

Managing Electronic Waste in a Climate of Constant Change

by **Rebekah Fraser**

Rebekah L. Fraser is a freelance writer based in New Salem, MA. E-mail: rebekah.fraser@gmail.com.

Discarded electronics is one of the fastest growing segments of our nation's waste stream, already accounting for 5% of the total waste volume. Researchers estimate an additional 75% of old electronics are stuck in storage, in part because consumers don't know what to do with them. Many are unaware that electronics contain hazardous substances.¹ If properly handled, these materials pose little risk and can be recycled or reused safely.

Circuit boards and circuitries have value because of the chemicals and precious metals. When an electronic product is dismantled properly, its component materials may be reused or recycled. If improperly handled, the toxins in electronics can be released into the environment. Once released into the environment, toxins come into contact with humans, animals, and natural resources causing harmful effects.¹

An Unregulated Waste Stream

The metals market is very strong, making disassembling circuit boards for their component metals popular. In addition to precious metals, such as gold, many of the most toxic substances found in electronic waste (e-waste) are on the circuit boards.

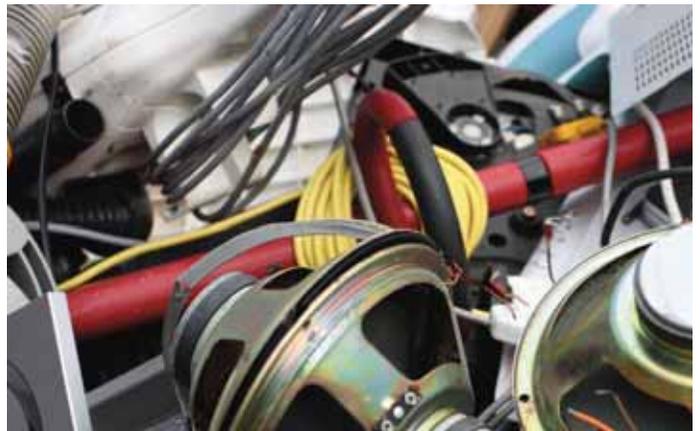
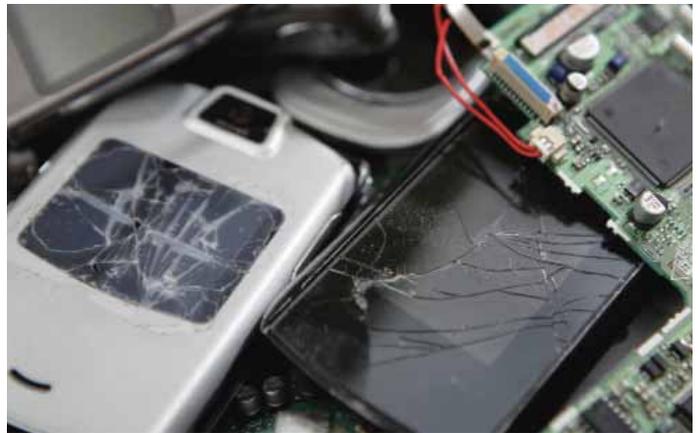
Proper handling standards dictate circuit boards should be sent to up-to-date smelters. In such facilities, the materials are separated and recovered for recycling and the fumes released during smelting are properly

handled. At present, there are no smelting operations in the United States equipped to handle circuit boards. Canada, Sweden, and Belgium have smelters equipped to recycle circuit boards, but Barbara Kyle of the Electronics TakeBack Coalition says more often than not circuit boards end up in developing nations.² Once there, workers who lack the equipment and infrastructure to safely handle the items break the electronics apart using rudimentary tools, thus potentially releasing dangerous substances into the air, water, and soil.

Jim Schrack of the Product Stewardship Institute says lead, mercury, cadmium, and brominated flame retardants are among the substances of greatest concern found in electronics.³ Quoting from the U.S. Environmental Protection Agency's (EPA) Web site, Schrack explains, "These substances are included in the products for important performance characteristics, but can cause problems if the products are not properly managed at end of life." (In fact, many electronics manufacturers have

Some electronics test 'hazardous' under federal law. If so, they are subject to special handling requirements under federal law, subject to certain exemptions.

>>EPA regulations governing the management of used electronics





‘California’s intent was to capture not only business e-waste, but also residential. Many states have modeled their regulations after ours.’

>>Leonard Robinson,
California DTSC

found safer alternatives at the insistence of the European Commission.)

