Government Challenges and Opportunities in Developing Electronics Recycling Programs

Presented to:

SUR Corporacion de Estudios Sociales y Educacion
Santiago, Chile

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October 2006

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1.0 Introduction

The transfer of personal computer equipment and other electronic devices from the US, Canada and similar countries to Latin American and the Caribbean countries offers a tremendous opportunity to reduce the digital divide between the North and the South. There is concern, however, that this practice could result in a trans-boundary shipment of wastes which may under some definitions be regulated as hazardous. Personal computer equipment and other electronic devices are known to contain toxic chemicals which may pose environmental and human health risks if improperly managed, or may at the very least result in large disposal costs. The objective of the study proposed here is to examine the roles that governments can and do play in the management of shipments of electronic devices from one country to another in legal and environmentally sound manner.

This study will categorize the current practices, regulations and government policies regarding the reduction of EWaste; the regulatory and environmental implications of different management options; and its shipment, recycling, reuse and disposal in recipient countries. The first step will be to summarize the current understanding of the regulatory requirements for management of discarded electronic devices (which will differ depending on the country) and the risks that different management options may pose on human health and the environment. This information will be based on the investigator's current knowledge base on the subject; collection of information from academic and web-based resources; and contact with appropriate organization and individuals. Using this same information gathering methodology, current challenges

facing governments will be highlighted and best practices currently in place will be highlighted.

The information gathered will be assimilated into a document that will highlight the possible roles of government and other organizations, and how these organizations might interact with one another. Based on the information learned, a series of possible strategies for action at the local, state and regional level will be outlined, including a discussion of possible advantages and disadvantages of each strategy. Strategies for elevating awareness of these issues in countries in the region of interest will be outlined..

2.0 Motivation and Challenges

2.1 The Discarded Electronics Waste Stream

Discarded electronic devices represent a growing segment of the solid waste stream. According to a study prepared for the US EPA, discarded electronic devices have been estimated to comprise approximately 2% to 5% of the US municipal solid waste (MSW) stream (Global Futures Foundation, 2001). Industry experts have projected that more than 20 million personal computers became obsolete in 1998, and more than 60 million personal computers will be retired in 2005 (National Safety Council, 1999). Approximately 3 million tons of E-waste were estimated to be disposed in US landfills in 1997 (Global Futures Foundation, 2001).

2.2 Environmental Concerns

Concerns have been raised that toxic chemicals will leach from discarded devices when disposed (Yang, 1993; Lee et al., 2000; White et al., 2003). The toxic chemicals commonly used in electronic devices include metals and metalloids (e.g., arsenic, cadmium, chromium, copper, lead, and mercury) and organic chemicals such as brominated flame retardants (BFRs). The printed wire boards (PWBs, also referred to as circuit boards) found in most E-waste, for example, may contain arsenic, cadmium, chromium, lead, and mercury (Nordic Council of Ministers, 1995; Five winds International, 2001). Cathode ray tubes (CRTs) in computer monitors and televisions may contain barium, cadmium, copper, lead, zinc, and several rare earth metals (Five Winds International, 2001). Lead is one heavy metal with known toxic properties that is found in large amounts in many electronic devices (Nordic Council of Ministers, 1995). Electronic devices, along with lead-acid batteries, are the major contributors of lead in the municipal solid waste stream (US EPA, 1989).

Lead-based solder (typically a 60:40 ratio of tin to lead), which is used to attach electrical components to PWBs, represents the major solder type used in most PWB applications (Nordic Council of Ministers, 1995; Five winds International, 2001). Typical PWBs have been reported to contain approximately 50 g of tin-lead solder per m2 of PWB (Five winds International, 2001), and approximately 0.7% of the total weight of a PWB (Electronic Industry Alliance, 2000). In CRTs, leaded glass provides shielding from X-rays generated during the picture projection process. Color CRTs contain 1.6 kg to 3.2 kg of lead on average (Microelectronics and Computer Technology Corporation, 1996). The possible effects of lead on human health and the environment are well documented (Waldron, 1980; Gosselin et al., 1984; Sitting, 1996).

