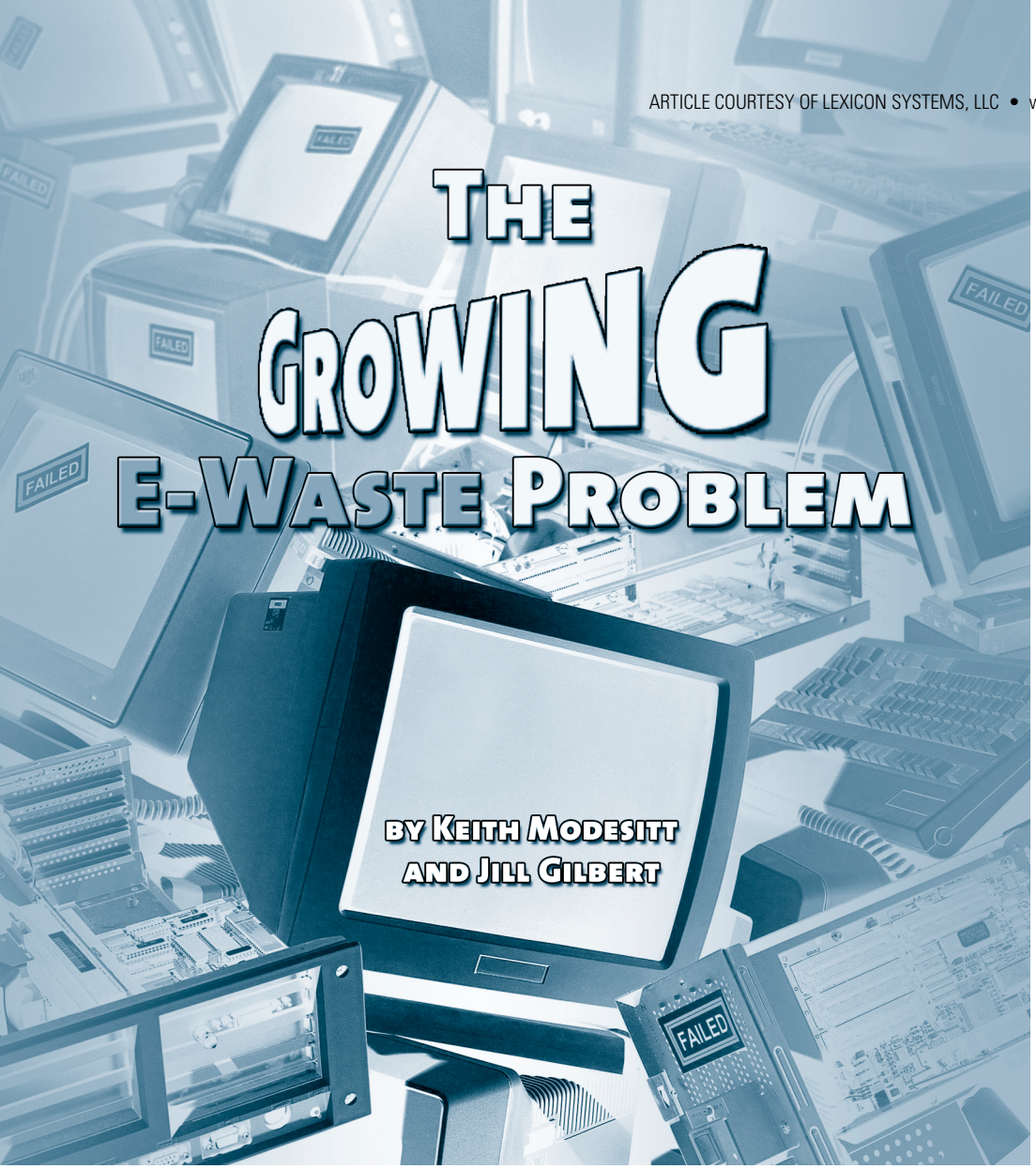

The Growing E-Waste Problem

BY KEITH MODESITT AND JILL GILBERT

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If your current PC is too slow or running out of storage space, it's probably more cost-effective to replace it than to upgrade it. But have you ever stopped to consider what happens to your old computer once you abandon it for a newer model? The workplace mantra of "reduce, reuse, recycle" often ends with office paper and aluminum soda cans, falling short when it comes to electronic waste. As a result, myriad computers considered obsolete by today's high-tech standards sit unused in back rooms, or worse, end up in landfills.[1]

