

End-of-Life Computer and Electronics Recovery
Policy Options
for the Mid-Atlantic States
2nd Edition

Prepared for:

**Mid-Atlantic Consortium of Recycling and Economic
Development Officials**

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Forward: Second Edition

In the two years since MACREDO published the first edition of *End-of-Life Computer and Electronics Recovery Policy Options for the Mid-Atlantic States*, the Internet and the computer industry have expanded more dramatically than anyone could have predicted. The Internet has effectively become our primary means of communication and information retrieval. In addition, the cost of new computer systems has fallen dramatically to well below \$1,000 and the link that retailers have made between hardware purchases and Internet subscription commitments has brought prices down to truly affordable levels for first time users. As a result, more than half the households in the United States now own computers. Most businesses also own computers and are highly dependent on Internet communications in one fashion or another. According to industry experts, computer related sectors of the economy will continue to grow annually at rates well over 10% for at least the next decade. Computer technologies now outpace televisions as the single most purchased electronic product in the country.

The end result: more obsolete electronic scrap than ever before. Electronics recycling and reuse is inevitably going to become a major component of municipal waste management programs before the end of the coming decade.

The first edition of *End-of-Life Computer and Electronics Recovery Policy Options for the Mid-Atlantic States* outlined issues unique to computer and electronics disposal. It identified *electroscrap* as a potential resource, rather than a waste burden, and offered viable recommendations for dealing with computer discards in ways that could reduce environmental impacts, improve local economies, and even help low-income areas bridge the *digital divide*. This second edition provides updated information, offers new data and case studies, and provides additional recommendations for MACREDO actions.

Like the information technology industry, we can build on existing programs, advancing local and regional waste management programs that view electroscrap as a resource rather than a waste material. We are pleased to offer this second edition of *End-of-Life Computer and Electronics Recovery Policy Options for the Mid-Atlantic States* to help you and your community learn how to be more compatible with the 21st century.

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I. Executive Summary

According to the National Safety Council, over 20 million personal computers became obsolete in 1998¹. In addition, another 16 million computer monitors and 11 million printers and scanners also became obsolete. For the most part, the rate of technology change in the computer software and hardware industries will continue to increase the number of obsolete computer products for at least the next five years, leveling off by the year 2005 at an estimated 60 million PCs annually². The Safety Council also estimates accumulated obsolete PCs from 1997 – 2007 will total approximately 500 million.³ This equates to 15 billion pounds of computers, or, 7.5 million tons of potential waste that must be handled by America's businesses and citizens. Such a huge quantity of obsolete, complex material represents a potential problem in the field of waste management, but it also represents a new and challenging opportunity for recycling and economic development specialists throughout the world.

In Europe the main policy emphasis is to establish and mandate industry "takeback" programs, also called extended product responsibility (EPR), requiring industry to initiate obsolete product reclamation and demanufacturing programs. In the United States, where waste disposal problems are still not perceived as imperative due in part to lower overall population densities and to a more open-ended free market waste management economy, a number of policy options are still on the table for outmoded computers and other electronics.

This report is intended to provide the members of the Mid-Atlantic Consortium of Recycling and Economic Development Officials (MACREDO) with a critical assessment of a number of issues surrounding electronics recovery policy options for their region.

The report identifies a number of key issues for consideration in the development of policy options. These issues include:

- Debates over how key environmental regulatory reform directly impacts on industry's ability to divert electronics from disposal systems.
- Design for the Environment (DfE) research and development requires more input from the public sector and environmental managers.
- The benefits of computer reuse go far beyond their environmental implications, requiring a broader approach to cost-benefit analysis than is often the case in the field of environmental management.

¹ "Electronic Product Recovery and Recycling Baseline Report: Recycling of Selected Electronic Products in the United States", National Safety Council, May 1999, pp. 28 – 31.

² Ibid, p.29

³ Ibid, p. 29

In addition, this report makes a number of recommendations for further investigation by MACREDO members. Key recommendations include:

- Development of a set of education and communications tools for promotion and outreach on local electronics recycling issues in the Mid-Atlantic.
- Research into the existing recycling and processing infrastructure for expansion of services to include electronics handling.
- Research into current and future obsolete computer disposition practices for regional, state and local government agencies.

II. Background and Problem Definition

Electronics Recovery Policy Typologies

As the Internet continues to weave its way into the fabric of everyday life, affecting everything from entertainment to personal communications to how business is transacted, it is likely that electronic commodities will continue to advance at ever faster rates. This is one of the main reasons that the world economy continues to expand. It is also the reason that waste management professionals are becoming increasingly concerned about so-called *electroscrap*.

Literature on the disposition of obsolete electronic products is growing at a staggering rate. A significant amount of research has been performed over the past decade on both a national scale and on a more applied basis regionally. In addition, specialized studies of collection systems, electronic recovery markets, and economic development opportunities abound. An annotated bibliography of hard-copy documents and on-line resources is included in the Appendices section of this report.

While the entire spectrum of electronic products is now under scrutiny from a materials management and disposal perspective, most available documents focus on computer and computer-related products. This is not surprising considering the dramatic changes in this technology field and the “turn over” of high-technology equipment. Some studies of the computer industry indicate an average replacement time for PCs of three to five years. Other studies assume more dramatic time frames of 18 - 24 months. Indeed, this should not be surprising since experts claim that the average computer loses 40 - 80 percent of its market value in the first year of ownership. With the huge advances in on-line Internet technologies beginning in the mid-1990s, industry estimates are that in 1999 over 50 percent of U.S. households owned at least one PC. Changes in all microprocessor-based technologies is an unprecedented occurrence in the history of technology.

Takeback: The European Model

During the last decade, countries in the European Union (EU) have debated and experimented with “takeback” policy options for a host of electronics products. Programs such as those in Sweden, Norway, Belgium, and Germany vary in scope and detail, but they are being watched carefully by supporters and foes alike. Programs in Asia and Australia are also underway.

In general, proposals by the European Commission that would fully globalize take-back requirements are meeting with stiff opposition by industry associations - especially those in North America. Original goals for product recovery, as laid out by the European Union’s environmental commission, have gone through two revisions since 1997 (see Table 1). The most recent document produced by the commission has significantly backed off from overtly defining recovery quantities for specific materials, but still calls for recycling and recovery rates of 70 percent for electronics. Even this watered-down

version of requirements is stirring debate. While industry lobby groups have declared that take-back requirements for electronic products are a violation of World Trade Organization (WTO) principles, advocates made electronics recycling and producer responsibility a major point in their demonstrations against the WTO in Seattle in Fall 1999. The debate then over producer responsibility and electronics is far from over and will likely see increasing public exposure over the next several years.

Although the final outcome of these debates is not clear, the intent is to establish an extensive network of centralized collection facilities and to optimize transportation and other logistics across country borders for white goods (appliances), brown goods (home electronics), and other electronic devices. Definitions of what constitutes waste and hazardous waste must also be worked out. Current agreements between member states will also likely need to be modified to meet a more standardized model. These developments are significant to North American companies which export products and materials to the EU. In addition, the successes and failures of the European program will be watched closely by environmental and waste policy experts around the world as they work to solve similar problems in their own regions.

Table 1: Original Proposed Waste Electrical & Electronic Equipment Goals - European Union

Type of Equipment	Minimum % Reuse/Recycled by Weight
Computers & Office Equipment	85%
Telecommunications Equipment	60%
Brown Goods (electronics/small appliances)	50%
Large White Goods	80%
Small White Goods	50%
Light Sources (gas discharge)	70%
Light Sources (incandescent)	40%
Cable	85%
Medical Equipment	70%
Monitoring and Control Instruments	70%
Automatic Dispensers	60%
Toys	50%

Source: "European Commission Releases Paper on Electronics Takeback," *Product Stewardship Advisor*, Oct. 1997

The EU environmental commission's proposal effectively pits the question of producer responsibility against the environmental management role of government – especially as regards point-of-purchase fees to cover the cost of takebacks. Industry argues that it is more cost effective to require final users to pay any additional waste management and recycling costs on the back end. It is acknowledged that markets and technologies exist for some of the items in Table 1, but the logistics of a full-scale international program are not deemed stable enough.

Design for the Environment: The U.S. Model

The Institute for Scrap Recycling Industries has put forward the principle of Design for the Environment (DfE), in order to begin the process of linking the manufacturing and industrial sectors with secondary materials markets. Other approaches to industrial design include green manufacturing, sustainable design, pollution prevention and source reduction. These principles are to a certain extent the outcome of a backlash against government regulation. They also present an alternative to the European takeback model described above.

To varying degrees the computer industry has begun the process of designing for the environment. The biggest success so far has been the partnership between the United States Department of Energy and a number of original equipment manufacturers (OEMs) to build energy star computers – computers designed to significantly reduce the amount of high tech energy consumption that had been the norm. Industry and government have now turned to the waste and recycling side of the equation for computers. In 1992 IBM became one of the first companies to code the types of plastics it used in its machines, making plastics recovery easier. Apple computer has engineered several of its PowerPC machines to be inexpensively upgraded. Many companies now make equipment allowing for simple upgrades of hard drives, modems, and other input-output devices.

IBM's industry leadership in DfE has grown significantly since 1992. It has established a research arm called Design for Environment and have established a world-wide asset recovery service organization providing a global remanufacturing and refurbishment focus for corporate and institutional accounts. Design for Environment has developed a lead-free circuit board solder and most recently the company has unveiled the IntelliStation E Pro CPU that maximizes the use of recycled components and sells at market rates. In particular, the IntelliStation is composed of 100 percent recycled plastic resin from discarded computer parts.

Apple's commitment to environmental responsibility includes open access information (on its website) for consumers on materials used in its computers. Apple's Product Environmental Specifications measure a host of environmental issues including energy use, battery technologies, safety, emissions, packaging, and recyclability. Apple has extensive take-back programs for batteries and toner cartridges, but has no computer recovery program in place. However, it does provide consumers with contact information on local donation and disposal programs.

Both Apple and IBM received positive grades (green candy canes) from the Clean Computer Campaign, a national organization devoted to environmental and safety issues surrounding computer technologies. Nine other manufacturers received relatively neutral grades, and eight companies were identified with "lumps of coal."

The current problem with obsolete PCs may well be modified immensely over the next decade if the commitment to DfE remains strong and expands through leadership from IBM, Apple, and the Electronics Industries Association. But this will require more than investment by OEMs. Input and advocacy from government, consumers and environmental managers will be key to the success of environmental design. Although it is clear that the takeback model would be a hard sell in the United States, it is not clear

whether industry, government, and environmental management companies can establish the kinds of lasting partnerships needed for a comprehensive and efficient electronics recovery system. This report attempts to identify some of the key issues with which both groups need to grapple. It also makes recommendations for further development of environmentally responsible design.

In the meantime, DfE cannot solve the problem of obsolete computers and outmoded home electronics that confronts us now. A brief summary of programs follows.

