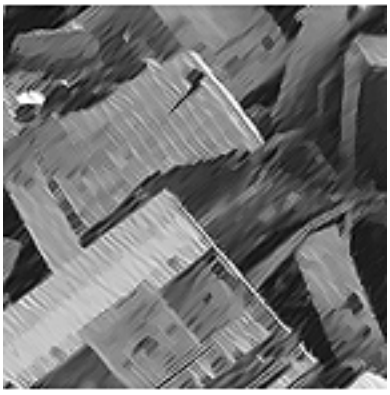
Poison PCs and Toxic TVs:

California's biggest environmental crisis that you've never heard of



"While millions of computers have been 'junked' over the past few years, the rate of recycling has decreased due to a lack of effective systems or policies. The industry's 'planned obsolescence' policy of frequently introducing upgraded products threatens to make the disposal problem worse."

– Ted Smith, Executive Director, Silicon Valley Toxics Coalition, "Should PC Makers Recycle Wares?" – zdnet, June 24, 1999

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Executive Summary

Electronic waste (E-waste) encompasses a broad and growing range of electronic devices ranging from large household appliances such as refrigerators, washers and dryers, and air conditioners, to hand-held cellular phones, fluorescent lamp bulbs (tubes), and personal stereos. 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 toaster, VCR or telephone to a repair shop. Replacement is often easier and cheaper than repair. And while these ever improving gadgets – faster, smaller, 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 new report for the EPA, analysts estimate that the amount of E-waste in US landfills will 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. Due to their growing waste volume, toxicity and management cost, they are the focus of this report. How California chooses to address the problems posed by obsolete computers is likely to set the tone for the broader spectrum of E-waste.

1 **The volume of obsolete computers thrown out or temporarily stored for later disposal is already a serious problem that is escalating at a rapid rate.**

Today's computer industry innovates very rapidly, bringing new technologies and "upgrades" to market on the average of every 18 months. The average life span of a personal computer has shrunk from four or five years to two years. [3] Users in California buy more than 2.2 million new computer systems each year. Currently, about 50% of US households own a computer. [4]

Analysts estimate that more than 6,000 [5] computers become obsolete in California every day. They are either tossed out with the trash and subsequently landfilled by trash collectors – often illegally – or stored in attics and garages for a later day when they will be dumped.

Consumers have, on average, 2 to 3 obsolete computers in their garages, closets or storage spaces. US government researchers estimate that three-quarters of all computers ever sold in the United States remain stockpiled, awaiting disposal. [6] Should every consumer attempt to throw out their obsolete computer at once, California and the nation would face a major budgetary and environmental crisis.

The crisis continues to grow. 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] By the year 2005, one computer will become obsolete for every new computer put on the market.

2 **Recycling rates for computers are low – and opportunities are virtually nonexistent for most California consumers.**

The National Safety Council reported in 1999 that only 11% of discarded computers were recycled, compared with 28% of overall municipal solid waste. [9] In California, 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. [10]

For large commercial customers, computer system distributors may negotiate for the collection and management of obsolete computer systems. However, there remains very little information on where and if these computers are recycled.

For the individual consumer looking to properly manage an obsolete home or office computer, options for recycling are virtually nonexistent. Recycling options that do exist typically come with a price tag of $10 to $30 per unit.

3 Discarded computers 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 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." [11]

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 municipal solid waste landfills is prohibited. Additionally, collection, whether for recycling or disposal, must be regulated and permitted as a hazardous waste activity.

Each computer or television display contains an average of 4 to 8 pounds of lead. [12] The 315 million computers that will become obsolete between 1997 and 2004 contain a total of more than 1.2 billion pounds of lead. [13] Monitor glass contains about 20% lead by weight. [14] 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. [15] 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. [16]

Lead can cause damage to the central and peripheral nervous systems, blood system and kidneys in humans. Lead accumulates in the environment, and has highly acute and chronic toxic effects on plants, animals and microorganisms. Children suffer developmental effects and loss of mental ability, even at low levels of exposure.

Other hazardous materials used in computers and other electronic devices include cadmium, mercury, hexavalent chromium, PVC plastic and brominated flame retardants. Mercury, for example, leaches when certain electronic devices such as circuit breakers are destroyed. The presence of halogenated hydrocarbons in computer plastics may result in the formation of dioxin if the plastic is burned. [17] The presence of these chemicals also makes computer recycling particularly hazardous to workers, as well as the environment.

