CANADIAN INSTITUTE FOR ENVIRONMENTAL LAW AND POLICY

L'INSTITUT CANADIEN DU DROIT ET DE LA POLITIQUE DE L'ENVIRONNEMENT

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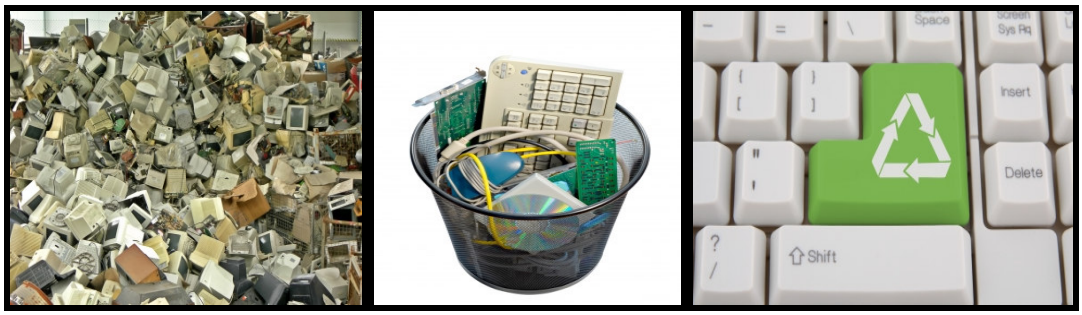
130 Spadina Avenue Suite 305
Toronto, Ontario M5V 2L4

Tel: (416)923-3529
Fax: (416)923-5949
www.cielap.org
cielap@cielap.org

Discussion Paper on the

Sustainable International Management of Waste Electrical & Electronic Equipment



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Contributors:

Abena Amoako-Tuffour
Satya Mohapatra
Carolyn Webb

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Table of Contents

1. Introduction

Electrical and Electronic Equipment (EEE), also known as electronic waste or e-waste, consists of appliances that need electric current or electromagnetic fields to work. When this equipment reaches the end of its useful life, whether surplus, obsolete, broken or discarded, it becomes Waste Electrical and Electronic Equipment (WEEE). Broadly, WEEE includes large and small household appliances, information technology (IT) and telecommunications equipment, consumer and lighting equipment, electrical and electronic tools, toys, medical equipment systems monitoring and control instruments and automatic dispensers.[1] According to Environment Canada, electronic waste comprises used appliances, such as colour televisions, microwaves, toasters, computers, coffee makers, VCRs, DVD players, camcorders, portable CD players, mobile devices, and vacuum cleaners,[2] although several more appliances are included in the European Union directive. Various Canadian provinces have defined and established categories of WEEE for the purpose of implementing stewardship programs.[3]

WEEE is one of the fastest growing waste streams in the world. Although it contains valuable materials such as aluminum, ferrous metals and copper, WEEE is a source of a variety of toxic substances that may be released into the environment.[4] When WEEE is disposed of in landfills, these toxic substances can leach into and contaminate ground and surface water. Improper disposal of WEEE, such as by dumping into informal landfills (e.g., swamps and open plots of land) and burning it through open air incineration, intensifies the adverse effects of WEEE on the environment as well as on human and other life-forms. As WEEE may contain a combination of metals, glass and plastics along with toxic substances, this waste stream is complex and difficult to address.

Many industrialized countries ship hazardous electronic waste to developing countries in Asia and Africa due to tough local environmental regulations that result in high domestic recycling and/or disposal costs. Exporting WEEE to developing countries for recycling and disposal has been much cheaper because of low labour costs and the use of dirty recycling methods that flout environmental and occupational safety standards. Most developing countries that import e-waste lack environmental, safety, and trade regulations. If they have any at all, these rules may not be properly enforced. These countries have seen the constant growth of an informal sector that is engaged in e-waste recycling. This informal sector generates economic activities and livelihood opportunities for people living in poverty at a heavy cost to their health and the environment. Unfortunately, these factors perpetuate a toxic trade among countries that thrives even in the wake of national and international regulations to curb such efforts.

On the whole, the management of WEEE is complex due to the toxic content and increasing rate of accumulation of this waste stream as well as the many environmental, social and economic factors involved. CIELAP sees this as a rapidly emerging issue for which current methods of management are inadequate. A proactive, multi-stakeholder approach, including the development of appropriate policy, is needed for the sustainable global management of this waste stream.

This paper explores the range of different perspectives that exist with regard to this complex issue, including environmental, economic, social and legal perspectives, in order to provide the background for discussion on how to move forward.