Lead is used in glass TV and PC cathode ray tubes (CRTs), as well as solder and interconnects; older CRTs typically contain between 4 and 7 lb of lead, while newer CRTs contain closer to 2 lb of lead. Because lead overexposure is one of the most common found in industry and is a leading cause of workplace illness, the U.S. Department of Labor’s Occupational Safety and Health Administration (OSHA) has established the reduction of lead exposure as a high strategic priority.⁴

Leonard Robinson, federal liaison to California’s Department of Toxic Substance Control (DTSC), and a former environmental manager, considers smelting a viable alternative to current practices in the United States, provided the metals market remains strong and the operation has systems in place to handle heavy metals. “I used to work at a steel mill, and we smelted a lot. That’s what they do in Pennsylvania with rechargeable batteries for chrome and cadmium and the other heavy metals.”⁵ In a proper smelting operation, the crude lead produced is remelted in cast-iron kettles and refined by the addition of reagents, such as sulfur and caustic soda. The purified lead is then cast into molds or ingots.

However, this is not the process that Kyle describes happening in developing nations. “They’ll take the circuit board and melt it on a wok, so they can melt down the solder, which has lead in it.”²

Significant lead emissions can occur from poorly controlled refining, casting, and drossing operations. According to OSHA’s safety and health information Web site, lead poisoning is the leading environmentally induced illness in children. At greatest risk are children under the age of six because they are undergoing rapid neurological and physical development.⁶

Mercury, a naturally occurring substance that exists in several forms, is used in small amounts in bulbs to light flat-panel computer monitors and notebooks. High mercury exposure can result in permanent nervous system and kidney damage. Mercury may be absorbed through the skin as a vapor. There is no odor warning when toxic concentrations are present. Contamination of the air by evaporation can occur quickly at room temperature. The half-life (whole body) of inhaled mercury vapor is approximately 60 days. Thus, some symptoms may occur below the recommended limits due to long-term accumulation.⁶

Brominated flame retardants (e.g., polybrominated biphenyls [PBBs] and polybrominated diphenyl ethers [PBDEs]) are man-made materials widely used in plastic cases and cables for fire retardancy; the more problematic flame retardants (PBBs) were phased out of electronics sold in the United States in 2004, but deca-PBDEs are still in use today. As consumers begin disposing of older electronic equipment, more dangerous PBDEs may enter the waste stream.⁶

EPA has listed PBDEs as a suspected carcinogen. In Europe, research has established that brominated flame retardants are persistent, bioaccumulative, and toxic. They can cause liver and neurodevelopmental toxicity and affect thyroid hormone levels. Brominated flame retardants have a long life cycle, and levels increase along the food chain (e.g., from fish to humans). While only two are governed by new European Union (EU) law, some 70 different brominated flame retardants are used as fireproofing, in electronic equipment, circuit boards, computer casings, and cables.⁷

Cadmium (Cd) was widely used in nickel-cadmium rechargeable batteries for laptops and other portables. Newer batteries (e.g., nickel-metal hydride and lithium ion) do not contain cadmium. OSHA regulates cadmium carefully because of its extreme toxicity. Overexposures may occur even in situations where trace quantities of cadmium are found in the parent ore or smelter dust. According to OSHA, several deaths from acute exposure have occurred among welders who have unsuspectingly welded on cadmium-containing alloys or worked with silver solders. Cadmium emits a characteristic brown fume upon heating, which is relatively nonirritating, and thus does not alarm the exposed individual.⁶

Laws vs. Guidelines

In 2006, the EU’s Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC,⁸ which restricts the use of hazardous materials found in electrical and electronic products, came into effect. Restricted materials include lead, mercury, cadmium, hexavalent chromium, and PBBs and PBDEs. Since July 1, 2006, all applicable products in the EU market have had to pass RoHS compliance. The directive has impacted the entire electronics industry. One month after implementing RoHS, the EU then put the Waste from Electrical and Electronic Equipment (WEEE) Directive into action.⁹ WEEE mandates the treatment, recovery, and recycling of electrical and electronic equipment. Since August 2006, all applicable products in the EU market have had to pass WEEE compliance and carry the associated “wheelie bin” sticker.