4 What should we do with obsolete computers?

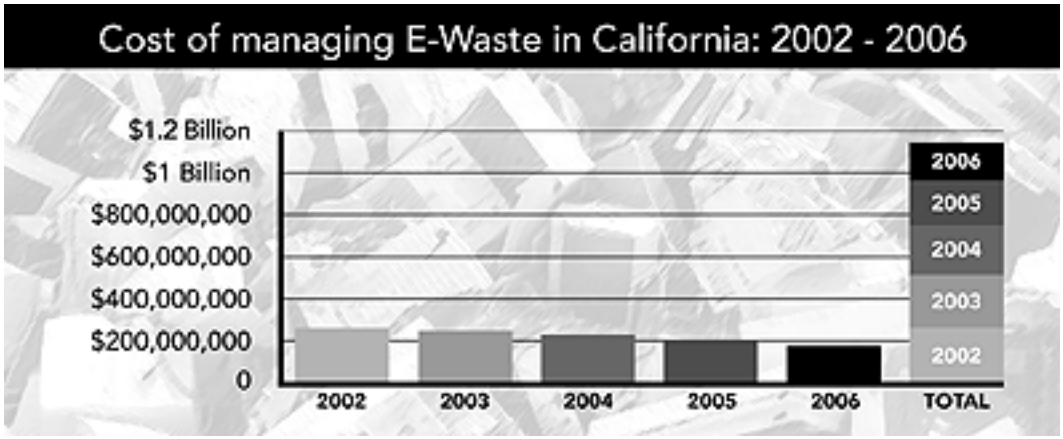
Recycling of computer materials and components – when properly implemented – represents the safest and most cost effective strategy for addressing the problems posed by inoperative or outdated computers. Recycling computer materials and components and removing and/or reducing and treating the hazardous 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-scrap contain valuable materials and components that are technically recyclable. The problem is the lack of collection incentives and recycling infrastructure, as well as the high cost of material collection, handling and processing.

Estimates for the cost of recycling computers range from $10 to $30 per unit. While this is less expensive than the estimated $25 to $50 per unit cost for disposal, someone must still pay these costs.

Even if recycling levels were to double, the total cost of managing California's current output of obsolete computer scrap will range from $25 million to $42 million annually. Add to that the cost of cleaning up the last two decades' legacy of stockpiled obsolete computers, and the total cost over the next 5 years could easily range from $500 million to over $1 billion.

If the task is left to local governments, the management of obsolete computer monitors alone is likely to double both the volume and cost of already overburdened and under-funded household hazardous waste (HHW) programs.



See table on page 21 for more details.

Consumers and local governments have neither the technical ability nor financial resources to address this problem on their own.

Recently, some local governments and at least two computer manufacturers have established "pay-as-you-go" collection programs that require consumers and small businesses to pay a fee in order to drop off or ship their obsolete computers for recycling. Costs for these programs range from $7 to $30 or more per unit. These programs are doomed to failure.

It is appropriate to internalize the cost of proper waste management into the price of electronic devices at the time of purchase. However, 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 in California, reliance on back end disposal fees – such as those currently in place for used tires – 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.

IBM sold more than 3 million computers in the United States last year and was the first manufacturer to establish a pay-as-you-go system for recycling obsolete computers. So far, the results have been underwhelming. According to the company, less than 1,000 computers (0.03% of annual sales) have been recycled under this system.

The State of California has taken an important first step, by recognizing that electronics scrap and junk computers are hazardous wastes that must be kept out of landfills. But 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." 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. California should follow the EU's lead.

What we are proposing:

1 Manufacturers of electronic devices 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, providing 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 proven approach will provide manufacturers with an incentive to design products for recyclability, as well as to develop markets for recycling.

4 Taxpayer funded local household hazardous waste (HHW) programs are already overburdened and under-funded 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 – HHW programs should be authorized to charge-back manufacturers for the costs of managing their electronic devices.

5 California 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.

Established in 1977, **Californians Against Waste** (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. They advocate policy initiatives at the local, state, and federal levels.

The Materials for the Future Foundation supports community-based initiatives that integrate the environmental goals of resource conservation through waste prevention, reuse, and recycling with the economic development goals of job creation/retention, enterprise development, and local empowerment. Their work focuses on low-income communities, communities of color, and areas of high worker displacement, especially in the San Francisco Bay Area.

Silicon Valley Toxics Coalition (SVTC) envisions a sustainable world where a healthy environment is a right, rather than a privilege. To bring about this vision, SVTC works for the empowerment of people locally, nationally and globally. SVTC is a diverse, grassroots organization committed to the practice of social justice and multiracial democracy.

The fiscal watchdog for California's environmental movement, **Green Capitol** fights to expose irresponsible government taxing and spending practices that destroy California's unique environmental assets.

ACKNOWLEDGMENTS

We would like to thank the author of this report, Keirsten Scanlon, for her hard work and diligent research – and Michael Picker of Lincoln Crow for his oversight of the project.

Overview

Over the last two decades, a technological revolution has taken place in California and around the planet. Driven primarily by faster, smaller and cheaper microchip technology, society is experiencing an exponential evolution in the capability of electronic appliances and the growing genre 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 – or E-waste – encompasses a broad and growing range of electronic devices, ranging from large household appliances such as refrigerators, washers and dryers, and air conditioners, to hand-held cellular phones, fluorescent lamp bulbs (tubes), and personal stereos. 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 for California and for the planet. With the recent designation of CRTs as hazardous waste, the cost to taxpayers and local governments for their collection, processing and cleanup, could easily exceed $1 billion over the next five years. [18] And, the E-waste problem will continue to grow at an accelerated rate. Californians are expected to buy more than 2.2 million new computer systems every year, [19] rendering their older systems “obsolete.”