Growing Concern

A number of household hazardous waste recovery programs in the United States already collect numerous types of electronics. These programs can often be found in waste sheds using incinerators for large quantities of local waste due to the obvious need to minimize the combustion of products containing concentrations of various types of heavy metals and PCBs. Toxic elements found to be of particular concern include lead, cadmium, and mercury.⁴ Studies of bottom and fly ash from incinerators show that concentrations of these elements are exceedingly high and that the main reason for this appears to be a large amount of complex, multi-material based electronics in mixed municipal solid waste (MSW). Electronics industry experts claim that “studies confirm that municipal landfills do not exhibit [cathode ray tube (CRT)] lead release problems in their leachate.”⁵

To counteract environmental problems, electronics collection programs are therefore offered in many areas of the country as part of local and regional hazardous waste drop-off programs. Unfortunately, data on the electronics aspect of these recovery programs is spotty at best. Generally, the recovery of electronics per se is not a predominant concern of these programs, although as special markets and technologies develop in North America and Europe, electronics recovery is obviously gaining more attention. As will be discussed below, to a certain extent the growth of computer recycling markets will naturally stimulate the development of other electronic recycling programs. It should also be pointed out that it is not clear whether the typical hazardous waste collection program seeks to ensure the recycling of electronic equipment or whether they seek to simply dispose of this material as hazardous waste. In parts of the country where the electronics recovery industry is still developing, it is likely that recycling is not yet an option. In the Mid-Atlantic and the Northeast in general, it appears that a significant infrastructure is already in operation and that government programs should seek to recycle electronics and/or actively promote the reuse of collected electronics.

It should be noted that industry experts feel asset management on the corporate level is more than adequate to take care of outmoded institutional and corporate discards, but

⁴Winka, et al, “Demufacturing: Redefining Solid Waste and Product Management,” 1997, p. 3.

⁵George R. Burris, et al, “Green Paper on the Environmental Issues and Needed Research in Color Displays,” (EIA Website), December 1996, p. 2.

that solutions for discards from small businesses, home offices and residential applications are more difficult. There is certainly a need for asset recovery specialists to stay informed about all the options available to them. Government agencies should also continue to examine how they manage end-of-life disposition for obsolete equipment.

More generally, electronics can be broken down into constituent components based upon the collection, processing and markets aspects of recovery. To this end, environmental managers and recyclers employing varying recovery and salvaging techniques have clearly identified the computer-related aspect of electronics as a distinct field. Similarities between television sets and computer monitors also make TVs a separate component within the broader category of electronics. Other items such as VCRs, audio equipment, telecommunication devices, air conditioners, and microwave ovens are then lumped into another category – brown goods.

Since TVs can be handled by the same processors who handle CRT screens, a brief discussion of TV recovery issues is given below with the assumption that the recycling of this commodity is actually a subset of the computer recycling and demanufacturing process. A discussion of TVs is provided below for reference purposes, but the main object of this report is to put computer recycling issues into context as the first wave of emphasis in electronics recovery overall.

Television Recovery Issues

The coming of high definition television (HDTV) technologies during the next decade will sound the death knell of the standard definition television set (SDTV). It is estimated more than 500 million televisions are in homes, businesses, and institutions nationwide. Data are not available on how many televisions become obsolete annually, but nearly 24 million CRT-based TVs were shipped to consumers in 1998⁶ – and it is likely that the majority of these new TVs replaced older ones. Although the lifespan of televisions has been much higher than PCs, new high definition technologies have the potential to render standard TVs obsolete before the end of the decade.

It is not clear, however, whether industry standards will drive these changes or whether consumer demand will be the major factor. The common wisdom is that once HDTV unit costs approach a consumer level for purchase, outmoded SDTVs will begin to be retired. A 1997 survey by Price Waterhouse suggests that consumers are willing to spend \$150 more for an HDTV set over a conventional analog set.⁷ Furthermore, the broadcast industry intends to utilize dual transmission modes for at least the next six years or so – both digital and analog. There is an inherent recognition that the profitability of television will require the ability to address both technology markets simultaneously.

⁶ National Safety Council, May 1999, p. 33.

⁷ Personal e-mail communication with David Isaacs, Director of Environmental Affairs with the Electronic Industries Alliance (EIA), February 18, 1998.

Perhaps most important, even after the broadcast industry has completely converted over to digital transmission, inexpensive converter boxes that attach to the rear of analog sets may make it possible to receive digital signals. It is likely then that consumers will not be pushed as hard as originally thought into investing in this new technology until their old sets cease to operate under normal circumstances.

Industry analysts liken this situation to the advent of color systems in the mid-1960s. People typically did not place old black and white systems in the trash once they had purchased color TVs; rather, they moved old sets to other rooms in the house, gave them away, or sold them for a small amount of money. Eventually, of course, these obsolete TVs are discarded in household trash. It is not clear whether the change to HDTV will be the same. A great deal depends upon the availability of signal converters and their economics.

CRT technology is used in both television sets and computer monitors. Review of studies on the recycling of CRT displays from computers indicates that television recycling can be a part of this same process. Indeed, the time lag in HDTV market penetration (according to a representative of the EIA, at least 6-8 years) will mean that this recycling technology will have ample time to develop and that there is at least the technical means of keeping televisions out of disposal streams for landfills and incinerators.

Interestingly, many of the pilot municipal and county electronics collection programs that have been implemented over the last several years have yielded large numbers of televisions in their inventories. Sometimes this can be profitable. Union County, New Jersey's electronic collection program found that the dismantling of TVs and recovery of TV circuit boards could yield up to \$25 a unit by selling boards to local repair shops. Union County had hired an individual who used to run an electronics repair shop. With the standard charge for CRT processing at \$5.00 to \$10.00 a unit, recycling costs can be offset for TVs through circuit board recovery. The economics for TV recycling may be better than has previously been thought.

III. Computer Systems Recovery

The complexity of computer recovery options cannot be overstated. The remainder of this report outlines a number of issues that must be considered when evaluating end-of-life policy options.

Summary of Carnegie Mellon Study “Disposition and End-of-Life Options for Personal Computers”

A 1991 study by Carnegie Mellon University student H. Scott Matthews gained international attention as one of the first organized attempts to estimate the scope of computer disposal and recycling options. Matthews’ study estimated that by the year 2005, approximately 148 million personal computers would be landfilled on a global basis while only 2 million would be recycled. The study made several key assumptions regarding the disposition of end-of-life options for PCs:

- Computer purchasing would grow at an estimated five percent
- The initial life of a PC was estimated at five years
- Nine percent of all computers displaced by new purchases would be landfilled
- One percent of all computers would be recycled
- Eighty percent would be placed in storage (stockpiled) pending future decision on options
- Ten percent would be resold or reused
- Lifetime for a reused PC was three years
- Lifetime of a stockpiled PC was three years

A subsequent study by the same investigator utilized a similar methodology but made somewhat different assumptions based on better data and changes in computer industry growth models:

- Computer purchasing would grow at an estimated fifteen percent
- The initial life of a PC was estimated at five years
- Five percent of all computers displaced by new purchases would be landfilled
- Five percent of all computers would be recycled
- Forty-five percent would be placed in storage (stockpiled) pending future decision on options
- Forty-five percent would be resold or reused
- Lifetime for a reused PC was three years
- Lifetime of a stockpiled PC was three years

The new model, developed in 1997, thus predicted different outcomes with only 55 million PCs landfilled by 2005 and 143 million PCs recycled. In addition, whereas the original 1991 model predicted purchases during a 25 year period of 340 million PCs,

the 1997 model now predicts purchases of 680 million computers sold. In summary, the authors conclude:

Our updated model predicts over 680 million sold but only 55 million computers landfilled in the US by that time [2005]. Finally, we predict that 143 million will be recycled rather than the original 2 million. In short, the computers originally headed for landfills will [now] be recycled. The numbers of computers landfilled will be roughly equal to the number sold through 1989, when recycling markets were just being formed and there were few end-of-life options for obsolete equipment.⁸

Matthews and the other investigators on his team are quick to point out that their model is limited by the data available to them. As with all data in the field of solid waste and recycling, PC disposal and recycling information is, at best, a rough estimate. But the analytical exercise this group describes in its study illustrates two very important issues:

1. The scope of computer end-of-life options is directly related to the geometric growth of this industry (see Figure 1 below);
2. The dramatic expansion of computer recycling and reuse options has been extremely significant and has already had a major impact on the disposal of computers.

Figure 1a depicts the results of the revised 1997 CMU predictive model. What is clear is that the infrastructure for the reuse of obsolete computers, according to this model, is having a significant effect on end-of-life choices. However, it is also important to note that the model identifies the propensity to stockpile obsolete computers as being as significant as reuse.

⁸ Matthews, et al, "Disposition and End-of-Life Options for Personal Computers," Graduate School of Industrial Administration, Carnegie Mellon University, Green Design Initiative Technical Report #97-10, July 7, 1997, p. 5.

Figure 1: Summary of 1997 CMU Model

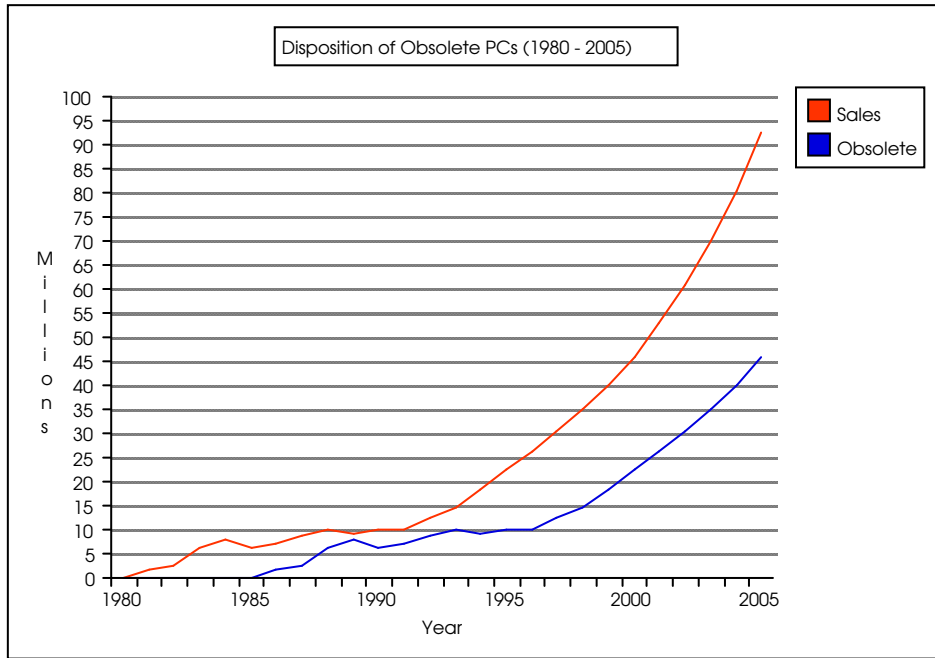
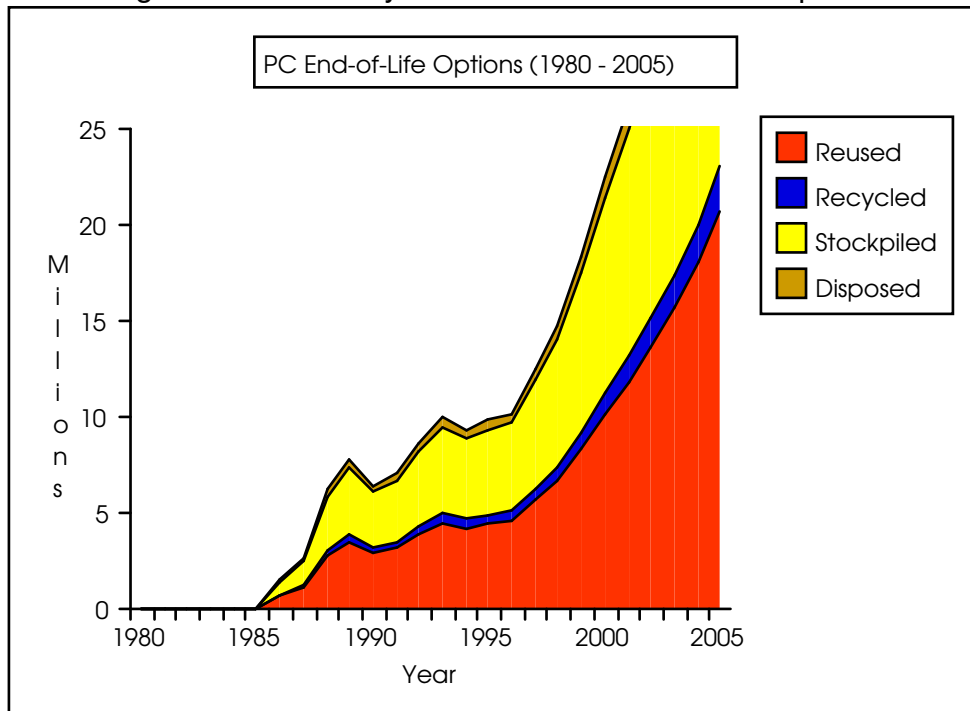


