

March 15, 2005

Electronic Waste: Finding Sustainable Solutions that Work Better for Consumers

A Consumers Union White Paper

Carolyn Cairns
Senior Project Leader
Consumers Union of U.S., Inc.
101 Truman Avenue
Yonkers, NY 10703-1057 USA
914-378-2303
cairca@consumer.org

Consumers Union (CU), publisher of Consumer Reports, is an independent, nonprofit testing and information organization serving only consumers. CU is a comprehensive source for unbiased advice about products and services, personal finance, health and nutrition, and other consumer concerns. Since 1936, CU's mission has been to test products, inform the public and protect consumers. CU's income is derived solely from the sale of Consumers Reports and its other services, and from noncommercial contributions, grants, and fees. CU is online at <http://www.consumersunion.org>.

Contents

	<u>Page</u>
INTRODUCTION	1
RECOMMENDATIONS	4
I. THE PROBLEM: HIGH PRODUCT TURNOVER/ GROWING QUANTITIES OF WASTE	10
- <i>E-waste Costs Consumers in Two Ways</i>	10
- <i>Product Obsolescence is the E- Waste Engine</i>	
- <i>The Challenge of Changing Technology</i>	11
- <i>Some Barriers to Using Old Equipment are Artificial</i>	13
- <i>Consumers Lack Tools and Technical Support to Extend Product Life</i>	14
II. CURRENT OPTIONS TO REDUCE AND RECYCLE E-WASTE ARE LIMITED	14
- <i>State Governments Try Different Approaches</i>	15
- <i>Voluntary Corporate Programs Won't Solve the Problem</i>	17
- <i>Consumer Convenience is not adequately Considered</i>	17
III. CLOSING THE LOOP WITH REFURBISHED AND RECYCLED EQUIPMENT	19
- <i>Fate of Equipment Returned for Recycling is not Tracked or Verified</i>	19
- <i>Post-consumer Equipment Must be Available, Safe and Reliable</i>	21
- <i>Many Barriers to Refurbishing Products for Donation or Resale</i>	22
TABLES AND APPENDICES	
TABLE 1 Estimate of the Quantity of Electronic Waste Generated by a Typical Household	24
APPENDIX A Consumer Tips for Recycling Electronic Equipment	25
APPENDIX B Recommendations for Future Research	26

Electronic Waste: Finding Sustainable Solutions that Work Better for Consumers

INTRODUCTION

Waste electronics equipment has been characterized as one of the fastest

growing categories of municipal solid waste. The growth of the electronics sector and the rapid changes in technology mean that more consumers are replacing more equipment more often than ever before. Though the actual volume of electronic waste generated in the U.S. is not tracked, the National Safety Council and others have projected that the cumulative number of obsolete computers alone may now approach, or even exceed 300 million.¹ Many of these units are being stored in homes while consumers look for acceptable reuse or recycling options. However, if all these units were discarded, waste hauling and disposal systems would have to absorb a huge amount of material that could contain a host of toxic constituents including:

- some four billion pounds of plastic,
- nearly one billion pounds of lead,
- two million pounds of cadmium, and
- four hundred thousand pounds of mercury.²

Cell phones are also piling up. INFORM, a non-profit environmental group, estimates that consumers are replacing about 100 million units each year, and that less than 1% is collected for recycling.³ In total, EPA estimates that about 2 million tons of used electronics equipment is thrown away each year.⁴

¹ United States. Environmental Protection Agency, "Recycling Old Computers," October 15, 2002. August 31, 2004 <<http://www.epa.gov/region02/r3/compute.htm>> 1; ---, ---, "Market Trends," October 15, 2002. August 25, 2004 <<http://www.epa.gov/epaoswer/hazwaste/recycle/ecycling/trends.htm>> 1.

² United States. Environmental Protection Agency, "In the News- Electronic Recycling," June 10, 2002. August 31, 2004 <http://www.epa.gov/earth1r6/6xa/elec_recycle.htm>.

³ Most, Eric, Calling All Cell Phones: Collection, Reuse, and Recycling Programs in the US. (INFORM, Inc., 2003) 1.

⁴ United States. Environmental Protection Agency, "Electronics" June 10, 2004. December 1, 2004 <<http://www.epa.gov/epaoswer/non-hw/recycle/jtr/comm/electron.htm>> 1.

Finding workable solutions to this growing problem is increasingly urgent. Drawing in part on Consumer Reports evaluations of electronics products, telecommunications services, and existing equipment recycling options, this paper characterizes the e-waste problems facing consumers and describes the types of changes needed to enable consumers to reduce their e-waste burden while continuing to partake of the benefits of technological innovation.

A Product Life Cycle Approach is Needed

The rapid turnover of electronics products is a growing problem for consumers at both ends of the chain of commerce. At the front-end, changes in electronics technologies and the wide range of telecommunication and other wireless services often make it difficult, if not impossible for consumers to avoid replacing electronic equipment at a rapid pace. Still-functioning equipment is rendered obsolete by changes in software, telecommunications systems or more sophisticated computing demands of new peripherals such as video cameras or scanners.

Manufacturing new equipment consumes an enormous amount of natural resources. According to researchers at United Nations University, production of one desktop computer consumes at least 530 lbs fossil fuel, 50 lbs of chemicals and 3,330 lbs of water.⁵ Water consumption is especially high for the manufacture of silicon wafers, a mainstay of all digital equipment. It takes an estimated 17 gallons to produce a single square inch of silicon. On average, a single semiconductor factory can use up to 20 million gallons per month⁶ – roughly the equivalent amount consumed by a town of 8,000 people (assuming 89 gallons/person/day).

This high level of product turnover has, in turn, precipitated a growing volume of toxic inputs to the local waste stream. If not contained, these toxic chemicals can come back to consumers and the public as air, food, and water contaminants. The Environmental Protection Agency has identified electronic waste (e-waste) as the largest single source of lead contamination in municipal solid waste, comprising an estimated 30% of the total lead inputs.⁷ Polybrominated

⁵ United Nations University, “UN study shows environmental consequences from ongoing boom in personal computer sales.” Public Release March 7, 2004. [EurekaAlert.org](http://www.eurekalert.org). 2004. (American Association for the Advancement of Science.) August 18, 2004 <http://www.eurekalert.org/pub_releases/2004-03/tca-uss030204.php> 1.

⁶ Mathews, H.S., and D.H. Mathews, Information Technology Products and the Environment. Computers and the Environment: Understanding and Managing their Impacts. Eds. Ruediger Kuehr and Eric Williams. (Kluwer Academic Publishers, 2003) 24.