The purpose of this report is to raise awareness of the large and growing scope of the E-waste problem in California. 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 inevitable by-product of a 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 (such as the broken toaster or the boom box that's cheaper to replace than repair), exhaustion (such as batteries, light bulbs and fluorescent tubes), or obsolescence (such as that old 286 computer you've been meaning to donate to Goodwill... or the Nintendo your kid begged you for 5 years ago, but hasn't touched since the introduction of the latest Playstation) 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, 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 in the last 18 months as a hazardous waste crisis at the local, state, national and even international level, and is a central focus of this report. 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 image we ultimately see on the screen. 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 a toxic heavy metal, exposure to which poses a serious public health risk. 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 18 months. The useful life-span of a personal computer has shrunk from four or five years to two years. [20] 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.

The world according to Moore: "Moore's Law"

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 [21]

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

How big is the problem?

Electronic waste generally, and CRTs specifically, are a growing waste problem, and only getting bigger. Nationally, an estimated 5 to 7 million tons of computers, televisions, stereos, cell phones, electronic appliances and toys, and other electronic gadgets become obsolete every year. [22] A small fraction – just 2% to 3% in 1997 – of this E-waste is recycled. While a sizeable portion – as much as 30% or more – remains in E-waste purgatory – unused but stockpiled in closets, garages, basements and office storerooms – the vast majority is 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.

Today, the CRTs in computer monitors, television sets and 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. Since 1980, an estimated 280 to 330 million computer CRTs have been sold in the United States. And, it's projected that over the next 5 years an additional 130 million computer CRTs will be sold. [24]

Approximately 25 million television sets are sold in the United States annually. [25] Yearly sales have equaled or exceeded 20 million units for the last decade. The numbers 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 was 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 televisions (HDTV) become effective in 2004.

SRI also projects that in 2001, more than 41 million personal computers will become obsolete in the United States – a total of nearly 500 million obsolete computers between 1997 and 2007. [26]

Figures for CRT monitors and televisions sold in California are hard to come by. Sources estimate that computer sales in California range from 2.2 million to more than 5 million annually. [27] Based on these figures, it is estimated that more than 6,000 computers become obsolete in California every day. [28]

Many consumers, unwilling to accept that the latest and greatest system they paid top dollar for just 2 or 3 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 [29] 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 [30] California's legacy of obsolete CRTs could number 40 million or more already.

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

The numbers presented earlier in this section illustrate that the crisis is already here and growing. By the year 2005, one computer will become obsolete for every new one put on the market, [31] creating problems not only of space in landfills but also creating serious long-term threats to health and environmental safety.

Computers 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 so 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 & sometimes barium
- Brominated flame-retardants used in printed circuit boards, cables and plastic casing.
- Poly Vinyl 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 fact, the California Department of Toxic Substances Control has recently confirmed that the cathode ray tubes (CRTs) in computer monitors, television sets, ATMs and other devices contain concentrations of lead that classify them as hazardous waste when they are discarded. [32]

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."

Under these laws, disposal in municipal landfills in prohibited.
See website: www.ciwmb.ca.gov

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. [33] The total amount of lead in the 315 million computers that will become obsolete between 1997 and 2004 is estimated to be more than 1.2 billion pounds. [34] Monitor glass contains about 20% lead by weight. [35] The diagram on page 11 illustrates the construction of a CRT and highlights areas within the CRT that hold concentrations of lead.

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.

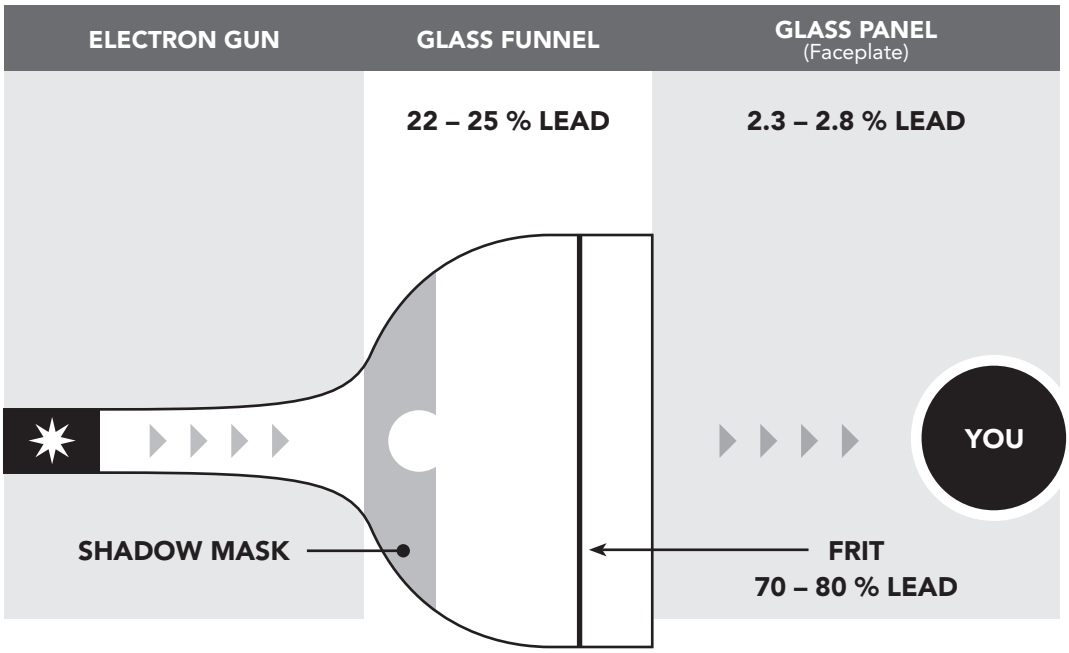
NAME	Content (% of total weight)	Weight of material (lbs.)	Recycling Efficiency (current recyclability)	Use/Location
Plastics*	22.9907	13.8	20%	Includes organics and oxides (other than silica)
Lead	6.2988	3.8	5%	Metal joining, radiation shield/CRT, PWB
Aluminum	14.1723	8.5	80%	Structural, conductivity/housing, 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.