Figure 1a: Summary of 1997 CMU End-of-Life Options



Summary of National Safety Council Study, “Electronic Product Recovery and Recycling Baseline Report: Recycling of Selected Electronic Products in the United States”

In 1998, the National Safety Council (NSC) commissioned Stanford Resources, Inc., a management and market research firm specializing in electronic display and related industries, to research computer-related recycling and recovery activities. This was one of the first attempts to gather actual quantitative information from firms involved in electronics recycling. Research and analysis centered on eight major types of electronic waste (mostly computer-related) and involved data collected from 123 firms. This study contains a wealth of highly detailed and important information on a national scale, especially regarding quantities of material currently recycled. It also contains key economic information on the estimated value and materials composition of computer components.

Key findings include:

- The top five firms surveyed account for 50 percent of the electronic equipment recycled in the United States in 1997 and 1998.
- 14 percent of the PCs that became obsolete in 1998 were actually recycled.
- The ratio of PCs recycled to new PCs purchased in 1998 was 6 percent.

- Notebook computers will be one of the biggest growth areas in electronics recycling during the next decade.
- The number of PCs that become obsolete in 2002 should exceed the number of new ones shipped that same year.
- In all, nearly 500 million PCs will become obsolete from 1997 – 2007.

Information in the NSC study varies somewhat from that in the CMU study. One of the most important differences is the estimate of 45 percent recycling and reuse in the CMU analysis and the 14 percent rate that NSC has established. This is not surprising, as the two were performed for different purposes and use different methodologies and assumptions.

Regulatory Challenges: RCRA Implications

Standards for handling waste are defined by the Resource Conservation and Recovery Act (RCRA), originally passed by the US Congress in 1976. Among other things, RCRA defines how hazardous and non-hazardous waste must be handled and disposed.

A key element for defining whether a discarded item is hazardous or not is the Toxicity Characterization Leaching Procedure (TCLP). In a nutshell, the TCLP procedure is intended to simulate a 20 year decomposition process in a landfill. A sample of the item in question is ground into fine particles and then subjected to a weak acid. The mixture is then filtered and analyzed for evidence of heavy metals and other toxic substances. Using tables that define regulatory thresholds for concentrations of the items found, the relative hazardousness of the item in question is then determined. For computers and other electronics, the most hazardous substances identified are lead, cadmium and mercury. The most significant sources of these items are monitors (lead-based CRT screens), TVs, mercury switches, lighting products and batteries. This report is of course only concerned with computer and TV related waste.

It is not clear whether RCRA as it now stands can directly be used to govern the disposition of obsolete electronics as waste and/or recyclable commodities. Discussions with regulatory officials, industry representatives and environmentalists indicate that the application of RCRA standards to electronics is by no means a simple proposition. Indeed, contrary to what many people have asserted, there is no clear federal regulatory ban on CRTs from municipal solid waste landfills. Furthermore, even if there were regulations governing CRTs, residentially generated waste is exempt from RCRA hazardous waste regulations.

This uncertainty has been addressed by a stakeholders group convened by EPA as part of its Common Sense Initiative (CSI) program. The CSI Computer and Electronics Sector Subcommittee has issued a policy recommendation to EPA entitled “Computers and Electronics Sector Recommendation on Cathode Ray Tube (CRT) Glass-to-Glass Recycling.” This policy recommendation is the outcome of four years of discussion,

research, and compromise by the stakeholders represented in the group. Pointing out that the majority of recycled CRT glass is remanufactured back into CRT glass, the recommendation calls for revision of RCRA hazardous waste management regulations to facilitate CRT glass-to-glass recycling in much the same manner as the universal waste law considerations EPA has already applied to fluorescent lamps, mercury switches, and batteries.

EPA is expected to issue a formal directive for comment on this issue in July 2000, and it is likely that CRTs will receive universal waste status within the next several years. This ruling, of course, will not address small quantity generators or residentially-generated CRTs, but it will simplify operational issues for CRT collectors, processors, and transporters. Of special note in the CSI recommendation is the explicit position that glass-to-glass recycling is a proven technical and economic option for CRTs:

In addition to removing lead from the municipal waste stream, by supplying lead for CRT glass manufacturing, glass-to-glass recycling avoids mining and processing raw lead from ore. Industry experts estimate that U.S. CRT glass manufacturers could use up to 300,000 tons of recycled CRT glass annually. Most of this capacity is currently unused.⁹

Simultaneously, several states are taking matters into their own hands. Massachusetts has exempted intact CRTs from hazardous waste handling laws, but also has added them to the state's disposal site ban. This disposal ban means that obsolete CRTs must be reused, demanufactured, or recycled. As would be expected under such a program, the state is supporting infrastructure and market development initiatives for electronics recovery systems.

The states of Connecticut, Florida, Minnesota, and Wisconsin also have considered bills prohibiting the disposal of CRT equipment as MSW. North Carolina and California are considering bills to require industry to take back outmoded electric appliances. California also requires that CRTs be handled as hazardous waste, making the development of recycling programs exceedingly difficult.

New Jersey's program goes so far as to define electronics as universal waste. This is an important program to watch because, in essence, universal waste rules are intended to allow for the classification of materials that are potentially hazardous, but can be source separated, processed, and recycled or reused. New Jersey officials are considering the establishment of universal waste consolidation centers throughout the state that will not only handle electronics, but also handle more traditional consumer universal wastes such as thermostats and other mercury switches, batteries, and fluorescent lamps.

Most importantly, government and industry recognize that existing environmental laws and regulations are not adequate for addressing electronics waste streams. Clearly,

⁹ "Computers and Electronics Sector Recommendation on Cathode Ray Tube (CRT) Glass-to-Glass Recycling," CSI, June 1998.

given their hazardous nature, the simplest way to keep outmoded electronics out of the waste stream would be to ban them. However, to do so would mean that these items must be handled as hazardous waste – an expensive proposition for all involved. This, and a number of other environmental regulations, are viewed as impediments to industry in developing solutions for demanufacturing. Simultaneously, the infrastructure for properly handling much of this material is still not fully in place. While there are a growing number of computer reuse options available (typically run by community-oriented non-profits or entrepreneurs), the number of high capacity electronics processing and demanufacturing facilities is by no means adequate to handle a wholesale flow of high-tech machines across their weigh scales. Finally, there are a number of economic questions that still have not been answered about electronics demanufacturing, including:

- What economy of scale is required to make operations profitable?
- Can OEMs coordinate their efforts to create uniform standards for material and components, thereby ensuring quality control on the processing end?
- Is current equipment adequate for future processing requirements?
- What can be done to make plastics recycling more profitable?
- Should demanufacturing centers be developed solely on a market economy basis, or should government be the driving force?
- If the computer industry is to continue to modify the materials used for state-of-the-art equipment, will it also adequately invest in developing new technologies for waste recovery and recycling?

Cathode Ray Tubes: Technology Challenge

As has already been noted, the recycling of television sets is dependent upon the development of an adequate infrastructure for processing CRT screens in general. CRTs contain large concentrations of lead and other hazardous heavy metals which are often considered beyond the acceptable levels by EPA. The state of New Jersey and Hennepin County, Minnesota both indicate high levels of lead, cadmium and mercury in incinerator ash and attribute this in large part to TV and computer CRTs¹⁰. Diversion of CRTs from municipal waste disposal systems is therefore clearly necessary. And while reuse and resale of useful equipment is important, over time all CRTs will burn out, thereby necessitating the need for processing and recycling or for handling them as a source of potentially hazardous waste.

¹⁰“Demanufacturing: Redefining Solid Waste and Product Management,” Michael Winka, et al, *Pollution Prevention Review*, Autumn 1995, pp. 89 - 95; “Minneapolis Launches Curbside Collection of TVs, Computers,” *Product Stewardship Advisor*, Volume I, No. 6; November 1997.

CRT technology has been in a constant state of development for over 100 years. With the advent of television and then high definition computer screens, this technology has truly taken off since the early 1970s. There are now more than 100 different CRT panel compositions in existence plus several different transmission technologies for each composition. In addition, TVs, monochrome computer monitors, and the vast array of color monitors all have different constructions. The result is that development of a standardized disassembly technique is difficult due to the lack of uniformity in this technology.

Industry recycling of broken and defective preconsumer CRT glass has been common for some time, mainly as an internal feedstock in CRT glass manufacturing. In these cases, glass composition is known and quality can be ensured. In post-consumer situations, recycling is much more difficult.

There are several demanufacturing programs in operation on the East Coast that claim to recycle CRTs. The most significant of these is the Envirocycle facility located in Hallstead, Pennsylvania.

In 1996 Envirocycle processed 23 million pounds of CRT glass (11,500 tons). It charges \$5 - \$15 to recycle monitors – depending on quantity and quality, and most of its business still comes from equipment manufacturers. Company officials note that maintaining a quality feedstock is the key to success.

Technically, then, the capacity to process and recycle CRTs exists. In addition, at least one of the three manufacturers of CRT glass in the US has made a commitment to use cullet from Envirocycle's recovery operations. But it is clear that Envirocycle's distance from most Mid-Atlantic urban centers makes transportation costs prohibitive. The cost per monitor to ship via common carrier ranges from \$3 (for tractor trailer loads) up to \$30 for just a few. Adding transportation costs to processing costs yields recycling costs of \$10 - \$45 per unit, or roughly \$0.30 - \$1.50 per pound – far in excess of the cost to landfill them as hazardous waste.

It is therefore likely that significant efficiencies would be gained for the Mid-Atlantic were several similar state-of-the-art facilities located more centrally.