⁷ Shapiro, Andrew, D. Ogunseitan, et al., “The devil that we know: Lead (Pb) replacement policies under conditions of scientific uncertainty.” California State University, Northridge Alumni (CSUN) Presentation. <http://www.industrial-ecology.uci.edu>, Downloaded January 4, 2005.

diphenyl ethers, a common class of flame retardants used in electronics products, have been measured in computer dust and can be released to the environment when products are used, recycled, or disposed in landfills and incinerators. Animal studies show these compounds can cause neuro-developmental toxicity and disrupt thyroid and liver function. They also tend to persist and bio-accumulate in the food chain, ultimately posing risks to human health.⁸ Effective solutions must focus not only on the end of the chain of commerce, when products are discarded, but they must also confront the sources of e-waste and the barriers to reuse and recycling that exist throughout the product life cycle.

Reuse and Recycling Options Must Work Better for Consumers

Alternatives to sending this equipment to landfills and incinerators have been growing. We identified no fewer than 30 different national programs that promote reuse and recycling of discarded equipment. But consumer awareness of electronic waste recycling options is low, and the infrastructure for reuse and recycling is highly fragmented, inconsistent, inconvenient, and often costly for consumers. As a result, just a small fraction of the total volume of electronic waste is actually collected, and not all the equipment that is collected is actually reused or recycled. Manufacturers have little incentive to redesign products to extend their useful life expectancy and facilitate recycling.

Consumer and environmental impacts of the equipment that is returned for recycling and reuse extend to its fate in the U.S. and in other parts of the world. A substantial quantity of the equipment returned for recycling, more than half by some estimates may actually be exported for disposal in other countries where environmental and occupational health protections are weak and landfills are not properly controlled.⁹ However, because electronic recycling programs rarely track the actual fate of products returned for recycling or track it in a transparent manner, firm data are not available. Some electronic products are refurbished for resale, raising questions about the safety and quality of these goods and their impact on the waste stream in countries where they are sold.

⁸ Sjodin, Andreas et al, "Flame Retardant Exposure: Polybrominated Diphenyl Ethers in Blood from Swedish Workers." (*Environmental Health Perspectives* August 1999) 643.

⁹ Puckett, Jim et al, *Exporting Harm: The High-Tech Trashing of Asia*. (The Basel Action Network and Silicon Valley Toxics Coalition, February 25, 2002) 1.

RECOMMENDATIONS

The implications of waste electronic equipment for consumers and the environment are clearly significant. Effective solutions must, at the same time, protect the consumer right to a clean environment as well as a fair and just marketplace. The following recommendations outline the types of changes in government policies and business practices that are needed to improve consumer recycling options, to remove obstacles to longer product life, artificial drivers of product turnover and barriers to product reuse, and to make products with less toxic and more recycled material.

Streamline Recycling: Develop a National Product Take-back System

Recommendations: 1) establish a national system; 2) make it convenient for consumers; 3) study Maine and California programs; 4) certify the fate of electronic waste and track its impact on the environment and waste management system.

Government action is key to developing meaningful electronic recycling options for consumers. Consumers need a national recycling system based on the principles of Extended Producer Responsibility, which shifts the cost of managing discarded electronic equipment to brand-owners and producers. Such a system would internalize the costs of managing electronic waste into the price of the product, thereby promoting competition among manufacturers to reduce product obsolescence and facilitate recycling.

Systems such as the California Advanced Recycling Fee that place the entire burden on the consumers and state government, provide no incentive for manufacturers to design products to reduce waste and facilitate recycling. Further, such systems run the risk of attributing an even greater share of the costs for recycling to consumers as municipal and state waste management budgets grow increasingly stretched. As mandatory state recycling programs in California and Maine go into effect, it will be extremely important to fully assess the financial impact of both approaches on the consumer and the impact on product design and marketing patterns. Even more important is to analyze the impact of these different approaches on the amount of e-waste that's generated, reused or recycled.

Electronic waste management systems must be transparent about the fate of discarded, refurbished or recycled products. Systems are needed to track the environmental fate of e-waste

to ensure that products dismantled for recycling are actually recycled and that hazardous constituents are properly managed. The amount of equipment that is disposed in landfills or incinerators in the U.S. and abroad must be reduced. The recent efforts by the Basel Action Network, and the EPA, to work with stakeholders to explore a possible certification system to verify the fate of recycled equipment is an important development in this regard and should be continued.

Eliminate Toxics and Increase the Use of Recycled Materials and Components

<p><u>Recommendations:</u> 1) Institute government policies and business practices to eliminate the most toxic substances and promote the use of safer alternatives; 2) establish time-bound targets for the use of recycled content in new products.</p>

Producing electronic products with less toxic constituents and more recycled materials is critical. Industry standards, government regulations, and consumer education are all important tools that must be developed to ensure that new products are introduced in a manner that protects consumers and the environment.

Increasing consumer education about the hazards associated with disposing e-waste with regular trash can help promote recycling. Labels identifying electronic goods that contain toxins like lead or brominated flame retardants could both encourage consumers to recycle those items and help ensure that recyclers handle them appropriately.

New product designs that reduce the use of lead and brominated flame retardants are being developed, partly in response to regulations in the European Union to phase out the use of these chemicals.¹⁰ While these are positive developments, the ultimate benefits to consumers and the environment will depend heavily on finding less toxic alternatives that are affordable and functional. Further research in both areas must continue.

The recyclability of electronics components and the use of recycled materials in new equipment are pre-requisites to cost-effective and environmentally sustainable reuse and recycling systems. Again, industry standards can make product components more consistent and recyclable. Government regulations could help establish time-bound targets for component recycling and the use of recycled materials in new products.

¹⁰ [“The WEEE and RoHS directives: Highlights and Analysis, July 2003”](#) (INFORM Inc. July 2003) 2.

Remove Obstacles to Equipment Upgrades and Repairs and Develop Quality and Safety Standards for Refurbished Products.

Recommendations: 1) make interchangeable components, aftermarket parts, and product repair services more available and affordable for consumers; 2) develop and enforce quality and safety standards for second-hand and refurbished

The functional lifespan of many electronic products is often cut short by design deficiencies and the limited availability of affordable replacement parts and repair services. For example, the lifespan of many products including PDA's, cell phones, MP3 players, etc. depends on whether the battery is replaced. Often new batteries are priced remarkably high relative to the cost of new equipment, and in many cases the product design requires the consumer to return the item for service in order for the battery to be replaced. Manufacturers must make battery replacement easier and more affordable for consumers.