Compared to recycling programs for other materials, such as aluminum, the recycling process for electronic waste, commonly known as "e-waste," is still in its infancy. With approximately half of all states currently developing or implementing e-waste recycling programs, also known as "e-cycling," a consistent approach to handling e-waste still does not exist. One reason for this is that recycling electronics such as PCs and televisions is labor-intensive, involving "demanufacturing," or the disassembly and separation of highly engineered plastics, circuit boards, wires, and other components. In addition, no official certification process currently exists for recyclers of e-waste. Indeed, recycling advocates say much of the e-waste collected in the United States is sold to brokers, shipped to Asia, and then stripped of any valuable material before being dumped.[2]

A GROWING PROBLEM

Advances in Technology Generate More Waste

E-waste includes electronic products, components, and accessories that are no longer deemed useful and discarded. Computers, televisions, and cell phones are among the most recognized forms of e-waste, since their life spans continue to decline with each passing year and technological advancement. The computer industry continues to introduce new technological advances and upgrades, with speed and capacity doubling approximately every 18 months.[3] Because of this almost exponential change, the average life span of a PC has shrunk from 4.5 years in 1992 to an estimated 2 years in 2005.[4]

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The U.S. Environmental Protection Agency (EPA) estimates that e-waste accounts for approximately 1% of the nation's 210 million tons of solid waste generated each year,[5] while an estimated 220 tons of e-waste are dumped in landfills or destroyed in incinerators.[6] Other estimates range as high as 2–5%, with as much as 300,000 tons of e-waste landing in U.S. landfills.[7] A February 2002 report by the Silicon Valley Toxics Coalition predicted that 500 million computers would become obsolete between 1997 and 2007.[8] In 2005, for example, one

computer will become obsolete for every new computer put on the market.[9] Similarly, in a study conducted by Inform Inc., Americans discard approximately 130 million cell phones annually, which adds up to nearly 65,000 tons of trash.[10]

E-Waste Contaminants and Pathways

With e-waste increasing in volume each year, the amount of potentially hazardous or toxic chemicals released into the environment also increases. These chemicals can create problems if not properly disposed of or recycled. According to EPA, the following contaminants of concern and potential pathways are associated with electronic equipment and may be hazardous to human health and the environment if not properly managed:[11]

- **Cadmium**—*found in chip resistors, infrared detectors, and semiconductors.*
  Cadmium can damage human kidneys. The principal exposure pathways are through respiration and contaminated food sources.
- **Lead**—*found in glass panels in computer monitors and in lead soldering of printed circuit boards.*
  Lead can cause damage to the central and peripheral nervous systems, blood stream, and kidneys. It is estimated that consumer electronics may be responsible for 40% of the lead found in landfills. The principal pathway of concern is leaching of lead from landfills and the contamination of drinking water supplies.
- **Mercury**—*found in thermostats, position sensors, relays and switches (e.g., on printed circuit boards), discharge lamps, and batteries. It is also used in medical equipment, data transmission and telecommunications equipment, and mobile phones.*
  When mercury makes its way into waterways, it is transformed into methylated mercury in the sediments. Methylated mercury accumulates in living organisms and travels up the food chain, where it can cause brain damage. The principal exposure pathway is through contaminated food sources.
- **Hexavalent Chromium or Chromium VI**—*used to protect against corrosion of untreated and galvanized steel plates.*
  Chromium VI can damage human DNA and is linked to asthmatic bronchitis. The major pathways are through landfill leachate or from fly ash generated when materials containing Chromium VI are incinerated.