Because there are no such federal laws in the United States, many of the same companies that manufacture electronics to meet RoHS standards for the European market have failed to produce similar eco-friendly products for the North American market. Nokia is one notable exception. According to the company Web site, Nokia intends to produce electronics free of brominated and chlorinated compounds and antimony trioxide by 2010 and all new Nokia devices for all markets are free of PVC, lead, mercury, cadmium, hexavalent chromium, PBBs and PBDEs¹⁰ (see sidebar “Nokia Leads the Way in Producer Responsibility” opposite).

Many computer companies have voluntarily launched programs to take back and recycle old and unused products. While some manufacturers charge a fee for this service, Dell, Lenovo, and Toshiba run completely free take-back programs. Of the television manufacturers operating in the United States, only Sony, LG (Zenith), and Samsung have take-back programs, and all three are free.

Although the aforementioned companies’ commitment to environmental stewardship is admirable, many environmentalists still claim the lack of producer responsibility in the industry overall demonstrates that federal legislation is necessary to turn the tide of toxic waste leaving this country for vulnerable shores. In the absence of federal government action, it is nongovernmental organizations (NGOs) and state and local governments that have picked up the slack.

States’ Rights—California Leads the Way

In California, when someone asks the state whether a material is hazardous, then it’s the state’s responsibility to investigate it. Marjaneh Zarrehparvar, Household Hazardous Waste Program Coordinator for San Francisco’s Department of the Environment, explains that for many years, people suspected computer monitors would fail state standards for lead, but “no one wanted to deal with it.”¹¹

In 2001, when a grantee for the city of San Francisco asked about lead levels in monitors, the state was obligated to test them. When the results came back, the state decided that residents were no longer allowed to dispose of monitors with their household waste. Zarrehparvar says that when something is identified as “hazardous,” it is the government’s responsibility to establish a program that will keep it out of harm’s way. However, new state restrictions do not always come with the necessary funding to enforce the mandate. “It’s what we call a ‘Ban without a Plan,’” says Zarrehparvar. “This is

Nokia Leads the Way in Producer Responsibility

In February 2008, Nokia released an updated version of its “Substance List,” which includes all materials and substance groups banned, restricted, or targeted for restricted use by the company. Nokia requires its suppliers to adhere to these restrictions. The current list includes:

Antimony Trioxide — a metalloid often used as a flame retardant on plastic polymers, this substance is listed as a suspected carcinogen, skin irritant, and secondary hepatotoxin by the National Institutes of Health.

Arsenic and compounds — metalloid compounds used in semi-conductors, arsenic is known to cause lung cancer and aplastic anemia. It is also a neurotoxin, nephrotoxin, reproductive toxin, secondary hepatotoxin, skin sensitizer, and a known carcinogen.

Asbestos — a fibrogenic dust released during metal mining, this substance is known to cause lung cancer.

Benzene — an aromatic solvent used mainly to synthesize organic chemicals, benzene can induce narcosis and anesthesia acutely. Regular exposure can cause aplastic anemia and leukemia.

Beryllium and compounds (other than BeO) — these metallic elements are used in the manufacturing of electronics. They are known to cause toxic pneumonitis and lung cancer. In addition, these substances are hepatotoxins, nephrotoxins, and fibrogenic.

Bromine and compounds — these gases are used in bleaching and manufacturing ethylene dibromide and are known to cause toxic pneumonitis. In addition, bromine compounds are lacrimators and dermatotoxins.

Cadmium and compounds — metals used in nickel-cadmium batteries, cadmium compounds are nephrotoxins, reproductive toxins, carcinogens, and cause toxic pneumonitis.

Carcinogens, mutagens, and reproductive toxins — agents that cause cancer, cell mutation, and damage to male or female reproductive systems

Cobalt and compounds — a metal that causes asthma, chronic dermatitis, and toxic pneumonitis, it is also a secondary hepatotoxin, suspected carcinogen, and is known to be fibrogenic.

Isocyanates — used in molding plastics, isocyanates are the leading cause of occupational asthma in many post-industrial countries where incidence rates have been measured.

Lead and compounds — a metal found in many older manufactured products is the leading environmentally induced illness in children, affecting neurological and physical development.

Mercury and compounds — a metal used found in bulbs, flat-panel computer monitors, and notebooks causes nervous system and kidney damage.

Nickel and compounds — metals used in battery manufacturing, nickel compounds cause occupational asthma, allergic contact dermatitis, nasal sinus cancer, lung cancer, and toxic pneumonitis.

