The WEEE Report

Waste Electrical and Electronic Equipment Reuse and Recycling in Canada – 2013

CM CONSULTING

December 2013

CM Consulting

315 Pearl Avenue
Peterborough, ON
K9J 5G4

416.682.8984
www.cmconsultinginc.com

The WEEE Report 2013

Painting an accurate picture of the total scope of the electronic waste problem is like playing a game of Whac-A-Mole. The only thing that is constant is change. Millions of new electronic gadgets are being made and sold each year, replacing millions of gadgets from five, seven, or twenty-five years ago. Consumers may be taking their old gadgets to a recycling facility, storing them in their basements, or simply throwing them into the garbage.

New pieces of electronic equipment are often much smaller or lighter than the ones they are replacing, but, some new items, such as large flat panel television sets, will be much bigger and heavier. New electronic devices such as mobile tablets may perform the same functions as a 30-pound computer from years ago, but they could be made from an entirely different range of materials, which may require an entirely different method of collection and recycling.

In 2004, Alberta became the first Canadian province to mandate a product stewardship program that collects funds from electronics consumers to finance the collection and proper end-of-life management of waste electrical and electronic equipment (WEEE). Since then, nearly all Canadian provinces have followed suit and have implemented similar laws and programs that levy funds aimed at increasing the collection and recycling of WEEE. This report describes the management of end-of-life electronics in Canada and offers important considerations for planning for the future—a future in which electronic waste will be quite different from what it is today.

This report also outlines the specific details of WEEE programs in each province, including the costs of these programs, how the performance of these programs is measured, and who is ultimately responsible for program operation. Included in this analysis is a discussion about the importance of measuring program performance and details regarding best practices in terms of recycling standards and the international policies that force producers to make electronic devices less toxic.

Life-cycle analysis is used to describe some of the environmental benefits of recycling end-of-life electronics and to provide a hierarchy framework that can be used to rank various end-of-life management options. The opportunities that exist to recover valuable components from WEEE, materials such as gold, silver, and nickel, are quantified and the risks posed by the toxic substances contained in WEEE are discussed.

This report provides government, producers, program operators, recyclers, the public, and the media with an accurate picture of Canada's programs for waste electronics management, and it offers insight into how these systems can be made more effective in terms of human health and environmental protection.

I trust you will find this report to be informative in your efforts. Please do not hesitate to contact me if you require other data or further analysis.

Respectfully Yours,

Clarissa Morawski
Principal

Table of Contents

List of Tables

List of Figures

Author's Note

Our research took us beyond just Canada. We discovered a lot of extremely valuable information about how waste electronics coming from North American and European consumers ends up in countries such as China, India, Africa, and Pakistan, to name a few.

Many of these countries do not have the proper operating standards or laws in place to ensure that WEEE recycling is done right—in a manner that protects human health and the environment.

Although this report is limited to WEEE collection and recycling in Canada, we felt it was worthwhile to include a list of valuable reports that document some of the important issues related to WEEE management in other parts of the world.

Two excellent sources for information regarding e-waste in developing countries are the Basel Convention (http://www.basel.int/) and the Stop the E-Waste Problem (StEP) initiative, a collaboration of scholars and scientists with the United Nations University. StEP has published numerous excellent papers on how e-waste is affecting developing countries.

To learn more about StEP and view its publications, visit http://www.step-initiative.org/index.php/Home.html

Here is a list of some of the publications that were researched in the making of this report but deemed to be outside its scope.

Huo, Xia, Lin Peng, Xijin Xu, Liangkai Zheng, Bo Qiu, Zongli Qi, Bao Zhang, Dai Han, and Zhongxian Piao "Elevated Blood Lead Levels of Children in Guiyu, an Electronic Waste Recycling Town in China. *Environmental Health Perspectives* 115, no. 7 (2007): 11113–1117.

*Info*Dev (The World Bank Group). *Wasting No Opportunity: The Case for Managing Brazil's Electronic Waste, Project Report.* Washington, DC: The World Bank, April 2012. http://www.infodev.org/infodev-files/resource/InfodevDocuments_1169.pdf.

Salehabadi, Djahane. *Transboundary Movements of Discarded Electrical and Electronic Equipment.* Solving the E-Waste Problem (StEP) Green Paper. Tokyo: United Nations University, 25 March 2013. http://isp.unu.edu/publications/scycle/files/ewaste_flow.pdf.

Schluep, Mathias, Christian Hagelueken, Ruediger Kuehr, Frederico Magalini, Claudia Maurer, Christina Meskers, and Esther Mueller et al. Recycling: *From E-Waste to Resources. Sustainable Innovation and Technology Transfer Industrial Sector Studies.* Paris: United Nations Environment Program (UNEP), 2009. http://www.ewasteguide.info/files/UNEP_2009_eW2R.PDF.

Schluep, Mathias, Andreas Manhart, Oladele Osibanjo, David Rochat, Nancy Isarin, and Esther Mueller. *Where are WEee in Africa? Findings from the Basel Convention E-waste Africa Programme.* Châtelaine, Switzerland: Secretariat of the Basel Convention and UNEP, December 2011. http://www.basel.int/Implementation/TechnicalAssistance/EWaste/EwasteAfricaProject/Publications/tabid/2553/Default.aspx#.

Wang, Feng, Ruediger Kuehr, Daniel Ahlquist, and Jinhui Li, *E-Waste in China: A Country Report.* Solving the E-Waste Problem (StEP) Green Paper Series. Tokyo: United Nations University. April 5, 2013. http://www.ehs.unu.edu/file/get/11082.pdf.

Part I: Introduction

Waste electrical and electronic equipment (WEEE) recovery, reuse, and recycling continue to emerge as a challenging and highly political issue for both industry and government.

In evaluating these initiatives, one must assess not only waste diversion performance, e.g., factors such as WEEE collection and recycling rates, but also net program costs, breadth of collection infrastructure, the effectiveness of consumer and market incentives for diversion, and the breakdown of who bears the costs of the recovery and disposal of WEEE.

The WEEE Report 2013 aims to clarify and offer essential insight into the field of WEEE collection, reuse, and recycling programs in Canada.

By offering current data and discerning analysis and by identifying a number of trends in WEEE collection, processing, refurbishment, and recycling, The WEEE Report provides a comprehensive examination of WEEE programs in Canada.

Methods Used in This Report

This study is based on secondary research. This means evaluating existing authoritative literature, government-sponsored studies, and industry reports. Evaluating the sources within the scope of this study also includes assessing the transparency and certainty of data in order to present the study as objectively as possible on the basis of compatible results. In addition, experts and system operators were interviewed and discussions were held with stakeholders with a view to validating work results.

