacy waste and building an ongoing E-waste program.

The WEEE Directive requires that producers supply systems for the treatment of E-waste. The goals of the Directive are to:

- Prevent E-waste
- Improve the reuse, recycling and other forms of recovery to reduce E-waste
- Improve the environmental performance of all economic operators involved in the life cycle of electrical and electronics equipment

The Directive also requires labeling of E-waste by identifying the different components and materials within those components. The ROHS takes prevention a step further by phasing out the use of hazardous substances in the production of electrical and electronics equipment by 2006. Due to its danger to human health and the environment, lead is particularly targeted by this legislation. [60]

The European Union holds the electronics industry responsible for assisting in the solution on several levels. Essentially, the EU is demanding that the industry find better, less toxic ways to produce their products in hopes of diminishing future environmental risks from electronic the equipment. The Directives also place full financial responsibility on producers to set up collection, recycling and disposal systems, and contain effective and feasible goals for recycling. The estimated cost for this legislation is only an additional 1% to 3% of retail prices. [61]

The United States government and American manufacturers have claimed that the EU's environmental and health protections constitute "unnecessary barriers to trade, particularly the ban on certain materials, burdensome take-back requirements for end-of-life equipment, and mandated design standards. [62] Additionally, US high-tech companies, through their trade association, have threatened to challenge

the European initiative through the World Trade Organization (WTO) when the Directive goes into effect. Even in the face of these threats, the Parliament not only approved the WEEE and ROHS Directives, but also went so far as to strengthen the directives initially proposed by the Commission.

Elsewhere overseas

A study from the International Institution for Industrial Environmental Economics concluded that as a result of mandated extended producer responsibility, manufacturers in Japan are building computers with end-of-life consequences in mind. Because the companies will bear the burden of disposal/recycling, they are finding ways to produce equipment that will last longer, can be disassembled more easily, is less toxic, and contains more standard components. [63]

Costs of E-waste

Programs for properly recycling current and future E-waste must be built now. This new effort requires a sober analysis of costs, and a policy discussion of who should pay. Instead, some manufacturers like IBM, reducing their traditionally high levels of sales of PCs to consumers and shifting into new service-oriented lines of business, are arguing in a national policy forum established by EPA, the National Electronics Product Stewardship Initiative (NEPSI) for a national bottle-bill style advance fee to partially pay for costs of collecting and handling old E-waste. IBM would force current manufacturers and the public – through increased costs to local government's waste programs– to subsidize their past sales. The Chart on Page 23, National Costs of E-waste Collected 2006-2015, estimates the cost of properly recycling or disposing of collected computers and televisions through the year 2015.

Failure to act will result in an even greater cost for environmental cleanup at public expense. While computers and TVs – including CRTs – are recyclable, the cost of collection, handling, dismantling and processing for recycling can range from $10 to $60 or more per unit. [64] The cost of properly disposing of old computers and televisions as hazardous waste can also easily run $25 to $60. [65] The cost of cleaning up several decades of obsolete computers and TVs could easily exceed $10.7 billion. [66]

What should be done?

Electronics waste already represents as much as 5% of the United States municipal solid waste stream – 3.2 million tons annually – and is growing. The furious cycle of technical innovation and obsolescence can only mean more waste. The current stockpiling of obsolete electronics – computers specifically – only serves to postpone the day when the electronic waste tsunami tears into the nation's waste management system.

The toxic heavy metals and other hazardous wastes contained in E-waste represent a real and serious threat to public health and the environment.

Public awareness of the health and environmental threat posed by E-waste generally and CRTs specifically is virtually nonexistent. Awareness of, and access to, recycling opportunities for E-waste is limited.

If we continue to do nothing, these costs and problems will fall squarely on the backs of local governments and taxpayers. In order to best protect public health and the environment without unfairly burdening taxpayers, state and federal policy makers must be willing to fundamentally redesign our approach to E-waste management.