IV. The Emerging Infrastructure

End-of-life options for computers are numerous. Secondhand computer retail outlets and non-profits specializing in distributing donated computers to community groups and educational institutions abound. Specialty electronic scrap businesses can also be found in many parts of the country with a concentration of high tech industries. The *Electronics Reuse and Recycling Directory*, published by the EPA in January 1997, lists more than 200 recycling and reuse resources in 34 states and Canada. As described in the Institute for Local Self-Reliance's book, *Plug Into Electronics Reuse*, these resources run the gamut from small, one-person non-profits operating part-time out of someone's garage, to large companies employing several hundred people and processing several hundred thousand items a year. Summaries of the five major end-of-life options for computers are given below. These five areas are, to some extent, both interactive and competitive.

Reuse

The majority of entities addressing the issue of recovering outmoded computers are non-profit and community groups. Some are very small and operate with virtually no capital and financing, others are very large with extensive management structures and significant sources of funding. A number of organizations are mid-sized and growing, with small sources of funding and a small number of employees, but energetic support from committed professionals in the community.

The goals of nearly all of these groups are three-fold. First, they seek to recover old computer systems as an environmental social service. Second, they see the refurbishment of computers as a way to create jobs and job-related skills for people in their community – particularly disadvantaged youth. Finally, they seek to distribute computers to people and institutions who otherwise might not have computers – public schools, community groups, disadvantaged businesses, literacy programs, senior centers, and low-income families.

The efforts of these groups recently have been enhanced by a new tax provision called the Tax Payers Relief Act of 1997. A portion of this act, known as the 21st Century Classrooms Act, is intended to encourage the donation of computers and peripherals to schools. This is in addition to existing provisions for older computers that allow for tax deductions of the depreciated value of electronic equipment. The Classrooms Act allows for a full deduction of the purchase price of equipment up to two years old, plus deductions on installation and transfer costs. Eligible donations for the Classroom Act must be made to K-12 schools or foundations supporting these schools. These deductions make it more lucrative to transfer outmoded equipment to educational institutions than to allow them to sit beyond a two-year timeframe.

One very important factor affecting the success of reuse groups is the fact that they often receive as many non-functioning computers and peripherals as they do working ones. This means they are saddled with the responsibility of disposing of broken

equipment. To fully complete their mission, it is therefore necessary to transport this scrap and to pay for the processing of at least some of the items they cannot refurbish. Especially when this involves monitors, an unanticipated cost ensues since monitors require specialty processing techniques. Since many of these organizations are charitable and rely solely on donations of equipment and small grants, this added cost has the potential of being burdensome. In light of the tax deduction corporations can take, it is also inequitable. For reuse to remain a viable option, it is recommended that this problem be fully investigated. A mechanism to support the scrap management aspect of these groups through, for instance, a local business trust funded by participating companies might be one approach. Another approach might involve coordination of educational activities with donors, requesting the recognition that they cover the cost of scrap management once problem equipment has been identified and logged.

In evaluating the merits of reuse in computer recovery operations, it also is important to note that the social benefits provided by these groups are significant. In establishing broad policies for electronics recovery, it is essential that a concerted effort be made to establish a clear, quantitative definition of these benefits. It also is important to begin to quantify the number of computers these organizations currently handle on a monthly basis, and the number that could be handled were the public more educated about this issue.

Resale

A number of small businesses and organizations specialize in computer refurbishment for resale. Many of these are connected to asset recovery management programs run by OEMs, large corporations, and institutions. A number cater to individual consumers and small businesses. Many computer retail outlets also take trade-ins when customers buy new machines. They clean up and refurbish the old machine, and then sell the used equipment for a profit. Perhaps the best known of these companies is Computer Renaissance (<http://www.compren.com/main.html>), a national company that sells franchises. In many ways, this group is similar to the used car industry. None of the literature reviewed for this report (see Appendix) includes this group in its analysis and evaluation of policy options. No data are readily available on the contribution of resale ventures to computer recovery in general.

Clearly, a better understanding of the resale option and more comprehensive inclusion of this group in directories and economic development initiatives is vital. Small business assistance to individuals (or even non-profits) considering resale ventures may need support and coordination. At the same time, it is important to recognize that reuse groups and resale businesses can be in potential conflict. It is likely that government officials will need to coordinate programs that appropriately support the work of both groups.

Recycling

Scrap metal professionals have understood the value of computer recovery for several decades. While computers are highly complex amalgams of numerous materials (plastic housing, glass screens, metal conductors and wires, switches, silicon chips, capacitors, etc.), until recently, they typically contained enough precious metals to allow for a volume-based scrap recovery process. Printed circuit boards (PCBs) tend to be the main source of precious metals. In general, a ton of circuit boards yields approximately 10 ounces of gold.¹¹ The average computer contains .25 - 1.0 grams of gold. Other metals recovered include platinum, silver, copper, steel, and aluminum.

Over the last several years, to reduce costs, the computer industry has cut its use of precious metals by as much as 90 percent. In addition, computer recyclers and scrap dealers are becoming inundated with various plastics – particularly ABS plastics (acrylonitrile-butadiene-styrene) typically used to make CPU and keyboard housings. This shift in available material is making it more difficult for computer scrap recyclers to operate effectively. Most agree that if they are to continue to make a profit, they will need greater volumes of material and more advanced processing technologies.

In addition, electronics recycling is a very labor intensive industry that must continually address occupational safety and environmental health concerns along with costs. Tin/lead solder is a large problem, as are the lead and phosphorous in monitors. As such, environmental liability insurance and other regulatory costs can be very high.

Demanufacturing

Often coupled with computer scrap recycling is the process of dismantling computers into their constituent components, removing and testing chips, hard drives, CD-ROM drives, circuit boards, etc. Once removed, components are cleaned, sometimes repaired, packaged, cataloged, and then sold as used parts. While highly specialized, this niche field, often called demanufacturing, has vast potential as microprocessor-based technologies continue to advance. Although there are certain computer components that are difficult to handle once they are broken, for the most part many items that can be salvaged from non-functioning computers are in working order – particularly computer chips.

A number of issues have a direct impact on this growing field. First and foremost, the price of random access memory (RAM) in the global marketplace has fallen from approximately \$8.00 per four megabyte single inline memory module (SIMM) to around \$1.00. Businesses specializing in this field reported 40 - 50 percent revenue increases during the early 1990s when there was a RAM shortage. By the end of 1995, those revenues had dropped significantly and many of the companies who once provided demanufacturing services were forced to shut down. Those remaining rely on diversified practices, including the recovery and testing of various disk and CD-ROM

¹¹ Broughton, "Circuit Board Recycling Increases," *Recycling Today*, May 1996, p. 71.

devices, consignment services for large corporations, spare parts management, and consulting and logistics planning services. One firm even offers a mobile circuit board shredding operation for OEMs concerned about the availability of proprietary circuitry and other uses of obsolete equipment. As with most recycling companies, market declines serve to weed out overnight businesses, but the complexity of this field may require more than market forces to allow for full development.

Besides the fluctuating value of chips and component parts, the use of refurbished components in new equipment has become a big issue. A number of large manufacturers have recently faced lawsuits for using recovered parts in equipment sold as “new.” In some cases, companies have been challenged legally by competitors for being able to reduce prices through the use of secondhand parts and refurbished machines.

As demanufacturers continue to develop new markets and new techniques, it is clear that computer industry changes must be closely watched. DfE projects and extended producer responsibility programs are viewed as the key to future environmental success for computer and electronics companies. A lack of coordination and planning with demanufacturers may create problems down the line.

Disposal

Even though there are a clear number of reuse and recycling options for computers, solid waste companies and municipal governments continue to haul electronic scrap to landfills and incinerators. Conversations with a number of waste industry representatives provide ample evidence that even in the face of clear economic incentives and/or landfill bans, some waste haulers continue to dispose of equipment as a matter of course.

Careful consideration needs to be given to the regulatory aspect of the trash industry and how it affects electronics recovery operations. The higher the cost to dispose of non-recyclable material, the higher the cost of doing business. For well-developed companies with deep pockets, high disposal costs may provide the incentive to develop new recovery techniques, but for smaller, emerging companies, more stringent waste disposal regulations could be disastrous.

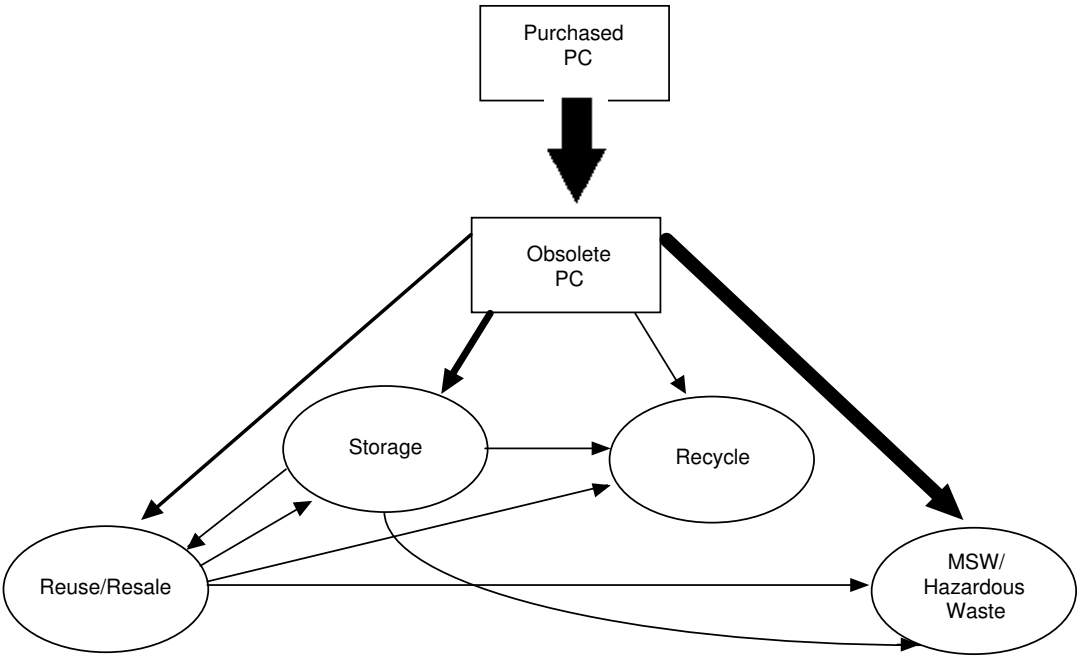
More importantly though, the proper disposal of electronic equipment is a vital aspect of the entire recovery system. No matter how well-developed the demanufacturing and reuse industries, there will always be the need to dispose of material that can not be used. Clear regulations that protect the public’s health as well as the computer recovery industry’s integrity are vital.

Emerging Infrastructure

A study by the Recycling at Work Campaign (a program affiliated with the US Conference of Mayors) indicates that the “whole computer” reuse infrastructure is surprisingly well-developed – whether through resale or reuse. It is clear though, in examining available options for computer demanufacturing, scrap recovery, and other forms of recycling that the infrastructure is not as mature as it needs to be. There are a number of unanswered questions and important policy decisions yet to be made. This uncertainty makes sustained growth for electronics recovery somewhat difficult. Most importantly, the survey performed by the Recycling at Work Campaign and conversations with numerous people in the computer recovery field indicate a clear need for better promotion and increased public education of existing end-of-life options, and more support for the development of local processing capacity.

From the public policy perspective, the complexity of this field requires careful consideration of all the participants' needs and abilities. Figure 2 offers a scenario depicting the infrastructure as it currently stands. This is a modified diagram taken from the Carnegie Mellon model referenced earlier in this report. Arrows indicating the flow of materials are of different width in order to denote relative quantities of material.