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 have been 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 (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 types of cathode ray tubes contain cadmium. Furthermore, cadmium is used as a plastic stabilizer. Between 1997 to 2004 over 315 million computers will become obsolete and this represents almost 2 million pounds of cadmium content. [5A]

Mercury [6A]

When inorganic mercury spreads out in the water, it is transformed to methylated mercury in the bottom sediments. Methylated mercury easily accumulates in living organisms and concentrates through the food chain particularly via 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 basically used in thermostats, (position) sensors, relays and switches (e.g. on printed circuit boards and in measuring equipment) and discharge lamps. Furthermore, it is 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 apply this substance as corrosion protection of untreated and galvanized steel plates and as a decorative and hardener for steel housing. Chromium VI can easily pass through membranes of cells and is easily absorbed producing various toxic effects within the cells. It causes strong allergic reactions even in small concentrations. Asthmatic bronchitis is another allergic reaction linked to Chromium VI.

Chromium VI may also cause DNA damage. In addition, hexavalent chromium compounds are toxic for 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 destined to become 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 will become obsolete between 1997 and 2004 and that plastics make up 13.8 pounds per computer on average, there will be more than 4 billion pounds of plastic present in this computer waste. [8A] An analysis commissioned by the Microelectronics and Computer Technology Corporation (MCC) estimated that the total electronics plastic scrap amounted to more than 1 billion pounds per year (580,000 tons per year). This same study estimated that the largest volume of plastics used in electronics manufacturing (at 26%) was polyvinyl chloride (PVC), which creates more environmental and health hazards than most other type 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 contained 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 has been mainly used in cabling and computer housings, although most computer moldings are now being made of ABS plastic. 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. Such alternatives are low-density polyethylene and thermoplastic olefins. PVC is a difficult plastic to recycle and it contaminates other plastics in the recycling process. Of more importance, however, the production and burning of PVC products generates dioxins and furans. This plastic 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 disposal gloves and IV bags because of the dangers of incinerating these products. Many local 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 out into children's mouths have lead to further restrictions on PVC.

Brominated Flame Retardants

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

Various scientific observations indicate that Polybrominated Diphenylethers (PBDE) might act as endocrine disrupters. Research has revealed 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. [11A] 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 the chemicals in early life could induce neurotoxic effects similar to those caused by other toxic substances such as PCBs and some pesticides. [12A]

Other studies have shown PBDE, like many halogenated organics, reduces levels of the hormone thyroxin in exposed animals and have been 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. [13A] Researchers in the US found exposure to Polybrominated Biphenyls (PBBs) may cause an increased risk of cancer of the digestive and lymph systems. The study looked at cancer incidence in individuals exposed to PBBs after a 1973 food contamination incident in Michigan. About a ton of PBB fire retardant was added to cattle feed in error and contamination spread through the animal and human food chain. Some nine million people were affected. A study published in 1998 found that the group

with the highest exposure was 23 times more likely to develop digestive cancers, including stomach, pancreas and liver cancers. Preliminary results also found a 49-fold increase in lymph cancers. [14A]

The presence of PBBs in Arctic seal samples indicates a wide geographical distribution. The principal known routes of PBBs from point sources into the aquatic environment are PBBs plant areas and waste dumps. PBBs are almost insoluble in water and are primarily found in sediments of polluted lakes and rivers. PBBs have been found to be 200 times more soluble in a landfill leachate than in distilled water, which may result in a wider distribution in the environment. Once released into the environment, they can reach the food chain, where they are concentrated. PBBs have been detected in fish from several regions. Ingestion of fish is a source of PBB transfer to mammals and birds. Neither uptake nor degradation of PBBs by plants has been recorded. In contrast, PBBs are easily absorbed by animals. [15A]

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 Parkman 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, citation to follow.
[10A] See the report section at: http://www.greenpeace.org/~toxics/reports/reports.html
[11A] Persistent Organic Pollutants. Swedish Environmental Protection Agency. See website: http://smn.environ.se/miljonat/english/sokning/sokning.htm
[12A] Evidence mounts on risks of brominated flame retardants. ENDS report 283. August 1998, London, UK.
[13A] Ibid.
[14A] Hoque, A et al, 1998. Epidemiology Vol 9(4) P. 373-8.
[15A] WEEE Explanatory Notes, EU 1999.