National Cost of E-waste Collected: 2006 – 2015

Best Case:

		Pre - ARF 2006	ARF Year 1 2007	ARF Year 2 2008	ARF Year 3 2009	ARF Year 4 2010	ARF Year 5 2011	ARF Year 6 2012	ARF Year 7 2013	ARF Year 8 2014	ARF Year 9 2015	TOTALS
1	Units of E-waste Collected [1]	59,648,551	126,772,516	162,900,354	175,561,567	166,344,792	162,055,471	144,387,415	111,192,337	96,315,223	99,377,606	1,244,907,281
2	Recycling Rate [2]	73%	79%	79%	85%	89%	89%	90%	90%	90%	90%	
3	E-waste Units Recycled	43,596,615	100,296,606	128,879,296	149,869,315	147,678,088	144,907,291	129,655,762	99,826,504	86,431,847	89,223,524	1,076,768,233
4	Recycling Cost per Unit [3]	$10	$10	$10	$10	$10	$10	$10	$10	$10	$10	
5	Recycling Cost (Total)	$435,966,150	$1,002,966,061	$1,288,792,961	$1,498,693,151	$1,476,780,885	$1,449,072,908	$1,296,557,622	$998,265,039	$864,318,465	$892,235,241	$10,767,682,333
6	Landfill Rate [4]	27%	21%	21%	15%	11%	11%	10%	10%	10%	10%	
7	E-waste Units Landfilled	16,051,936	26,475,910	34,021,058	25,692,252	18,666,704	17,148,180	14,731,653	11,365,833	9,883,376	10,154,082	168,139,048
	Average Weight/Unit in lbs. [5]	43	43	43	43	43	43	43	43	43	43	
8	Weight Landfilled in Tons	345,117	569,232	731,453	552,383	401,334	368,686	316,731	244,365	212,493	218,313	
9	Average Cost of Landfilling @ $40/ton [6]	$13,804,665	$22,769,283	$29,258,110	$22,095,337	$16,053,365	$14,747,435	$12,669,221	$9,774,617	$8,499,703	$8,732,510	$144,599,581
10	Advanced Recovery Fee (ARF) Charge per Unit		$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	
11	Annual Television Unit sales [7]	23,472,000	22,700,000	22,400,000	22,100,000	21,800,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	189,000,000
12	Annual PC + Laptop Unit Sales [8]	57,848,558	60,740,986	63,778,035	66,966,937	70,315,284	73,831,048	77,522,601	81,398,731	85,468,667	89,742,101	669,764,390
13	Subtotal Units Sold	81,320,558	83,440,986	86,178,035	89,066,937	92,115,284	93,831,048	97,522,601	101,398,731	105,468,667	109,742,101	858,764,390
	Units for which ARF is collected [9]		80%	80%	80%	80%	80%	80%	80%	80%	80%	
14	Total ARF Dollars Collected		$333,763,944	$344,712,142	$356,267,749	$368,461,136	$375,324,193	$390,090,403	$405,594,923	$421,874,669	$438,968,402	$3,435,057,561
15	ARF Shortfall (line 5 minus line 14)		($669,202,117)	($944,080,819)	($1,142,425,402)	($1,108,319,749)	($1,073,748,715)	($906,467,219)	($592,670,116)	($442,443,796)	($453,266,838)	($7,332,624,772)
16	Total Costs of E-waste collected [10]		($691,971,399)	($973,338,929)	($1,164,520,739)	($1,124,373,114)	($1,088,496,150)	($919,136,441)	($602,444,732)	($450,943,500)	($461,999,349)	($7,477,224,353)
17	IBM Units' Share of Total Costs		13.4%	16.5%	15.6%	14.3%	12.6%	12.4%	10.5%	8.8%	8.7%	12.3%
18	Taxpayer Subsidy to IBM		$43,874,853	$55,927,824	$55,050,589	$52,141,546	$46,942,462	$48,069,015	$42,131,147	$36,578,715	$38,045,673	$418,761,822