Figure 2: Current End-of-Life PC Options



Modified diagram from “Disposition and End-of-Life Options for Personal Computers,” 1997 Figure 2, p. 4

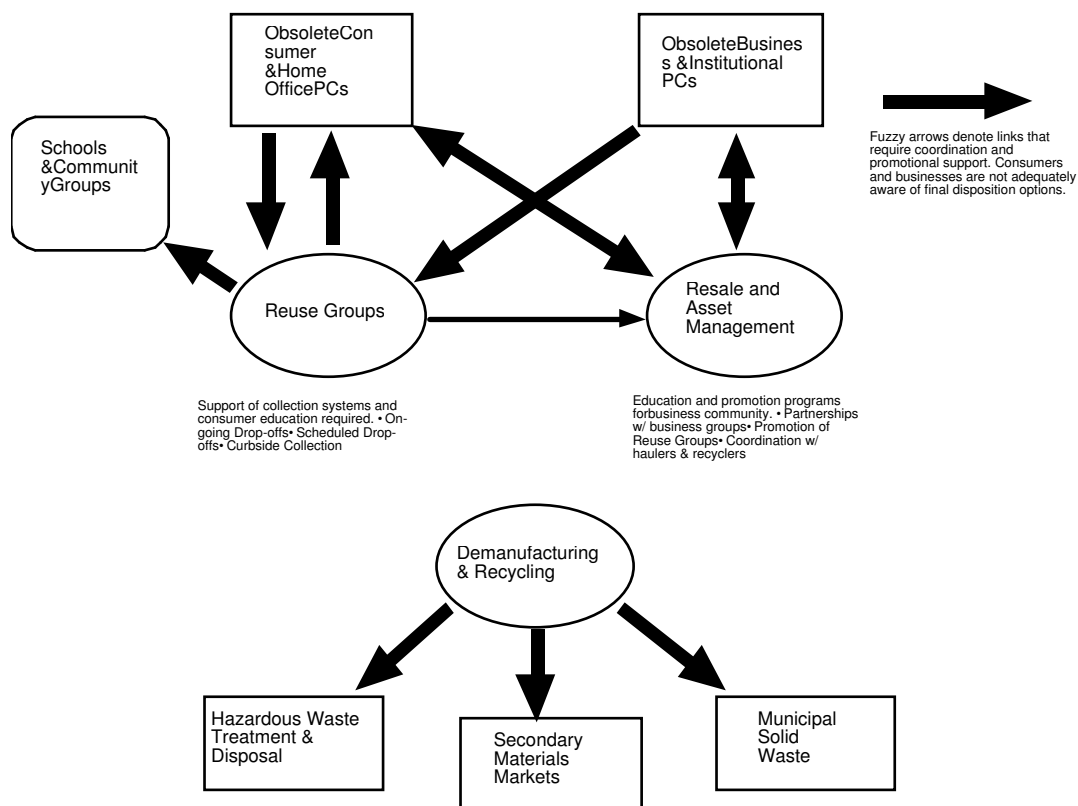
Proposed System Model

Figure 3 illustrates a model that would allow for the flow of computers through a system that eliminates waste disposal as an option for consumers and businesses. In essence, this system depends on reuse groups and resale companies as a first level filter for product management and evaluation and then assumes that recycling and demanufacturing companies will take on the responsibility for salvage work and disposal where necessary. This system could potentially be established through promotions, financial support and certification of the organizations in question, allowing market forces to govern materials flows. The other means, of course, is to establish regulations requiring PC reuse and recycling or banning such material from MSW landfills.

This model is predicated on the notion that DfE research and development will mature into active programs and that government and industry will be able to cooperate in establishing working programs. Early efforts in Minnesota, New Jersey, Massachusetts and New York already show how this might work.

Clearly, policy making will depend upon the cooperation and willingness of industry groups like the Electronic Industries Alliance (EIA) and the American Electronics Association (AEA) to work with government to set up sustainable programs and lasting partnerships.

Figure 3: Model End-of-Life PC System



V. Markets and Economic Development

Markets

Markets for computer-derived components and scrap vary tremendously. This is due in part to the wide variety of materials used to manufacture computers and to engineering changes that facilitate the production of faster, more powerful, and cheaper computers.

Table 2 provides a comparative breakdown of the value of some materials recovered from a typical PC. The table shows that approximately 55 percent of a standard desktop PC is recoverable, with a 1996 scrap value of \$34.

Table 2: Material Composition of a Desktop Computer¹²

Component	Percent (%)	Value (\$)
Plastics	23.00%	11.73
Aluminum	6.30%	9.11
Steel	20.50%	4.18
Gold	0.001%	6.27
Silver	0.02%	1.03
Lead	6.30%	1.93
Cadmium	0.01%	0.01
Mercury	0.0022%	0
Totals	56.13%	\$34.26

It is important to note that the largest single component material identified in the Table is plastic. It also provides the highest potential value of any component (due in part to quantity). To date, however, no large-scale commercial efforts by the electronics scrap industry have been established for plastics recovery. Conversations with processors indicated that this is due to the wide variety of plastic resin types used by computer and electronics manufacturers (most of which is not labeled), and the difficulties in handling, storing, and transporting plastics. As a result, plastics is viewed as one of the more challenging aspects of electronic recycling.

As indicated in Table 3, below, plastics is only a medium-range raw material output by the electronics recycling industry. This is clearly an area that must be addressed both

¹² Microelectronics and Computer Technology Corporation (MCC), *1996 Electronics Industry Environmental Roadmap*, February 1996, MCC Technical Report MCC-ECESM-001-96EIE Roadmap 1996.

by OEMs in DfE research and implementation. It is also an important consideration for design of processing facilities.

Table 3: Material Output from U.S. Electronics Recyclers¹³
(millions of pounds)

Component	1997	1998
Glass	25.6	29.2
Plastic	8.2	14.4
Aluminum	8.7	9.9
Steel	31.9	43.9
Copper	6.9	7.9
Precious Metals (gold, palladium, platinum, and silver)	2.5	2.2
Other	7.8	5.4
Totals	91.6	112.9

Component Materials

Components and materials that are commonly recovered from computers are listed below. A more detailed listing, especially of circuit board parts, is provided in Appendix D.

- Populated Circuit Boards
- Circuit Boards (sheared flush)
- Scrap Whole Computers
- Scrap CPU Units
- Scrap Drives
- Scrap Keyboards
- Scrap Printers
- Scrap Plastics (Computer Shells)
- Assorted Scrap Computer Plastics
- Scrap Floppy Disks
- Scrap CDs
- Scrap Monitors (VDT)

¹³ National Safety Council, May 1999, p. 36.

The following grades are included in the CRT (Cathode Ray Tube) recycling category:

- Whole VDT/TV Scrap
- CRT Scrap
- 1/8" Recovered CRT Glass (Andela #16)
- 3/8" Recovered CRT Glass (Andela #17)
- CRT Tailings
- Other CRT Scrap

Economic Development

As noted, both the reuse and resale components of computer recovery are well developed. As organizations and entrepreneurs continue to gain experience in this new field, it is likely that they will become more efficient and more effective at procurement, collection, refurbishment, and redistribution. To illustrate the extensive network of these organizations, they are listed below for MACREDO member jurisdictions. A more detailed listing with addresses, phone numbers, and contact names may be found in Appendix C.

Delaware

Goodwill Industries of Delaware - Wilmington

District of Columbia

Davis Memorial Goodwill Industries
(See also Maryland and Virginia)

Maryland

Computer Reclamation, Inc. - Beltsville
Lazarus Foundation - Columbia
The Phoenix Project - Ellicott City

Pennsylvania

Carnegie Mellon Computer Recycling Center - Pittsburgh
Goodwill Computer Recycling Center - Pittsburgh
Latino Tech Collective - Philadelphia
Philadelphia Reuse Collaborative - Philadelphia
Share the Technology - New Jersey/Philadelphia area
Student Computer Recycling to Offer Underrepresented Groups in Education
(SCROUNGE) - State College area

Virginia

Educational Institutions Partnerships Program - Arlington

Gifts in Kind America - Alexandria

R. Frasier, Inc. - Salem

Second Chance Program - Fairfax County

West Virginia

None Listed

The recycling and demanufacturing infrastructure for obsolete electronics is not as well developed as reuse and resale options. EPA's *Electronics Reuse and Recycling Directory* lists only three facilities on the East Coast that recycle CRT monitors and TVs on-site.¹⁴ Two of these facilities are located in New Jersey, and one is located in northeastern Pennsylvania. In addition, there are only five facilities on major national lists that indicate they provide recycling and/or demanufacturing services. CRT processing and handling facilities include:

New Jersey

Advanced Recovery - Belleville

Hesstech, Inc. - Sayerville

Rustec - Camden

Pennsylvania

Envirocycle, Inc. - Hallstead

Elemental, Inc. - Philadelphia (intact monitors only)

Economic Development Support

Reuse and resale organizations may be abundant throughout most of the MACREDO region (except for West Virginia), but it is unclear whether this infrastructure is adequate to meet a growing inventory of decommissioned equipment. Further research needs to be performed to definitively establish the capacity of this group. In addition, a needs assessment should be performed to determine quantitatively the levels of support they require to meet their goals. Discussions with several reuse group directors indicate a need for government recognition, promotions, collection equipment, and staffing to manage a regularly-scheduled collection system and, in some cases, warehouse space for inventory. Education of consumers and business managers also is a concern – especially regarding fee-for-service. Although these organizations are able to procure a fairly large number of computers, they must still contend with an inventory of roughly 50 percent that do not function properly. As such, there is a cost associated with transporting scrap to a demanufacturing facility. There is also a cost for ensuring that non-functional CRTs are recycled (\$200 - \$300 per ton). In essence, while donating

¹⁴ It should be noted that numerous small scrap companies process various electronic components as a regular part of business, but data for this group is not available except insofar as has been documented by the USEPA.

businesses often receive tax breaks for their computers, reuse organizations must bear the cost of recycling scrap they cannot refurbish.

Special attention should be paid to the state of West Virginia, as well. It is probable that several computer reuse initiatives are in operation and have simply not been reported. If no programs exist, MACREDO could provide support and guidance to relevant decision makers in the state to help get something started.

The demanufacturers and recyclers network also requires assistance. There clearly is a need for at least one facility in the Baltimore-District of Columbia area, and another one in the Philadelphia-Wilmington area. As was the case with the EPA, Inc. facility in Union County, local government support for a multi-material facility would yield the greatest benefit. Detailed engineering and design work is required, and capital costs can range from \$250,000 to \$500,000 or more, with operating costs in the neighborhood of \$10,000 to \$15,000 a month – or more, depending upon facility throughput.¹⁵

Ideally, support would come from a partnership between state and local governments and the computer industry. Revenues would be generated through service charges to municipalities for materials processing (see Appendix A) and through the sale of computer components and scrap.

Job Opportunities and Skills Training

Strong recycling infrastructures typically provide regional governments with the opportunity to create jobs. This is particularly true in the case of computers and other electronic equipment. Moreover, this particular branch of resource recovery requires semi- to high-skilled jobs. Many of the computer reuse groups connected to schools and community organizations are already deeply involved in training disadvantaged individuals and low-wage workers in computer repair and refurbishment. The value of these programs cannot be overstated.