Industry standards can play an important role in enabling the development of a product repair infrastructure, cost effective product upgrades to enhance usability, and better design for remanufacture and recycling. The International Standards Organization (ISO) has embarked on an effort to develop standards for the sale of second-hand goods.¹¹ A similar effort should be undertaken to develop standards to improve product repairability and recyclability.

In addition, the Cellular and Telecommunications Industry Association (CTIA) has also developed guidelines for the refurbishment of used wireless devices and the collection and transport of these products.¹² If followed, these guidelines may be useful for reuse and recycling efforts, but more work is needed to confront obsolescence issues at the product design and distribution end of the chain of commerce.

Enable Consumers with Information, Tools and Technical Support

Recommendations: 1) track and publish e-waste statistics; 2) survey consumer reasons for product replacement; 3) provide better tools and technical support to help consumers secure privacy prior to recycling and facilitate product maintenance, upgrades and repairs.

2004).

¹² Cellular and Telecommunications Industry Association. CTIA Guidelines for the Refurbishment of Used Wireless Devices, October 22, 2003.;--- CTIA Guidelines for the Collection and Transport of Used Wireless Devices, October 22, 2003.

Reducing electronic waste depends not only on providing reliable and convenient opportunities for reuse and recycling, but also on educating consumers about the problems associated with e-waste and the things they can do to minimize it.

The limited amount of existing information on the quantities of e-waste generated, and its impact on environmental and human health and the municipal, state and federal tax burden is increasingly outdated and based on very rough estimates and projections. Providing consumers with better information of this nature is critical to demonstrating, in a compelling way, how waste reduction, recycling and reuse benefits them and their community directly and is worth their effort and support.

Helping consumers fully exhaust the capabilities of existing equipment before upgrading to new equipment can help reduce the flow of electronic waste. Consumers may be unaware of the options for upgrading an existing computer to meet emerging computing needs, rather than purchasing a new machine. Further survey research and product testing could help assess the extent to which consumers are willing or able to upgrade equipment, identify barriers to developing a more robust market for used equipment, and estimate the impact that product upgrades and used equipment markets could have on the e-waste burden.

Likewise, consumer education campaigns encouraging computer reuse and recycling can appeal to consumers' natural reluctance to relinquish old units by emphasizing that this equipment, which represents such a large investment, need not go to waste. Many consumers may be unaware of the rapid rate of technological obsolescence and economic depreciation of old equipment and not realize that long-term storage only reduces its value for prospective second-hand users, be they family members, buyers or charities. Analyses of the amount of waste stored, the hidden costs of such storage, and consumer attitudes about the relative value of reuse and recycling versus storage will also help increase the amount of retired equipment returned for recycling and reuse.

Other factors that limit retired equipment return rates, such as security concerns about personal information stored on old units, could be addressed by educating consumers about how to confidently erase hard drives and making tools they need to do so more widely available.

The impact of recycling fees, deposits and taxes is another important factor determining e-waste reuse and recycling rates. Deposits paid at purchase and redeemed when the product is returned have served as important incentives for consumers to return beverage containers and car batteries for recycling. These deposit systems offer useful models with which to analyze the likely impact of deposits on electronic waste recycling. However, such fees should only serve as an incentive to return equipment; they should not provide financing to pay for recycling. The benefits of a deposit system need to be weighed against the potential negative impact on low-income consumers who would have to pay more for electronic products. Convenience of product return and the management of unredeemed deposits are important consumer protection issues that need to be appropriately addressed.

Eliminate Artificial Drivers of Product Turnover and Barriers to Reuse

Recommendations: 1) Establish policies to enable consumers to use the same electronic products with different broadcast and telecommunication service providers; 2) Develop ways to design and introduce new technologies that are more compatible with existing equipment and that give consumers meaningful alternatives to replacing old equipment; 3) incorporate full costs of changes in technologies into regulatory and business decisions.

A tremendous amount of product turnover results from the power that broadcast and telecommunication or other wireless service providers have to control product configuration and compatibility between products and the systems in which they operate. Consumers need more protection from the power that service providers have in driving product replacement and more information on choices they do have with respect to services and new technologies.

For example, cell phone service providers gain competitive advantage by locking handsets to prevent consumers from moving to another carrier. Consumers become hostage to their service provider in part because handset locks and technology incompatibilities prevent consumers from reprogramming their handset for use with another provider. Consumers Union supports regulations that prohibit cell phone carriers from locking phones and preventing consumers from using technologically-compatible phones with a new service.

Additionally, changes in telecommunication providers' platforms and computer software can impact the functionality of existing equipment and services. A detailed analysis of these impacts

and their full costs is needed to begin to identify ways to design and introduce new technology to minimize product turnover and waste and to incorporate related costs and other impacts into business and regulatory decisions.

I. THE PROBLEM: PRODUCT TURNOVER IS HIGH AND QUANTITIES OF E-WASTE ARE GROWING

Mention electronic waste to anyone and you're bound to hear a plea for advice on what to do with the old computers and cell phones cluttering their home, and a frustrating story about why the old equipment had to be retired in the first place. Projections by the National Safety Council and others suggest that over 300 million computers are now obsolete and that most retired units are probably stored in America's attics, garages or basements.¹³ This large volume of waste reflects a high rate of product turnover. Many computers and cell phones are replaced as frequently as every 2-3 years,^{14 15} even though both products generally remain functionally operative for much longer.

At this rate, the cost of collecting and recycling the existing inventory of retired equipment currently in storage will be huge. The Silicon Valley Toxics Coalition, a non-profit environmental group, estimates that without legislation shifting the burden to manufacturers, it could cost governments, taxpayers and consumers more than \$7 billion over the next decade to collect and recycle old televisions and computer equipment alone.¹⁶

E-waste Costs Consumers in Two Ways

Electronic waste is a problem that affects consumers in two ways: when an obsolete product has to be replaced, and when the old equipment is discarded. Beyond the lost storage space, fees for recycling and disposal, and potential environmental contamination from recycling and disposal processes, the cumulative cost to consumers of replacing this equipment at such an unprecedented pace is staggering. Assuming that current estimates of product penetration and life expectancy hold steady, we can expect a typical household to retire or discard an average of 3 to 4 electronic products each year.

¹³ United States. Environmental Protection Agency, "Recycling Old Computers".