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 recent 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 garbage 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. [36] The situation is far worse for older or less stringently maintained dump sites.

Lead can cause brain damage in children and can damage our kidneys and central nervous system. Lead can enter our drinking water by leaching from landfills, contaminating the clothes of workers at improperly regulated recycling plants, or reach our homes from crushing CRTs in landfill. Significant amounts of lead ions are dissolved from broken lead containing glass, such as the cone glass of cathode ray tubes, when mixed with acid waters that commonly occur in landfills. [37]

About 70% of the heavy metals (including mercury and cadmium) found in landfills come 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. [38]

Mercury will leach when certain electronic devices, such as circuit breakers and switches, are destroyed. 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 the landfills, 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. [39] Due to the volume and variety of these substances, incineration 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 of 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 as the incineration of brominated flame retardants (BFRs) at a low temperature (600-800°C) may lead to the generation of extremely toxic polybrominated dioxins (PBDDs) and furans (PBDFs). [40]

Most plastics used in electronic products now in the waste stream were made of polyvinylchloride (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, [41] which makes the flue gas residues and air emissions particularly dangerous. [42]

The introduction of E-waste into incinerators results in high concentrations of metals, including heavy metals, in the slag, in the fly ash, the flue gas and in the filter cake. More than 90% of the cadmium put to an incinerator is found in the fly ash and more than 70% of the mercury in the filter cake. [43] Cadmium (which is used in plastic of computers) can cause damage to human kidneys. And, an estimated 2 million pounds of cadmium are contained in the 315 million computers that will become obsolete between 1997 and 2004. [44]

While the high cost and environmental questions surrounding the incineration of garbage as a waste management option has limited its expansion in California, more than 2.3 million tons of solid waste continue to be burned each year at the state's three remaining garbage burning facilities.

The most dangerous form of burning E-waste is open air burning of the plastics in order to recover the copper and other metals. These practices have been documented in various parts of Asia. The toxic fallout from open air burning is affecting both the local environment as well as global air currents, depositing the highly toxic by-products in many places throughout the world.

The hazards of recycling computer junk

While recycling may be the key to the management of E-waste in California, 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 clean-up costs. *Recycling of hazardous materials has limited environmental benefit – it simply moves the hazards into secondary products that eventually require disposal. Unless the goal is to redesign the product to use non-hazardous materials, such recycling can be a false solution.*

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.

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. [45]

Hazardous emissions to the air can also result from the recycling of E-waste containing heavy metals, such as lead and cadmium. [46] These emissions could be significantly reduced by means of pre-treatment operations. Another problem with heavy metals and halogenated substances in untreated E-waste occurs during the shredding process. Since most E-waste is shredded without proper disassembly, hazardous substances, such as PCB contained in capacitors, may be dispersed into the recovered metals and the shredder waste. [47]

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) 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. [48] As a consequence, the German chemical industry stopped the production of these chemicals in 1986. [49]

In an alarming discovery, high concentrations of PBDEs were found in the blood of workers in electronics recycling plants. [50] 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 cleaners. 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 PBDEs 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 PBDE's in the phaseout contained in recent the European wide regulation regarding E-waste. [51]

E-waste exporting: The unknown, dangerous, and secretive activity

"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 of the Environmental Health Coalition, a bi-national environmental group 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.

It is difficult to find data on the amount of computer scrap leaving the United States for countries such as the Philippines, Korea, Taiwan, and China. This is both because of past bad publicity, and the practice by producers of selling E-waste to recyclers without bothering to find out the final destination and fate of their end-of-life product.

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. [52]

While exporting E-waste to less developed countries may reduce the short-term problem in the United States, it creates catastrophic events in the countries importing the E-waste. A 1990 study of Thai Ping on the island of Taiwan, home to the largest lead smelter in Asia, concluded that workers had high blood-lead levels – high enough to result in the development of kidney and nerve problems. Additional research uncovered the fact that children located near the smelting plant had blood lead levels twice as high as those of an average city-dwelling child in the capital city, Taipei. The children were exposed to lead which had either been carried by workers in their clothing or by dispersion through air and water. [53]

Because of the many diverse toxic components, E-waste, including computers, 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 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 do computer manufacturers respond to the challenge?

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

"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, "Should PC Makers Recycle Wares?" – zdnet, June 24, 1999

For the three years between 1997 and 1999, it is estimated that some 50 million U.S. computer towers have been dumped, burned, shipped abroad or stored to await eventual disposal.