[1] Does not include units being stored or reused, after original owner's use. E-Waste is defined here as the sum quantity of all units going to recycling + all units going to landfill/disposal per year. E-Waste is defined here to include personal computers (CPUs, CRTs, peripherals), laptops, and TVs which have reached the end of useful life, after reuse and storage cycles. Expressed in # of units, with 1 computer unit = a CRT + CPU + peripherals; 1 laptop = 1 unit; and 1 television = 1 unit. Calculated by National E-waste Model derived from Carnegie-Mellon/Matheson model 1997. **[2]** Recycle Rate from National E-waste Model = Units Recycled/Total E-waste in that year. **[3]** It is assumed the cost of collection is embeded in the total recycling cost. Basis of $10/unit: Recent data from Snohomish Co., WA + review of recent institutional recycling contracts. **[4]** Landfill Rate from National E-waste Model = Units Landfilled/Total E-Waste per year. **[5]** Weighted average of the weight of PCs plus TVs. TVs @ 50lbs; PCs w/ CRTs @ 41 lbs; laptops @ 10 lbs. Based on assumptions from EPA contractor, Lynn Knight. **[6]** Assumption made on the basis of current national average tipping fees. **[7]** From Electronic Industries Association, *Trends in Television,* 1980-1998 and *Appliance Magazine.* 49th Annual Appliance Industry Forecast, 1999-2006. After 2006 sales are assumed to very slowly decline. **[8]** We assume an annual growth rate of 5% for PC/laptop unit sales. Number sources: IDC US shipments. Checked against additional sources: For 1993-2003, National Safety Council. *Electronic Product Recovery and Recycling Baseline Report,* May 1999; (We assume all PCs have one monitor from 1980-2003. For 2004-2015, we assume gradual decline of direct view monitors as they are replaced by flat panel LCD monitors and laptops.) **[9]** Based on experience with state programs collecting surcharges on sales of tires, and difficulty of enforcing widespread collection of a national levy. There is uncertainty regarding collection surcharge on sales over the Internet. Also assumes ARF is charged on units sold to all residential, commercial, and institutional markets. **[10]** Includes costs of landfilling from line 9.

In May, 2001, the European Union (EU) Parliament adopted a directive requiring the manufacturers of electronic devices to take responsibility, financial and otherwise, for the recovery and recycling of E-waste. A second directive requires manufacturers to phase out the use of hazardous materials in consumer electronics.

The US must follow the EU's lead. Policy makers and consumers – at the national, state and local level – must demand that the manufacturers of consumer electronics take responsibility for reducing the environmental hazards and wastes posed by their products, including financial responsibility for the recycling and sound environmental management of obsolete electronics.

State toxic regulators have taken an important first step, in Massachusetts, California, Minnesota, Maine, and several other states, by recognizing that discarded computer and television CRTs are hazardous waste, and affirming the prohibition on landfilling them as mere solid waste. Massachusetts addresses the issue at length on the state's website: "During the next five to ten years, today's television signals will be replaced by High Definition Television (HDTV) transmissions. [67] The website states that TV and PC manufacturers, and national and state governments alike expect that this innovation will "result in the push [of] older TVs and PCs into company warehouses and household attics. Soon after, Massachusetts began looking for financial assistance from manufacturers. According to waste policy expert Scott Cassel, "with government budgets unable to meet this growing financial burden, state and local officials are now asking product manufacturers to be part of the waste management solution." [68]

SB 20, legislation adopted in California in 2003, while a groundbreaking effort, falls short of placing the responsibility for E-waste on manufacturers. Instead, it creates a complex bureaucracy funded by a bottle-bill style advance (or customer paid) recycling fee. Furthermore, the levels set for those fees, from $6 to $10 per unit, fall short of most estimates for the eventual costs of properly collecting and managing obsolete units.

What we propose

While the manufacturers and retailers of computers and televisions that utilize CRTs have been aware of the public health and environmental threat posed by their products for some time, they have been slow to accept responsibility or to offer meaningful solutions to address the problem.