¹⁴ Lynch, Jim, Islands in the Wastestream 28. ; United States. Environmental Protection Agency, "Life Cycle of Old Computers" United States Environmental Protection Agency. October 15, 2002. November 23, 2004 <<http://www.epa.gov/region02/r3/problem.htm>>. ; ---. ---, "Market Trends". ; United States. Department of the Interior, "Obsolete Computers" 1.

¹⁵ Fishbein, Bette, Waste in the Wireless World: the Challenge of Cell Phones. (INFORM, Inc., 2002) 5.

¹⁶ "Poison PCs and Toxic TVs." 23.

As illustrated in Table 1, a typical household could expect to discard approximately 68 items over a twenty-year period including:

- 20 cell phones,
- 10 computers,
- 7 televisions,
- 7 VCRs or DVD players,
- and several answering machines, printers and compact disc players.¹⁷

For early-adopters of new technologies, the volume of product turnover would be even higher. Confronting this cascade of consumer purchasing decisions is as critical to reducing e-waste as developing convenient, cost-effective and environmentally sound recycling and reuse systems.

Product Obsolescence is the E- Waste Engine

Consumer product obsolescence is a complex source of the e-waste problem. Product design, manufacturing, and marketing decisions, changes in telecommunication systems and consumer interest in new product features and technologies serve as the pump that moves electronic products through the chain of commerce and into the waste stream. The challenge is to find ways to enable consumers to benefit from technological innovations without generating such a large quantity of waste, and to maximize product life cycles and interoperability across the family of digital products and services that most consumers are using. Progress is needed in designing products for easy maintenance, upgrading and repair, and in finding ways to introduce new features and technological innovations in a manner that does not impede the functionality or flexibility of existing equipment.

Industry standards have yet to be developed for many electronics products that could make parts and peripheral equipment more compatible and interchangeable with existing equipment. For example, proprietary interconnections between personal computer “motherboards” and the controls, indicators and connectors on the cabinet currently prevent motherboard upgrading, even though their dimensions, mounting points and power supplies are standardized.

¹⁷ Numbers calculated based on estimated product life expectancy and number of units per household – see Table 1 for references.

The Challenge of Changing Technology

Regular changes in computer operating systems and the digital formats used by wireless telecommunications service providers have played an important role in driving equipment replacement. In the last 2 years, U.S. wireless carriers AT&T/Cingular have migrated from the older Time Division Multiple Access (TDMA) system to Global System for Mobile Communication (GSM). Both use a similar method of digitizing and compressing wireless phone calls to allow several calls to share the network at the same time. Yet the networks are not compatible and few phones have been specially designed to work on both systems. Wireless carriers SprintPCS and Verizon use Code Division Multiple Access, CDMA, yet a third format, which is also incompatible with GSM and TDMA.¹⁸

Rapid changes in technology further complicate electronics purchasing decisions beyond traditional measures of functionality and durability. The purchasing decision now has become a gamble on equipment compatibility with software, other hardware, and with new technologies coming down the pike. For example, the simple purchase of a new digital camera could escalate into the purchase of a new computer and/or printer in order for the consumer to take full advantage of the camera's new features.

Poor coordination between new software and existing hardware can also accelerate equipment upgrades by consumers who unknowingly purchase software that exceeds their existing system's capacity. The highly sophisticated interactive video game, DOOM III, has been developed and marketed even before computers with sufficient graphics-processing capacity to run the software are available on the consumer market.

Rapid changes in technology can also leave many consumers "orphaned" without support to continue to get full functional use of existing equipment. For example, several years ago, when many web designers started using Java Script and other new platforms, consumers with computers equipped with insufficient Random Access Memory (RAM) found their web access increasingly limited unless they were able to add more RAM to their machine.

¹⁸ Consumers Union, "Frequently Asked Questions About Cell Phone Portability" [ConsumersUnion.org](http://www.consumersunion.org/campaigns/learn_more/000960indiv.html). 2004. <http://www.consumersunion.org/campaigns/learn_more/000960indiv.html>.

Some Barriers to Using Old Equipment are Artificial

Some barriers to using old equipment and reducing product turnover are not the result of limitations in technology, but of artificial barriers introduced by product manufacturers and service providers to limit consumer choice and maximize a company's competitive advantage. For example, nearly all wireless service providers use software locks that prevent consumers from taking a technologically compatible phone to another network when they change carriers. While testing cell phones in 2003, Consumers Union (CU) attempted to switch to another GSM carrier to get adequate coverage to perform the tests. Instead of simply unlocking the phone to use it with the new network, the carriers required CU to purchase a new sample of exactly the same phone from the new carrier.¹⁹

The way that new versions of computer operating systems are introduced and distributed can also limit product upgrades and spur product replacement. New versions often sell for about one-third the price of a new computer, tempting many consumers to pay the extra money and get a whole new machine rather than make what are often costly and difficult upgrades to existing equipment. Software licensing agreements can also be a major barrier to reuse. Newer versions usually require more hard drive space and more RAM than older versions, and some are designed in a way that impedes hard drive upgrades. For example, Windows XP's security and user-authentication schemes make it more difficult than with prior Windows versions to flawlessly copy an entire system drive's contents to a new drive. Essentially, Windows XP bonds itself to the hard drive and motherboard when it's installed. Moving an installation to another drive requires software that takes these bonds into account, making it extremely difficult for the average consumer.²⁰

Consumers Lack Tools and Technical Support to Extend Product Life

Also contributing to the rapid rate of product replacement is the lack of built-in, effective tools and technical support to help consumers maintain, upgrade and repair existing equipment. Many consumers may be unaware of the kinds of routine maintenance or repairs (e.g. recovering from

¹⁹ Consumers Union, "Consumers Union Letter to the FCC – Handset Portability, March 11, 2004 <http://www.consumersunion.org/campaigns/escapecellhell/learn.html>.

²⁰ "Moving to a New Computer," Consumer Reports, March 2004.

viruses, expanding Random Access Memory, deleting unnecessary or obsolete files, etc) that are needed to maximize computer performance; or they may have difficulty making simple repairs. They may lack the skills or tools necessary to perform such tasks, or they may be frustrated with technical support services, and, as a result, replace equipment prematurely.

A 2004 Consumer Reports reader survey indicates that consumer satisfaction with computer technical support services is extremely low, with long hold times, voice-messaging systems that are difficult to navigate, and technicians with whom it is difficult to communicate.²¹ A 2000 Consumer Reports reader survey found that readers replacing a computer overwhelmingly did so for greater speed and more features; not because the old one was broken. Presumably these consumers did not perceive equipment upgrades to be a feasible solution.