In the US, under regulations promulgated as part of the Resource Conservation and Recovery Act (RCRA), solid wastes containing large amounts of leachable lead are regulated as hazardous wastes unless otherwise exempted. Lead leaching is measured using a batch extraction test known as the Toxicity Characteristic Leaching Procedure (TCLP, US EPA Method 1311) (Federal Register, 1986; US EPA, 1996). In a previous study, color CRTs from televisions and computer monitors were found to leach enough lead using the TCLP to be toxicity characteristic (TC) hazardous wastes in most cases (Musson et al., 2000). The majority of samples tested exceeded the TC limit of 5 mg/L for lead. Discarded color CRTs are thus considered TC hazardous wastes unless test results show otherwise (Federal Register, 2002).

Generators other than households who dispose of more than 100 kg of color CRTs per month must manage them via a permitted hazardous waste facility. Generators who produce less than 100 kg per month (conditionally exempt small quantity generators [CESQGs]) may under

RCRA dispose of these wastes in a state-permitted solid waste management facility (e.g., MSW landfill). Many states, however, ban CESQG hazardous waste from landfills. RCRA regulations exclude solid waste produced by households from the definition of hazardous waste; a color television or computer monitor that is disposed by a household is not a hazardous waste. At least one state, California, has not adopted the household waste exclusion. Because many CRTs can still be legally disposed in MSW landfills, state environmental regulators and local communities must determine what additional initiatives, if any, should be enacted to address CRT disposal. One possible action is to provide funding so CRTs can be collected at household hazardous collection facilities, by curbside collection or through special collection events. The estimated cost to recycle one CRT has been reported to range from $9 (computer monitors, small TVs) to $ 35 (console TVs) (Price, 1999). States also have the option of banning the disposal of these devices in landfills. In the US, both California and Massachusetts have banned CRT disposal in landfills (Federal Register, 2002). With recent research indicating that other discarded electronic devices (those that contain PWBs with lead solder) will in many cases fail the TCLP for lead (Townsend et al., 1999), similar questions will be raised for E-waste as a whole.

Even if a waste is determined to be hazardous by the TC, there will still be times when it is disposed in a landfill (from household waste, CESQG waste). In addition, wastes that do not exceed TC limits using TCLP might still leach sufficient concentrations of pollutants to elevate concentrations in the landfill's leachate. While modern MSW landfills are lined to intercept and collect the leachate, elevated pollutant concentrations in a landfill's leachate can pose problems for leachate treatment and disposal and perhaps impact the long term management of leachate after the landfill is closed.

2.3 Opportunities for Reuse and Recycling

The presence of toxic chemicals in discarded electronic devices provides impetus from a environmental regulatory perspective. Another major motivating factor behind the desire to reuse and recycle these materials is the potential value of the devices and the materials they contain.

Although devices such as personal computers are commonplace in most homes and schools in first world economies, poorer parts of the world often do not have access to such equipment. Consumers in the "North" tend to discard devices as they become outdated and as new software applications require greater computing power. Yet these devices, if routed to the appropriate hands in a country from the "South," could prove of tremendous value. Organizations have been set up to help reduce the "digital divide" by providing donated computers and computer equipment to those in need. As described below, a number of major challenges exist to seeing this form a reuse fully implemented.

Devices that are not longer functional or that for some reason are not destined for reuse still contain a wealth of material that can be recycled into new applications. These materials include plastics, glass, steel, aluminum, copper and several lucrative trace metals that are contained in many of these devices. Technologies now exist that can take most electronic devices and separate them into their base components for reclamation. In these systems, devices are normally mechanically size-reduced after some degree of manual component separation. The size-reduced fraction is then processed for separation into saleable materials.

2.4 Challenges

Given the motivating factors described above, it might seem a simple choice to reuse and recycle the discarded electronic devices from the solid waste stream rather than dispose of these items in landfills or waste-to-energy facilities. At the current time in much of the North, however, most discarded electronic devices are not recycled.

Perhaps the greatest challenge with respect to recycling this waste stream stems from the fact that although these devices do contain materials of value, it costs more money to collect and process these materials for reuse and/or recycling than to simply dispose of them with the rest of the waste stream. Landfills remain the least expensive manner of managing solid waste, and given that in many cases discarded electronic devices are not hazardous waste by regulation, or they have not yet been interpreted to be hazardous waste (or have not been enforced), the least expensive management is landfills. If electronics recycling is to occur, this additional cost must come from somewhere.