State and federal policy makers should mandate that manufacturing industries bear these costs. We do not believe that consumers or local governments have the ability to solve this problem on their own. Firstly, manufacturers and retailers provide very little information on the hazards of disposing of obsolete hardware. Secondly, the cost to taxpayers of managing this problem on behalf of manufacturers is huge. A third reason to enact EPR requirements is that manufacturers will become economically motivated to produce products in a more responsible manner in order to save money in the long-run. Otherwise when companies successfully pass these costs indirectly to consumers and taxpayers, manufacturers have no incentive to improve design and materials.

To address the environmental and economic problems posed by obsolete computer and television CRTs, we are calling for legislation requiring that the producers of these electronic products take responsibility for the proper management and recycling of used televisions and CRTs. At minimum, this legislation should include:

1. Manufacturers of electronic devices in the US should be required to phase down – and where feasible, phaseout – the use of hazardous materials in electronic devices.

2. Manufacturers should be responsible for meeting specified recovery and recycling goals for electronic devices. This will provide manufacturers with an incentive to help finance the development of a convenient and effective collection infrastructure.

3. Manufacturers should be required to pay the net cost of recycling electronic devices (or the cost of proper disposal for devices that are not recyclable). This approach, proven in Europe, will provide manufacturers with an incentive to design products for recyclability as well as to develop markets for recycling.

4. Taxpayer-funded local programs are already overburdened and underfunded and should not be financially responsible for the new task of electronic waste management. In the short-term, in areas where no other collection opportunity exists, local waste programs should be authorized to charge-back manufacturers for the cost of managing their electronic wastes.

5. State and federal policy makers must establish a workable regulatory framework for the management of electronic waste that encourages recycling while protecting public health, worker safety and the environment.

6. Manufacturers of computer monitors, television sets and other electronic devices containing hazardous materials must be responsible for educating consumers and the general public regarding the potential threat to public health and the environment posed by their products, and for raising awareness of the proper waste management protocol. At a minimum, all computer monitors, television sets and other electronic devices containing hazardous materials must be clearly labeled to identify environmental hazards and proper materials management.

Computer TakeBack Campaign Platform

Discarded electronic equipment is one of the fastest growing waste streams in the industrialized world, due to the growing sales and rapid obsolescence of these products. Electronic equipment is also one of the largest known sources of heavy metals and organic pollutants in the waste stream. Without effective phaseouts of hazardous chemicals and the development of effective collection, reuse and recycling systems, highly toxic chemicals found in electronics will continue to contaminate soil and groundwater as well as pollute the air, posing a threat to wildlife and people.

The Computer TakeBack Campaign supports the guiding principle called Extended Producer Responsibility (EPR) for post-consumer electronics waste. The objective of EPR is to make brand-name manufacturers and distributors financially responsible for their products when they become obsolete. Our ultimate aims are pollution prevention and waste avoidance through a hierarchy of practices, including source reduction, reuse, re-manufacturing and recycling.

Currently, the expense of collecting, managing and disposing of discarded electronics – including household hazardous waste collection and hazardous waste site cleanup – is borne by taxpayer-funded government programs, primarily at the local level. We support having manufacturers and distributors assume responsibility for these costs, so that they can be internalized and reflected in product prices. This creates a powerful incentive for manufacturers of electronics to reduce such costs by designing products that are clean, safe, durable, reusable, repairable, upgradeable, and easy to disassemble and recycle.

Companies that innovate quickly have a competitive advantage over companies that delay. Many companies in countries throughout Europe and Asia are already implementing EPR programs in response to public pressure and resulting government regulations.

To achieve the vision of electronics EPR, we have adopted the following platform:

Take it back!

Financial and/or physical responsibility

Manufacturers and distributors of electronic equipment must take financial and/or physical responsibility for their products throughout the entire product life-cycle, including in particular take-back and end-of-life management. This responsibility must include:

- Reduced use of hazardous materials in manufacturing;
- Collection, disassembly, reuse and recycling of discarded computer equipment to the highest degree practicable; and
- Requirements that recycling is done in an environmentally sound manner.