Likewise, consumers report higher repair rates for computers than for most products. When replacement parts are unavailable or costly relative to the price of new equipment, the ability for consumers to repair even minor product malfunctions is constrained. For many products, what ought to be a simple task, such as replacing a battery, can be a difficult and costly undertaking. Batteries for most portable products including PDA's, cell phones, MP3 players, etc., are often priced remarkably high relative to the cost of new equipment. A battery for a Sony laptop computer can cost between \$250 and \$500, whereas a new laptop sells for about \$1,800. Consumers Union paid \$35 for a Panasonic KXTC 1486B cordless phone, and \$14, nearly half as much, for a new battery. Batteries in some equipment, like PDAs with the Palm operating system, can't be replaced by the user. Instead, consumers must send the unit out for service to have the battery replaced, usually at a substantially higher cost than the battery, itself.²² Sending equipment out for service can also take a lot of time, during which the consumer cannot use the equipment. Making battery replacement easier and more affordable is critical to extending product life and reducing waste. Better tools and technical support to make other repairs and upgrades easier for consumers, to the extent that they lengthen product life, might have a greater impact on e-waste than simply doing more to promote computer recycling programs.

²¹ "Computers Shiny Apple." Consumer Reports, December 2004 41.

²² "PDAs For a Networked World," Consumer Reports, July 2004, p. 32

CURRENT OPTIONS TO REDUCE AND RECYCLE E-WASTE ARE LIMITED

Once a new product is purchased consumers face the dilemma of what to do with the old equipment. Most consumers are reluctant to discard in the trash items that are still functional and that they perceive to be of value. A recent survey of Consumer Reports Online subscribers found that three-quarters of the respondents indicated they had replaced a cell phone within the past two years. More than half of those (56%) still had the old phone, and 25% reported donating the old unit for reuse or recycling.

Once consumers do decide to discard such equipment, finding alternatives to sending it to the local landfill becomes a challenge for even highly motivated consumers. The developing infrastructure for consumer electronic waste reuse and recycling is an incomplete patchwork of programs ranging from infrequent municipal or retailer collection events and manufacturer mail-back services, to charitable donation programs and fee-for-service operations. Simply maintaining a comprehensive and current directory of these programs has proven challenging for even well-funded organizations due to the wide range of products that different programs accept, the frequency and cost of collections and the periodic changes in the way these programs operate.

The changing environment of how these programs work, how much they cost the consumer, what equipment they accept, and the actual fate of returned equipment can all limit consumer participation. Concerns about the environmental fate of returned equipment and security of personal information embedded in equipment that is recycled or reused may also deter consumers from relinquishing old units.

State Governments Try Different Approaches

Several different types of state government programs are emerging to increase reuse and recycling of this growing source of municipal solid waste. California and Maine, the only two states to adopt mandatory recycling legislation, are each taking different approaches to shift the burden away from taxpayers. The California approach shifts the costs to consumers. Maine's approach requires manufacturers to pay for recycling, which will provide an incentive to design products in ways to promote longer life expectancy and facilitate recycling. Municipal taxes will

cover costs of transporting equipment to regional collection sites, whereas manufacturers must pay for collected material to be recycled.²³ While some will inevitably pass these costs on to consumers through price premiums, costs will force manufacturers to compete to lower their recycling costs, providing an incentive to make products easier to recycle.

California's recycling system will charge consumers an advanced recycling fee at the point of purchase. However, it is widely expected that this fee will not be sufficient to support the new infrastructure and full costs of recycling equipment. While revenues from recycled material will offset a portion of these costs, taxpayers will most likely be subsidizing the program.²⁴ Since all manufacturers will be charging the same fee, there will be no incentive to lower recycling costs through product redesign and recycling efficiency. How these different approaches will influence consumer participation and overall recycling rates remains to be seen.

The State of California has also just recently adopted legislation to require manufacturers to collect and recycle cell phones. Under the new law, retailers are required to collect cell phones for recycling at no charge to the consumer.²⁵

In other states e-waste recycling is voluntary, though some, like Massachusetts, have banned certain types of electronic equipment from landfills. In these states, most recycling programs are run by local municipal or public interest organizations, with recycling costs paid through a mixture of tax revenues, government and/or corporate grants, and fees charged consumers who return equipment for recycling.

A recent study of these programs in Massachusetts explores the link between consumer participation and fees for recycling.²⁶ The report suggests that many assess a fee now, and more are expected to do so in the future as financial pressures on municipalities increase. Whether fees or deposits encourage or deter consumer participation is something that requires further research.

²³ State of Maine. An Act to Protect Public Health and the Environment by Providing for a System of Shared Responsibility for the Safe Collection and Recycling of Electronic Waste. Chap 661H.P. 1402-L.D. 1892. July 30, 2004.

²⁴ State of California. Electronic Waste Recycling Act of 2003. Chap. 526 Stat.of 2003. September 24, 2003.; "Computer TakeBack Campaign analysis and position statement on California SB20". September 19, 2003. Computer TakeBack Campaign November 29, 2004, http://www.computertakeback.com/legislation_and_policy/e_waste_legislation_in_the_us/ca_sb20_analysis.cfm.

²⁵ State of California. Assembly Bill No. 2901, approved by the Governor, September 29, 2004.

²⁶ Northbridge Environmental Management Consultants, Characteristics of Massachusetts' CRT Recycling Program. (October 21, 2002) 3-5, 3-16.

Voluntary Corporate Programs Won't Solve the Problem

Like government programs, voluntary corporate recycling programs have been equally piecemeal, inconvenient and costly for many consumers. The most reliable corporate recycling programs are offered by several major manufacturers (Apple, HP, and Dell). These companies offer recycling services that allow consumers to obtain a shipping label and send equipment back to the company. Some companies offer this service is for free or very low cost for customers buying new equipment from these companies; however, consumers buying other brands and those not purchasing new equipment are charged upwards of \$30 per unit.

Some manufacturers have teamed with retailers like Best Buy and Office Depot to sponsor limited-time in-store collection events. In many cases these services are free, but some retailers charge fees or may only collect certain types or brands of equipment. Though these in-store events are more convenient for consumers, the quantities of waste they collect are limited by the frequency with which they are held and the geographic regions they serve.