In addition to costs, other challenges must be overcome. Infrastructure needs such as collection and transportation are not trivial, even if economics is not an issue. Even if it does not cost the consumer anything additional, if they have to deliver their old television to a special location, the ease of disposing it as part of their normal waste stream may be the overriding factor. Data remaining on discarded devices, especially those destined for reuse, is a major concern. The shipment of electronic devices can be an impediment to reuse of devices, especially in other countries, as a result international regulations and policies on trans-boundary movement of hazardous wastes. This issue has been highlighted in well-documented abuses in Asia and Africa of EWaste exported from the North.

3.0 Recycling System Components

Governments can influence the recycling of electronic devices in many different manners. To discuss these different avenues, it is important to under the different components of the lifecycle of a discarded electronic device.

- **Point of Waste Generation.** Although it might seem like a relatively minor point, government regulations can have a large impact on recycling electronics activities simply in the definition of when a device is considered a waste. For example, if a batch of laptop computers is no longer of use to a company and they decide to donate them, they may wish to send to another country where computers in schools are much less common. By regulatory definition, if the laptops are considered a waste, then they may be subject to hazardous waste shipment rules. If this were the case, the laptops might not be allowed to be shipped to another country.

  As another example, to encourage the glass-to-glass recycling of discarded cathode ray tubes, the US EPA interprets whole CRTs destined for this market to not be solid waste, and thus not subject to hazardous waste regulations (which may be so costly that they discourage recycling). However, if the CRTs are not intended for this recycling option, they are not exempt and may thus require management as a hazardous waste.

- **Collection and disposition**. Governments play a large role in the collection of discarded electronic devices since they are already responsible (at least at some level) for the collection of solid waste. Governments can institute curbside collection of discarded

electronic devices and they can provide drop-off centers for such equipment.

In a similar manner as dictating when a discarded electronic device is a waste or not, governments can also dictate where such equipment can go by designated it a hazardous waste or by prohibiting its disposal with the rest of the waste stream.

- **Refurbishment and Recycling**. Another key components in the EWaste lifecycle is the facility where the devices are tested to determine their functionality or where they are separated and shipped for ultimate recycling. As pointed out under the challenges, recycling EWaste costs more money than the products market value, so the cost of recycling must come from somewhere. Governments can dictate where these funds come from and how they are distributed.

- **Transportation**. When devices are recycled and reused, at some point they must be shipped to either their end-use destination or to a location where they are further processed. The shipment of materials and wastes can prove a challenge when they are considered hazardous, so government policies and regulations can impact this issue dramatically.

4.0 Government Regulatory and Policy Options

In this section, we examine several major government initiative that have been enacted to help support electronics recycling activities.

4.1 Disposal Bans

Typically the least expensive method for disposing of solid waste, including discarded electronic devices, is in landfills. Some electronic devices meet the definition of hazardous waste under federal regulations; however, some do not. Governments have in some cases enacted separate landfill bans that prohibit the disposal of electronic devices in landfills. For example, Maine and Massachusetts have enacted bans that prohibit the disposal of color cathode ray tubes in landfills.

4.2 Government Funded Collection Systems

Collection and disposal of solid waste is a major responsibility of municipalities, and as such, many municipalities have enacted programs that encourage the recycling of EWaste. In a small number of cases, electronic waste can be placed at the curbside and collected separate from the rest of the waste stream. A more common practice is to have dedicated drop-off facilities or to hold collection events where residents can drop off electronic devices. The funds used to pay for these activities are typically part of the normal funds used for municipal waste management.

4.3 Mandated Product Stewardship

In the European Union, the model is for the companies who produce electronic devices to participate in the recycling of these devices. The major question that is raised is who pays for the recycling of collected discarded electronic devices. In the US, a group of government, industry and NGOs worked to develop a nationwide system that would fund the

recycling of EWaste. Differences could not be overcome and now many companies have set up their own product stewardship initiatives. In addition, many states have proposed legislations to address these needs. The most far reaching example of this is the legislation recently enacted in the state of California. In California, consumers who purchase certain electronic devices (display devices at this point) pay an extra fee ($10 - $15) that goes toward a fund that supports EWaste recycling infrastructure.

5.0 Summary and Conclusions

The reuse and recycling of discarded electronic devices offers great benefit from both a social and an environmental perspective. Major challenges remain before this method of management reaches its full potential, most notably the costs incurred. Government organizations at all levels can influence the success of EWaste recycling at all levels. Local governments can provide resources and education for collection. State and federal government can enact legislation and policy that dictates whether these devices can be disposed in less expensive landfills or whether more expensive management options such as recycling are required. Government agencies can also help in developing systems that establish the cost structure for paying for recycling programs. In the US, federal initiatives for establishing this cost structure have not been successful. The recent legislation in California is the most advanced of its kind in North America, and most closely approaches models used in Europe. Additional debate and discussion is needed to help foster more international donations of electronics equipment for reuse in a manner that will be safe for the environmental and the health of the receiving country population.