2. Controlling the International Movement and Management of WEEE: Current Status

2.1 International Protocol

On a global scale, the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (Basel Convention) is the only international agreement that restricts the transboundary movement of hazardous waste among countries. It was originally adopted to protect human health and the environment from the serious effects of the mismanagement of hazardous and other wastes due to "toxic trade" after a number of scandals involving uncontrolled waste dumping in developing countries came to light in the 1980s.[5]

The Basel Convention, which entered into force on May 5, 1992, has established a framework for controlling the transboundary movement of hazardous wastes including WEEE,[6] and has developed criteria for the environmentally sound management of hazardous wastes. One mechanism that the Basel Convention has put into place is the requirement that exporters receive prior informed consent (PIC) from authorities in the importing country.[7]

There are several loopholes in the Basel Convention, primarily one that permits the movement of WEEE for purposes of reuse.[8] Studies[9,10,11] indicate that players in many industrialized countries, including those that have ratified the convention, have taken advantage of this loophole and a lack of enforcement of the Convention to export e-waste to developing countries in Asia and Africa in the guise of fixing the "digital divide" (the gap in people's access to digital and information technology between developed and developing countries).[12] In response to concerns raised by developing countries about this illegal traffic in hazardous wastes, an amendment to the Basel Convention commonly known as the Basel Ban was proposed in 1995 to prohibit all forms of hazardous waste exports from countries of the Organization of Economic Cooperation and Development (OECD) to all non-OECD countries. However, the ban has not yet come into force due to opposition from several developed countries including Canada and the United States.[13]

In the ninth meeting of the Conference of the Parties to the Basel Convention, held in June 2008 in Bali, Indonesia, the Conference of the Parties officially acknowledged that there had been breaches of tenets of the Convention through illicit transport and dumping of hazardous wastes and through improper management of these wastes.[14]

2.2 Legislation in Exporting Countries

Many industrialized countries have established domestic regulations to control their export of hazardous waste, including WEEE.

Canada

While Canada has no national legislation to control the management of WEEE, the Canada-Wide Principles for Electronic Stewardship were endorsed by the Canadian Council of Ministers of the Environment (CCME) in June 2004.[15] These principles include: producer responsibility; minimization of health and environmental impacts; reduction, reuse, recycling and recovery of materials; consumer access to collection; the designation of responsible parties; performance targets; and recycling

standards. The Principles provide a framework for developing and setting up WEEE programs in each province. They also promote harmonization between provinces and explicitly state that "e-waste should be exported from Canada for recycling only at facilities that have a documented commitment to environmentally sound management and fair labour practices."[16]

In Canada, many environmental issues, including WEEE management, fall under provincial jurisdiction. Some provinces already have WEEE legislation and programs in place while other provinces are in various stages of developing legislation and programs (see Appendix A).

Since November 2005, Environment Canada and the Canadian Border Services Agency have been jointly monitoring Canadian borders to prevent the illegal export of WEEE. In December 2006, the team intercepted 50 containers filled with metals and plastic scrap containing hazardous waste. The containers leaving from the Port of Vancouver were destined for Hong Kong and China.[17]

The United States (US)

There is no national WEEE legislation in the US; however, several states have passed their own e-waste laws.[18] In 1976, the EPA enacted the *Resource Conservation and Recovery Act* (RCRA) to protect the public and the environment from harm caused by waste disposal, to conserve valuable material and energy resources and to clean up spilled or improperly stored wastes.[19] The RCRA hazardous waste regulations promote the reclamation and reuse of materials containing metals; however, they do not specifically mention WEEE.

In 2008, the United States Government Accountability Office criticized the current regulatory controls as being ineffective at stemming export of e-waste for the following reasons:

- Narrow scope of regulatory control: only electronic devices that contain cathode ray tubes (CRTs) are regulated as hazardous waste.
- Easily evaded regulatory controls: in 2007 the CRT rules came into effect requiring exporters to inform the EPA and receive written consent from the importing country before shipping any CRTs overseas.[20] However, exports of CRTs from US recyclers continue in breach violation of the CRT rule.
- Slowness of EPA to enforce CRT rule: in 2006 Hong Kong officials intercepted and returned 26 illegal shipments of CRTs to the United States. The EPA did not issue the first penalty until July 2008.[21]

The US Environmental Protection Agency (EPA) has initiated a number of programs to address WEEE including: the Electronic Product Environmental Assessment Tool (EPEAT);[22] the Design for the Environment (DfE) partnership program;[23] and the Federal Electronics Challenge.[24] The EPA has also initiated Plug-In to eCycling, a program that helps establish and educate consumers about recycling and reuse opportunities, and Guidelines for Materials Management to support the program.[25]

The European Union (EU)

The Waste Electrical and Electronic Equipment (WEEE) Directive 2002/95/EC and Restriction on the Use of Hazardous Substances (RoHS) Directive 2002/96/EC both came into force in February 2003.[26] The WEEE Directive encourages the reuse, recycling and recovery of materials and supports the establishment of collection schemes that allow consumers to return WEEE free of charge. The RoHS

Directive restricts the use of hazardous substances in EEE and requires that heavy metals, such as cadmium, chromium, lead, and mercury, and flame retardants, such as polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE), be substituted with safer alternatives.[27]

Regardless of the EU rules, it is reported that only one third of electrical and electronic waste in the EU is treated in the appropriate manner. The remaining two thirds goes to landfills or to treatment sites of inferior standards that are either within or outside the European Union.[28] In December 2008, the European Commission proposed making amendments to the Directives to ensure appropriate treatment of e-waste and to reduce the amount going to final disposal.[29] However, these amendments have not yet been passed into law.