Nonylphenols and nonylphenol ethoxylates — these liquid phenols are added to plastics and cause toxic pneumonitis and skin irritation.

Perfluorooctane sulfonates (PFOSs) — this compound is highly bioaccumulative, occupational exposure may occur through inhalation and dermal contact with this compound at workplaces where perfluorooctane sulfuric acid is produced or used; the general population may be exposed to perfluorooctane sulfuric acid via ingestion of contaminated fish and drinking water, and dermal contact with this compound and other products containing perfluorooctane sulfuric acid.

Phthalates — used in production of plastics, these compounds are skin sensitizers, secondary hepatotoxins, and reproductive toxins.

Tributyltin and tributyltin oxide — a fungicide used in antifouling paints, this substance causes occupational asthma.

Note: All medical information here sourced from the Web site of the National Institute of Health: <http://hazmap.nlm.nih.gov/cgi-bin/hazmap>.

'A ban without a plan.'

>>Marjaneh Zarrehparvar,
San Francisco
Department of the
Environment

an expensive waste stream, so there was a lot of push back. Local governments wanted industry to help fund end of life management." Local officials felt municipalities shouldn't have to be solely responsible for something that manufacturers profit from.

California Learns from Its Mistakes

Zarrehparvar continues: "This was a huge initiative, so local governments got together and said, 'You're tripling the cost of our program, we don't have the money for it, we don't want to increase garbage rates or taxes to cover it. Industry needs to take responsibility for this and fund a program.'"

In 2003, California adopted an advanced recycling fee system and set up a funding mechanism. Senate Bill 20, introduced by State Senator Byron Sher, imposed a recycling fee on all electronics that failed tests for lead. Now, it's the retailers' responsibility to collect that fee from consumers. Manufacturers must inform retailers about the law and about which products have components containing lead; retailers pass the fee on to consumers.

"When these laws took effect, other states were looking at it in different ways," says DTSC's Robinson. "California's intent was to capture not only business e-waste, but also residential. Many states have modeled their regulations after ours."⁵

California RoHS Regulations

California modeled its RoHS regulations after the EU RoHS Directive 2002/95/EC, though California's RoHS is narrower in scope. The EU RoHS Directive applies to essentially any device that depends on, or generates, an electric current for its function. California's restrictions are limited to "covered electronic devices," specifically, video display devices that have been listed in DTSC's regulations.¹²

California Collectors and Recyclers

As a result of California's Senate Bill 20 passage into law in 2003, many collecting and recycling businesses have emerged. But private industry and waste management aren't the only beneficiaries of the law. It's also allowed nonprofit organizations and schools to use electronic take-back programs as fundraisers. For example, one school in California hosted three e-waste roundup events that earned a combined total of US\$25,000.⁵

Although anyone can become a collector, electronics recyclers in California must undergo training and pass certain standards in storage, worker safety, and competency. DTSC offers workshops and verifies that people

are trained in hazardous waste handling. Many recyclers also receive training from OSHA or from various computer manufacturers.

Collectors and recyclers in California are also required to provide thorough documentation, showing from where they received items and ultimately where they're shipping items. When major violations occur, DTSC will do a site visit to instruct the collector or recycler to change their practices. At worst, DTSC will issue a cease-and-desist order, so that the violator can no longer operate their business in California.

San Francisco Takes the Lead

In San Francisco, Zarrehparvar and her colleagues are aware that the public looks to local governments for information regarding garbage disposal. "We want to provide the public the best info that we can, but we don't have the ability to go audit every company," says Zarrehparvar.¹¹ San Francisco's Department of the Environment screens responsible recyclers, using DTSC's list of approved U.S. vendors. In addition, with information from the Basel Action Network (BAN) Web site (www.ban.org), the department lists companies who have pledged not to export waste to developing nations. In lieu of a national export ban, this is the best a municipality can do. State and local governments do not have the jurisdiction to ban exports.

"It's a different waste stream," says Zarrehparvar. "With other toxics, like paint, we have facilities. But with electronics, we don't have as much control. The burden is for us to try to screen out who the public uses." San Francisco has been increasingly relying on BAN to do the screening process for them.

NGOs Step In

Since 2000, BAN has worked to create and promote producer and recycler accountability from cradle to grave in the design, manufacture, use, and recycling or reuse of electronics. Starting with the Basel Convention in 1989,¹³ when more than 170 countries ratified a treaty known as the Basel Ban Amendment, all 27 EU communities have implemented a prohibition on export to developing nations.