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US EPA, 1989. Characterization of Products Containing Lead and Cadmium in Municipal Solid Waste in the United States, 1970 to 2000, EPA/530-SW-89-015B, Office of Solid Waste, Washington DC, 1989.

Yang, G. C., 1993. J. Haz. Mater. 34 (2): 235-243.

Appendix A. Discarded Electronics Recycling Resources

The following resources contain information of value to those interested in the government's role in systems for recycling discarded electronic devices.

International Government

United States Government

http://www.epa.gov/epaoswer/hazwaste/recycle/ecycling/index.htm

http://www.federalelectronicschallenge.net/index.htm

http://www.computers.fed.gov/public/aboutProg.asp

State of California EWaste Resources

http://erecycle.org/index.htm

http://www.ciwmb.ca.gov/electronics/

http://www.crc.org/

State of Colorado

http://www-ucsu.colorado.edu/comex/

State of Connecticut

http://dep.state.ct.us/wst/recycle/computel.htm

State of Florida

http://www.dep.state.fl.us/waste/categories/electronics/default.htm

State of Massachusetts

http://www.mass.gov/dep/recycle/reduce/electron.htm

State of Minnesota

http://www.moea.state.mn.us/plugin/index.cfm

State of New Jersey

http://www.nj.gov/dep/dshw/lrm/uwaste/

State of New York

http://www.dec.state.ny.us/website/dshm/hzwstman/electron.htm

State of Ohio

http://www.epa.state.oh.us/ocapp/p2/recyc/comp-rc.html

Non-Governmental Organizations

http://eerc.ra.utk.edu/clean/nepsi/

http://www.pcsforschools.org/

http://www.c4k.org/

http://www.compumentor.org/recycle/

http://www.recycles.org/forms/donate.htm

http://www.eiae.org/

International Governmental Information

http://www.rohs.gov.uk/

Appendix B. PowerPoint Presentation Summarizing Report

Government Challenges and Opportunities in Developing Electronics Recycling Programs

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Presentation Outline

- Scope of problem
- Challenges faced by government agencies
- System components
- Government initiatives
  - Disposal bans
  - Government funded take back
  - Mandated product stewardship

Scope of Problem

- Large quantities of discarded electronic devices are produced
- Reuse and recycling are preferred over disposal
  - Reuse of functional equipment
  - Recycling of components parts
  - Keep toxic elements out of landfills

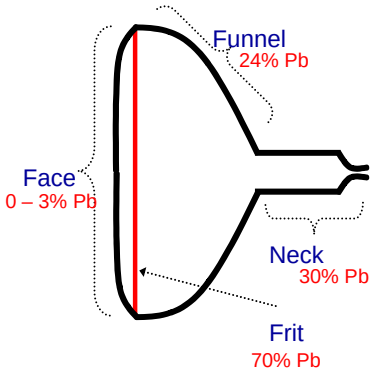
Reuse and Recycling

- Reuse
  - Donation of functional devices for use by schools, disadvantaged population, or in other countries
  - Resale of functional equipment
- Recycling
  - Reclamation of components chemicals for new uses

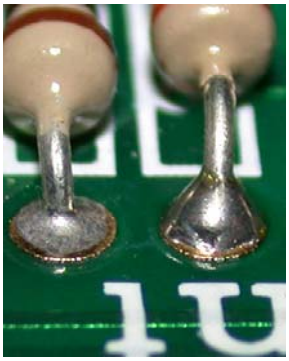
Environmental Concerns

Example: Lead is comment element in many devices

Cathode Ray Tube



Printed Wiring Boards



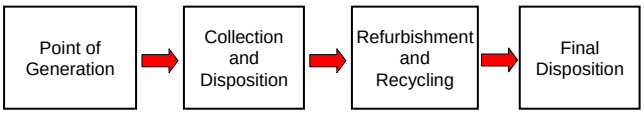
Challenges

- Economics
  - In most cases, it costs more money to recycle discarded electronic devices than it does to dispose with rest of waste
- Infrastructure
  - Systems are not in place that allow easy donation or recycling of devices
- Education
  - Opportunities are not always known to individuals or organizations with electronic devices to discard