Contributors to the report include Clarissa Morawski, Dr. Jeff Morris, Jason Wilcox, and Samantha Millette.

This report has been jointly funded by business, government organizations, and not-for-profit groups. CM Consulting would like to thank the following supporters of this report:

Alberta recycling
www.albertarecycling.ca

SASKATCHEWAN WASTE REDUCTION COUNCIL

CESA
Canadian Electrical Stewardship Association

OWMA
ONTARIO WASTE MANAGEMENT ASSOCIATION

ARCADIAN SOLUTIONS

RECYC-QUÉBEC
Québec

Front commun québécois pour une gestion écologique des déchets

Recycle NB

Special Thanks

The gathering of accurate and detailed information, analysis, and peer review could not have been achieved without the generous assistance of certain individuals whose work supports e-waste recycling in Canada.

A very special thank you to the following individuals:

Shannon Castle, Alberta Recycling Management Authority (ARMA)
Libby Chaplin, Arcadian Solutions
Carl Fils, EPRA Saskatchewan
Sean Homenick, SARCAN
Jay Illingworth, Electronic Products Recycling Association (EPRA)
Shelagh Kerr, Electronics Product Stewardship Canada
Frank LeBlanc, Environment and Local Government, New Brunswick
Dominique Levesque, EPRA Quebec
Dr. Jeff Morris, Sound Resource Management
Gordon Murphy, Multi-Materials Stewardship Board (MMSB)
Dennis Neufeld, EPRA Manitoba
Sandra Pakosh, Ontario Electronic Stewardship (OES)
Katie Reilly, Electronic Recyclers International
Julie Robertson, Canadian Electrical Stewardship Association (CESA)
Brad Schultz, Alberta Recycling Management Authority (ARMA)
Rob Sinclair, Natural Resources Canada
Craig Wisehart , EPRA British Columbia
Doug Wright, Alberta Recycling Management Authority (ARMA)

Abbreviations

ACES Atlantic Canada Electronics Stewardship
AMO Association of Municipalities of Ontario
ARMA Alberta Recycling Management Association
C of A certificate of approval (issued by MOE)
CRT cathode ray tube
CSR corporate social responsibility
DfE design-for-the-environment
EBR Environmental Bill of Rights
EEE electrical and electronic equipment
EfW energy from waste
EOL end-of-life
EPSC Electronic Product Stewardship Canada
EPR extended producer responsibility
ERS Electronics Recycling Standard
ESABC Electronics Stewardship Association of British Columbia
FPD flat panel display
IC&I industrial, commercial, and institutional
IEB Investigations and Enforcement Branch (of the MOE)
IFO Industry Funding Organization
ISP Industry Stewardship Plan
MHSW municipal hazardous or special waste
MOE Ministry of the Environment
MTS material tracking system
OECD Organisation for Economic Co-operation and Development
OEM original equipment manufacturer
OES Ontario Electronic Stewardship
P&E promotion and education
PDA personal digital assistant
PDBEs polybrominated diphenyl ethers
RCC Retail Council of Canada
R&D research and development
RP rear projection

Part II: Performance Measures for Electronics Recycling Programs

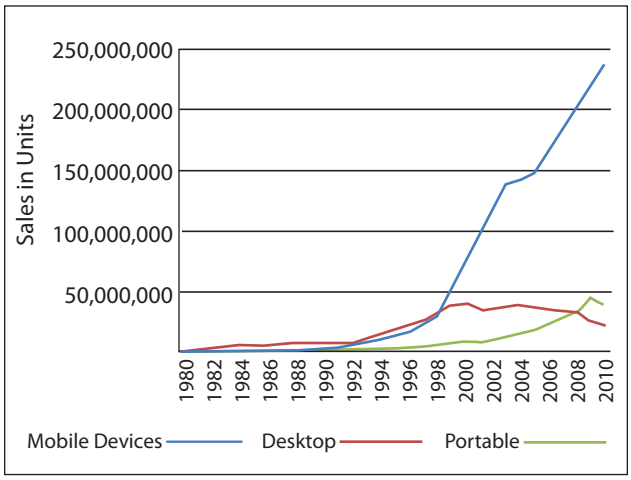
The Challenge of Measuring Success

Traditionally, measuring the performance of provincial electronics recycling programs has been limited to indices of program results, such as tonnes collected for recycling per capita and, in some cases, the capture rate, which is a percentage of the material assumed to be collected relative to what is available for collection. Although such measurements are useful, the information they provide is void of any real meaning in terms of program performance.

To start with, weight measurements offer no information about the composition and toxicity of WEEE, nor do they take into consideration that weights of products are constantly changing. Recent trends toward producing multi-function electrical and electronic equipment, as well as toward light-weighting products and miniaturization, suggest that, over time, overall WEEE tonnage will decrease.

However, while some EEE products have decreased in size and weight, others have increased or remained the same. The weight of an average cathode ray tube (CRT) TV over 19 inches has remained static at 70–75 pounds since 1980, for example. Similarly, the average weight of a desktop CPU (22 pounds) has not changed since 1980. Flat screen TVs, on the other hand, entered the market place in 1989 with an average weight of 29 pounds. Due to consumer demand for larger screens, the average weight of a flat panel display (FPD) TV had increased to 61.1 pounds in 2005, and to 85.3 pounds in 2010. These are the FPD TVs that are being collected today. Unlike televisions, which have increased in weight over the years, laptops are becoming lighter. When they were introduced in 1992, they weighed 9 pounds. Today, in 2013, the average weight of a laptop is only 6.4 pounds. At the same time, the desktop is losing market share and is expected to make up only 18% of all PCs sold by 2015, while the mobile phone, which weighs only a fraction of a pound and has many of the same consumer-friendly applications as the desktop, is gaining market share. It is expected that billions of hand-held mobile devices will be sold worldwide throughout this decade alone.

Figure 1: US sales of desktop PCs, laptop PCs, and mobile devices, 1980–2010



Understanding the effects of sales on the weight collected now and in the longer term is a critical question when planning for end-of-life management in the future. It can also provide some indication of program success. But further difficulties arise with the addition of the variable that accounts for the lifespan of an electronic device. This, too, is a moving target.