2.3 Legislation in Importing Countries

A number of developing countries are net importers of WEEE. Nation states in Asia and Africa, including India, China, Nigeria and Ghana, are among the top importers of WEEE in the developing world.[30,31,32] Many importing countries, in agreement about the hazardous effects of WEEE, have signed on to the Basel Convention, and developed legislation to limit the dumping of this hazardous waste stream. This includes the jurisdictions described below.

India

India's *Hazardous Wastes (Management and Handling) Rules* were created in 1989 and amended in 2000, 2003 and most recently in 2008 as the *Hazardous Materials (Management, Handling and Transboundary Movement) Rules, 2008*.[33] The new Rules are intended to clarify how hazardous wastes are classified to make them consistent with international agreements. Wastes intended for import and export are now banned or restricted and, unlike the original Rules, the new Rules address the recycling of e-waste and provide procedures for the registration of environmentally sound recycling facilities.[34] The Central Pollution Control Board of the Government of India also published a "Guideline for Environmentally Sound Management of E-Waste" in March 2008.[35] However, the current Rules do not require collection, recycling and disposal, nor do they assign any responsibility or penalty to the manufacturers of electronic appliances for non-compliance.

China

China's State Environmental Protection Administration issued Order No. 40, *Management Measures for the Control of Environmental Pollution by Electronic Waste*, which came into effect February 1, 2008.[36] The Chinese State Council officially approved the *Regulations for Recycling and Disposal of Waste Electrical and Electronic Products* on March 4 2009, which will be effective from January 1 2011.[37] These regulations require mandatory recycling of electrical and electronic appliances discarded by the consumer and impose obligations on manufacturers including disclosure of the toxic and hazardous contents of WEEE, handling/use restrictions to facilitate recycling, and a requirement to contribute to a WEEE Treatment Fund. A catalogue of included products is to be drafted by January 2011 and work is underway to finalize measures to implement the Regulations.[38]

China's *Administrative Measure on the Control of Pollution Caused by Electronic Information Products* effective March 1 2007, is intended to be similar to the EU RoHS Directive and cover domestic and imported WEEE sold in China.[39] This measure requires information disclosure or self-

declaration, including labeling requirements applicable to certain electronic information products, materials restrictions and pre-market certification.[40]

Africa

The Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa was adopted in 1991 and came into force on April 22 1998.[41] It was drawn up by the Organization of African Unity. The objectives of the Bamako Convention are to:

- prohibit all import of hazardous and radioactive wastes into Africa;
- minimize and control the transboundary movement of hazardous wastes within Africa;
- prohibit incineration of hazardous wastes and the dumping of hazardous wastes into the ocean and inland water bodies;
- ensure the environmentally sound disposal of hazardous wastes;
- promote cleaner production; and
- establish use of the precautionary principle.

The Bamako Convention aims to control hazardous waste trade within Africa.[42] However, many African countries, including Kenya, Nigeria and South Africa have not yet ratified it.[43]

In general, developing countries face a number of challenges in implementing responsible WEEE legislation:

- The absence of formal recycling infrastructure leaves these countries to rely on informal recycling and its inherent environmental and health risks.[44]
- Lack of reliable data about e-waste flows prevents policy makers from designing appropriate waste management strategies and poses challenges for industry players wishing to make rational investment decisions.[45]
- Discrepancies exist between national legislation and the Basel Convention.[46]
- Legislation does not specify sound disposal methods and fails to mention the transfer of environmentally sound technology for recycling and reclamation.[47]
- While national authorities in many countries are working to prevent import and to upgrade recycling facilities, many people at the local and regional levels, including authorities, are impeding progress in this area. Local and regional governments gain political support by allowing informal waste recycling facilities to exist.[48]

3. Effects of WEEE on the Environment and Human Health

WEEE contains toxic substances harmful to the environment and human health. Some WEEE is reused or recycled. Much of it is currently disposed of in landfills at the end of its useful life. Unfortunately, few formal recycling units in the developing world take sufficient measures to address health and environmental safety. Most of the recycling units in developing countries are in the informal sector where crude recycling methods are used with scant regard to occupational health and safety or the

environment. Many contaminated plastics, glass, hazardous components, and other materials are often not recovered and are simply disposed of. When disposed of on land, WEEE breaks down and leaches toxic substances into the soil, eventually contaminating groundwater. Incineration causes toxic dioxins and furans to be released into the air.[49]

3.1 Toxic substances present in WEEE

Toxic substances contained in electrical and electronic equipment, their specific sources, pathways for exposure and potential health effects are presented in Appendix B. These substances broadly fall into two categories: heavy metals and organic chemicals. Other than copper and zinc, which are micronutrients, all other metals are highly toxic and can have harmful effects on human health even at very low concentrations.[50]