THE HIDDEN COSTS OF UNMANAGED E-WASTE

Organizations can unwittingly spend significant time and money on the collection and disposal of e-waste, especially if they lack the environmental management systems to handle end-of-life electronic equipment. Some charitable organizations are even turning down older computer equipment because it is difficult to maintain, so donation is not always an option. According to recycling services provider LifeSpan Technology Recycling, businesses may find that managing obsolete electronics is both costly and time-consuming. For example, the average cost to properly dispose of a PC is $226.[12] Some of the hidden costs of addressing e-waste in-house include

- **Use of Internal Labor**—Removing, sorting, cataloging, and preparing unwanted technology assets for disposal diverts resources from higher value activities.
- **Storage Costs**—Idle technology equipment occupies valuable warehouse space that could be reclaimed for other necessary storage.
- **Data Security**—Companies must completely destroy confidential personal data and financial records in order to comply with new information privacy laws. Failure to do so can result in the disclosure of proprietary data (i.e., if third parties purposely or inadvertently access files left on disks or hard drives) and/or subject an organization to substantial fines and penalties (e.g., related to HIPPA, the Health Insurance Privacy and Portability Act).
- **Transportation**—In many states, technology assets are subject to hazardous waste regulations, and need to be handled and transported accordingly.
- **Insurance and Inventory**—A number of jurisdictions deem unused equipment to be "business property," requiring careful tracking and proper insurance.
- **Environmental Regulations**—Emerging environmental standards are forcing companies to more closely track and report on the ultimate disposition of their technology assets. Most e-waste is unsuitable for landfills and other disposal channels. Businesses need to be sure that their waste haulers comply with federal and state regulations.

E-Waste Issues to Consider

- Should you dispose, sell, donate, or recycle?
- How do you ensure that sensitive data is completely and securely destroyed?
- What regulations apply in your state and local area?
- How do you ensure that equipment is disposed of in an environmentally sensitive and regulatory compliant manner?
- What is the best way to quickly redeploy technology assets that will soon be going off lease?

Source: LifeSpan Technology Recycling.[13]

GUIDELINES AND REGULATIONS

U.S. Federal and State Regulations

In the United States, regulations governing e-waste disposal and management vary widely for both consumers and businesses. The closest piece of federal legislation addressing this form of waste is EPA's 1995 Universal Waste Rule,[14] which applies to four categories of waste: hazardous waste batteries,

E-Waste: Not Spam, But a New Wave of Recycling Possibilities

by Shelby Sheffield

Upon hearing the term "e-waste" most people likely think of "spam," that is, unwanted junk electronic mail that appears in their in-boxes. Instead, e-waste is actually waste generated from electronics. Made with a variety of elements—including steel, lead, mercury, cadmium, and fire-retardants—electronics, when thrown away, can potentially release toxins into the environment, polluting the air and groundwater. However, many of these elements can be recaptured through recycling.

Technological advancements and shorter product life spans due to increasing product capabilities have led to the use of larger amounts of materials and energy. Federal and state legislatures recognize the ability to recycle e-waste and have started promulgating bills and developing initiatives aimed at implementing programs to cost-effectively recycle e-waste.

As many as two dozen e-waste bills are currently under consideration by state legislatures. Notable examples include:

- **California**—The nation's first comprehensive e-waste law was signed in California in September 2003, which established a funding system for the collection and recycling of certain e-wastes. The law also included a collection fee at the point of sale to finance the recovery of TV and PC monitors and other electronic parts. Point-of-sale funds are used to reimburse local governments providing collection and recycling services to the public at no charge (Electronic Waste Recycling Act of 2003; www.ciwmb.ca.gov/Electronics/Act2003/).
- **Massachusetts**—Effective April 2000, Massachusetts banned individuals and companies from disposing of cathode ray tubes (CRTs), used in computers and televisions, in municipal solid waste landfills. Massachusetts was the first state to impose such a ban on individuals (CRT Recycling Program; www.mass.gov/dep/recycle/crt/crthome.htm).
- **Minnesota**—Minnesota developed a statewide stewardship policy addressing CRTs. The state's House of Representatives used the policy to draft a bill banning e-waste containing CRTs from landfills effective July 2004 (H.F. No. 2815; www.revisor.leg.state.mn.us/).
- **Rhode Island**—Effective February 2001, Rhode Island became the first state to establish a statewide recycling collection facility for computers (Rhode Island Resource Recovery Corp.; www.epa.gov/epr/products/estate.html).