Infrastructure development

- EPR will foster development of effective, environmentally sound and sustainable infrastructure for collection, reuse, re-manufacturing and recycling of electronic equipment.

Stop hazardous waste exports

- The federal government should ban exports of hazardous materials from discarded electronic waste equipment.

Taxpayer relief

- We oppose efforts to force taxpayers to pay for electronic waste collection, recycling and disposal through local government initiatives, such as household hazardous waste programs.

Community reinvestment

- The recycling infrastructure developed under an electronics "take back" system should support local economic development in domestic reuse, re-manufacturing and recycling processing systems.

Internalize costs

- EPR internalizes "end-of-life" management costs in the price of electronic equipment by shifting the burden from taxpayers to industry, so that those with effective take-back and recycling programs are not put at a competitive disadvantage.

Recycling goals

- The electronics industry should meet aggressive recycling goals and implement methods for tracking and publicizing success.

Make It Clean!

Adopt the Precautionary Principle

- Where there is a threat to health or the environment, a precautionary approach requires taking preventive action even before there is conclusive scientific evidence that harm is occurring. The federal government should develop and implement strict protocols for testing chemicals and mixtures before they are introduced into the markets.

Phase out hazardous materials

- The electronics industry should end the use of chemicals that are dangerous to human health or the environment (including lead, mercury, cadmium, brominated flame retardants, chlorinated solvents, and other hazardous materials).

Proper handling of hazardous materials

- Manufacturers of electronic products should protect workers, the public and the environment from hazardous materials until safer substitutes are developed and used.

Design for the environment

- Manufacturers of electronic products should develop and use safer, less toxic materials;
- Design for durability, upgradability and disassembly; avoid designing 'disposable' products; and
- Reduce consumption of water and energy resources throughout the product life-cycle.

Closed-loop recycling

- The electronics industry should design products to be easily repaired and upgraded to extend their useful life;
- Incorporate recycled content and remanufactured components into new products; and
- Develop closed materials cycles.

Zero waste

- The goal is to ban all discarded electronic equipment from going to landfills or trash incinerators and to end environmentally unsound recycling practices.

Fair Labor!

Protect workers

- The electronics industry should apply stringent occupational health and safety standards to manufacturing and recycling facilities throughout the product chain;
- Eliminate exploitation of workers in prisons and within manufacturing facilities throughout the world; and
- End unsafe labor practices.

Fair pay

- The electronics industry should institute livable wages for all workers throughout the product chain, including subcontractors.

Right to organize

- The electronics industry should recognize the rights of workers to organize at electronic equipment manufacturing plants and recycling facilities throughout the product chain.

Endnotes

1 Arensman, Russ, "Ready for Recycling?" Electronic Business, The Management Magazine for the Electronics Industry, November 2000.

2 Global Futures Foundation. Computers, E-waste, and Product Stewardship: Is California Ready for the Challenge? An unpublished draft report to USEPA Region IX.

3 www.idc.com "IDC US Shipments"

4 Silicon Valley Toxics Coalition, Just Say No to E-waste: Background Document on Hazards and Waste From Computers. See website: www.svtc.org/cleancc/pubs/sayno.htm.

5 Based on data assembled for chart "National Costs of Handling E-waste Collected. In 2006, 59,648,551 computers and televisions per year are sent for disposal or 163,420 per day, each weighing an average of 43 pounds or roughly 3513 tons per day.

6 Silicon Valley Toxics Coalition, op. cit. See also National Safety Council.

7 This is almost certainly an underestimate, as there are no reliable numbers for computers manufactured between 1980 and 1992. See also, National Safety Council, op. cit.

8 Matthews, Scott, Disposition and End-of-Life Options for Personal Computers, Carnegie Mellon University Green Design Initiative Technical Report #97-10, July 7, 1997.

