Strategies for Improving the Sustainability of E-Waste Management Systems

Concept Document

Prepared by:

The University of Illinois at Urbana-Champaign
Sustainable Technology Center
1 Hazelwood Drive
Champaign, Illinois 61820

http://www.istc.illinois.edu/
http://www.sustainelectronics.illinois.edu/

February, 2009
Revised July, 2009

Executive Summary

Strategies for Improving the Sustainability of E-Waste Management Systems

Americans currently own nearly 3 billion electronic products and as new products are purchased, obsolete products are stored or discarded at alarming rates. About two-thirds of the electronic devices removed from service were still in working order. However, only about 15% of this material is recycled while the vast majority is disposed in landfills (United States Environmental Protection Agency Office of Solid Waste and Emergency Response, 2008). The existing system for managing e-waste is generally not sustainable because mechanisms for collecting, sorting, reuse, refurbishing, repairing, and remanufacturing are not well developed and/or implemented. Problems associated with market issues, obsolescence issues, feedstock collection, feedstock management, and product-design need to be addressed. Given the complexity, uncertainty and diversity of the e-waste problem, a rigorous multidisciplinary academic approach is necessary to develop and implement systems that effectively utilize and recycle these products.

A need exists for a Consortium dedicated to the development and implementation of a more sustainable system for designing, producing and handling electronic devices. Specific elements of such a Consortium would include programs for research, education, data management and technical assistance. The Consortium would be formally referred to as the Sustainable Electronics Initiative (SEI) and housed at the Illinois Sustainable Technology Center (ISTC) located at the University of Illinois at Urbana-Champaign (UIUC). The UIUC has a rich history of industrial leadership and the State's first in the nation "extended producer responsibility" legislation encourages reuse of electronic products.

Specific research and education elements of SEI would include: 1) a complete, accurate and useful data collection and management system 2) use of "greener" raw materials and recovery of valuable constituents, 3) methods for making products that are more easily disassembled, repaired, remanufactured and reused, 4) methods for managing the complexity of recycled feedstock, 5) techniques for collection, labeling, tracking, transportation, storage, data security, 6) assessing quality of recovered feedstocks, and 7) alternative mechanisms for delivering performance (e.g. leases, service contracts, etc). Design and engineering courses would be developed regarding these topics to advance the science of e-waste management. Additionally, student projects would be developed where students design and construct useful products from e-waste.

Technical assistance activities undertaken by SEI would include managing and maintaining a database to facilitate the tracking of dozens of parameters associated with products, components, quantities, quality, availability, value, age, materials, etc. Additionally, technical support would be provided regarding methods for e-waste collection, storage, feedstock management and data management. Seminars and training regarding best practices associated with e-waste management would help promote behavior change. All activities and products would be communicated nationwide through existing networks on pollution prevention and waste minimization.