On the federal level, the Federal Electronics Challenge (FEC; www.federalelectronicschallenge.net/index.htm) is a new voluntary partnership program that encourages federal agencies and facilities to purchase greener electronic products, reduce the impact of electronic products during use, and manage obsolete

banned and recalled pesticides, mercury thermostats, and hazardous waste lamps. (For more on the Universal Waste Rule, see "Breaking Down the Rules Governing Universal Wastes," *EM* April 2005, p. 45.) Although most e-waste is not covered under this law, it does leave room for states to add other waste types in their versions. Several states, including California, Maine, Massachusetts, Minnesota, and Rhode Island, have legislation enacted or pending regarding the disposal of cathode ray tubes (CRTs) and other forms of e-waste (see "E-Waste: Not Spam, But a New Wave of Recycling Possibilities").

The California Legislature, for example, passed the Electronic Waste Recycling Act of 2003, also known as Senate Bill 50, which requires the collection of a fee when a consumer purchases new CRTs, such as those used in televisions and computer monitors. Starting January 1, 2005, retailers must collect the fee on covered electronic devices and remit the fee to the California State Board of Equalization.[15] The fee is used to permit qualified e-waste collectors and recyclers to recover costs for certain collection and recycling activities. The e-waste recycling fee is calculated as follows:

Viewable Screen Size (measured diagonally)	Recycling Fee
>4 in. and <15 in.	$6
≥15 in. and <35 in.	$8
35 in. and larger	$10

Maine now requires all households to recycle waste products containing mercury (i.e., thermometers, thermostats); household e-waste, such as televisions and computer monitors, must be recycled beginning no later than January 2006. Manufacturers will begin to pay a portion of the handling and recycling costs for household e-waste beginning in 2006.[16] As state e-waste initiatives vary widely, readers are encouraged to seek additional information from their local waste haulers or EPA's E-Cycling Web page (www.epa.gov/ecycling/).

European Union Directives

The European Union (EU) is progressing much faster toward recycling e-waste than the United States. Two new EU directives published in 2003 target electronics recycling and toxic substances.[17] The Waste Electrical and Electronic Equipment (WEEE) directive requires producers to recover and reuse separately collected e-waste and applies to the following categories of electrical and electronic equipment: large and small household appliances; IT and telecommunications equipment; consumer electronics; lighting equipment; electrical tools (with the exception of large-scale stationary industrial tools); toys, leisure, and sports equipment; medical devices (with the exception of implanted and infected products); monitoring and control instruments; and automatic dispensers. The Restriction of Certain Hazardous Substances (RoHS) directive bans cadmium, hexavalent chromium,

electronics in an environmentally safe way. The federal government purchases more than $38 billion worth of electronic equipment each year, giving it the opportunity to provide leadership regarding the environmentally sound and cost-effective life-cycle management of electronic assets. Any federal agency or facility can participate in FEC as a program partner. Program partners complete a baseline survey and set goals in three areas: acquisition and procurement, maintenance and operation, and disposal. FEC organizes conferences and produces technical training materials to help partners change their current electronic equipment management practices. The White House Task Force on Recycling sponsors an awards program to provide recognition for partners' achievements.

Other programs, such as the National Recycling Coalition, offer a database searchable by zip code where users can find growing numbers of e-waste recyclers, reuse organizations, and municipal programs accepting old electronic equipment (Electronics Recycling Initiative; www.nrc-recycle.org/resources/electronics/search/getlisting.php). The National Safety Council's Electronic Product Recovery & Recycling Directory (EPR2; www.nsc.org/ehc/epr2/recycler.htm) also contains a database of e-waste recycling and donation organizations listed by state. In addition, various reuse, trade-in, and upgrade type programs offered by private sector participants appear in the database.