In some cases, the technology is improving at rapid rates, so a product becomes obsolete quickly. Smart phones, for example, have an estimated replacement time of only 18 months.[1] Printers are designed with built-in obsolescence and usually die after only three years.[2]

In addition is the factor of reuse. For some WEEE, refurbishment and reuse take place in the economy, but this fact is not recognized in collection data. This would have a deflation effect on the capture rate. Export of WEEE (legal or illegal) is yet another variable affecting our ability to project how much e-waste is produced, and export data cannot be determined accurately.

---

[1] US Environmental Protection Agency, *The Life Cycle of a Cell Phone*, accessed July 23, 2013, http://www.epa.gov/osw/education/pdfs/life-cell.pdf.
[2] Steve Pociask, president of the American Consumer Institute, in interview with the author on printer life and printer ink, July 2013, estimated 3 years as the "life of the printer." See also Jeff Bertolucci, "How Much Ink Is Left in That Dead Cartridge?" *PC World*, November 2, 2008, http://www.pcworld.com/article/152953/printer_ink_costs.html.

There are several e-waste projection models that have been designed to consider weights, lifespans, and hoarding patterns. These offer the best estimates of WEEE availability for future planning and can provide some performance information in terms of year-over-year tracking.

EPRA Key Performance Indicators

The Electronic Products Recycling Association (EPRA) uses a suite of core performance indicators to measure the performance of each provincial program (Table 1). Using the same set of indicators for each province is part of EPRA's mandate of harmonizing the programs for better comparison.

Table 1: EPRA performance indicators

COLLECTION	Total tonnes collected
	Tonnes collected per capita
ACCESS	Percentage of population within a specific driving distance of a collection depot
	Number of collection sites
AWARENESS	Percentage of population aware of the program
	Number of participating stewards
COST	Operational costs per tonne
	Overhead costs per tonne
	Total program costs per tonne

None of the indicators, by itself, can paint an accurate picture of the performance of a program. For example, one province might collect significantly more tonnage than the others, but this larger amount could be reflective of the province's size and the scope of materials accepted rather than an indicator of superior performance.

The summaries in this report will provide data for six of these performance indicators. Note that, in the provinces where EPRA is the program operator, collection events are no longer used as an indicator.

Table 2: Performance indicators used in this report

Total tonnes collected
Tonnes collected per capita
Number of collection events
Number of collection sites
Percentage of population aware of the program
Total program costs per tonne

New Measurements: Performance Rates

In terms of measuring performance, EPRA's key performance indicators certainly represent a step in the right direction. However, other measurements, specifically, those that relate to the efficiency of the actual recycling process and to the end destination of material, provide further clarity on program performance.

To understanding the benefits that come from recycling WEEE, research must rely on science-based life cycle analysis (LCA). LCA examines the environmental implications of a product throughout its entire life cycle, from raw material extraction, production, and use of the product, through to final disposition. LCA compiles an inventory of relevant energy and material inputs and environmental releases and identifies the potential environmental impacts associated with identified inputs and releases.

LCA consistently shows[3] that the greatest environmental benefits in material management are derived from those systems that keep the material in use longer, thereby replacing virgin material extraction and production for as long as possible.

Each time virgin metals and elements are replaced with recycled raw material, there is a significant reduction in pollution, greenhouse gas emissions, and energy consumption. Metal recycling derives the greatest environmental benefits compared to recycling plastic and glass products.

These benefits suggest that the output of the recycling process—what WEEE is recycled into—offers important information and can determine the environmental merit of the collection program.

The United Nations Environment Programme (UNEP) published *Recycling Rates of Metals: A Status Report in 2011*.[4] It was compiled by UNEP's International Resource Panel, a group of experts from industry, academia, and government, and it evaluates recycling rate information for sixty different metals.

[3] US Environmental Protection Agency's waste reduction model (WARM) provides up-to-date net energy and pollution factors for source reduction, recycling, EFW, and landfilling with and without energy recovery.

[4] UNEP International Resource Panel, *Recycling Rate of Metals: A Status Report* (Nairobi, Kenya: United Nations Environment Programme, May 2011).

The report defines recycling rates and explains that the benefits of recycling are found in a **closed-loop system** where metalp can be continually recovered and used as substitutes for virgin metals. Pl j b j etal ob` lsboba _rq used in a manner in which the crk`qflk^ifqv lc qeb j bq^i is lost j ^v _b fk qeb clo j lc cfk^i t ^pqbp) pi^d) bccirbkqp ^ka arpq+ Qefp fp `^iiba klk*crk`qflk^i ob`v`ifkd ^ka fq fp bu`iraba co l j qeb obv`ifkd o^qb+

If this definition is extended to other materials found in WEEE, then knowing the fate of the recyclate from WEEE processors (or the flow of materials) will further inform program performance.

Figure 2 illustrates a basic model for the flow of most products and material destined for recycling, energy recovery, and disposal. The flow of materials and products in the recycling chain passes through a series of stages, from virgin extraction to the manufacturer (a) and then to the user (b) and on to the various EOL and reuse destinations.

These are all of the stages in the recycling chain in which material may be lost as waste (w), recovered as energy (x), diverted as non-functional recycling (y), and recycled into a secondary raw material (e & f). Each material's flow path is identified by a letter, which can be used in performance rate calculations.

Each rate is important because it offers different types of information to evaluate how well the EOL programs are working relative to the overall program objectives. These rates also offer insight into the individual links in the chain, which may be deficient (or weak) and require a modification or improvement in management.

Rate Calculations

Isolating the different flows of materials relative to their final disposition provides a framework on which to develop a series of performance rates and indicators. This section identifies the formula for calculating these rates and offers some insight as to how these indicators (rates) are useful.

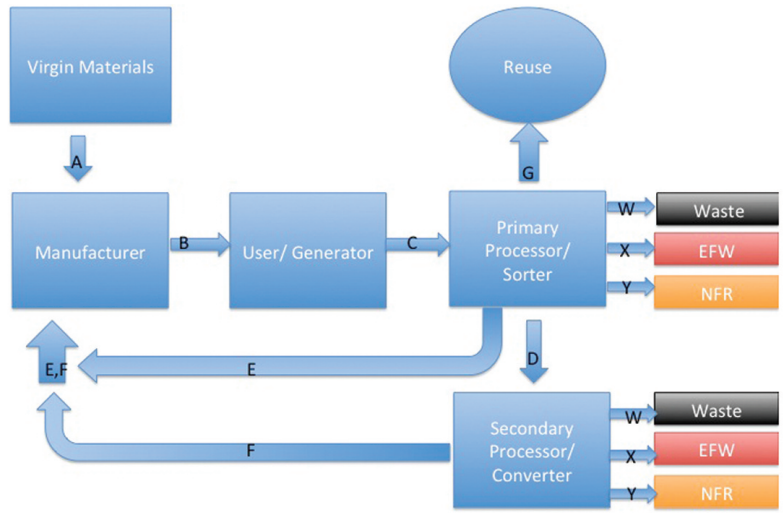
Each rate is calculated using the definitions in the legend of Figure 2. Datasets used for calculation (total product units or total material weight in tonnes) are identified with letters in the flow chart.