3.2 Environmental effects

Several reports have documented environmental contamination from the toxic components of WEEE. Samples taken from two open burning sites and from one shallow lagoon site in Ghana contained lead, cadmium and antimony at levels exceeding typical background levels for soils by over 100 times.[51] Samples of floor dust from three solder recovering workshops in Beilin, China, contained higher levels of lead, tin, copper, antimony and in some cases, cadmium and mercury. In the same report, dust samples collected from a number of battery dismantling workshops in Delhi, India, were also found to have elevated concentrations of lead, cadmium, PCBs and, in some cases, PBDEs.[52] River sediments in Guiyu, an e-waste processing town in China, have been contaminated with high concentrations of cadmium, copper, nickel, lead and zinc.[53] Road and farmland soil samples collected near the dismantling workshops of the Qingyuan e-waste recycling region in South China were found to contain elevated concentrations of PBDEs.[54]

Groundwater near e-waste recycling sites has also been found to be severely contaminated with toxic chemicals. For example, groundwater in the Chinese town of Guiyu was so contaminated with lead, cadmium and other contaminants one year after the appearance of the WEEE that the City began to truck drinking water from another town 30 kilometres away.[55]

3.3 Exposure pathways

Workers in informal recycling units are exposed to dust, fumes, and vapors of toxic substances during crude operations such as manual dismantling; manual printed circuit board separation and solder recovery; open burning of cables and circuit boards; shredding; and acid processing/leaching. Dust in e-waste storage facilities may contain toxic chemicals that workers may inhale.[56] Family members of e-waste recycling workers are exposed to the toxic dust carried home on workers' clothing. Children playing in fields and streets near e-waste recycling sites also become exposed to the toxic dust. The effluents from recycling units reach nearby streams, polluting water bodies in the region. Dust containing toxic chemicals also contaminates the soil and the food grown in it. In summary, human beings can be exposed to toxic substances through a number of pathways including ingestion, inhalation and by absorption through the skin.[57]

3.4 Health effects

A few studies have been published on the effects of toxic e-waste on human health. In one study in China, children living in Guiyu had significantly higher blood lead levels (BLLs) and blood cadmium

levels (BCLs) as compared with those living in Chendian, a town not involved with e-waste recycling.[58] Environmental pollution, particularly lead pollution, thus threatens the health of children living near e-waste recycling sites (see Appendix B).

It is clear that improper recycling and disposal of e-waste contaminates air, water and land. People who are exposed to the toxic substances present in WEEE during its processing, or by other means, are more likely to fall sick and endanger their lives, compared with those who are rarely exposed to such substances. Mechanisms need to be put in place for WEEE to be recycled and/or disposed of in an environmentally sound and safe manner. Further research on the extent of the environmental contamination in recycling workshops and the effects of such contamination on human health would be of great value.

4. Economics of the WEEE Industry

4.1 Key Economic Drivers of the Current Global System of WEEE Management

Economic gain by corporations, governments, and individuals is the primary reason why trade in WEEE continues to thrive despite the Basel Convention and domestic legislation that restricts the practice. The following are some key economic drivers of the current global system of WEEE management:

- **Strict Environmental Regulations in Some Jurisdictions**: In Canada, the US and other OECD countries, strict environmental regulations have made it costly to dispose of used electronics. Recyclers in these countries often coordinate with exporters to ship their waste to developing countries where such regulations do not exist or are not properly implemented, thus avoiding domestic costs.[59]
- **Demand for Precious Metals**: WEEE contains bulk metals such as lead, tin, copper, iron and aluminum and also contain small amounts of many precious metals, including gold, silver, platinum and palladium, that have high material value.[60, 61, 62] All these metals are costly and scarce and recycling activities are driven in part by the recovery of these materials.[63]
- **Market Demand for Low-Cost Electronics**: High demand by importing countries for used and, thus, more affordable electronic equipment drives some of the e-waste trade and creates jobs and business in the second-hand industry.[64]
- **Income Generation:** This is arguably the most potent driver of the thriving e-waste industry. An estimated 25,000 people are employed in the e-waste industry in Delhi.[65] In Guiyu, China, around 150,000 people are employed in the industry.[66] While e-waste provides a meager existence for some, it is a lucrative business for others. One WEEE recycling business owner in Guandong Province makes approximately 15 times the average salary in the province, at over $12,000 a year.[67]
- **Economic Development and Profit:** Local and regional governments, along with village entrepreneurs, gain economic development and tax income through the WEEE recycling industry.[68] Many developing countries have made huge investments into the information technology (IT) and electronics sectors by creating Special Economic Zones (SEZs) and loosening taxation laws while ignoring the problems caused by the informal recycling of these products.[69]

4.2 Economic Advantages of Alternative Approaches to WEEE Management

Alternatives to the current system of WEEE management have been proposed for the following economic reasons:

- **Local Investment:** A 2004 Canary Institute Report revealed that, each year, the Canadian recycling sector salvages about 10 million tonnes of metal. The monetary value of salvaging this metal is estimated to be $3 billion saved a year which would have gone into primary production.[70] According to the Canary Institute, Canada should strive to improve its recycling infrastructure to reduce the transboundary movement of recyclables. Domestic recycling could amass significant economic benefits through considerable energy savings, avoidance of increased costs of land-filling, and job creation.[71]
- **Consumer Willingness to Spend More for Responsible Management:** A study conducted last year by POLLARA Inc. for Sharp Electronics of Canada Ltd. revealed that 88% of Canadians are willing to spend more on consumer electronics that are energy-efficient, produce less waste, and are made of recycled materials. Around 96% of Canadians prefer purchasing recyclable products, while 92% prefer buying products that are manufactured using environmentally conscious processes.[72]
- **Hidden Costs:** Despite the economic benefits that may be derived from informal WEEE recycling, the adverse health and environmental effects outlined above are hidden costs of the system. These costs tend not to be accounted for as it is difficult to assign them a monetary value.