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lead, mercury, and two types of brominated flame-retardants (PBB and PBDE) in consumer, technology, and other products, beginning July 2006.

Many U.S. businesses that operate internationally, such as semiconductor and PC manufacturers, must change their manufacturing and waste handling processes to meet these EU directives. According to industry analysts, large U.S. exporting companies are expected to adopt EU standards for all of their products, not just those sold in Europe. For example, last year computer chipmaker Intel Corp. (www.intel.com) introduced a lead-free flash memory program in Japan, partly in an effort to meet the EU regulations. In addition, some manufacturers are replacing lead with an alloy of copper and tin that melts at a higher temperature. Although exemptions to the EU ban on lead are still available, experts say that the European rules will shrink the market for lead-based products in mainstream electronics.

E-WASTE SOLUTIONS

Solutions for handling e-waste range from legislation and regulatory directives to public information campaigns, upfront fees at the point of purchase, and tax incentives for recycling.

EPA and State Initiatives

In January 2003, EPA launched the Plug-in to eCycling Campaign to increase the number of electronic devices collected

Growing Market for E-Waste Recovery

Due to recent technological advancements that provide manufacturers with less toxic material choices and more cost-effective ways to recover electronic circuitry and associated equipment, the e-waste recovery industry is an emerging potential growth market. According to a new report by Business Communications Co. (BCC) Inc., *The Electronic Waste Recovery Business*, the worldwide market for e-waste will rise at an estimated average annual growth rate of 8.8% from $7.2 billion in 2004 to $11 billion in 2009.

E-waste has been increasing rapidly with the rise of the information society. According to the report, it is the fastest growing segment of the municipal solid waste stream. E-waste equals approximately 1% of solid waste on average in developed countries and is expected to grow to 2% by 2010. In developing countries, e-waste as a percentage of solid waste ranges from 0.01% to 1%. However, led by China, developing countries will be the fastest growing segment of the e-waste market with the potential to triple output over the next five years. Electric and electronic equipment equals 6% of the U.S. gross domestic product, up from 5% 10 years ago. Yet that growth is easily eclipsed by China, where the gross domestic product is growing in excess of 8% per year versus 3% for the United States, the report says.

At the same time, the rate of obsolescence of electronic equipment is rising. Globally, computer sales continue to grow at rates of more than 10% annually. Yet the life cycles of these products are shortening, shrinking to an average of 10 years for televisions to 2–3 years for a PC.

The recycled plastics sector will register the fastest revenue growth (10.2%), as demand increases for high-value engineered plastics, the report says. Growth in metals mined from end-of-life e-waste will continue to outpace the broader recycled metals market, the report says, growing at an average annual growth rate of 8.1%. The market for recycled glass continues to be stagnant, with low value attached to recycled glass. Overall, the market for post-consumer recycled materials from electronics will be strong over the next five years, the report says (see Figure 1). The largest driver of growth will be the regulatory-driven responsibility on original equipment manufacturers to manage their hazardous waste materials from cradle-to-grave.

A copy of the full report, *The Electronic Waste Recovery Business,* is available from BCC Inc., Norwalk, CT, at www.bccresearch.com.