Collection rate (CR)

This measures the amount of category-specific material (by weight) or products (by count) collected for recycling compared to the amount available for end-of-life management.

The CR is a good indicator of program success in relation to consumer awareness and collection optimization.

Figure 2: Recycling Flow of Materials Schematic



Legend:

a: Virgin material extracted and shipped to the manufacturer
b: Products or material sold to users which are available for recycling
c: EOL materials collected for diversion
d: Sorted material shipped to secondary processors or converters
e & f: Secondary materials shipped to manufacturers as substitutes for virgin materials
g: Products shipped for reuse and refurbishment
h: Reused and refurbished goods re-sold to users
w: Waste for disposal
x: Waste for energy
y: Materials shipped for non-functional recycling

The CR is measured as the amount of material collected for diversion divided by the amount of material available for diversion:

$$\frac{c}{b}$$

(Note that all equations in this section are as per flow chart in Figure 2.)

Diversion rate (DR)
This measures the amount of category-specific material (by weight) or products (by count) collected for recycling minus any material sent for disposal compared to the amount available for end-of-life management.

The difference between the collection rate and the diversion rate is the amount of "other" waste that was collected along with targeted material. The DR, then, is a good indicator of how well generators and users are source-separating WEEE.

The DR is measured as the amount of material shipped for diversion divided by the amount of material available for diversion:

$$\frac{c\text{-}w}{b}$$

(Note that w is the sum of all waste shipped from primary and secondary processors combined.)

Recovery rate (RVR)
This is a measure of the amount of material that is recovered for reuse, functional recycling and energy recovery (EfW) compared to the amount of material available for end-of-life management. This rate excludes any non-functional recycling. The difference between the diversion rate and the recovery rate identifies how much non-functional recycling is occurring for a particular flow of materials.

The RVR is measured as the amount of material shipped for reuse, functional recycling and energy recovery divided by the amount of material collected for diversion:

$$\frac{e+f+g+x}{c}$$

(Note that x is the sum of all material shipped for EfW.)

Recycling efficiency rate (RER)
Recycling efficiency is the percentage of original production nutrient inputs that are recirculated into industrial and natural material cycles rather than lost to wastes that cannot be metabolized by industrial systems as technical nutrients or by natural production systems as biological nutrients.

The RER measures the efficiency of a recycling process. It is the amount of material (by weight) or by product (by count) as an output of a processing process (primary and secondary combined) divided by the material weight (net of water) or the product count that was originally processed. Outputs exclude discarded residual, material used as fuel (i.e., EfW), and any non-functional recycling that occurs further in the recycling chain.

The RER provides a clear picture of an existing recycler's or converter's level of high-value recycling or "functional recycling."

The RER is measured as the amount of material shipped for functional recycling (from both primary and secondary processors) divided by the amount of material received by the primary processor:

$$\frac{e+f}{c\text{-}g}$$

(Note that, if metal is recovered from an EfW facility for functional recycling purposes, the weight of this metal should also be included in the numerator. Likewise, if a manufacturer ships a portion of its secondary feed stock out to EfW, disposal or non-functional recycling, this flow should also be accounted for.)

Recycling rate (RR):
The RR measures the net effect of both the collection and recycling efficiency rates. The RR is the most informative performance indicator because it measures the entire recycling process, from collection to final disposition. It is represented this way:

$$\frac{e+f}{b\text{-}g}$$

Verified mass balance data to calculate these rates can offer a consistent approach to measuring recycling of WEEE versus measuring only the amount collected. These more detailed measurements would help level the playing field between different processors and encourage improved recycling.

Part III: WEEE Recycling

Following WEEE after Collection

When a consumer determines that his electronics have reached the end of their useful life and decides to have the products recycled rather than sent to a landfill, the consumer brings them to a collector. Most collection sites in Canada operate as private businesses or at municipal landfill sites. At these sites, the materials are generally sorted as boxes or pallets of similar materials; for example, the consumer puts a computer monitor onto a pallet with other computer monitors.

The materials are then transported to a primary processor or converter where they are de-manufactured or otherwise separated into constituent parts. Generally the first stage is a pre-sort, which not only removes items that should not go through the process (e.g., toner cartridges, mercury switches, and batteries) but acts as a "triage" to determine if an item has a potential for reuse. If an item can be refurbished and resold or donated to a charitable computers-for-students type of organization, then it is set aside.

After the pre-sort, the first stage for materials bound for recycling is usually shredding, which allows for the separation and recovery of plastics, metals, and glass. Many metals such as steel, aluminum, and copper, along with circuit boards that likely contain gold and silver, are manually removed during or after shredding. These valuable metals are recovered at secondary processors or converters and reused.

Other materials will contain mixed metals; these are sent to a separate secondary processor or converter to be mechanically separated, often using a pyrometallurgical procedure such as burning in a furnace.

Plastic will be separated and sent to a secondary processor or converter. The majority of plastic materials will end up being exported, often to China, for this stage. This mix of plastics will contain multiple resin types and colours and range in size. Some of the resins in the plastic will contain toxic elements such as lead or polybrominated diphenyl ethers (PDBEs). The secondary processor or converter may sort the plastics by resin and send them to a third processor/converter to be turned into clean flake for remanufacturing. Some secondary processors may, rather than sort the various resins, use them as feedstock for furnaces.

Glass that is recovered is crushed and sent for further processing. Much of the glass from EOL electronics is leaded cathode ray tube (CRT) glass that needs to be burned in a furnace to separate the lead as a fume. One of the greatest challenges facing WEEE programs today is what to do with the glut of CRT glass that has entered the stream and will continue to do so for the foreseeable future. At present, CRT glass has little to no value, so it is not being sold but is warehoused by most recyclers hoping it will increase in value and become a saleable commodity.