5. Social Considerations

5.1 Key Social Drivers of the Current Global System of WEEE Management

- **Poverty and Livelihood:** Poverty plays a key role in the persistence of the current global system. Although some workers in the informal recycling sector recognize that their actions pollute the environment and jeopardize their health, they are nonetheless unwilling to give up the income.[73] The issue of livelihood is common to all forms of informal waste management work. However, due to the significant presence of toxic substances, participation in the WEEE recycling sector without protective measures poses a more serious problem to workers and their families and surrounding communities than most other forms of informal waste management. Economic benefits can not simply override the health risks and more sustainable methods of WEEE management are needed.

  National government agencies in some e-waste importing countries have been working to prevent WEEE import and to upgrade recycling facilities. Unfortunately, various stakeholders in these regions are impeding such progress. For many workers in the industry, e-waste has become their lifeblood.[74] According to the China Labour Bulletin, e-waste workers in Guiyu are usually migrant labourers from rural areas who must choose between working in dangerous and unfavorable conditions and going hungry. Local and provincial governments gain political support by allowing the informal waste recycling facilities to exist.[75]

- **Lack of Public Education and Awareness in Exporting Countries:** Consumer participation has been cited as the most important barrier to effective e-waste recycling.[76] Individuals in North America and other developed countries generally lack awareness about how to dispose of their obsolete electronics. While a number of government, industry, and social programs and activities have been recently initiated to encourage WEEE recycling, social infrastructure such as the availability of drop off depots is still lacking.[77] Fragmented programs across sectors and between jurisdictions can also add confusion. Members of the public in Canada and the US have also seen less government leadership than would be desirable given the reluctance of the US to ratify the Basel Convention, and the fact that neither the US nor Canada have ratified the Basel Amendment.[78]
- **Lack of Public Education and Awareness in Importing Countries:** Workers that recycle WEEE in the informal sector in developing countries often lack awareness about the toxic substances they deal with and the associated health and environmental impacts. In Ghana, children as young as five years old are known to work with e-waste with no protective equipment in order to earn income for their families.[79] Other workers are aware of the hazards in their workplace. An adult worker in one of the recycling units in Ghana told Greenpeace that the smoke was making many workers sick and that they wanted it to stop.[80] According to Clean Production Action (CPA), household hazardous waste collection workers take measures to protect themselves during e-waste collection events and CPA suggests that similar safety measures be put into practice for e-waste workers.[81] Unfortunately, there has been little public education about the dangers of WEEE and the precautions that should be taken.
- **Lack of Skills:** Assessments by the Swiss Federal Laboratories for Minerals Testing and Research (Empa) in Delhi, India, Beijing, China, and Johannesburg, South Africa have revealed that these countries lack the appropriate technologies and skilled workers that would be required in the formal recycling sector.[82] Empa recommends that these countries train low- and medium-skilled workers in using cleaner technologies and handling processes using best affordable technologies.[83]

It is evident that the current global system of WEEE management persists due to poverty and social disparities. In order to improve the global management of this waste stream, a broader spectrum of in-depth studies is required to better understand how WEEE management impacts, and is impacted by, social aspects such as culture, gender, ethnicity, education, and livelihood.

6. Recommendations for Extended Producer Responsibility

Extended Producer Responsibility (EPR) aims to assign responsibility to manufacturers for their products over the course of the entire product life-cycle, including resource extraction, production, use and disposal, in order to minimize the negative environmental impacts of their industry.[84] A number of stakeholders have given the following recommendations for supporting the sustainability of the sector through EPR:

- **Voluntary Producer Responsibility Programs:** Environmental groups Greenpeace, CPA, Friends of the Earth US and Silicon Valley Toxics Coalition (SVTC), have called for electronics manufacturers to voluntarily introduce producer responsibility programs worldwide.[85] According to Greenpeace, it is necessary to extend the scope of WEEE legislation

governing the use of hazardous substances across jurisdictions to include the hazardous substances and materials that are used in manufacturing products. Until such legislation comes into force, Greenpeace has argued that EEE manufacturers should voluntarily phase out all hazardous chemicals and materials from their products, offer free take-back programs globally, and internalize their own product end-of-life costs.[86]

A number of ENGOs, including Friends of the Earth USA and the SVTC, have asked US state governments to collaborate with them and pressure industry to establish EPR programs through existing trade groups such as Electronic Industries Alliance (EIA).[87]