The National Safety Council reported in 1999 that only 11% of discarded computers were recycled, compared with 28% of overall municipal solid waste. [54] In California, 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) 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 collection, or recycling programs are in place. [57]

At best, California's existing E-waste recycling infrastructure (which includes local governments, private and non-profit recyclers, as well as some electronics retailers and manufacturers) are recovering an estimated 250,000 to 500,000 obsolete computers annually. [58]

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 type of 'takeback' program. We were unable to find any manufacturer or retailer willing to take back television sets for recycling.

Manufacturers may be slowly acknowledging the inevitability of "extended producer responsibility" (EPR) campaigns. Some producers of E-waste have taken steps to mitigate potential legislative action and

to act responsibly by establishing their own voluntary take-back programs. These programs however, are limited in scope and are not sufficient to dealing with the problems we face in the coming years.

Several computer manufacturers, including Hewlett-Packard (HP) will include the take-back of old systems as part of a sales package for marketing new systems to large 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 their own recycling facility in Roseville, California.

Some other examples of existing take-back programs include companies like Gateway, IBM, Xerox and Sony. While many of the larger manufacturers are providing take-back services, these services fall short of a suitable solution. Gateway, Dell, and Hewlett-Packard limit their take-back programs to customers only and some of the programs require that the consumer pay a fee for the service. For example, Gateway, the nations fourth largest seller of personal computers, offers customers a rebate of up to $50 towards the purchase of a new Gateway PC when they bring in any old PC for reuse or recycling. IBM, the nations fifth largest seller of PCs, will, *for a fee of $29.99,* provide customers with a box and mailing label to ship old computers via UPS for reuse or recycling. The fee covers the cost of a box and mailing charges by UPS.

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

Extended Producer Responsibility (EPR) in the European Union

The European Union (EU) 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 continent's governing body understands the cost of cleaning up the legacy waste and building an on-going E-waste program.

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

- Prevent E-waste
- Improve the re-use, 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 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 2008. Due to its danger to human health and the environment, lead is particularly targeted by this legislation. [59]

The European Union holds the 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 the risks of the equipment in the future. 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 cost for this legislation is only an additional 1% to 3% of retail prices. [60]

The United States government and American manufacturers are claiming 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. [61] 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. However, 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 recent study out of 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. [62]

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 in California, and a policy discussion of who should pay. The table below estimates the cost of properly recycling or disposing of the legacy and newly generated obsolete CRTs through the year 2006. Failure to act will result in an even greater cost for environmental cleanup at public expense.

California Costs of E-waste (CRTs only)

Projected costs from 2002 to 2006 if no action is taken now – based on current trends
Failure to act will result in greater costs for environmental cleanup at public expense.

	2002	2003	2004	2005	2006	Total
Current Generation	2,190,000	2,409,000	2,649,900	2,914,890	3,206,379	13,370,169
Legacy Generation	5,250,000	6,125,000	7,000,000	7,875,000	8,750,000	3,500,000
Total Annual CRTs	7,440,000	8,534,000	9,649,900	10,789,890	11,956,379	48,370,169
Recycling Rate	25%	35%	45%	55%	65%	45% (avg.)
Recycling Cost per unit	$22.50	$20.00	$17.50	$15.00	$12.50	$17.50 (avg.)
Recycling Cost (total)	$41,850,000	$59,738,000	$75,992,963	$89,016,593	$97,145,579	$363,743,134
Disposal Rate	75%	65%	55%	45%	35%	55% (avg.)
Hazardous Waste Disposal Cost per unit	$40.00	$35.00	$30.00	$25.00	$20.00	$30.00 (avg.)
Hazardous Waste Disposal Cost (total)	$223,200,000	$194,148,500	$159,223,350	$121,223,350	$83,694,653	$781,652,766
Total CRT Management Cost [63]	**$265,050,000**	**$253,886,500**	**$235,216,313**	**$210,402,855**	**$180,840,232**	**$1,145,395,900**

While computers – including CRTs – are recyclable, the cost of collection, handling, dismantling and processing for recycling can range from $10 to $30 or more per unit. [64] The cost of properly disposing of old computers and televisions as hazardous waste could easily run $25 to $50 or more per unit. [65] Even if recycling levels were to double, the cost of managing California's current output of obsolete CRT scrap could range from $25 to $42 million annually. The cost of cleaning up the last two decades' legacy of obsolete CRTs could easily exceed $500 million. [66]

The problems and costs are not limited to California alone. Sitanon Jesdapipat, a Thai Electronics Institute senior researcher, said last year that costs of collection for Thai exports could reach 300 to 600 million euros – and that reuse and recycling could total another 200-300 million euros. [67]

What should be done?

Electronics waste represents a growing solid and hazardous waste problem for California, the nation, and the world.

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 wasteberg collides with 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 non-existent. Awareness of and access to recycling opportunities for E-waste are extremely limited.

The combination of E-waste volume and toxicity brings with it the prospect of enormous solid and hazardous waste cleanup and management costs. Even if current recycling levels were to double, the cost of properly managing the current output and legacy stockpile of CRTs alone could range from $500 million to over $1 billion dollars over the next 5 years.