Voluntary corporate cell phone recycling programs, by comparison, have become more widely available and reliable. Some retailers, including Staples and Radio Shack collect old cell phones right in the store. Some organizations even share resale profits with schools or nonprofit organizations that help collect old phones. However, a recent study by INFORM suggests these programs collect only a small fraction of the total number of discarded cell phones and that more consumer education and improvements in these programs are needed in order for a greater portion of waste cell phones to be recycled.²⁷ Further, it is unclear how these programs would change if markets for refurbished equipment weaken.

Consumer Convenience is not Adequately Considered

Recycling programs vary widely in cost and convenience and are generally limited to computer and television equipment. What consumers consider “convenient” has not been clearly defined, and only one survey of consumer preferences could be located in the literature. A survey of residents in King County, WA, found that some 67% of residents surveyed preferred taking their

²⁷ Fishbein, Bette. Waste in the Wireless World 5.

electronic waste to a local retailer rather than taking it to a landfill, transfer station, or shipping it to the recycling facility.²⁸

A few communities, such as Flint, MI, and Wilmington, MA, offer curbside pick-up, which would appear to be the most convenient option for most consumers.²⁹ Many others have established collection centers, modeled after existing household hazardous waste collection programs. Some of these programs offer permanent drop-off sites, while others organize specific collection events. Drop-off sites with regular hours, in well-traveled locations are generally more convenient than collection events. Consumers need only learn the site location and operating hours, whereas infrequent collection events pose scheduling challenges. One-time events also tend to attract crowds and consumers may have to wait in long lines to return equipment.

Programs that require consumers to ship equipment back to the manufacturer are among the least convenient, particularly for recycling old equipment that is not replaced. Scheduling pick-up is an extra step that can be particularly difficult for apartment dwellers or others who cannot leave large boxes out for postal pick up. Finding shipping boxes and packing material can also be a barrier. Consumers purchasing new equipment may be reluctant to use the box for recycling in case it is needed to return equipment for service. For those not upgrading, the box would be an additional expense. As a result, consumer participation in these programs is likely to be limited.

By contrast, collection events held at retail stores like Best Buy and Office Depot have had an overwhelming response. These limited events have attracted large crowds and collected large quantities of electronic waste. Some retailers distribute coupons and other incentives to attract consumer participation. However, these voluntary programs only reach consumers where stores are located and are only scheduled sporadically in certain regions.

Cell phone recycling is easier, mainly because there is an apparent market for refurbished equipment in developing countries. However, a recent RBRC survey found that more than 70%

²⁸ United States. Environmental Protection Agency, Plug-in to recycling with USEPA: Voluntary Shared Responsibility Pilots for Electronics Recycling. (USEPA, September 22, 2003) 6.

²⁹ Electronic Industries Alliance, "Reuse and Recycle Program in Massachusetts: Program Details." EIA Environment Consumer Education Initiative <http://www.eiae.org/reuse_recycle/state.cfm?id=316&state=MA&state_name=Massachusetts&sortby=name>.http://www.eiae.org/reuse_recycle/state.cfm?id=1175&state=MI&state_name=Michigan&sortby=name

of consumers surveyed were unaware that their cell phone could be recycled, yet 90% said they would participate in collection programs if convenient drop-off points were provided.³⁰

III. CLOSING THE LOOP WITH REFURBISHED AND RECYCLED EQUIPMENT

Successfully reducing e-waste depends on finding ways to “close the loop” - ensure that discarded equipment gets reused or recycled to make new equipment. Ensuring that equipment is appropriately recycled is also important in engaging consumers both in collecting retired equipment and in developing markets and distribution channels for equipment that is refurbished or made with recycled materials and components (post-consumer equipment). Consumer confidence depends on a transparent, reliable system that ensures environmentally sound materials management and the safety and reliability of post-consumer equipment that is re-sold, donated, or recycled.

Fate of Equipment Returned for Recycling is not Tracked or Verified

Some 26 states have proposed or adopted legislation governing the management of electronic waste. California, Maine, Wisconsin and Massachusetts have all taken steps to ban at least some products from local landfills and incinerators. While these programs help keep some types of electronic equipment out of local landfills and incinerators, they offer no guarantee that equipment won't be sent to waste disposal facilities in other countries, or in another state later in the process. Some organizations estimate that the amount of equipment collected for recycling but exported to developing countries for recycling and disposal is likely to be quite substantial. Furthermore, not all components can be recycled. In many cases, equipment is sent to smelters where metals are reclaimed, but plastics are burned, potentially releasing flame retardants and other contaminants into the environment. Municipalities rely on private contractors for e-waste recycling services. Unless they specify in their contracts that equipment must be sent to an audited facility in the U.S., consumers cannot be sure that the equipment they return for recycling will stay out of the environment. Verifying the fate of equipment returned for recycling is critical to secure consumer participation in and taxpayer support for these programs.

³⁰ Rechargeable Battery Recycling Coalition 1.

A coalition of environmental groups has recently established an initial voluntary mechanism for verifying the fate of equipment returned for recycling, known as the Electronics Recycler's Pledge of True Stewardship. Companies signing this pledge agree to prevent the export of hazardous computer components to developing countries, the disposal of waste equipment in municipal landfills and incinerators not equipped to contain hazardous constituents, and the use of prison labor for product recycling. Companies wishing to sign the pledge are initially vetted by the Basel Action Network to verify that they have the appropriate mechanisms in place to comply with the pledge.³¹

The fate of cell phones donated for refurbishing is also at issue. Critics question whether consumers are misled by companies that characterize refurbish-for-re-sale programs as recycling and donation programs. Some companies emphasize the equipment donations that are made to protect against domestic violence, even though, in many cases, the number of units donated is dwarfed by the much larger fraction that is refurbished for sale in developing countries; often a portion of proceeds is donated to charity.³²

Similarly, the fate of equipment that is not refurbished is also a concern. The most commonly recycled component is the battery. The Rechargeable Battery Recycling Coalition (RBRC) has established an industry-wide recycling system that is funded by 300 RBRC licensees whose companies represent more than 90% of the rechargeable power industry. The fee enables licensees to use the RBRC Battery Recycling Seal on their Ni-Cd, Ni-MH, Li-ion and Pb batteries and/or battery-powered products.³³ However, the number of batteries actually returned for recycling is not tracked, and a recent analysis by INFORM suggests that it may be quite low. Some firms claim to replace all batteries in phones refurbished for resale. Others grade the equipment and sell to buyers based on the assessed condition of the battery and the phone itself. Bulk purchasers will almost certainly discard a substantial percentage of the phones that they buy in "as-is" condition. Only one of the cell phone recycling firms we contacted for this report claimed to track and collect unused parts from their clients that purchase in bulk, and pay for it to be managed in an environmentally-appropriate manner. Without a universal tracking system, it is

³¹ Basel Action Network, Instructions for Qualifying for the Electronics Recyclers' Pledge of True Stewardship, <http://www.ban.org/pledge/Instructions%20for%20Qualifying.pdf>.