- **Focus on Product Redesign:** CPA encourages electronic manufacturers to commit to product "eco-design," including using green chemistry and products that can be easily disassembled into components.[88]
- **Cooperation Between Recycling Companies and IT Manufacturers:** Hidden flows of e-waste still exist despite the development of systems that have EPR in place. Commercial recycling companies and manufacturers need to collaborate to help reduce these flows.[89]
- **Introduction of stringent regulations:** Greenpeace and CPA have recommended that EEE manufacturers encourage all countries to introduce stringent regulations regarding the design, generation and end of life management of WEEE.[90,91] Such regulations should aim to promote green chemistry, eliminate highly hazardous chemicals and require manufacturers to provide comprehensive safety data for all chemicals on the market.

While some IT manufacturers (see Appendix C) have proactively addressed WEEE issues, others have been slow to take early action or respond to WEEE legislation. A 2005 Hong Kong Productivity Council survey indicated that half of the 100 manufacturers interviewed were unaware of the RoHS (48%) and WEEE (53%) Directives. Of those familiar with the Directives, 30% had taken no measures to prepare for compliance and about half were unsure about how best to prepare.[92]

While groups such as the Information Technology Association of South Africa (ITA), Friends of the Earth (US) and SVTC have stated that voluntary EPR programs are viable, others, including Greenpeace and CPA, emphasize the need for government legislation to govern and enforce EPR. They insist that in countries such as China, where businesses have hesitated to make proactive decisions, mandatory legislation would be more effective than voluntary EPR measures.[93] Appropriate incentives and supporting measures are essential for making EPR initiatives successful.[94]

7. Conclusion

This paper has highlighted the tensions that exist around the establishment of a sustainable global management system for WEEE. Two of the main competing perspectives are that: a) WEEE recycling is an important income-generating activity for a number of developing countries and stakeholders; and b) the current system for managing WEEE is not only ineffective but also highly hazardous.

E-waste can be made significantly less harmful if recycled in a responsible manner. It is imperative that alternate systems for WEEE management be put in place and that the global community should focus on stricter management and the development of infrastructure for this sector. The issue needs to

be further examined and better understood in order to develop a comprehensive solution. The ultimate goals must include reducing the amount of WEEE generated, while also ensuring that all WEEE generated is recycled and disposed of in a manner that protects social, environmental and economic interests.

Engaged citizens and community participation are essential to managing e-waste. Consumer knowledge can influence purchasing decisions, how appliances are disposed of, and whether pressure is put on governments to take the issue seriously. Knowledge among recyclers can influence how these individuals protect themselves and the technologies they use. Awareness-raising programs and activities, as well as health and safety training, are essential components of a sustainable management system for WEEE.

In conclusion, this report indicates that the current manner in which e-waste is exported from developed to developing countries contravenes existing international conventions and poses significant damage to the environment and health. It is necessary to give careful consideration to the stakeholder perspectives and recommendations that have been expressed in this paper, and to seek further input from other stakeholders involved in WEEE management, in order to determine how this complex system can be sustainably managed.

Appendices

Appendix A - WEEE Programs and Legislation in Canadian Provinces

Province	WEEE Legislation	Description
British Columbia	2006: British Columbia Stewardship Plan for End-of-Life Electronics published 2007: Province-wide "Return-It Electronics" program implemented	Designated collection sites available for BC households and businesses to drop off regulated products, without charge, for responsible recycling.[95]
Alberta	2004: WEEE Management Program established	100 drop-off sites established in rural and urban locations with no charge to the consumers at the time of disposal; Advance Disposal surcharge is collected at the retail level.[96]
Saskatchewan	2007: Saskatchewan Waste Electronic Equipment Program (SWEEP) established	Non-profit, industry-run collection system; Original electronics sellers must either join SWEEP or establish their own province-wide government-approved take-back and recycling program.[97]
Manitoba	2007: Proposed Household Hazardous Waste Stewardship Regulation	Regulation to prohibit the sale of regulated products not covered by a stewardship program; Yet to come into force.
Ontario	2009: Phase 1 of WEEE Program took effect April 1; the Revised (Phase 1 and 2) WEEE Plan was approved by the Minister of the Environment in August.[98]	Ontario Electronics Stewardship, a non-profit corporation, established by designated stewards. Phase 1 of industry-funded take-back program covers desktop and portable computers, monitors, fax machines, printers and televisions. Phase 2 adds telephones, copiers and audio visual equipment.[99]
Quebec	2007: Legislative amendments to the *Environmental Quality Act*	Proposes mandatory producer responsibility for WEEE; still awaiting implementation.
New Brunswick	Amended *Clean Environment Act* to allow new Multi-Material Stewardship Board to manage all stages of handling from manufacture to disposal	Board to manage manufacture, storage collection transportation, recycling and disposal of designated materials and to create new WEEE management programs.
Nova Scotia	2008: Phase 1 of Electronic Product Stewardship Regulations implemented. 2009: Phase 2 implemented.	Bans disposal of e-waste in landfills and creates province wide-collection system; Phase 1 includes desktop computers, laptops, printers, computer peripherals (e.g mouse, keyboard) and televisions. Phase 2 includes home theater systems, telephones, cellphones, wireless devices, computer scanners, and audiovisual playback and recording equipment.[100] Manufacturers and distributors responsible for costs.
Prince Edward Island	2009: Bill introduced into legislature; supports development of e-waste management system.	E-waste system to begin in early 2010 based on EPR model where handling fee is placed on each product to pay for end-of-life disposal; system will be run by representatives of electronics industry.[101]