Table 3: Reuse and recycling in Canada: Recyclers and the processes and materials they accept

Canadian WEEE Processors	Province	City
eCycle Solutions	AB	Airdrie
eCycle Solutions	AB	Edmonton
GEEP	AB	Edmonton
GEEP	AB	Calgary
Recycle-Logic	AB	Red Deer
Shanked Computer Recycling	AB	Acheson
Technotrash Alberta	AB	Calgary
eCycle Solutions	BC	Chilliwack
FCM Recycling Inc.	BC	Delta BC
Sims Recycling Solutions	BC	Langley
Teck Metals Ltd	BC	Trail
Exner E-Waste Processing Inc.	MN	Morden
FCM Recycling Inc.	NS	Elmsdale
ADL Process Inc.	ON	Toronto
Artex Environmental	ON	Toronto
eCycle Solutions	ON	Mississauga
Electro-Shred Ltd.	ON	Brantford
FCM Recycling Inc.	ON	Cornwall
FCM Recycling Inc.	ON	Toronto
GEEP	ON	Barrie
Greentec	ON	Cambridge
SHIFT Recycling Inc.	ON	Brampton
Sims Recycling Solutions	ON	Mississauga
Target Recycling Services Inc.	ON	Ajax
Toronto Recycling Inc.	ON	Toronto
AFFI Informatique	QC	St. Hubert
Carrefour Environnement Saguenay	QC	Chicoutimi
Reseau Quebecois des CFER	QC	9 locations
Kadisal Canada	QC	Montreal
Evolu-TIC Outaouais	QC	Gatineaux
eCycle Solutions	QC	Salaberry
FCM Recycling Inc.	QC	Lavaltrie
GEEP	QC	Laval
Insertech-Angus	QC	Montreal
L'Entreprise - École RECYPRO d'Argenteuil	QC	Lachute
Ordinateurs Pour les Écoles du Quebec	QC	Verdun
Cartonek	QC	St. Marie
Valoritec (La Relance)	QC	Gatineaux
Sims Recycling Solutions	QC	Laval
SARCAN	SK	Saskatoon
Estevan Diversified Services	SK	Estevan
KIN Enterprises Inc.	SK	Prince Albert

Environmental Standards for Recycling Facilities

Why Is Environmental Management for WEEE Important?

Ensuring the proper management of WEEE is important to everyone.

Manufacturers of electronic products are heavily invested in their technology and brand and want assurance that the programs and service providers managing their products at the end-of-life stage are considerate of environmental health and safety.

Consumers that purchase and use electronic devices and participate in WEEE collection schemes assume that their e-waste will be handled properly, without risk to human health or the environment.

Government wants to ensure that domestically produced e-waste is recycled in an environmentally sound manner consistent with policies, regulations, and international agreements.

Finally, processors and recyclers of electronic products and scrap materials count on fair operating requirements, which protect workers, promote innovation, and foster a competitive marketplace.

What Do These Standards and Certifications Cover?

Today, there are a number of end-of-life operating standards for electronics processors. Some are voluntary certification programs while others are built into new legislation. These standards set a base level for operations, for areas that include environmental, health, and safety management systems (EHSMS); legal requirements; data security; emergency planning and response; audit requirements; and environmental, health, and safety controls for collection, treatment, and logistics downstream and for the full chain of custody management. These standards may also establish acceptable markets for final disposition and downstream processing—usually guided by federal and international regulations and conventions on the international flow of e-waste.

It is important to note that these standards and certifications are not static. As a consequence of regulatory, economic, and technological dynamics, as well as our evolving understanding of the toxins involved in the production of WEEE, they are in a constant state of adjustment and revision.

Canadian Standards for WEEE Management

Over the last two decades, electronic primary processors have been setting up facilities in Canada. Some facilities manage large volumes of material using large high-tech mechanical separation equipment while others offer manual refurbishment and disassembly.

The Recycler Qualification Program (RQP) for EOL electronics recycling has been developed for Canadian electronics stewards as the operating standard for their service providers.[5] The Recycling Qualification Office (RQO) operates under Electronic Products Recycling Association (EPRA), a national, non-profit entity created by Canada's electronics industry to develop a set of operating standards for Canada's industry-led extended producer responsibility programs. The RQO manages all recycler assessments and approvals for the regulated provincial programs and uses the RQP as its governing base standard.

How does Canada compare?

In December 2012, the International Sustainable Development Foundation commissioned a report by Arcadian Solutions aimed at better understanding how leading certifications and standards for WEEE processing met the e-waste management standards of the IEEE (Institute for Electronic and Electrical Engineers). The IEEE's 1680-series is considered the de facto standard for sustainable desktop computers and serves as the verification requirement for the Electronic Product Environmental Assessment Tool (EPEAT) used by manufacturers.

In an easy-to-follow format, the report outlines key elements of the standards and describes implementation and certification programs, providing a concise description of how each standard compares with the IEEE 1680 end-of-life processing requirements.

[5] Electronics Product Stewardship Canada, *Recycler Qualification Program for End-of-Life Electronics Recycling*, October 27, 2010, http://www.rqp.ca/ESW/Files/Recycler_Qualification_Program_FINAL_10.10.27.docx;

The findings show that Canada's RQP has, in most cases, met similar minimum criteria as international standards such as WEEELABEX (Europe), e-Stewards (Standard for Responsible Recycling and Reuse of Electronic Equipment, USA/OECD), and R2 (Responsible Recyclers, USA). However, RQP does not require a certified management system, as do the e-Stewards and R2 standards. In the case of WEEELABEX, the standard is embedded in the legislative text.

In sum, the comparison presented by Arcadian Solutions offers valuable insight into what kinds of improvements can be made to Canadian processing requirements, existing regulatory targets, and program requirements.

Our interviews with Canadian operators and primary processors indicate that, in general, the RQP is considered a good standard on paper, with room for continuous improvement. Most processors agree that these standards have helped them develop a system for better communication with employees, assisted with training, added layers to data tracking and reporting, and informed them about downstream markets and due diligence expectations. However, the audit to certification process of the RQP has been shown to be lacking in some areas, for example, approving downstream vendors without an on-site audit.

Standard Certification and Verification

Stakeholders also agree that standards play a vital role in the establishment of best practices and should be overseen by government or a third party. In an effort to avoid the proverbial "fox in charge of the hen house," all auditors and standard development and certification bodies should be independent with public reporting.

Most regulated Canadian WEEE programs (except those in Alberta) approve the standards offered by RQO as part of their stewardship plan, which means that, ultimately, stewards are in control. Alberta is the only province that registers its processors and audits their facilities using third-party auditors.

Further complicating the picture of Canada's existing operating standards is the fact that e-waste managed outside of a provincial stewardship program—for example, the imported and commercial e-waste that finds its way to Canadian operations—is governed only by a set of rules outlined in provincial and federal laws, which vary by province.