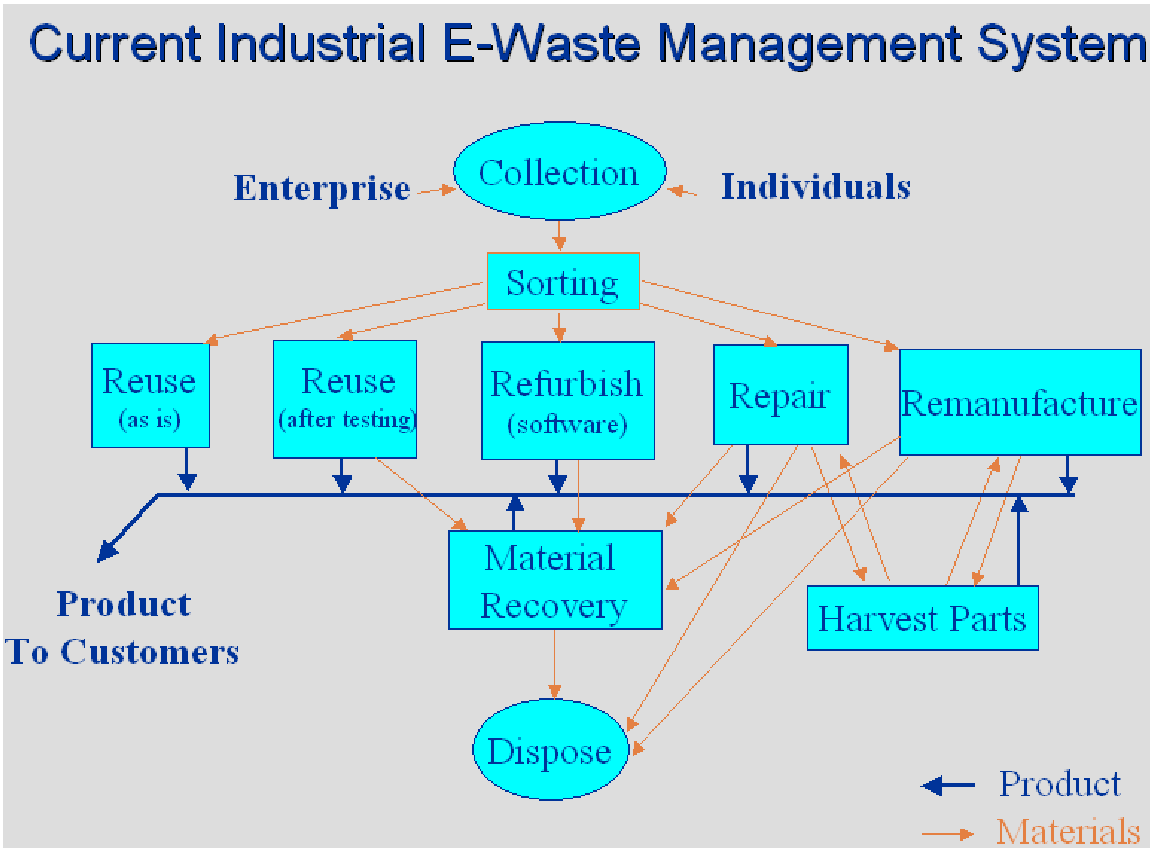
Introduction

Americans currently own nearly 3 billion electronic products and as new products are purchased, obsolete products are stored or discarded at alarming rates. For instance, in 2005, the USEPA estimates that 26-37 million computers became obsolete. In addition to computers, large numbers of TVs, VCRs, cell phones, and monitors also became obsolete such that an estimated 304 million electronic devices weighing between 1.9 and 2.2 million tons were removed from U.S. households. According to Consumer Electronics Association estimates, about two-thirds of the electronic devices removed from service were still in working order. However, only about 15% of this material was recycled while the vast majority was disposed in landfills (United States Environmental Protection Agency Office of Solid Waste and Emergency Response, 2008).

Electronic wastes contain toxic substances such as lead, mercury, cadmium, and lithium (Cui, Jirang, 2008). These toxic materials can be released upon disposal, posing a threat to human health and the environment. Inconsistencies in worker safety and environmental protection mean potential liability concerns for those sending electronics to recycling facilities – especially if these facilities are located in developing countries. However, electronic wastes also contain precious metals such as gold, silver, which offer opportunities for economic extraction. For example, precious metals contribute well over 70% of all metals related value in cell phones, calculators and printed circuit board scraps. In other items such as TV boards, and DVD players they still contribute about 40% of the value (Cui, Jirang, 2008).

Many states such as California, Maine, Washington, Minnesota, and Illinois have or are considering legislation that will require manufacturers to pay for the cost of the ‘end of life’ treatment of electronic products (Electronics TakeBack Coalition, 2008). Industry experts estimate that the cost in Illinois alone will be over $10 million each year. Nationwide, the costs could exceed $200 million. It is estimated that Dell alone could face a $1.5 million expense in 2009 for its share of the e-waste stream. Most of the products received at electronic collection sites are functional but not necessarily the latest or the greatest. The collection and management of the electronics stream is an industry that is in its infancy. Given the complexity, uncertainty and diversity of this stream, a rigorous multidisciplinary academic approach is necessary to develop and implement systems that effectively utilize and recycle these products.

The figure provided below describes the current processes available for managing e-waste. It was developed with input from an e-waste focus group convened at the University of Illinois in September of 2008. This focus group was comprised of experts from industry, government and academia. As shown, the existing process, when functioning properly, provides mechanisms for collection, sorting, reuse, refurbishing, repairing, and remanufacturing. Given that two-thirds of electronics are still in working order when they are discarded, these steps are critical for an effective e-waste management system. Unfortunately, in most instances these mechanisms are not available for the vast majority for discarded electronics thus leading to the relatively low 15% recycle rate that currently exists (United States Environmental Protection Agency Office of Solid Waste and Emergency Response, 2008).



Problems with Existing System

The University of Illinois focus group identified a number of deficiencies associated with existing e-waste management systems that have prevented more widespread recycling and reuse. A summary of these issues is provided below:

- Market Issues – A severe lack of "market intelligence" exists with respect to how the market values individual components. The materials are extremely complex and information regarding the availability and quality of recyclable materials is very limited.
- Obsolescence Issues – Some electronic devices have relatively short life spans with limited opportunities for maintenance and recycling. However, many electronic products are perceived to be obsolete well before their

useful life has expired due to reduced performance associated with lack of software maintenance and upgrades.