9 See, for example, "Test of Manufacturer Mail-Back Programs," a report prepared for the Snohomish County Solid Waste Management Division by PRR, January 3, 2004. This study cites an average cost to consumers of approximately $68.00 per system, based on five existing manufacturer programs. The local Seattle-area private-sector Take-It Back Network estimated costs of $15 dollars, but depended on consumers to transport their old systems to a central location. Also, see "Dell Asset Recovery Services: Remove, Recycle or Resell, An Executive White Paper," by the Aberdeen Group (www.aberdeen.com). This November 2003 study estimated costs of anywhere from $25 to $50 for recycling. When packing and moving were priced, costs for handling business systems were gauged "at an infrequent low of $12 to a more probable average of $132 per unit." When businesses take privacy and cleansing issues into consideration, the Aberdeen study suggests an overall reclamation cost range of from $115 to $387 per device. Even more recently, at a January 22, 2004 forum at Santa Clara University in California, a representative of Hewlett Packard responded to a question that the cost of recycling a computer, a monitor and a printer exceeds $60.

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14 Silicon Valley Toxics Coalition, op. cit.

15 Minnesota Office of Environmental Assistance. Management of waste electronic appliances, Saint Paul, MN, July 1995.

16 Silicon Valley Toxics Coalition, op. cit.

17 "Computers, E-waste, and Product Stewardship: Is California Ready for the Challenge," May 11, 2001, Report for the US Environmental Protection Agency, Region IX, page 13.

18 SB 20, signed into law in 2003 by Governor Gray Davis, will require an $6 to $10 advance fee at the point of sale of TVs computer terminals, intended to fund local government programs to collect and handle TVs and computer terminals.

19 See "National Costs of E-waste" on page 23 for more. Or consult www.computertakeback.com for additional details used in our modeling

20 Ibid.
21 for CPU, excluding cache. Source: Linley Gwennap, Microprocessor Report, December, 1996
22 Franklin and Associates, "Characterization of Municipal Solid Waste in the United States: 1998 Updates," Report for US EPA.
23 Arensman, Russ, "Ready for Recycling?" Electronic Business, The Management Magazine for the Electronics Industry, November 2000.
24 See "National Costs of E-waste" on page 23 for more. Or consult www.computertakeback.com for additional details used in our modeling.
25 Stanford Resources, Inc., Television Systems, 1998.
26 National Safety Council op. cit.
27 National Safety Council op. cit.
28 Harris, Peggy, Chief, State Regulatory Programs Division, Hazardous Waste Management Program, Department of Toxic Substances Control, in a March 20, 2001 letter to Sheila Davis of Materials for the Future Foundation.
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33 For example, 5600 landfills are operated in Slovakia. It is estimated that only 11 of these landfills might meet the general requirements for all classes of landfills as set out in the Annex 1 of Council Directive 99/EC of 27 April 1999 on the landfill of waste.
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35 "Computers, E-waste, and Product Stewardship: Is California Ready for the Challenge," May 11, 2001, Report for the US Environmental Protection Agency, Region IX, page 13.
36 Silicon Valley Toxics Coalition op. cit.
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39 Environmental aspects of PVC (Kopenhagen 1996) Danish Environmental Protection Agency and Position Paper of the Netherlands on PVC (The Hague 1997) Ministry of Housing, Spatial Planning and the Environment.
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65 Californians Against Waste, based on an estimated $1 per pound cost of handling and disposing hazardous waste in California.
66 See "National Costs of E-waste" on page 23 for more. Or consult www.computertakeback.com for additional details used in our modeling.
67 "About TV and Computer Reuse and Recycling." MA Dept. of Environmental Protection. See website: www.state.ma.us/dep/recycle/crt/aboutcrt.htm
68 Karen Goff (Edited article: Sources Cutter Edge Environment). "U.S. beginning to wrestle more earnestly with electronic waste." See website: www.solidwaste.com