Appendix B - Toxic Substances found in WEEE and their potential health effects

The following table presents a list of toxic substances that are known to be found in WEEE as well as known adverse health effects of these substances. Please note that not all of these substances are found in all WEEE. Also note that the indicated health effects may or may not result, depending on the levels of contamination to which individuals are exposed.

Toxic substances	Occurrence in WEEE	Exposure pathways	Health effects
Heavy Metals			
Antimony	Cell phones		
Arsenic*	Light emitting diodes, cell phones	Inhalation of dust	**Carcinogenic, can affect skin and nervous system**
Barium*	Sparkplugs, fluorescent lamps, getters in cathode ray tubes (CRT)	Aerial exposure	**Gastrointestinal problems, brain swelling, muscle weakness, damage to the heart, liver and spleen**
Beryllium*	Power supply boxes which contain silicon controlled rectifiers and x-ray lenses, cell phones	Inhalation of beryllium dust, fume or mist	**Respiratory inflammation known as Chronic Beryllium Disease (beryllicosis),**
Cadmium*	Rechargeable Nickel-Cadmium (NiCd)-batteries, fluorescent layer (CRT screens), printer inks and toners, photocopying-machines (printer drums), cell phones	Absorbed through respiration and consumption of contaminated food	**Flu-like symptoms of weakness, fever, headache, chills, sweating and muscular pain; long term exposure are lung cancer and kidney damage; may cause pulmonary emphysema and bone disease (osteomalacia and osteoporosis).**
Chromium (Hexavalent)*	Data tapes, floppy-disks	Absorbed through respiration and consumption of contaminated food	**Affects eyes, skin and mucous membranes**
Copper	Cell phones	Inhalation of dust, Consumption of contaminated water and food	**Beneficial/safe at low concentration; may cause vomiting, diarrhea and nausea at elevated concentrations**
Lead*	CRT screens, batteries, printed wiring boards, cell phones	Inhalation of dust, consumption of contaminated water and food	**Vomiting, diarrhea, convulsions, appetite loss, abdominal pain, constipation, fatigue, sleeplessness, irritability and headache; can affect kidney and nervous system**
Lithium	Batteries	Inhalation of dust	**Affects central nervous system**
Mercury*	Fluorescent lamps that provide backlighting in liquid crystal display (LCD), in some alkaline batteries and mercury wetted switches	Inhalation of mercury vapour, consumption of contaminated water and food	**Causes brain, kidney and liver damage, respiratory failure, affects nervous system**
Nickel	Rechargeable NiCd-batteries or Nickel-metal hydride (NiMH)-batteries,	Inhalation of dust, consumption of contaminated water and	**Respiratory problems, asthma, allergic problems, possible carcinogen**

	electron gun in CRT, cell phones	food	
Selenium*	Older photocopying-machines (photo drums)	Inhalation of dust	**Causes selenosis resulting in hair loss, nail brittleness, and neurological abnormalities**
Tin	Soldering material	Inhalation of dust, absorption through skin, Consumption of contaminated water and food	**Eye and skin infection, liver and brain damage**
Zinc	Interior of CRT screens, mixed with rare earth metals, cell phones	Inhalation of dust, Consumption of contaminated water and food	**Beneficial at low concentration, can damage the pancreas and disturb the protein metabolism at very high levels**
Organic chemicals			
Brominated Flame Retardants: Polybrominated biphenyl **(PBB),** Polybrominated diphenyl ether **(PBDE),** Tetrabromobisphenol - A **(TBBPA)***	Fire retardants for plastics (thermoplastic components, cable insulation, printed circuit boards and casings, cell phones	Indoor dust and air through migration and evaporation from plastics	**Endocrine disruption. Upon burning plastics release dioxins, furans and polycyclic aromatic hydrocarbons (PAH) that are carcinogenic and also cause impairment of the immune system**
Organophosphorus Flame Retardants: Triphenyl phosphate **(TPP)**	Fire retardants for plastics	Indoor dust and air through migration and evaporation from plastics	**Dermatitis, endocrine disruption**
Polychlorinated biphenyls **(PCB)***	Condensers, Transformers, heat transfer fluids and as additives in adhesives and plastics	Indoor dust and air, consumption of contaminated food	**Carcinogenic, also affects immune system, reproductive system, nervous system and endocrine system**
Nonylphenol	Antioxidant in plastics	Indoor dust and air through migration and evaporation from plastics, consumption of contaminated food	**Endocrine disruption, genetic disorder**
Chlorofluorocarbons **(CFC)***	Cooling unit, Insulation foam	Accumulate in the stratosphere affecting the ozone layer that shields UV rays	**Exposure to high UV rays causes skin cancer and genetic disorders**
Polyvinyl chloride (PVC)*	Cable insulation	Inhalation of fumes	**Respiratory problems**

* Adapted from information available on the website of the E-stewards Initiative: "Hazardous Substances in e-Waste" at http://ewasteguide.info/hazardous_substances. (Accessed May 20, 2009).