Certification programs offer a formal management system, which is continually verified and independent. Such a system is a useful measure to include in any provincial legislation, as it offers legislators the assurance that operators managing their material are adhering to a high standard.

The "Annual Corporate Declaration Criterion" (section 4.6.2.1 of IEEE 1680 series) provides an example of text that attempts to ensure independence and transparency in the system:

> In jurisdictions where the manufacturer has control over the choice of initial service providers, the manufacturer shall ensure that all equipment collected ... is managed by initial service providers that are certified on an ongoing basis to a qualified recycling standard by independent certification bodies. These certification bodies shall be accredited by an IAF [International Accreditation Forum] member accreditation body to certify to the specific qualified recycling standard.[6]

Auditing

Auditing must be on site, informed, and performed on a regular basis. The scheduled audits should be augmented with a series of spot audits. These unscheduled visits will foster a greater level of compliance to the requirements. All incoming and outgoing material must be accountable to a mass balance check. Qualified auditors familiar with the particular complexities and challenges of WEEE are required.

Reporting

Mass-balance reporting necessitates a complete accounting of all incoming and outgoing WEEE (for reuse, recycling and EfW) at least twice a year, if not monthly. The mass-balance approach goes one step further than material tracking because it requires balancing all inputs and outputs and provides an opportunity for reconciliation to ensure that no WEEE is unaccounted for. Mass-balance reporting can also be a very useful tool for auditors, who can select loads randomly and track their destinations and associated documentation upstream and downstream. For these reasons and because of its usefulness in demonstrating compliance to program requirements, mass-balance reporting should be a program prerequisite in all Canadian provinces.

[6] Institute of Electrical and Electronics Engineers, *IEEE Standard for Environmental Assessment of Televisions* (New York: IEEE, October 2012), 1680.3-2012, section 4.6.2.1.

Downstream Processors

Secondary processors and converters are also known as "downstream" processors. These are the facilities at the end of the recycling chain that receive used or end-of-life electronic equipment, components, or materials from a primary processor or other secondary processors for the purpose of additional processing or disposition. Downstream processors include entities that bulk and blend, shred and separate, process materials into new products, and process materials to recover metals, energy, or other resources.

Industry and media reports of substandard downstream WEEE operators in developing countries such as Africa, India, China and Pakistan continue to emerge on a regular basis. For primary processors and program operators, weaker environmental regulations and monitoring in other parts of the world make it difficult to weed out the legitimate operators from the bad operators who exhibit little consideration for health and safety and environmental protection.

Due diligence

Given the concerns just outlined, due diligence in the selection of downstream processors by primary processors is critical, and diligence must continue to the final resting place of the material (e.g., to its use directly in the manufacturing of a new product). Although performing due diligence is the responsibility of both the primary processor and the program operator, the level of due diligence carried out by each may vary. Consequently, requirements and expectations should be clearly outlined in the standards and leave little room for interpretation.

As an example, e-Stewards (the US certification standard) specifies a documented system of direct controls for all e-waste shipped to downstream processors. It includes specific requirements such as initial due diligence prior to shipping materials, on-site audits of downstream processors, random sampling of shipments over a minimum length of time, verification that intermediaries are directing shipments to approved destinations, and the provision of full transparency to all customers. Most standards and certifications also require certified or trained auditors to perform audits in accordance to the standard.

Part IV:
Quantifying the Benefits of WEEE Recycling

Using Life Cycle Assessment (LCA)

The objective of LCA is to inform decision making by identifying changes at every stage of a product's life cycle that can reduce its environmental impact and overall cost. The result is a full-cost accounting of the true impact that diversion programs, such as WEEE, can have in terms of the environmental and human health savings to society.

The life cycle of a product comprises several phases, including production, distribution, consumption, and end-of-life management, as well as the upstream and downstream processes associated with production (e.g., the extraction of raw materials) and disposal (e.g., the collection, processing, hauling, and disposal or recycling). LCA illustrates the importance of fully accounting for the broad range of environmental impacts of a product throughout its life cycle, rather than focusing on a single impact, such as climate change. Environmental impacts can be defined as all things that affect the environment, including extractions from the environment (e.g., ores, crude oil) and emissions to the same (e.g., waste, carbon dioxide, methane).