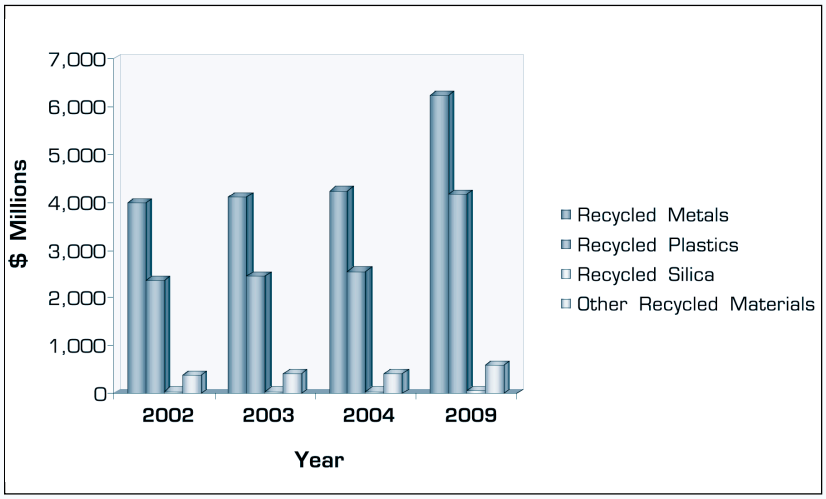

Figure 1. Global sales forecast of e-waste recovery market, 2002–2004 and 2009 (U.S. $ millions). *Source:* BCC Inc.[12]

and safely recycled in the United States (see www.epa.gov/ecycling/). The campaign focuses on three major areas:

1. Providing the public with information about e-cycling and increasing opportunities to safely recycle old electronics.
2. Facilitating partnerships with communities, electronics manufacturers, and retailers to promote shared responsibility for safe e-cycling.
3. Establishing pilot projects to test innovative approaches to safe e-cycling.

EPA, along with local government and state agencies, is constantly improving its e-waste initiatives, as more information is gathered on how to best dispose of and recycle electronic products. To help keep consumers and businesses up to date on e-waste initiatives, the Silicon Valley Toxics Coalition, a grassroots coalition that engages in research and advocacy concerning the potential environmental and human health problems caused by the rapid growth of the high-tech electronics industry, maintains a Web site (www.svtc.org). This site identifies e-waste legislation, organizations working on e-waste, and organizations and cities that have adopted resolutions on e-waste across the United States.[18]

In an effort to create the first-ever nationwide e-waste recycling infrastructure, Senators Ron Wyden (D-Ore.) and Jim Talent (R-Mo.) introduced in March the Electronic Waste Recycling and Promotion and Consumer Protection Act of 2005,[19] which would establish an $8-per-unit tax credit for companies that recycle a minimum of 5000 display screens or computer systems per year. Consumers who recycle their old PCs and televisions with qualified recyclers would receive a $15 tax credit per unit recycled.

Industry Initiatives

In part in response to new and forthcoming regulations, industry e-cycling initiatives are proliferating, with most major PC vendors now offering recycling services to customers. Hewlett-Packard Co. (www.hp.com) offers consumers and business customers the ability to return any piece of computer hardware from any computer manufacturer using an automated online service. The cost of the service ranges from $13 to $34 per item, depending on the type and quantity of the hardware to be returned. Dell Inc. (www.dell.com) offers consumers the option,

when purchasing a new Dell computer, to have their old computer recycled at no cost. Also through Dell Recycling, consumers may donate their old PCs to the National Christina Foundation, which benefits people with disabilities, students at risk, and economically disadvantaged persons. And customers of Apple Computer Inc. (www.apple.com) can recycle their Apple computers using a take-back program. For $30, customers can ship their old computers to an Apple recycler via United Parcel Service. After approximately four weeks, Apple notifies customers that their old computers were properly recycled in an environmentally friendly manner.

Independent E-Cyclers

Filling the gap between legislation and voluntary industry efforts, a new "e-cycling" industry has developed in recent years. Several independent e-cyclers have sprung up in proximity to the Silicon Valley, CA, high-tech industry or in response to recent legislation, such as California's Senate Bill 50. Companies such as E-Tech Recycling (www.etechrecycling.com), LifeSpan Technology Recycling (www.lifespanrecycling.com), Onyx Environmental Services (www.onyxes.com), RMD Technologies Inc. (www.rmdrecycling.com), and Retire-IT LLC (www.retire-it.com) provide turnkey removal and resale services of PCs, cell phones, and other electronic equipment. Many firms provide free e-waste collection; some provide special e-waste containers comparable to waste overpack drums; while others focus on complete life-cycle asset management.