The number of jobs that can be created through further development of high tech reuse, recycling, and demanufacturing projects is significant as illustrated in Table 4, below. An average of 30 jobs per 1,000 tons of reused and recycled computers can be created in this industry. Assuming that approximately 20 percent of the annual computer discards in the country are available in the MACREDO region, this translates into a potential resource base of approximately 100,000 tons annually – roughly 3,000 new jobs. The growth in discarded computers over the next decade will substantially increase this opportunity for new jobs.

Table 4: Electronics Reuse and Recycling Data¹⁶

	%	Units/	Tons/	Full-Time	Jobs per
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¹⁵ Platt & Hyde, “Plug Into Electronics Reuse,” Institute for Local Self-Reliance, 1997, pp. 13-38.

¹⁶ Derived from Platt & Hyde, “Plug Into Electronics Reuse,” Institute for Local Self-Reliance, 1997, p. 40.

Company	Reused	Yr.	Yr.	Job Equiv.	1000 Tons
Computer Reclamation	90%	4800	60	3	50
Computers 4 Kids	70%	2200	22	3	136
Detwiler Computers	70%	15000	188	8	43
DRAGNet	60%	6800	85	6	71
East West Foundation	90%	7000	88	12	136
Goodwill Computer Ctr.	60%	7500-12000	94-150	10	67-106
National Cristina Found.	95%	>40000	>500	8	16
Surplus Exchange	35%	104000	1300	20	15

VI. Recommendations

1. Closely monitor local and national debates over key environmental regulatory actions, recognizing that this directly impacts industry's ability to divert electronics from disposal systems.
2. Stay informed about Design for the Environment research and development.
3. Prepare a standardized electronics recovery fact sheet for distribution to local government and businesses.
4. Establish an on-line and hard-copy list of regional non-profits and businesses that handle electronic equipment. This list should be updated regularly.
5. Stay informed about the Common Sense Initiative's electronics-related programs.
6. Prepare a member presentation package including hand-outs, overheads, slides and script for presentation to local business, trade, and citizen groups.
7. Survey state and regional federal agencies about obsolete computer disposition practices.
8. Target educational agencies for specific assistance in developing reuse capabilities.
9. Survey major school districts about obsolete computer disposition practices, student computer needs, and future MIS plans.
10. Survey regional recycling centers about their plans and interests in adding electronics recycling to services.

Appendices

Appendix A: Summary of Municipal Collection Programs

Minneapolis, Minnesota

Contact: Andy Castellano, Div. of Solid Waste and Recycling (612) 673-2917

Minneapolis recently implemented one of the first curbside collection programs to include electronics. The program sought to collect TVs, CRT monitors and computers from households at the curb on a designated recycling day. Equipment intended for collection required a note reading "For Solid Waste." Only two items were allowed per residence. The city estimated that about 50 percent of the material would be recycled. While no official data is available at this time, in an interview Andy Castellano, the project coordinator, noted that TVs constituted the predominant item set out for pick up.

Prior to the development of this program, Hennepin County, where Minneapolis is located, had documented that half the lead found in regional incinerator ash came from CRT screens and televisions. A county drop-off collection program for household electronics has been in operation for years and averages about 250 - 300 tons of electronics a year. Recovered equipment is disassembled by a local jobs training organization and the proceeds from components and scrap material are returned to the county. Disposal costs of non-recycled material are handled by the county as well.

Figures for the curbside collection program are not readily available. However, county estimates are that of the 366 tons of material collected in 1997, approximately 12% was collected in the curbside program, 62 percent were collected at the permanent drop-offs and 26% at special collection events.

Union County, New Jersey

Contact: Steve Stanaback, Electronics Processing Assoc., (908) 382-9400

Union County municipalities have held several extensive electronics drop-off programs in the last few years. Items collected were delivered to the county's special electronics processing facility operated by Electronics Processing Associates, Inc. This facility is no longer in operation

Data from the first six month pilot program held from October 1996 to March 1997 is provided below. Overall, 18 tons of electronics were collected. Roughly 45 percent of the items collected were computer-related. The processing facility serviced 21 municipalities in the region, but only five of these participated in the pilot program. Of special note is the fact that the facility charged each municipality it serviced a fee per electronic item delivered. Although the fee was nominal, it helped defray basic program costs.

Union County Electronics Recovery Program			Total Cost
Item	Unit Fee	# of Items	Per Item
Computers	\$1.00	229	\$229.00
Monitors	\$5.75	201	\$1155.75
Televisions (>22")	\$7.00	239	\$1673.00
Televisions (<22")	\$9.50	47	\$446.50
Computer Printers	\$2.00	85	\$170.00
Keyboards/Mice	\$0.75	105	\$78.75
Home Audio Equipment	\$2.50	232	\$580.00
Computer Peripherals	\$1.00	66	\$66.00
Copiers	\$5.00	20	\$100.00
Home Video Equipment	\$2.00	95	\$190.00
Telecommunications Equip.	\$2.00	137	\$274.00
Microwave Ovens	\$2.00	85	\$170.00
		1541	\$5133.00
Total Tons	18		
Avg. Cost per ton	\$285.17		

Source: Union County Utilities Authority

Binghamton, New York

Contact: Christine S. Beling, EPA, Region 1, (617) 565-3241

Two pilot projects have been implemented by EPA as part of their Common Sense Initiative in the northeast – one in Binghamton, New York, the other in Somerville, Massachusetts. Projects were managed in conjunction with local government planners. Results from both projects follow.

Binghamton's program reports two different collection events lasting two days each, one in the fall of 1996 and one in the spring of 1997. A third event is scheduled for the spring of 1998. The collection system was fashioned after local hazardous waste drop-off days with outreach and promotion well in advance of the weekend collection days. Over 90 percent of the material recovered was reported recyclable or reusable.

Results of the events are as follows:

Binghamton Electronics Collection

The cost for this project has been estimated at \$374 per ton for the Fall '96 event and \$412 per ton for the Spring '97 event. For comparison, trash collection and disposal costs in Binghamton are estimated at \$75 per ton; recycling collection and processing are estimated at \$90 per ton. Compared to hazardous waste collection these event costs are relatively low. As in any pilot waste collection program, modification of promotions and outreach planning plus "word of mouth" will see this program become more efficient over time.

Binghamton Electronics Collection (in pounds)

Material	Fall '96	Spring '97
Large TVs/ACs	893	2932
Office Equipment	102	0
Large Electronics	205	878
Computer Equipment	339	1487
Monitors/Small TVs	226	1177
Small Electronics	134	761
Kitchen Appliances	162	1090
Miscellaneous	311	706
Total	2372	9031

Source: *Residential Collection of Household End-of-Life Electrical and Electronic Equipment Pilot Collection Program*, USEPA, February 1998 (EPA-901-R-0022).

Somerville, Massachusetts

Contact: Christine S. Beling, EPA, Region 1, (617) 565-3241

Somerville, Massachusetts conducted two electronic collection events in conjunction with Binghamton's program as part of the same EPA project. Although both cities are very similar in many ways, Somerville's program was somewhat more effective than Binghamton's. Collection figures are given below:

Somerville Electronics Collection (in pounds)

Material	Fall '96	Spring '97
Large TVs/ACs	1665	3508
Office Equipment	266	619
Large Electronics	1196	762
Computer Equipment	852	3529
Monitors/Small TVs	631	1158
Small Electronics	738	584
Kitchen Appliances	694	362
Miscellaneous	1406	2132
Sub-Totals	7448	12654
Resale/Computer Equipment		1069
Total	7448	13723

Source: *Residential Collection of Household End-of-Life Electrical and Electronic Equipment Pilot Collection Program*, USEPA, February 1998 (EPA-901-R-0022).

Cost efficiencies for Somerville's program were estimated at \$886 per ton for their Fall '96 event and \$159 per ton for their Spring '97 event. EPA researchers note that while the cost effectiveness of Somerville's program increased significantly, Binghamton increased the amount of material it collected by 281 percent as opposed to Somerville's 84 percent increase.

Participation rate analysis shows the following:

Somerville Fall '96	193 households
Somerville Spring '97	250 households
Binghamton Fall '96	47 households
Binghamton Spring '97	128 households

San Jose, California

Contacts: Tom Bartel, Unisys Corp., (602) 224-4221
Dave Jones, EPA-Region 9, (415) 744-2266
Leah Jung, Vista Environmental™, (303) 674-8420

EPA's Common Sense Initiative also sponsored electronics collection pilot research in San Jose, California. This project was modeled more on corporate "takeback" principles. Three San Jose electronic retail outlets volunteered to be outlets for electronic drop-offs in the month of October, 1997. The volunteer companies were Fry's Electronics, Office Max and Computer City. Fry's is reported to have been responsible for 80 percent of the 62,000 pounds of material collected. By weight, nearly half of the material collected was computer monitors that could not be resold. In quantity, researchers report the following breakdown:

CPUs	35%
Monitors	33%
Printers	15%
Other	16%
Laptops	>1%

No detailed material breakdown is available at this time; however, the economic analysis for this project is substantial. Researchers were able to document overall project costs for transportation, processing, and monitor recycling of roughly \$23,000 and revenues from material resale at approximately \$5,000 for a net cost of \$18,000 or \$584 per ton. They further document that 38 percent of the resale revenues came from equipment while 62 percent came from the sale of scrap material – presumably non-functioning equipment.

In addition, a cost analysis of monitor recycling overseas vs. in the U.S. indicates a cost of \$1,500 for the overseas option and \$15,000 for the U.S. The overseas option yielded net costs of \$142 per ton as opposed to \$584 per ton for shipment of monitors to processors in the eastern United States.

One interesting aspect of this project is the fact that two of the participating retail corporate offices were not able to support their local store with advertising funds. The third retailer, Fry's, had full corporate support. As a result, Fry's achieved the lion's share of recovery – 10 times the amount of the other stores combined. In addition, Fry's reports "increased sales due to end-users' browsing following equipment drop-off."¹⁷

¹⁷ "San Jose Takeback Pilot Collects 31 Tons ... and Increases Sales?" Product Stewardship Advisor, November 1997.

Naperville and Wheaton, Illinois

Contacts: Marta Keane, City of Naperville
Kay McKeen, Dupage County, Illinois

Naperville held special one-day drop-off events in the fall of 1996 and the spring of 1997. The town of Wheaton held their event in the spring of 1998. These events were organized and supported by a local demanufacturing firm. Naperville has a population of 85,000 with 32,000 households and Wheaton has roughly 50,000 citizens with 18,000 households. Both towns have active, well-developed HHW collection programs. Collection figures are given below:

Naperville Electronics Collection (number of units)

Material	Fall 1996	Spring 1997
Computers	367	305
Monitors	152	290
Keyboards	160	65
Printers	113	130
TVs	111	292
VCRs	54	236
Microwaves	28	40
Stereos	286	120
Totals	1367	1575
Aggregate Weight (pounds)	24,267	Approximately 60,000

Wheaton Electronics Collection (number of units)

Material	Spring 1998
Computers	99
Monitors	226
Keyboards	0
Printers	102
TVs	102
VCRs	109
Microwaves	33
Stereos	115
Totals	786
Aggregate Weight (pounds)	22,414

Cost efficiencies for Naperville's program are estimated at \$1,160 per ton and \$460 per ton for their Fall and Spring events respectively. Wheaton's program costs are estimated at \$1,240 per ton. Cost factors include transportation, processing, and disposal fees for unsold scrap and residuals.