In 2003, BAN created the E-Stewards Program, a group of electronics recyclers who pledge not to send discarded electronics to developing countries, prisons, landfills, or incinerators. In November 2008, BAN announced it is transforming the e-stewards program into a third-party certification program. BAN's Sarah Westervelt said the

program will be akin to the certification programs run by Forest Stewardship Council and Fair Trade Coffee. "There's no other program that will adequately deal with this crisis," she says. Currently in development, the certification program is expected to be up and running in 2010.¹⁴

Neil Peters-Michaud, chief executive officer of Cascade Asset Management, an information technology data retirement company, strongly supports BAN's e-stewards certification program. "Consumers need an assurance, and the e-stewards program offers that assurance. In an era when anyone can put a slogan and slick marketing campaign on a Web site, we really do need a system that audits people."¹⁵

EPA and R2 Guidelines

In the past several years, EPA has amended or relaxed various hazardous waste rules with the intent of increasing electronics recycling. The agency states on its Web site: "EPA encourages reuse and recycling of used electronics, including those that test 'hazardous.' To facilitate more reuse and recycling of these products, EPA has less stringent management requirements for products bound for reuse and recycling. Computer monitors and televisions sent for continued use (i.e., resale or donation) are not considered hazardous wastes. In order to encourage recycling and reuse of used [CRTs] and CRT glass, EPA amended hazardous waste rules in 2002 regarding CRTs sent for recycling. Since then, CRTs are subject to streamlined handling requirements under the Resource Conservation and Recovery Act (RCRA). These materials are now excluded from the RCRA definition of solid waste if certain conditions are met. Circuit Boards are also subject to a special exemption from Federal hazardous waste rules."¹⁶

In October 2008, EPA released the *Responsible Recycling (R2) Practices for Use in Accredited Certification Programs*, a set of guidelines for accredited certification programs to assess electronics recyclers' environment, health, and safety, and security practices. Since January 2006, EPA has facilitated a multistakeholder group to develop this document.¹⁷

The voluntary R2 practices include general principles and specific practices for recyclers disassembling or reclaiming used electronics equipment, including those electronics that are exported for refurbishment and recycling. (For more on the new EPA guidelines, see "EPA Releases E-Waste Guidelines; Environmental Organizations Cite Loopholes," *News Focus*, p. 42.)

2009 Digital Deadline

California's DTSC is working with the postal service to create a mail-it-back partnership to create extended producer responsibility for certain products. "When [manufacturers] know they'll get [a product] back," says Robinson, "They want to make it less toxic and more valuable. Instead of a disposal fee, we may adopt a 'no-deposit, no return' [system]. So you turn in your old computer, and there's a trade-in value."⁵

Many waste managers fear February 17, 2009, deadline—the U.S. federal government's deadline for all broadcasters to switch from analog to digital—will be the most massive obsolescence event ever. While some people may get a cable box to adapt their old TV, Robinson and others believe a majority will use this as an excuse to get rid of the old TV and buy a new one (see sidebar "Getting Ready for the Digital TV Switch" opposite).

California's DTSC is engaging its citizens in planning for this major event. Robinson says California went through a similar event when the state banned fluorescent lights from household waste. Cities and counties complained they didn't have resources to deal with it. DTSC started the take-back coalition, inspired by IKEA's practice of taking back fluorescent light bulbs. "We spoke to environmental managers at companies who were freaked out. But then we went to marketing managers and said, 'They have to return a bulb, they need a new one,' and suddenly manufacturers were interested."⁵

DTSC brought other players to the table and started the California "take it back" partnership. When Robinson and his colleagues were wondering where the funding would come from, PGE offered assistance. PGE uses public goods funds that are collected with every household electric bill. Robinson points to other companies following suit both at the state and national level. For example, all Home Depot stores take back compact fluorescent light bulbs, and Orchard Supply takes back compact fluorescent light bulbs, tubes, and batteries. With assistance from Sesame Street, DTSC started the Oscar the Grouch "Not in my trash," campaign. Robinson says the last step is for manufacturers to get involved. In the meantime, California's "take it back" campaign is slowly evolving into a nonprofit organization.