Kyle Marks, manager of IT disposal and logistics for Retire-IT, says that the emerging e-cycling business is changing rapidly in response to a patchwork of legislation. However, he notes that executive awareness of how to handle end-of-life electronic equipment is generally low, with many companies avoiding the issue altogether by storing obsolete equipment in back rooms or warehouse facilities.[20]

E-WASTE POLLUTION PREVENTION

As with other pollution prevention programs, one way to avoid generating e-waste is by using alternative materials or technologies. Companies today are discovering alternative technologies to minimize e-waste, while maximizing current technology functionality. Two of the technologies gaining the most attention because they help to minimize the growth of e-waste are liquid crystal display (LCD) monitors and thin client computers.

- **LCD Monitors**—The environmental friendliness of LCDs over CRTs comes in both energy savings and component recycling. According to Current Analysis, a technology research company in California, the power savings from using an LCD monitor over a CRT ranges from 50% to 60%. Also, the components in the LCD contain fewer

hazardous materials and are thus easier to recycle.[21]

- **Thin Client Computers—** Thin client computing, also known as server-based computing, provides employees with an inexpensive workstation stripped down to the bare essentials: mouse, keyboard, and display. The applications accessed by each client computer reside on a central server, rather than on an employee's individual computer. Using this approach, each workstation requires less processor speed, hard disk space, and power consumption to operate. Server-based applications require fewer people to install and maintain, while computer upgrades mainly occur at the server. Thin client computing is not for everyone, and enterprises should carefully evaluate software licensing, functionality, and user acceptance needs before implementation.

As companies look toward technologies to minimize e-waste, they must also look at the processes that manage e-waste. More and more companies are paying a price through bad publicity, regulatory fines, and litigation when their e-waste is not managed properly. The following guidelines can help to minimize the risk associated with e-waste disposal and recycling.

1. **Define Liability—** Most organizations outsource the e-waste disposal and recycling process, since they do not have the time or in-house resources to properly dispose of or recycle electronic equipment. When making your vendor selection for e-waste recycling and disposal, verify that they clearly understand all current state and federal regulations that apply to your e-waste stream. It is important to follow up with the proposed vendor's other clients, who have a similar e-waste stream, to verify their experience in managing the liability, transportation, and data security, as appropriate.
2. **Verify Data Security—**Before transporting any e-waste for disposal or recycling, be aware of whether it might contain sensitive or confidential information. This might occur if you dispose of computers with their hard drives intact, old CDs, disks, or magnetic tapes. If the information contained is sensitive or confidential, you should consider having the electronic media storing the data destroyed so that the information is not readable once the e-waste is transported for disposal or recycling. Multiple technologies exist for destroying sensitive or confidential information, ranging from shredders capable of shredding electronic media to U.S. Department of Defense-compliant software that overwrites all data on electronic media several times. Carefully evaluate which method will work best in your situation.
3. **Implement an E-Waste Chain of Custody—** Ensure that, as with other wastes, you have a chain of custody procedure that tracks the entire waste disposal process from the time that the e-waste is transported from your site to ultimate disposal and/or recycling.
4. **Audit Waste Transporters, Recyclers, and Disposers—**It is imperative that you periodically audit the business that is transporting your e-waste to the disposal or recycling facility, as well as the e-waste recycler and/or disposal company. Review their documentation thoroughly and ask questions if you do not find the data you need to verify that your e-waste will be properly handled.

CONCLUSION

E-waste will continue to grow as long as technology advances continue to provide us with "better, faster, smarter" devices that have shorter and shorter useful lives. While there is currently no single consistent method of handling e-waste, one thing is clear: e-waste is starting to attract attention, and industry and government have begun to develop recycling programs and incentives. The best way to address e-waste is to avoid producing it in the first place, by selecting "greener," more environmentally friendly technologies. If you must produce materials or products that contribute to e-waste, be sure to put sound environmental management systems in place to minimize the risk to human health, the environment, your business, and its stakeholders. **em**

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