California's strategy for addressing the environmental and economic problems posed by obsolete CRTs will set the tone for how we deal with future hazardous and solid E-waste issues.

And, 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, California policy makers must be willing to fundamentally redesign our approach to E-waste management.

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.

California must follow the EU lead. California 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.

California toxic regulators took an important first step in following the lead of Massachusetts, Minnesota, Florida, and several other states, recognizing that discarded computer and television CRTs are hazardous waste and affirming the prohibition on landfilling them as mere solid waste.

Massachusetts recognizes the problem of the rapid increase of E-waste. In fact, the state's official website addresses the issue at length saying, "During the next five to ten years, today's television signals will be replaced by High Definition Television (HDTV) transmissions." [68] The website goes on to say that TV and PC manufactures, 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."

This warehousing of obsolete equipment will, of course, result in large volumes of solid waste containing hazardous materials. In a speech at the 1998 Environmental Issues Council Spring Conference, the Massachusetts Department of Environmental Protection's Deputy Commissioner, Allan Bedwell said, "Massachusetts is interested in doing something new about electronics reuse and recycling [for two reasons]. Those two reasons, simply put, are the future and common sense." [69] To deal with the growing problem of E-waste, Massachusetts passed a law prohibiting disposal of CRTs at all Massachusetts' combustion facilities and landfills, effective April 1, 2000.

The state chose not to require an extended producer responsibility program, such as computer take-back, by manufacturers. However, they are now finding that the cost to taxpayers for maintaining the current program are high.

Recently, 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." [70]

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.

The State of California should mandate that manufacturing industries bear these costs. We don't 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. (see Chart, "Costs of E-Wastes" on page 10). 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 longrun. 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 in California, we are calling for legislation requiring that the producers of these electronic products take responsibility for the proper management and recycling of used CRTs. At minimum, this legislation should include:

1 Manufacturers of electronic devices 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 proven approach will provide manufacturers with an incentive to design products for recyclability as well as to develop markets for recycling.

4 Taxpayer funded local household hazardous waste (HHW) 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, HHW programs should be authorized to charge-back manufacturers for the cost of managing their electronic wastes.

5 California 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.

Electronics *Take It Back!* 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 phase-outs 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 Electronics Take It Back! 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, upgradable, and easy to disassemble and recycle.

Companies that innovate more quickly will end up being more competitive than those that delay. Many companies in countries throughout Europe and Asia are already implementing EPR programs in response to 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 lifecycle, 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, re-use, 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 re-investment

- 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 sub-contractors.

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 National Safety Council, *Electronic Product Recovery and Recycling Baseline Report,* Washington, D.C.

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 Californians Against Waste, "Addressing the Environmental and Economic Costs of Obsolete Electronics (E-Scrap) in California." See also, National Safety Council, op. cit., for a national figure.

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 National Safety Council, op. cit.

10 Silicon Valley Toxics Coalition, op. cit.

11 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. See website: www.ciwmb.ca.gov/Electronics/RegIssues/DTSCMFF/032001Ltr.doc.

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

13 Silicon Valley Toxics Coalition, op. cit.

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

15 Silicon Valley Toxics Coalition, op. cit.

16 "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.

17 Silicon Valley Toxics Coalition, op. cit.

18 National Safety Council, *Electronic Product Recovery and Recycling Baseline Report.* Washington, D.C.

19 Californians Against Waste, "Addressing the Environmental and Economic Costs of Obsolete Electronics (E-Scrap) in California." See also, National Safety Council, op. cit., for a national figure.

20 National Safety Council, *Electronic Product Recovery and Recycling Baseline Report.* Washington, D.C.

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 Stanford Resources, Inc., *Monitor Market Trends,* 1999.

25 Stanford Resources, Inc., *Television Systems,* 1998.

26 *Appliance Magazine,* 1998; Stanford Resources, Inc. Estimates based on numerous sources.

27 Global Futures estimates 2.2 million annual California computer sales. Californians Against Waste, extrapolating from national sales data, estimates annual California computer sales at 5 million or more units.

28 Global Futures, op. cit.

29 National Safety Council op. cit.

30 National Safety Council op. cit.

31 National Safety Council op. cit.

32 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.

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

34 Silicon Valley Toxics Coalition op. cit.

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

36 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.

37 Environmental Consequences of Incineration and Landfilling of Waste from Electronic Equipment (Copenhagen 1995), Nordic Council of Ministers.

38 "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.

39 Silicon Valley Toxics Coalition op. cit.

40 "Bestimmung von polybromierten Dibenzofioxinen und-furanen in verschiedenen unweltrelavanten Materialien" U. Schacht B. Gras und S. Sievers in Dioxin-Informationsveranstaltung EPA Dioxin-Reassessment, edited by Otto Hutzinger and Heidelore Fiedler containing further references on this subject.

41 This is a similar estimate as that made by M. Rohr, Umwelt Wirschaftsforum, No. 1, 1992, who calculated that more than 20% of the plastic used in electrical and electrical equiment is PVC.