- Feedstock Collection Issues – No standardized methods currently exist for executing successful e-waste collection events. Existing methods have resulted in events that are inconvenient for potential users. Additionally, procedures for preserving the quality of harvested components have been inadequate and the economics of holding collection events have not been strong.
- Feedstock Management Issues – Labeling information on discarded electronics is limited, making it difficult to accurately identify parts. The available work force tends to lack experience in part identification and training is not available regarding best practices.
- Design Issues – Many electronic devices are not designed for disassembly and maintenance. Additionally, many items are not designed for remanufacturing.

Opportunities for Developing a More Sustainable System

In addition to the problems identified above, the University of Illinois focus group also identified some potential solutions that could address the majority of these issues. A summary of these opportunities is provided below.

Research Opportunities

- Data Management - Current methods for tracking the origin, use and management of e-waste are extremely limited. EPA currently estimates the amount of electronic products sold, stored, recycled, disposed of, and exported in the U.S. using a series of assumptions and estimates based on market research data for sales and data from electronics collection programs along with some government statistics for sales. These data are usually not complete or current and are developed only for purposes of deriving national estimates. Additionally, the information is woefully inadequate for making strategic decisions regarding feedstock, market and system management. Current EPA e-waste management efforts focus on:

  1. number and weight of products that become obsolete
  2. amount of electronic products that are recycled or disposed of
  3. amount of electronic equipment that is stock-piled
  4. collection rates of current electronics recycling programs, and
  5. export of electronic material

  The development of a more sustainable e-waste management system is contingent on the quality of data available for decision-making purposes. Consequently, development of a more complete, accurate and useful data collection and management system is paramount to establishing a more sustainable e-waste management system. Examples of additional data needed to support an effective system include the following.

1. Where the waste originated/how far it traveled
2. User information (personal, commercial, industrial, etc)
3. Manufacturer name
4. Model numbers
5. Serial numbers
6. Product type (TV, monitor, CPU, etc)
7. Product age
8. Product service life
9. Reason for discarding (e.g. obsolete, damaged, software issues, etc)

This information could be combined with other pertinent databases associated with product information (e.g. model numbers could be cross-referenced with specific parts lists) and demographic information (e.g. census, Thomas Registry, etc.) to create a comprehensive database that would be extremely valuable for users interested both in the quality of the products they produce, availability of reusable components, and methods for remanufacturing, reusing and recycling them.

- Materials - e-waste is well known for containing a wide range of materials that are hazardous to both the environment and the people who work with e-waste. Consequently, a need exists to develop products using "greener" raw materials and processes and to recover valuable materials from e-waste that can be used in other products.
- Design – Development of methods for making products that are more easily disassembled, repaired, remanufactured and reused are essential to a more sustainable system.
- Feedstock Management - Methods for managing the complexity of recycled feedstock are extremely important. Techniques for collection, labeling, tracking, transportation, storage, data security, and assessing quality of feedstocks are key components of an effective system.
- Delivery Mechanisms – Most users of electronics do not need to own them – they only need performance. Development of alternative mechanisms for delivering performance (e.g. leases, service contracts, etc.) could dramatically reduce waste.

Education Opportunities

- Courses – Specific design and engineering courses could be developed to advance the science of e-waste management. Some ideas for course topics include:

  -Life Cycle Assessment for Electronics Manufacture, Use and Recycling
  -Environmentally Conscious Design of Electronics
  -Designing Electronics for Disassembly

-Designing Electronics for Remanufacture

- Student Projects – Ideas for student projects with respect to e-waste are unlimited. Some project ideas that have been undertaken recently at the University of Illinois include:

  -Student competition to design and construct useful products from e-waste
  -Student competition to make a parallel computing system constructed from recycled processors
  -Student sponsored e-waste collection events

Outreach Opportunities

- Database Management – Managing and maintaining a database with relevant information regarding parameters that would be useful to electronics producers, recyclers, and users would be a key component of an e-waste outreach program. It is anticipated that dozens of parameters associated with products, components, quantities, quality, availability, value, age, materials, etc. would be tracked and maintained in the database. This information would be extremely valuable to database users and these customers would be willing to pay fees that would make the long-term viability of this activity self-sustaining.
- Technical Assistance – Technical support regarding methods for e-waste collection, storage, feedstock management and data management would be extremely important to ensure widespread diffusion of sustainable e-waste management. Additionally, seminars and training on best practices associated with e-waste management would promote behavior change. Help associated with implementation of pilot e-waste management programs would be another key component.

Sustainable Electronics Initiative (SEI)

Based on the problems and opportunities described above, a need exists for a Consortium to develop and implement a comprehensive strategy for sustainable electronic product design, production and e-waste management. Specific elements of such a Consortium would include programs for research, education, data management and technical assistance. The Consortium would be formally referred to as the Sustainable Electronics Initiative (SEI) and housed at the Illinois Sustainable Technology Center (ISTC) located at the University of Illinois at Urbana-Champaign (UIUC). A brief explanation of SEI's vision, programs and functions is provided below.