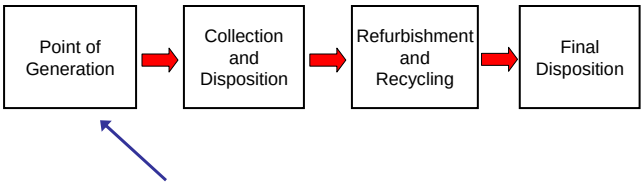
System Components

- Government agencies can influence recycling of discarded electronic devices at multiple points in the system
  - Waste definition
  - Requirements of waste management
  - Providing systems for collection and drop-off
  - Support and regulation of refurbishing and recycling facilities
  - Mandated product stewardship
  - Support and regulation of trans-boundary shipment of discarded electronic equipment for resale and reuse

The EWaste Lifecycle

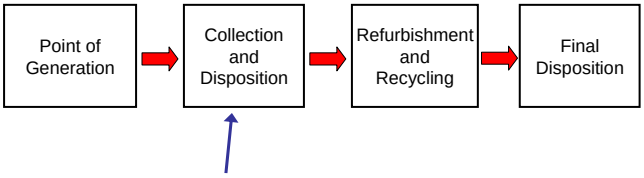


The EWaste Lifecycle



Governments can influence the point when a discarded device becomes a waste. For example, the US regulations pertaining to CRTs explain that discarded whole CRTS destined for some types of recycling are not wastes, and thus do not require management as a hazardous waste

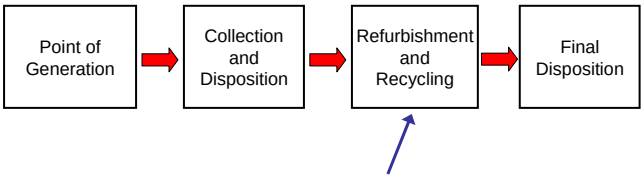
The EWaste Lifecycle



Local governments can choose to invest resources in curbside collection of discarded electronic devices or they can provide drop-off centers for the public to deliver their devices.

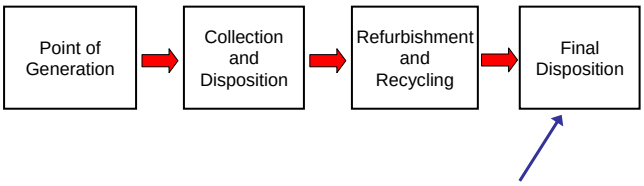
Governments can also ban certain types of electronic devices from being disposed in the normal waste management system, thus requiring that they be sent for recycle or reuse.

The EWaste Lifecycle



Governments can require that manufactures or sellers of electronic equipment to pay for the refurbishment and recycling discarded electronic devices.

The EWaste Lifecycle



Governments can influence where the electronic devices will be transported depending on the regulations and policies they adopt regarding shipment of these devices.

Government Initiatives

- The most common initiative in North America:
  - Disposal bans
  - Government funded collection systems
  - Mandated product stewardship

Disposal Bans

- In the US and Canada, federal rules provide requirements for management of hazardous waste.
- Some discarded electronic devices are considered hazardous waste, others are not.
- To ensure that particular devices are not disposed in landfills or WTE facilities, some states have enacted landfill bans (e.g., Massachusetts, California) which prohibit disposal. Enforcement of such bans can be difficult.

Government Funded Collection

- Many local governments provide a system for the public to dispose of their discarded electronic devices in a manner other than normal waste disposal.
  - Collection programs: although not common, some communities provide for separate collection of electronics at the curbside.
  - Drop-off facilities or events: local goverments often provide locations where the public can bring their discarded electronic devices for recycling and reuse.

Computer equipment and other discarded electronic collected from the public

Mandated Product Stewardship

- Governments can require that manufactures and sellers of electronic equipment provide for the take back of this equipment
- These systems exist in Europe
- The development of a national system in the US has been elusive
- California instituted their own system

California Case Study

- Consumers pay an extra fee when purchasing certain types of electronic devices (display devices at the current time).
- These fees go toward the funding of electronics recycling operations.
- These devices are prohibited from disposal with normal household waste.

Summary and Conclusions

- Challenges abound for management of discarded electronic devices, but federal, state and local governments can play a role in enhancing the reuse and recycling of discarded electronic devices.