42 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.

[43] Further data are given in "Messung der Gutter-und Stoffbilanz einer Mullverbrennungsanlage" (Wien 1994) Umweltbundesamt and MA 22.

[44] Silicon Valley Toxics Coalition op. cit.

[45] Compare the example given on page 18 if the report C Voute, Recycling and Waste Control Officer, Corporation of London, on "Electrical and Electronic products recycling in Germany" to ICER (Industry Council for Electronic Equipment Recycling).

[46] The case of the Austrian copper recycler in Brixleg is well documented and confirms this situation (compare "Montanwerke Brixlegg-Wirkungen auf die Umwelt"; Umweltbundesamt, Monographien Bd25, Wien, Juni 1990)

[47] When there is a lack of proper dismantling of WEEE, the shredder waste of white goods can have a high concentration of lead, ranging from 940 to 9,400 mg/kg. Around 95% of the PCB contained in condensers (617,500 mg/kg) ends up in the shredder dust. Therefore, the contaminated shredder has to be dealt with as dangerous waste. Compared to the incineration of ordinary wastes, the incineration of dangerous waste is an expensive process. As a consequence, the PCB contamination of shredder waste entails an enormous increase in costs.

[48] Silicon Valley Toxics Coalition, op. cit. further citation to Hoque, et al, 1998. Epidemiology Vol 9(4) P. 373-8.

[49] Silicon Valley Toxics Coalition, op. cit. further citation see, "Formation of Polybrominated Dibenzofurans (PBDFs) and Dioxins (PBDDs) during extrusion production of a Polybutyleneteneraphtalate (PBTP) Glassfibre resin blended with Decabromodiphenylether (PBDPE)/Sb203; product and workplace analysis" Brenner, Kniew, BASSF, 1986. Further information to be found in "Polybrominated Diphenyl Ethers in the Swedish Environment" Ulla Sellstrom. Stockholm, 1996.

[50] Sjodin, et al. Flame Retardants Exposure – Polybrominated Diphenyl Ethers (PBDEs) in Blood from Swedish Workers. Environmental Health Perspectives. Vol. 107, Number 8, August 1999.

[51] USEPA report "Analysis of Five Community Consumer/Residential Collections of End-of-Life Electronic and Electrical Equipment", November 24, 1998) found at: www.eeb.org/activities/waste/weee.htm

[52] USEPA report "Analysis of Five Community Consumer/Residential Collections of End-of-Life Electronic and Electrical Equipment", November 24, 1998) found at: www.eeb.org/activities/waste/weee.htm

[53] Loopholes in the Law, page 72.

[54] National Safety Council op. cit.

[55] ibid.

[56] Silicon Valley Toxics Coalition op. cit.

[57] ibid.

[58] Californians Against Waste, "California CRT Waste Management and Cost Projections," April 2001.

[59] Richards, Brian. "Lead-free Legislation" at www.eeb.org/activities/waste/weee.htm.

[60] Silicon Valley Toxics Coalition op. cit.

[61] Additional US Points on DG-XI's Draft Directive on Waste from Electronic and Electrical Equipment, January 1999. Cited in Silicon Valley Toxics Coalition, op. cit. The position at the American Electronics Association is posted at www.svtc.org

[62] Tojo, Naoko. "Analysis of EPR Policies & Legislation through Comparative Study of Selected EPR Programmes for EEE." Lund University, International Institute for Industrial Environmental Economics, Lund, Sweden, September 1999.

[63] Assumptions used in the table page 21:

- 2.2 million obsolete CRTs generated annually with 10% growth
- California's share of stockpiled legacy CRTs of 35 million is 10% of the national total
- Legacy CRTs discarded over the next five years
- Cost of Recycling Range is $10 - $30 per unit; average cost reduced over 5 years
- 1992 Recycling Rate 25% increasing to 65% by 2006
- Assumes all CRTs not recycled are properly disposed of as hazardous waste

[64] Davis, Sheila, Materials for the Future Foundation, presentation in Santa Clara, date unknown

[65] Californians Against Waste, based on an estimated $1 per pound cost of handling and disposing hazardous waste in California.

[66] Californians Against Waste, "California CRT Waste Management and Cost Projections," April 2001.

[67] "EU Poses a Major Test for Exporters," Anchalee Kongrut, Bangkok Post, November 10, 2000.

[68] "About TV and Computer Reuse and Recycling." MA Dept. of Environmental Protection. See website: http://www.state.ma.us/dep/recycle/crt/aboutcrt.htm

[69] Allan Bedwell, Deputy Commissioner, Massachusetts Department of Environmental Protection. "Initiatives in Massachusetts for Recycling Electronics." Environmental Issues Council 1998 Spring Conference. Electronics Industries Association, Washington, D.C., March 16, 1998.

[70] Karen Goff (Edited article: Sources Cutter Edge Environment). "U.S. beginning to wrestle more earnestly with electronic waste." See website: http://www.solidwaste.com