Bay Area, California

Contact: Materials for the Future Foundation, 415-561-6530

In the spring of 1998 cities in the San Francisco Bay Area ran a 10-day combination drop-off and bulk curbside collection campaign for electronics. This program was coordinated and administered by Materials for the Future Foundation, a San Francisco based non-profit along with help from a number of community groups, businesses and local governments. This program is very significant in that it represents one of the only electronic collection efforts by community groups in a major metropolitan area. Detailed data was only available for Oakland.

Bay Area Collection (number of units)

Material	Oakland	Hayward	San Francisco
Computers	55		
Vacuums	93		
Heaters	23		
Fans	31		
TVs	198		
VCRs	20		
Microwaves	54		
Stereos	117		
Totals			
Aggregate Weight (pounds)	15,623	10,000	11,000

Source: *Analysis of Five Community Consumer/Residential Collections End-of-Life Electronic and Electrical Equipment*, USEPA, April 1999 (EPA-901-R-98-003) and "Bay Area Recycling," a promotional brochure published by Materials for the Future Foundation. .

Numbers for the programs identified here are still being compiled.

Appendix B: Annotated Bibliography

Major References

Electronic Product Recovery and Recycling Baseline Report, National Safety Council, Environmental Health Center, Washington, D.C., May 1999.

This document is the best single source currently available for documentation on quantities of electronic products available for recycling and quantities that are currently recycled. Besides extensive quantitative research, this report also provides important market analysis as well as several descriptive models of material flows and decision making trees. It also provides an excellent set of tables projecting market growth for electronic recycling.

Residential Collection of Household End-of-Life Electrical and Electronic Equipment, US EPA, February 1998 (EPA-901-R-002)

Provides a highly detailed description and analysis of some of the first EPA funded electronics drop-off pilot projects in Somerville, MA and Binghamton, NY. Gets down to important levels of detail, especially as regards logistics and program promotions. Highly detailed collection statistics. Absolutely a necessary read for anyone planning an electronics drop-off.

Analysis of Five Community Consumer/Residential Collections End-of-Life Electronic and Electrical Equipment, US EPA, April 1999 (EPA-901-R-98-003)

This report provides similar data on Somerville and Binghamton's programs (above), but also includes new data on programs in San Jose, Hennepin County, Naperville & Wheaton, Illinois and Union County, New Jersey. This too is must reading for anyone considering consumer based collection. Since there are a broad range of programs evaluated here, the report provides great comparative tables and statistics.

Plug Into Electronics Reuse, Brenda A. Platt & Jennifer Hyde, Institute for Local Self-Reliance, Washington, D.C., February 1997.

One of the best single publications available on the economic development potential of computer reuse. Provides detailed tables on job creation and other economic development and recycling indices.

Disposition and End-of-Life Options for Personal Computers, H. Scott Matthews, et al, Carnegie Mellon University Green Design Technical Report #97-10, Pittsburgh, PA.

This detailed analysis is by far the best single document available presenting an informed macro-economic analysis of old computer recovery and disposal options. It is a detailed model using 17 years of computer industry sales history as base data and then extrapolates out to the year 2005. Assumptions for estimating techniques are clearly stated. A flow chart diagram is offered representing path options for old computers once they become obsolete.

Designing for the Environment: A design guide for information and technology equipment, American Plastics Council Information Technology Industry Subcommittee, Washington, D.C., 1997.

While representing industry and promoting non-regulatory solutions, this booklet provides useful detailed technical information on plastics recovery, reuse and source reduction initiatives for the electronics industry. Plastics identification standards are also provided.

Computer Recycling in Layman's Terms, Texas General Land Office under a grant from the US EPA, Dallas, TX, March 1995.

Providing exactly what it promises, this publication is a 42-page summary of computer recycling as an issue in Texas circa 1994/95. Besides numerous first-hand quotes by practitioners in the field, this document also offers an interesting discussion on the lack of coordination for environmental technology R&D by the federal government and the simultaneous lack of centralized information on foreign developments along these same lines. While many of the companies identified here do not show up on more up-to-date lists (presumably because they are no longer in business or have changed their names), a list of recommendations specifically oriented to market development is offered at the end of the document. In addition, two informative tables are provided offering a 1994 version of a materials breakdown for old computers (remember, this would be for computers sold in 1988 and 1989). This document is out of print and somewhat dated, but worth the read.

“Green Paper on the Environmental Issues and Needed Research in Color Displays,” Burris, George R., et al, Electronic Industries Alliance, Washington, D.C., December 1996.

This summary paper accessed through the Worldwide Web presents basic engineering arguments for more research into CRT screen recovery. It also critiques EPA pretreatment requirements for “hazardous debris” from the CRT recovery process. Of particular note is the discussion of “downcycling” as a means to address the serious materials identification process that arises due to

unknown and obsolete glass compositions. The authors point out that over the last 25 years there have been more than “100 different panel compositions and several different transmissions for each composition.”

“Position Paper on the Management of Used Electronic Products,”
Electronic Industries Alliance, Washington, D.C., March 1997.

This paper provides a well-defined position by the electronics industry on managing used electronic products. Policy deliberation by MACREDO must clearly address the issues this paper defines. In particular, EIA posits that successful management techniques must be voluntary and market-based, rather than driven by regulation. The paper provides a concise summary of the industry’s best efforts on this front, i.e., design for the environment (DfE). A commitment to working with government, environmental groups, consumers, and other stakeholders is made clear. EIA’s stated goal is to develop a “new paradigm” stressing flexible, market-based solutions and encouraging local experimentation in developing an infrastructure to manage used products efficiently.

Recycling at Work: Computer Recycling Survey Results Summary, prepared by the Recycling at Work Campaign for the Municipal Waste Management Association (affiliated with the U.S. Conference of Mayors), Washington, D.C., 1997.

This research provides interesting statistics on surveys of 145 cities (38.3 million people). Survey highlights include the finding that half of the communities surveyed dispose computers in landfills and a little more than half reported that obsolete computers are donated to schools. One major conclusion of the research is that a fairly well-defined reuse network is in place to handle computer donations and resale. Another relevant conclusion is that communities need better knowledge of local markets and regulatory issues.

“Extended Product Responsibility for the Electronics Industry,” Patricia S. Dillon; in *Extended Product Responsibility*, Gary A. Davis and Catherine A. Wilt, et al, Center for Clean Products and Clean Technologies, The University of Tennessee, Knoxville, TN June 1997.

This chapter in *Extended Product Responsibility*, provides a series of case studies on Compaq Computer’s DfE work, Hewlett-Packard’s product stewardship program, and Nortel’s product life-cycle management program. State-of-the-art descriptions of numerous environmental initiatives are good illustrations of corporate leadership.

Electronics Reuse and Recycling Directory, US EPA, Washington, D.C., January 1997.

This is one of the more comprehensive national listings of companies involved in old computer and electronics recycling. During the course of research however numerous other firms have been encountered who are not listed on this EPA directory. Another useful list can be found through the Parents, Educators and Publishers (PEP) National Directory of Computer Recycling Programs on the Worldwide Web (see the list below).

Electronic Product Recovery and Recycling (EPR2) Conference Summary Report, National Safety Council, Washington, D.C., February 1997.

It provides a summary of the first national conference on electronic product recovery and recycling, including presentations on product design strategies, allocating responsibility for disposition of end-of-life equipment, electronic product reuse and economic aspects of electronic product recycling.

“Recycling Electronic and Computer Components: Regulatory Issues,” Matthew Brosco and Roy Deitchman, NYNEX Corporation, from the *Newsletter for the Demanufacturing Partnership Program - Rutgers University*, New Brunswick, NJ, 1996.

This paper is a very general description of the regulatory ambiguities surrounding the impact of RCRA Subtitle C on electronics demanufacturing.

Implementing Design for Environment, Massachusetts Institute of Technology, Cambridge, MA.

This document was prepared as a joint effort between MIT and Digital Equipment Corporation. It is billed as a short primer on implementing DfE in business.

“Nurturing Neighborhood Nets,” Gary Chapman and Lodi Rhodes, in *Technology Review*, October 1997.

This article provides excellent background information on the concept of community technology access which is becoming directly linked to computer reuse.

(<http://web.mit.edu/org/t/techreview/www/articles/oct97/chapman.html>)

“Program Recycles Government Computers for Schools,” Pamela Mendels, from *New York Times CyberTimes*, November 8, 1997.

Provides background on the “Computers for Learning” project backed by Vice President Gore. The program donates old computers from federal government offices to public schools and educational non-profits.

(<http://www.nytimes.com/library/cyber/week/110897gore.html>)

General Trade Magazine Articles

“Resurrecting the Computer Graveyard,” Cheryl L. McAdams, *Waste Age*, February 1995.

While providing only a quick and cursory description of computer recycling (the article was researched and written at the end of 1994), this piece gives a good simple description of the CRT recovery problem.

“Circuit Board Recycling Increases,” Anne Claire Broughton, *Recycling Today*, May 1996.

This article provides an excellent summary of circuit board recycling and demanufacturing issues. As the former editor of *Recycling Today*, Broughton provides the perspective of the recycling and scrap industry entrepreneur. Besides a rundown of the basic market and regulatory issues (mid-1996) she provides market data that are not easily found elsewhere, e.g., a ton of circuit boards contain about 10 ounces of gold; it costs \$5 a monitor or roughly \$200 a ton to process CRTs (plus the shipping cost); for every five PCs sold only one gets recycled.

“Scrapping the Information Highway,” Rob Arner; *Resource Recycling*, June 1997.

Good summary article on computer reuse. Provides a nice synopsis of several of the larger computers for schools programs and a summary of the economic development findings from ILSR’s *Plug into Electronics Reuse*. With publishing time lags, it is likely that this article was written nearly a year ago. Since that time the industry has expanded dramatically.

“Computers & electronics recycling: Challenges and opportunities,” J.D. Porter; *Resource Recycling*, April 1998.

Another good summary article on computer recycling options. Almost a primer on market opportunities. A definite read to understand the breadth of the challenge and opportunities for electronics recycling.

“Collecting Computers and other electronics,” David Biddle, Resource Recycling, August 1998.

General synopsis of residential collection options circa 1998. Provides a simple summary of curbside, HHW drop-off and public-private drop-offs.

“The Conundrum of Computer Recycling,” Leah B. Jung; Resource Recycling, May 1999.

An excellent summary of computer recycling issues and the complexity of being in the business. Provides solid succinct statistics at the beginning of the article and then leads the reader through all the basics. A great sidebar on the challenge of computer plastics is also offered.

“Making Electronic Recycling Connections,” Melissa Goodrich; Recycling Today, September 1999.

A good article identifying recent business innovations, short descriptions of key companies and a discussion of some of the pitfalls of electronics recovery. Focus is mostly on metal and other high end scrap recovery. Good “design for recycling” sidebar. Ends with a discussion of how European takeback policies could have a strong impact on the industry everywhere.

Worldwide Web Resources¹⁸

Electronic Industries Alliance Environmental Issues Council

http://www.eia.org/grd/eic/eic_docs.htm

Position papers, on-line .pdf directory; great set of comments and industry opinion on EPA and CRT recycling policy.