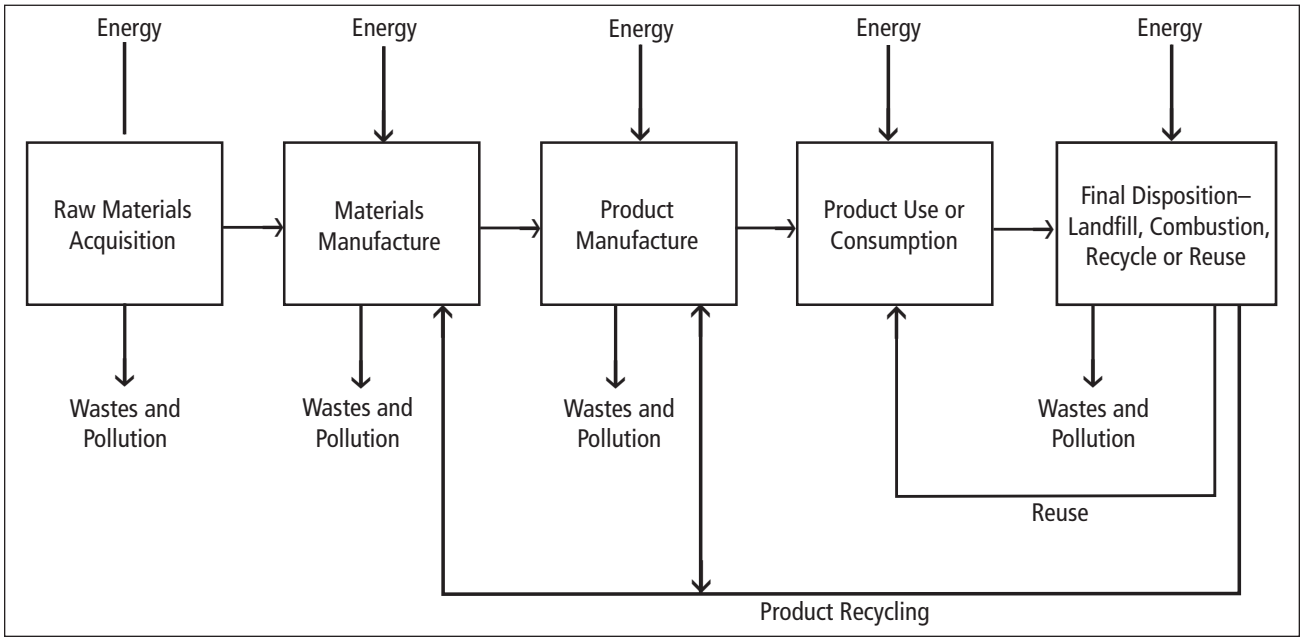
Benefits of Reusing and Recycling WEEE

The environmental benefits from WEEE diversion programs are drawn from the associated benefits of recycling, which include the environmental impacts of recycling (collection, processing, hauling), the avoided environmental impacts of raw material acquisition and manufacturing, attained when recyclables are used instead of virgin resources, as well as the avoided impact of waste disposal (landfill). Recycling WEEE products diminishes most or all of the inputs needed to manufacture the replacement product from virgin materials. Avoiding these "upstream" processes significantly reduces energy usage, associated greenhouse gas (GHG) emissions, and other pollutant emissions as well. Recycling desktop and laptop computers, for instance, has conserved approximately 86 and 89 gigajoules (GJ) of energy per tonne respectively, whereas recycling computer peripherals and printing devices conserves only 69 GJ per tonne.

Categorizing Pollution

As noted earlier, waste diversion programs are traditionally evaluated based on the weight (tonnage) or volume of materials diverted. Unfortunately, neither of

Figure 3: Typical product life cycle



these parameters are indicators of the environmental impacts these materials have when they are diverted or disposed. For instance, they provide no information on the amount of pollution avoided by reusing or recycling a product instead of manufacturing a new one with virgin material. This circumstance makes it difficult for lay people and, more importantly, decision makers to see the benefits of diversion in terms of its real effect on human health and the environment.

To remedy this problem, Sound Resource Management's MEBCalc™ (Measuring the Environmental Benefits Calculator) provides a new set of measurement parameters that are much more meaningful in terms of environmental impact. The calculator measures the environmental benefits of diversion in terms of seven categories of pollutants, each of which is related to a distinct set of environmental impacts.

These categories and some of the pollutants that cause the environmental effects measured are as follows:

1) **Climate change** (measured as carbon dioxide equivalents (C02e)—characterizes the potential increase in greenhouse effects as a result of human-caused emissions. CO2 from fossil fuel combustion is the largest source of greenhouse gases (GHGs).

2) **Human respiratory health** (measured as particulate matter ≤ 2.5 microns equivalents)—characterizes potential human health impacts from anthropogenic releases of coarse particles, fine particles, and particular precursors that are known to exacerbate respiratory conditions such as asthma or lead to more serious respiratory symptoms and diseases.

3) **Human toxicity** (measured as toluene equivalents)—characterizes potential human health impacts from releases of chemicals and heavy metal pollutants that are toxic to humans, including 2,4-D, benzene, DDT, formaldehyde, permethrin, toluene, chromium, copper, lead, mercury, silver, and zinc.

4) **Human carcinogens** (measured as benzene equivalents) – characterizes potential human health impacts from releases of chemicals and heavy metal pollutants that cause cancer in humans, including 2,4-D, benzene, DDT, formaldehyde, kepone, permethrin, chromium, and lead.

5) **Eutrophication** (measured as nitrogen equivalents)—characterizes the potential environmental impacts from adding mineral nutrients, such as nitrogen and phosphorous, to soil or water. These impacts can include shifts in the number of species in ecosystems, reduced ecological diversity, and increased algal production and the associated effects on fish and other species.

6) **Acidification** (measured as sulfur dioxide equivalents)—characterizes the potential environmental effects from anthropogenic releases of acidifying compounds, primarily from the burning of fossil fuels and biomass, which affect vegetation, soil, buildings, animals, and humans.

7) **Ecosystem toxicity** (measured as 2,4-D equivalents)—characterizes the potential for chemicals and heavy metals released into the environment to have a negative impact on terrestrial and aquatic ecosystems, including wildlife.

Monetizing Pollution

Each pollutant has a different effect on the environment and human health, so comparing the impacts of various pollutants is difficult. In order to make pollution data easier to understand and analyze, MEBCalc™ applies monetary values (in this case Canadian dollars) to each pollutant category based on either the estimated real financial costs to society in terms of environmental harm and human health impact or the actual market value of the pollutant's emissions established through trading schemes such as auctions for the US EPA's sulfur dioxide emissions permits under the Clean Air Act provisions for controlling acid rain.

Table 4: Avoided environmental impact value per tonne

CLIMATE CHANGE	HUMAN RESPIRATORY HEALTH	HUMAN TOXICITY	HUMAN CARCINOGENS	EUTROPHICATION	ACIDIFICATION	ECOSYSTEM TOXICITY
eCO_2	ePM2.5	eToluene	eBenzene	eN	eSO2	e2,4-D
$50	$13,779	$162	$4,175	$6	$668	$4,519

Net Environmental Impact (tonnes) X Monetized Value ($/tonne) = Net Environmental Benefit

After the pollution impact is measured for each category for each recycled or reused material, a monetary value is assigned to the pollution benefit reduction associated with reuse and recycling. Reuse and recycling are credited for saving energy and virgin material resources. The credit is based on avoided energy costs and their environmental effects, as well as avoided pollution from primary resource extraction, manufacturing, and related transportation.

Monetization provides decision makers with a quantitative tool for evaluating the trade-offs among the seven types of environmental effects to see where the greatest benefits can be gained through recycling or reuse. It also allows us to compare the environmental benefits to the financial costs of the various waste management options.

To calculate the dollar value of the environmental and human health benefits of diversion, MEBCalc multiplies the avoided pollution amount for each material diverted by its monetized value, as shown in Table 3. The net benefit is the monetized value of the avoided human health and environmental impact caused by pollution.

Understanding the Benefits of Recycling WEEE

To determine the environmental impact of WEEE recycling programs across Canada, actual WEEE tonnage diverted in a year is used as an input to MEBCalc. A study was conducted on the environmental benefits of Ontario's WEEE diversion program in 2007, and it was found that, on a per tonne basis, recycling desktop computers contributed the greatest environmental benefit at more than $975 per tonne, accounting for approximately 51% of the total. Recycling monitors was next at 29%, and printers were at 9%, with televisions in last place but still providing environmental benefits of $229 per tonne. Based on program targets, it is anticipated that TV recycling will account for an increasingly greater share of the environmental benefit as the WEEE recycling program matures. The economic value of the environmental benefits of recycling different types of WEEE is shown in Figure 4.