³² Batista, Elisa, "Recycling? It's Really Reselling" *Wired News* July 8, 2003. November 29, 2004 <<http://www.wired.com/news/print/0,1294,59530,00.html>>.

³³ [RBRC.org](http://www.rbrc.org) and e-mail communication with Emily Baldwin, Spokesperson for RBRC, October 20, 2004

hard to determine how much of the equipment that is collected for recycling is in fact, sent to a landfill or incinerator rather than refurbished for resale.

The likelihood that a given phone will be reused will depend heavily on its compatibility with the technology used by service providers in the recipient countries. TDMA systems, for example, are currently being phased out in many parts of the world and as a result, the market for TDMA phones is expected to diminish. Inevitably, countries that are among the last to adopt new technology can expect to have to handle the largest quantities of waste.

Post-consumer Equipment Must be Available, Safe and Reliable

Consumer concerns don't end once the product is sent back for reuse and recycling. In a closed loop environment, consumer interests carry over to the subsequent life of the product, whether it is refurbished for reuse or recycled into another electronic product or something else. In order for e-waste recycling and reuse to be successful, these products must first and foremost be safe and perform well. But they also must be available, affordable, and compatible with existing equipment. Manufacturer product design practices and warranty policies must enable and facilitate their use.

Currently, some waste computer equipment, and nearly all old cell phones returned for recycling in the U.S. are refurbished and sold to consumers in developing countries. No studies to date could be found of the fate of this equipment, how much it costs relative to new products, how well it works, or its environmental fate in recipient countries. Such questions must be addressed in order to evaluate the extent to which these donation/resale programs constitute a viable long-term solution for consumers and the environment.

Safety and quality of new products made with recycled or refurbished components is critically important for increasing markets for recycled equipment. For example, cell phones can be dangerous if the old battery is replaced with types that lack the proper mechanism to prevent over-heating. There have been some cases of consumer injuries when the use of faulty batteries caused a unit to explode or catch fire.³⁴

³⁴ United States. Consumer Product Safety Commission, "CPSC, Verizon Wireless Announce Recall of Counterfeit Cell Phone Batteries" [Recall Alert](#) (Washington:GPO June 24, 2004) 1 and US Consumer Product Safety Commission Press Release, January 23, 2004, "CPSC, Kyocera Wireless Corp. Announce Recall of Batteries in Smartphone Cell Phones." News from CPSC, Office of Information and Public Affairs, January 23, 2004.

Printer cartridges are vulnerable to quality problems, particularly for color printing with aftermarket units, which are often refurbished. Companies like Staples are collecting cartridges in the store and remanufacturing them for resale under their store brand to create a “closed loop” system. Recent testing by Consumers Union found that compared to the manufacturer brands tested, aftermarket units included in the tests had more problems, ranging from clogged heads to poor ink quality, resulting in limited performance and comparable or higher costs for color printing. However, consumer print quality preferences can vary and many consumers may find aftermarket cartridge performance adequate for many home applications.

Many Barriers to Refurbishing Products for Donation or Resale

Beyond the factors mentioned earlier that limit consumers in upgrading and repairing existing equipment, similar barriers limit equipment refurbishment for donation or resale. Software licensing limitations and hardware configurations can serve to make product reclamation cost prohibitive or functionally impossible. For example, companies like Epson and Lexmark have used microchips to make it more difficult for other companies to refill or refurbish their cartridges and to make it harder for consumers to use other brand cartridges in their printers. Governments in the U.S. and in Europe have challenged these barriers in an effort to promote more competition and bring down prices. Printer manufacturer warranties will not cover damage caused by the use of aftermarket or refilled cartridges. The high cost of printer cartridges relative to the cost of the printer may also help promote turnover of the printer itself, a much larger more material-intensive product.

Industry and government standards can play a large role in creating and supporting markets for recycled and refurbished products, and in ensuring that such goods are safe for consumers. However, if such standards remain voluntary, they may lack the broad compliance and the type of complete and transparent materials tracking systems necessary for success in reducing and recycling electronic waste.

The International Standards Organization (ISO) recently agreed to begin a process to develop standards for second-hand goods, including electronic products, and the Cellular and Telecommunications Industry Association (CTIA) has also taken steps to establish guidance and standards for recycling and reuse.

Intergovernmental agreements can also play a role in promoting recycling and reuse of electronic equipment. Under the auspices of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, governments in partnership with industry and nongovernmental stakeholders have begun a process to develop guidance on electronic waste reuse and recycling that will include standards for product design, and product collection and recycling programs.³⁵ However, their ultimate impact on consumers and the environment will depend largely on the degree of compliance throughout the industry. Equally important is how well products, materials, and waste are tracked, and how accurately progress in reducing and recycling e-waste is measured.

³⁵ UNEP/CHW.7/13 30 August, 2004, Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and Their Disposal, Seventh meeting, 25-29 October, 2004, “report on the Implementation of the Decisions Adopted by the Conference of Parties at its sixth meeting,” Item 6 of the Provisional Agenda. Downloaded from <http://www.basel.int/industry/index.html>, January 3, 2004.

**Table 1 Estimated Quantity of Electronic Waste
Generated by a Typical Household**

Product	Approx. replacement frequency (years)	Number per Household	Total units over 20 Years (1)
Cell phone (2)	2	2	20
Computer (3)(4)	3	1.5	10
Television (3)	8	2.6	7
Compact Disc Player (3)(5)	6	2	7
Printer (3)(4)	4	1.4	7
PDA, Palm pilot, or MP3 player (3)	6	1	3
VCR/DVD (3)	5	1.7	7
Cordless telephone (3)	7	1.5	4
Answering Machine (3)	6	1	3
Estimated total number of units over 20 years:			68

References:

(1) Approximate total number of units that a household would likely purchase over a 20 year period = (number per household/replacement frequency) * 20

(2) Cell Phone Service Survey, Consumer Reports Survey Research Division, November 1, 2004.