Another Byte - Non-profit Computer Recycling Directory

<http://www.infomagic.com/~abyte/byte/others>

Excellent set of web page lists!

¹⁸ Please contact and inform the author of any inaccessible sites or apparent typos in addresses at jango@aol.com.

California Materials Exchange

<http://www.ciwmb.ca.gov/calmax/search.asp>

Good source for state-of-the-art reuse information. On-line classifieds for creative reuse programs. Go to the "search listings" section and look up Electronics. Limited value as this program is for California region only.

Comp-Recyclers New and Used Computer Parts

<http://www.comp-recycle.com>

A full service, on-line used computer catalog with AMAZING deals!

Computer Recycling Organizations List (Dale Tersey)

<http://www.wco.com/~dale/list.html>

Good list of major programs around the country. Contains lots of hotlinks to other sites and email addresses. Hasn't been updated since October 1996 though.

Computer Recycling Project, Inc. (Dale Tersey)

<http://www.wco.com/~dale/crp.html>

Linked to the list above, this used to be one of the premier reuse non-profits in the country. Doesn't seem to have been updated in at least a year. They also seem to have changed their mission and no longer actively broker used products. Their main mission now seems to be helping network buyers and sellers. Located in California.

Recyclers World Computer Recycling Section

<http://www.recycle.net/recycle/computer>

One of the best sites with comprehensive info. on reuse, recycling, demanufacturing, etc.

Demanufacturing Partnership Program - Rutgers University

<http://www.rutgers.edu/Accounting/raw/gsm/dpp>

This is a great site that doesn't get visited much and doesn't seem to be updated enough. Several excellent, informative newsletters are available on-line from 1996 discussing extended producer responsibility, jobs through electronic demanufacturing, regulatory issues, etc.

Advanced Recovery, Inc.

<http://www.advancedrecovery.com>

One of the major demanufacturing companies on the east coast. Very informative site, very good links, offers scrap prices, recent newspaper articles about Advanced, and a decent synopsis of environmental issues.

Computers for Learning Project

<http://www.computers.fed.gov>

New program linking federal government obsolete computers with needy school districts and educational institutions. Application information is available on site.

DMC Recycling, Inc.

<http://www.dmcrecycling.com>

Excellent company site on demanufacturing. Good resources beyond self-promotion. Located in New Hampshire.

Envirocycle, Inc.

<http://www.enviroinc.com>

Premier east coast demanufacturing company specializing in CRT recycling located in northern PA.

ITParade.com

<http://www.remarketing.com>

A "remarketing" web site catering to asset recovery issues in general and resale of refurbished products. Offers used computer dealers and end users a marketplace. Requires membership.

Non-profit Technology Resources

<http://www.libertynet.org/~ntr>

A Philadelphia non-profit that is part of the city's computer reuse collaborative. A section called "History of Reuse Collaborative" may be accessed here.

Philadelphia Reuse Collaborative

<http://www.reusers.org>

This is a new site, but a good source for technical tips as well as general computer reuse information. Contains an interactive, nationally-oriented reuse database.

Common Sense Initiative (CSI) - Computers and Electronics Sector

<http://www.epa.gov/commonsense/computer>

This is a comprehensive computer recycling site by a leading computer recycling policy group. Lacks hotlinks to subcommittee members' sites and does not provide phone numbers and/or email addresses.

The Institute of Electrical and Electronics Engineers, Inc.

<http://www.ieee.org>

Provides access to numerous technical papers relating to electronics demanufacturing. Go to the electronic library and do key word searches.

Further Information

Green Design Initiative - Carnegie Mellon University

<http://www.ce.cmu.edu/GreenDesign>

This is the homepage for the group that did the study, *Disposition and End-of-Life Options for Personal Computers*, H. Scott Matthews, et al, Carnegie Mellon University Green Design Technical Report #97-10. Numerous other related publications are available including articles on battery recycling, and life-cycle cost analytical techniques.

Parents, Educators and Publishers List (PEP)

<http://www.microweb.com/pepsite>

Besides the EPA directory, this site is the best resource listing computer recycling programs around North America. Information is also available on international programs.

TecsChange Homepage

<http://www.tecschange.org>

Volunteer technology reuse collective working to bring electronic and other products to the third world.

United Nations Environmental Programme

<http://unep.org>

This is one of the more detailed and complete sites available on sustainable product development issues. Provides numerous esoteric but useful listings of other sites, details on research projects, and case studies of industry development programs.

Waste Prevention World

<http://www.ciwmb.ca.gov/wpw>

An on-line database providing a wealth of information on business waste prevention.

Appendix C: Comprehensive List of Mid-Atlantic Programs

Delaware

Computer Recycling Center
Goodwill Industries of Delaware
300 East Lea Boulevard
Wilmington, DE 302-761-4646

District of Columbia

Davis Memorial Goodwill Industries
2200 South Dakota Avenue, N.E.
Washington, D.C. 20018 202-636-4225 ext. 1215
Contact: Joe Carter

Maryland

Computer Reclamation, Inc.
10759 Tucker Street
Beltsville, MD 20705 301-495-0280
Contact: Peter Gentieu; Jim Offutt

Lazarus Foundation
10378 Eclipse Way
Columbia, MD 21044 410-740-0735
Contact: Don Bard

The Phoenix Project
8623 Spruce Run Court
Ellicott City, MD 21043 410-750-2435/301-731-9062
Contact: Art Silvergate

Pennsylvania

Goodwill Computer Recycling Center - Pittsburgh
2600 East Carson Street
Pittsburgh, PA 15203 412-481-9049
Contact: Lisa Campbell

Philadelphia Area Computer Society
1900 W. Olney Avenue
Philadelphia, PA 19141 215-951-1255
Contact: Steve Weissman

Philadelphia Reuse Collaborative
Non-profit Technology Resources
1600 Arch Street, 2nd Floor
Philadelphia, PA 19103 215-686-5923
Contact: John Zelson

Elemental, Inc.
5431 Erderick Street
Philadelphia, PA 19104 215-387-5379
Contact:

Share the Technology - New Jersey/Philadelphia area
PO Box 548
Rancocas, NJ 08073 609-234-6156
Contact: Barry Cranmer

Student Computer Recycling to Offer Underrepresented Groups in Education
(SCROUNGE)
Pennsylvania State University
101 South Frear Lab
University Park, PA 16802 814-863-7688
Contact: Geraldine Russell

Virginia

Educational Institutions Partnerships Program
Defense Information Systems Agency
701 South Courthouse Road
Arlington, VA 22204-2199 703-696-1904
Contact: Sharon Sellers or Gina Meehan

Gifts in Kind International
333 North Fairfax Street
Alexandria, VA 22314 703-836-2121

R. Frasier, Inc.
PO Box 1385
Salem, VA 24153 800-727-4258

Second Chance Program
10700 Page Avenue
Fairfax, VA 22030 703-246-4542
Contact: Bob Kelly

West Virginia

None Listed

Appendix D: Component Terms and Specifications¹⁹

Populated Circuit Boards

Populated Circuit Boards shall consist of whole circuit boards with all components still attached. (the term populated refers to the components "living on the boards" i.e.: IC's, Capacitors, etc.).

Circuit Boards (sheared flush)

Circuit Boards (sheared flush) shall consist of un-populated circuit boards or circuit boards that have had all the components removed either by manual dismantling (de-soldering) or by means of shearing the components off so that the surface of the circuit board is "sheared flush."

Scrap Whole Computers

Scrap Whole Computers shall consist of whole or un-dismantled PC or mainframe Computer systems.

Scrap CPU Units

Scrap CPU Units shall consist of whole, un-dismantled CPU's (Central Processing Units), free of monitors or keyboards.

Soldered Circuit Board Trimmings

Soldered Circuit Board Trimmings shall consist of trimmings or rejects from new etched (solder coated) copper clad circuit boards.

Finger Trimmings

Finger Trimmings shall consist of gold plated trimmed "male" cookout board connections.

Trimmed in such a fashion as to remove any excess non-gold content materials, trimmed as close to the gold as possible.

¹⁹ Downloaded from Recyclers World
(<http://www.recycle.net/recycle/computer/index.html>)

Mixed Scrap Integrated Circuits (IC chips)

Mixed Scrap Integrated Circuits (IC chips) shall contain assorted integrated circuit chips, whole or sheared from populated circuit boards, free of other types of components.
May include ceramic or balolite covered chips.

Sorted Integrated Circuit (IC chips)

Sorted Integrated Circuits (IC chips) shall consist of a single sorted style of integrated circuit chip.
Must be homogeneous material.

Scrap Capacitors

Scrap Capacitors shall consist of whole or recovered capacitors, must be primarily tantalum capacitor materials.
May include sorted capacitors from populated circuit board shearing.

Mixed Components (sheared or dismantled)

Mixed Components (sheared or dismantled) shall consist of assorted electronic components recovered from dismantling or shearing populated circuit boards.
Must be free of shredded circuit boards or trimmings of circuit boards.

Unclipped Internal Wires & Connectors

Unclipped Internal Wires & Connectors shall consist of wires & connectors attached to wires from the interior of the computer. May include ribbon wire & fine plastic insulated wires. May not include double insulated wires.

Clipped Internal Wires

Clipped Internal Wires shall consist of wires from the interior of the computer. May include ribbon wire & fine plastic insulated wires. May not include double insulated wires. Must be free of all connectors.

Unclipped External Wires & Cables

Unclipped External Wires & Cables shall consist of wires and cables with connectors still attached, may include double insulated wires.

Clipped External Wires

Clipped External Wires shall include all sorted trimmed computer wire & cable free of connectors and attachments.
May include double insulated wires.

External Connectors

External Connectors shall consist of sorted connectors, free of or trimmed from wires.

Transformers & Transformer Windings

Transformers & Transformer Windings shall consist of sorted copper wire coils on cores.
Free of attachments.

Scrap Drives

Scrap Drives shall consist of assorted hard drive units or floppy drive units.

Scrap Keyboards

Scrap Keyboards shall consist of sorted scrap keyboards.

Scrap Printers

Scrap Printers shall consist of whole scrap printer units.

Scrap Plastics (Computer Shells)

Scrap Plastics (Computer Shells) shall consist of sorted clean plastic shells or outer cases of computers, video display units, keyboards or printers. Must be free of metal (including screws) and other foreign materials.

Assorted Scrap Computer Plastics

Assorted Scrap Computer Plastics shall consist of any part of the computer system made of any grade of plastic, sorted & free of metal or other non-plastic materials.

Scrap Floppy Disks

Scrap Floppy Disks shall consist of assorted used or unused 3.5' or 5 1/4' floppy diskettes.

Scrap CD's

Scrap CD's shall consist of assorted used or unused compact disks.

Scrap Monitors (VDT)

Scrap Monitors (VDT) shall consist of whole Video Display Terminals which contain a Cathode Ray Tube in a shell or case.

Other Computer Scrap

Other Computer Scrap shall contain miscellaneous computer scrap materials not included in the listed grades.

The Following Grades are Included in the CRT (Cathode Ray Tube) Recycling Category:

- Whole VDT/TV Scrap
- CRT Scrap
- 1/8" Recovered CRT Glass (Andela #16)
- 3/8" Recovered CRT Glass (Andela #17)
- CRT Tailings
- Other CRT Scrap