Vision: A Consortium dedicated to the development and implementation of a more sustainable system for designing, producing and handling electronic devices.

SEI Programs

Research	Education	Data Management	Technical Assistance
•Design	•Design	•Quality	•Awareness
•Processing	•Processing	•Performance	•Demonstrations
•Remanufacturing	•Remanufacturing	•Demographics	•Pilot Programs
•Sustainability	•Sustainability	•Marketing	•Logistics
•Life Cycle	•Life Cycle	•Compliance	•Policy
•Waste Management	•Materials	•Inventory	•Recycler Certification
•Logistics			

UIUC Qualifications

The UIUC has a rich history of industrial leadership and the State's first in the nation "extended producer responsibility" legislation that encourages reuse could be significant assets in creating the world's premier research center devoted to the reuse of electronics. The Illinois Sustainable Technology Center (ISTC; formerly the Waste Management and Research Center) is a change agency that performs research, spreads awareness, and facilitates implementation regarding practices, technology and systems that improve sustainability. ISTC has been providing these services to businesses and the public since 1985. Examples of services offered include: research to develop innovative techniques to solve waste problems, sophisticated analytical laboratory support, a library and clearinghouse on environmental and pollution prevention topics, and technical assistance associated with implementation of more sustainable practices. ISTC has a long history of developing processes and solutions to minimize pollution in closely related industries such as electroplating and printed circuit board manufacturing that could be brought to bear in extracting metals from e-wastes.

ISTC has coordinated the Great Lakes Regional Pollution Prevention Roundtable (GLRPPR; www.glrppr.org) since 1995. This is a professional organization dedicated to promoting information exchange and networking to pollution prevention (P2) professionals in the Great Lakes regions of the United States and Canada. GLRPPR's membership consists of assistance providers, business, industry, governmental agencies, non-profits, consultants, vendors, and universities in WI, MN, IL, IN, OH, MI, PA, NY and Ontario. GLRPPR is one of eight centers that make up the national Pollution Prevention Resource Exchange (P2Rx; www.p2rx.org).

GLRPPR gives ISTC the regional and national reach to disseminate information about e-waste problems and opportunities and to exchange assistance and advice with professionals across the nation. This networking with peer organizations reduces duplication of efforts and leverages monetary and personnel resources. GLRPPR and P2Rx support technical resources through the GLRPPR web site (www.glrppr.org) listservs; fact sheets; calendars and funding information; news; information hubs devoted to specific topics; a help desk for P2inquires; and a P2 Library. GLRPPR's efforts also have included shepherding a portion of the national P2 measurement database since its inception. ISTC maintains an active account on the P2 measurement database.

The College of Engineering at UIUC (http://engineering.illinois.edu) is among the world's most prestigious and largest engineering institutions, with undergraduate and graduate programs rated among the top five nationally. Approximately 5,600 undergraduates and more than 2,500 graduate students are divided within 12 specialized departments within the College. The breadth and scope of research activities are enormous--over $167 million funding more than 1,900 projects by some 650 researchers and thousands of graduate and undergraduate students. In addition to long-standing leadership in traditional engineering specialties, they are pioneering new areas such as nanotechnology, bioengineering, trusted computer systems, novel materials, and much more.

The Industrial Design program of the School of Art and Design in the College of Fine and Applied Arts at UIUC (http://www.art.illinois.edu/content/undergraduate/programs/industrial-design) is one of the oldest programs in the nation with an impressive list of distinguished alumni who have risen to leadership positions in the profession. The Product Innovation Research Laboratory (PIRL) conducts sponsored interdisciplinary research involving applied design projects linking business, technology and design resources throughout the university. There are also interdisciplinary campus-wide education and research initiatives such as the solar decathlon, solar vehicle, engineering capstone projects, and racecar design. Most recently, a Sustainable e-waste design competition (http://ewaste.illinois.edu/) has been established, where teams of 3-5 students work together to create innovative uses for e-Waste. These students from across campus collaborate to create new uses for e-Waste will demonstrate positive ways of dealing with the growing e-Waste problem.

Bibliography

Cui, J. & Zhang, L. 2008, "Metallurgical recovery of metals from electronic waste: A review", *Journal of hazardous materials,* vol. 158, no. 2-3, pp. 228-256.

Electronics TakeBack Coalition 2008, "State By State E-Waste Law Summary", pp. 9.

United States. Environmental Protection Agency. Office of Solid Waste and Emergency Response. & United States. Office of Solid Waste. 2008, *, Fact sheet management of electronic waste in the United States* [Homepage of [U.S. Environmental Protection Agency]], [Online].