(3) 27th Annual Portrait of the U.S. Appliance Industry Statistics, The Life Expectancy/Replacement Picture, Appliance Magazine Sept. 2004, p-5-6.; Federal Communications Commission Spectrum Policy Task Force Report of the Unlicensed Devices and Experimental Licenses Working Group, November 15, 2002; California Energy Commission Post Occupancy Residential Survey, March 1997, P400-94-015CN, p. 3-22.

(4) PCs and Printers Per Household Rises for Third Straight Year, Lyra's Home Printing Survey Reveals, BusinessWire.com, October, 11, 2000;

(5) Soundata Consumer Panel, NARM Sounding Board, October 1996.

APPENDIX A

CONSUMER TIPS FOR REUSING AND RECYCLING ELECTRONIC EQUIPMENT

How to Safely Dispose of your Old Electronics

You know it is bad to trash that old computer or cell phone, but your closets are overflowing with obsolete equipment. What to do?

Electronics = Toxic Trash

The potential impact of electronic waste is staggering. If the volume of retired equipment currently stored in homes were discarded with the regular trash, municipal landfills and incinerators would have to absorb a huge amount of material containing a host of toxic constituents including nearly one billion pounds of lead (about 4 pounds in every monitor), two million pounds of cadmium (in circuit boards), and several hundred thousand pounds of mercury (used in Liquid Crystal Displays). The Silicon Valley Toxics Coalition, a watchdog environmental group, has created an informative visual showing the impact of computer waste on the environment. http://www.svtc.org/cleancc/recycle/life_cycle.htm

Find a New Home for Your Computer or Cell Phone

If the computer or cell phone isn't too old or broken, another user might buy it or take it for free through an ad in your local paper or an online auction site like eBay. Even a relatively old PC can usually be set up to access the Internet. Many local, regional, and national organizations will take usable PCs for groups or individuals who can't buy new PCs. One such national group is the Cristina Foundation (www.cristina.org/dsf).

Nonprofit organizations sometimes collect old cell phones, often then selling them in bulk to firms that either refurbish the phones for re-sale or recycle them. Phones may also be distributed to individuals in need of a phone for use in emergencies. Any working cell phone, even without a service contract, can be used to dial 911. For example, the Wireless Foundation's "Call to Protect" campaign collects wireless phones to benefit victims of domestic violence. Many phones are resold to raise funds. Others are refurbished and become lifelines for domestic violence victims when faced with an emergency situation.

Recycle Responsibly

Computer equipment: If nobody can use the old PC, or it's just too old (that is, it can't run at least Windows 95 or Mac OS 7.5), it may be destined for the scrap heap. Consider keeping the CRT monitor as a spare or giving it away, since it's the most environmentally hazardous component, with pounds of lead-filled glass and other toxics. Some states--Massachusetts was the first--have banned them in landfills.

If you're planning to buy a new PC, some manufacturers, like Dell and HP, offer low or no-cost recycling to customers who purchase new products or services, or special discounts on new equipment for customers who send equipment back for recycling.

Small Electronics, such as cell phones: For small electronic equipment, the most important component to recycle is the battery. Funded by rechargeable battery manufacturers, the Rechargeable Battery Recycling Corporation collects dropped-off batteries from over 30,000 locations listed in a zip-code searchable database on the RBRC web site, <http://www.rbrc.com>. Drop-off boxes for all types of small rechargeable batteries and mobile devices like pagers and cell phones are also available at some big-name retailers like Best Buy and Staples. These retailers may also occasionally host recycling events for larger electronic devices like televisions and computers.

Caution: Not all equipment that is returned for recycling actually makes it to an appropriately managed recycling facility. The Silicon Valley Toxics Coalition has found that some equipment has been diverted to developing countries where equipment is sent to uncontrolled landfills. As a result, the local environment in these areas can become contaminated and some local residents, in an effort to reclaim valuable metal components, can be exposed to hazardous materials. Some companies are pledging to track the equipment that is returned for recycling to prevent export to developing countries and to take special measures to keep the hazardous components out of the environment. When choosing a recycling program, look for ones that use a recycling firm that has taken the Electronics Recyclers' Pledge of True Stewardship [<http://www.ban.org/pledge/Locations.html>]. The program is new, but the number of firms taking the pledge is growing.

Find out Where to Recycle or Donate

To find local recycling opportunities or other organizations that reuse and refurbish computers, consult the state-by-state listings and zip-code searchable databases available on the following web sites:

- The Electronics Industries Alliance www.eiae.org
- Earth 911 www.Earth911.org
- TechSoup www.TechSoup.org. This site includes a zip-code searchable database listing organizations that will take used equipment, those that offer low-cost refurbished products, and other information.

Check with your local waste management agency to find out if your municipality has a recycling program that accepts electronic waste. Many municipalities in states that have banned computer equipment from landfills offer collection or drop-off programs.

Before you resell, donate or recycle:

Whichever option you choose, keep good records, as you may be eligible for a tax deduction for recycling or donating old equipment.

Erase all stored information on your computer hard drive, and/or your cell phone (including your phone book, text messages, and incoming/outgoing phone numbers). Click here for guidance on clearing your computer hard drive (link to Consumer Reports Online "Moving to a New

Computer”). Your handset may feature a manual reset function that should erase data and restore the phone's default settings. Check your phone's manual for details.

Make sure your cell phone account has been completely terminated. If your phone is resold and put back into use, you could find yourself getting the new user's bill.

APPENDIX B

Recommendations for Future Research

1. Assess the financial impact of the California and Maine computer recycling laws on the consumer, on product design and marketing patterns, and on amount of e-waste that's generated, reused or recycled.
2. Evaluate factors that would make replacing batteries easier and more affordable for consumers.
3. Survey consumers about their reasons for replacing electronic equipment and assess the extent to which they are willing or able to upgrade equipment. Identify information, training, and tools that consumers need to facilitate repairs and upgrades.
4. Identify barriers to developing a more robust market for used equipment, and evaluate the impact that product upgrades and used equipment markets could have in reducing electronic waste.
5. Analyze the amount of electronic waste stored in homes, the hidden costs of such storage, and consumer attitudes about the relative value of reuse and recycling versus storage.
6. Weigh the benefits of a deposit system for electronic products against the possible negative impact on low-income consumers.
7. Develop a detailed analysis of the impacts of changes in telecommunications provider platforms and in computer software on the functionality of existing equipment and explore approaches to introducing new technologies that could minimize the amount of waste that is generated.