Other information in this chart was compiled from the websites of BAN and Greenpeace.

Appendix C - Relevant Stakeholders and Initiatives

The following stakeholders are among those who are involved in researching, developing, advocating for, educating about, and influencing policy for sustainable solutions for WEEE management.

Basel Action Network (BAN) – http://www.ban.org/main/about_BAN.html

- A Global campaigning organization based in Seattle, Washington, US, that works to confront and mitigate the environmental injustices of "toxic trade" including toxic wastes, products and technologies. BAN promotes the Basel Ban and performs investigative research to encourage national solutions for hazardous waste management.
- BAN's "E-waste Stewardship Project" profiles the exports of toxic electronic waste to developing countries and aims to ensure that these exports are eliminated and replaced with producer responsibility and green design programs/legislation.

Electronics Take Back Coalition – http://www.electronicstakeback.com/index.htm

- A US-based organization that provides basic information about e-waste and the loopholes in the US legislation.

Electronics Product Stewardship Canada (EPSC) - http://www.epsc.ca/

- A not-for-profit organization created by leaders in Canada's Consumer electronics and information technology industry to tackle Canada's electronic waste problem.

E-Waste Association of South Africa (eWASA) - http://www.e-waste.org.za/

- A South African not-for-profit organization dedicated to educating the public about e-waste, how to dispose of it and how it is recycled.

Greenpeace - http://www.greenpeace.org/international/

- An independent global campaigning organization that has been active in the area of WEEE by tracking its disposal for the last number of years, writing numerous publications on the topic and holding related campaigns and activities.

Silicon Valley Toxics Coalition (SVTC) - http://www.etoxics.org/site/PageServer

- A grassroots, US-based research and advocacy organization that, in addition to other activities, holds campaigns to raise awareness about WEEE and promote the adoption of sustainable technology.

Toxics Link – http://toxicslink.org/

- An India-based environmental non-governmental organization that informs the public about toxics issues and brings global information to the local level.

Programs and Initiatives

SECO/EMPA E-waste Program - http://ewasteguide.info/

- A project established by Seco (Swiss State Secretariat for Economic Affairs) and implemented by EMPA (Swiss Federal Laboratories for Minerals, Testing and Research) in collaboration with other partners to assess and improve WEEE recycling systems in other parts of the world.

Solving the E-Waste Program (StEP) - http://www.step-initiative.org/

- A UN-led initiative to initiate and facilitate approaches for handling e-waste.

United Nation International Development Organization (UNIDO) Refurbished Computer Programme – http://www.unido.org/index.php?id=268.

- The programme aims to address the full lifecycle of ICT equipment by properly dismantling and recycling it once the equipment has become obsolete. Its objective is to foster the development of an environmentally sound e-waste recycling industry in developing countries.

Industry Initiatives

- On May 19 2009, IT manufacturer Dell introduced its Electronics Disposition Policy and became the first major US computer manufacturer to ban the export of non-working electronics to developing countries.[102] This new policy is said to exceed the requirements of the Basel Convention. Compliance with the Electronics Disposition Policy is mandatory for Dell employees, consultants, outsource and general service providers, independent contractors, and Dell environmental partners. However, enforcement methods are still unclear.[103] Dell is encouraging the rest of the industry to follow its lead.[104]

- Sims Recycling Solutions is a WEEE recycling company based in North America, Europe, Asia and Australia. Sims specializes in recovering end-of-life EEE for recycling, refurbishment and redistribution.[105]

- Swiss IT producers cooperatively created Producer Responsibility Organizations to responsibly manage e-waste and meet EPR regulations. By putting a working system in place before legislation was introduced producers developed a system that was both flexible and less expensive.[106]

- Information Technology Association of South Africa (ITA) is a non-profit organization that represents the information, communication and technology (ICT) sector. It has developed an e-waste recycling initiative called "ITA Recycling Guarantee", which has the objective of contributing to global warming reduction strategies and improving living conditions for South Africans through better waste management.[107]

- In 2006 Wal-Mart and Toshiba America Information systems partnered to develop a RoHS compliant laptop for the US retail market. Wal-Mart encourages computer suppliers to limit the quantities of hazardous materials in their products including lead, cadmium, mercury and other substances identified in the RoHS directive.[108]

- In 2004 Hewlett Packard (HP) joined with local authorities and industry associations across Europe to set up take back and recycling schemes. HP also partnered with Sony, Braun and Electrolux to create the European Recycling Platform (ERP), a common platform for recycling WEEE across Europe.[109] HP has a written statement detailing the ways in which it is in compliance with WEEE directives.

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