With a looming deadline, the Electronics TakeBack Coalition is working hard to prepare consumers, corporations, and waste managers for the inevitable onslaught of analog televisions that will flood the waste stream. The coalition's Kyle says there's no hierarchy of waste in this



Getting Ready for the Digital TV Switch

On February 17, 2009, television in the United States will switch from broadcasting an analog signal to a digital signal. Older television sets will not be able to tune in the new digital TV channels using just an antenna but will need a separate digital converter box or digital TV. While some will choose to use a converter box to tune in, many people will be taking this opportunity to upgrade their old televisions. Consumers are being inundated with technical advice about digital TV and attractive offers from retailers, but what should they do with their old TVs?

For California residents, one answer is to find a local GREENspot e-waste drop-off location and recycle their old TVs and help protect the environment.

Recycling an old TV is as easy as 1-2-3:

STEP 1.

Go to www.aslgreenspot.com and enter in the ZIP code of where you live.

STEP 2.

Choose a convenient GREENspot e-waste drop-off location.

STEP 3.

Drop off your e-waste for free. Some GREENspots will also let you recycle your bottles, cans, paper, and other consumer goods for free.

E-waste accepted at GREENspot drop-off locations includes TVs, cell phones, audio-video components, computer equipment, microwave ovens, and electronic equipment from offices and labs.

Source: www.aslgreenspot.com.

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case. All televisions made in the last several years have circuit boards. In addition, older televisions have CRTs containing 2 to 7 lb of lead, while flat-panel and liquid crystal display screens contain mercury.²

Moving Forward

Scott Cassel, founder and executive director of the Product Stewardship Institute, has provided key information to state legislators and staff members working on important regulations and bills. Cassel calls on environmental managers to be leaders, as he describes the three most important steps for those in both public and private sectors to take in managing toxic e-waste disposal:

"First, do not export materials until you are absolutely certain of the full tracking of those materials every step along the way. Groups like the Basel Action Network do not believe that this standard can be met so they have promoted export bans. Second, cooperate with environmental groups and government officials in ensuring that operations meet the highest recycling standards. Laws and regulations often respond to problems, and lag behind state-of-the-art leadership. Environmental managers should be leaders. Finally, consider all options to remove barriers to collection, whether regulatory or operational. Every day that a solution is not in place means that toxins will continue to be disposed of in landfills and incinerators. We have to think in terms of rapid ramp-up of collection and recycling operations."¹⁸

Priorities

Zarrehparvar says a nationally coordinated effort is severely needed, including incentive for industry to create something less toxic.¹¹

Robinson says education and outreach must be the top national priorities with regard to electronics manufacturing and disposal. "You have to make sure what you do in the urban areas is the same as what you do in the rural areas," he says, emphasizing that it's important to have a clear process and plan in place to handle the residential e-waste. "We find we get more participation if we make it free, convenient, and local. If we tell the consumer to pay \$2.00 to recycle it, they won't do it."⁵

Robinson also suggests enforcing strong quality control measures, to ensure no one is sending e-waste to developing nations. Further, he says manufacturers have to get involved in creating a cradle-to-grave policy, too, with an awareness that used products will return to them. "If I know I'm gonna get something back, I'm gonna

make sure it has some kind of value, so when I get it back, I want to use it," he quips.⁵

Finally, Robinson notes the importance of keeping consumers in the loop. Ultimately, as consumers become aware of the issues surrounding electronics disposal, they will help drive officials to create sustainable policies. By using their purchase power, consumers will drive manufacturers to create safer and more sustainable products.⁵ **em**

FOR MORE INFORMATION

Recyclers and waste managers following EPA's R2 guidelines can find detailed information about the export-related practices that extend the recycler's responsibility for focus materials online at www.epa.gov/osw/hazard/recycling/electron/index.htm. EPA expects exporters to get assurances from downstream vendors both domestically and internationally, in order to demonstrate those materials are being handled properly and legally by downstream vendors throughout the recycling chain. To comply with these practices, exporters that send electronics or focus materials for refurbishment and/or recycling will need documents that show the export is legal under the laws of the receiving country. Upon request, EPA has agreed to help exporters of e-waste obtain documentation from foreign governments to as to the legality of import of R2 focus materials that are contained in used electronic equipment or separated as components and sent from the United States. Recyclers who would like to request EPA's assistance in getting documentation on the legality of exports from foreign countries can contact Frank McAlister: EPA (5304P), 1200 Pennsylvania Ave., Washington, DC 20460; e-mail: mcalister.frank@epa.gov.