From a pollution perspective, the greatest benefits are reductions of toxics to humans that would have been released to the environment if the recycled WEEE products had instead been landfilled and virgin resources were used to produce the products manufactured, rather than materials recycled from discarded WEEE. The economic benefits are drawn from the benefits associated with avoided potential human health costs. Savings in GHG emissions and in emissions that cause respiratory illnesses come in second and third, respectively. Figure 5 shows MEBCalc's valuation for the public health and ecological benefits from recycling WEEE for each impact category.

The results of this analysis emphasize the need to collect greater amounts of WEEE for recycling, with a particular emphasis on those products that produce the greatest environmental benefits because of their diversion.

Figure 4: Environmental benefit of recycling WEEE per tonne (monetized into Canadian $ for Ontario 2007)

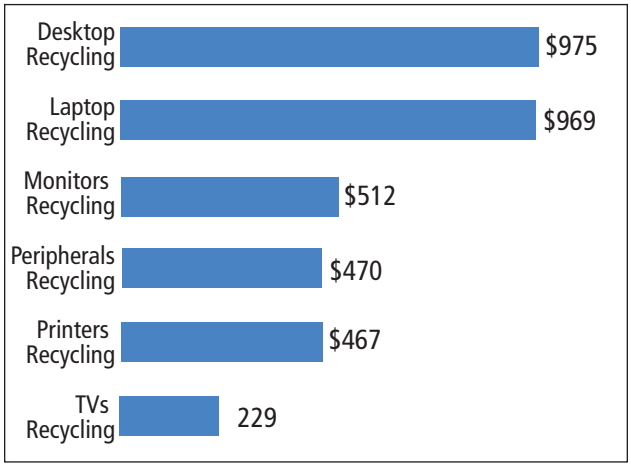
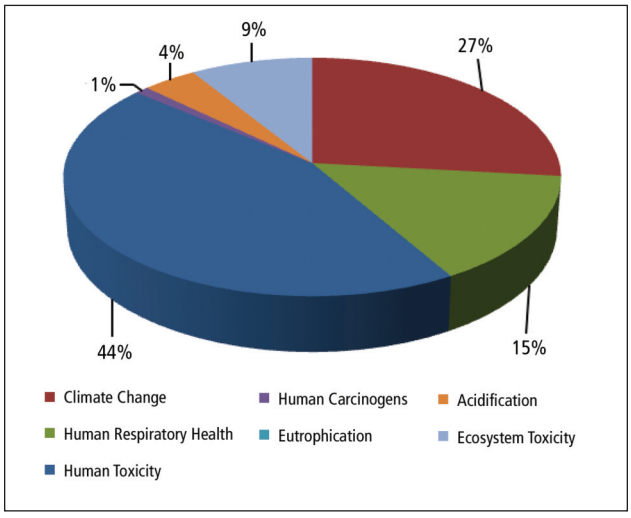


Figure 5: Share of pollution reduction benefit from recycling WEEE (per tonne)



Monetizing the Benefits of Reusing WEEE Discards

Though recycling WEEE has a significant impact in terms of avoiding the pollution that would have been generated if new electronic products had been created from virgin resources, WEEE reuse provides environmental benefits that are orders of magnitude larger than the benefits from WEEE recycling. These greater benefits result because the environmental impacts of reuse involve mainly refurbishing, which has a fraction of the effect on the environment that manufacturing new electronic products has (see Table 5). The importance of reuse over recycling is also explained by the fact that the recycling of electronic equipment under presently available technologies involves reducing a complex piece of equipment to shards of metal, plastic, and glass. While these materials are recyclable, the integral value they had prior to shredding is a large multiple of the value of the shards.

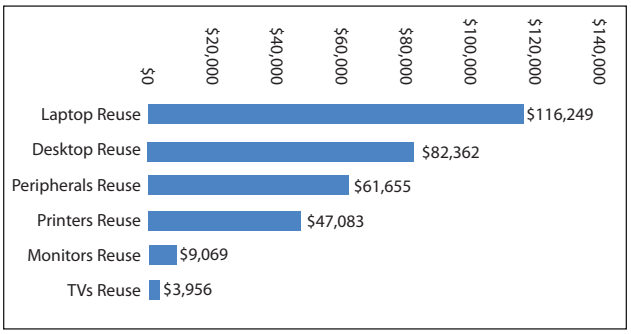
Table 5: Refurbishing energy and emission impact as a proportion of new product impact

TVs Recycling	20%
Printers Recycling	10%
Peripherals Recycling	1%
Monitors Recycling	5%
Laptop Recycling	10%
Desktop Recycling	10%

Measuring the environmental impact of WEEE reuse requires comparing the environmental impact of not having to manufacture new products as well as the impacts associated with raw material extraction for all the component metal, glass, and plastic materials that make up electronic equipment. It is estimated that processing WEEE products for reuse has a significantly lower energy impact than processing the same material for recycling, given that there is no shredding or grinding of material.

Reusing desktop and laptop computers, for instance, has an avoided energy impact of 587 and 1,234 GJ per tonne respectively, and provides the greatest environmental benefit per tonne. Reuse of computer peripherals and printing devices also have substantial benefits as a result of the avoided production of new products, but these benefits are smaller. The economic value of the environmental benefits of reusing different types of WEEE is shown in Figure 6.

Figure 6: Environmental benefit of reusing WEEE per tonne (monetized into Canadian $)



Although these energy savings are real, it is important to take into account the energy impacts of refurbishing activities and of the manufacture of replacement parts. It is also important to consider the additional usage of electricity that may result because of the continuance in the marketplace of older computers or television sets that are less energy efficient. These energy and environmental impacts will offset some portion of the upstream benefits of reusing WEEE products. If the energy inefficiencies of older products are substantial compared to those of new products, reuse could result in increased energy and environmental impacts.

In terms of particular types of environmental benefit, avoidance of emissions contributing to human toxicity, climate change, and ecosystems toxicity account for most of the environmental benefits gained from reusing WEEE products. Avoided human toxicity is by far the most important, accounting for 69% to 83% of the total environmental benefits for the six WEEE product categories collected in Ontario in 2007.

These data further emphasize the need to set up collection systems that prioritize reuse and repair over recycling in nearly all cases.

Part IV: Provincial Program Summaries

British Columbia

Electronic Products Recycling Association (EPRA), Canadian Electrical Stewardship Association (CESA), Major Appliances Recycling Roundtable (MARR), Recycle My Cell

Who is Responsible?

In line with the requirements of their approved stewardship plan, the province-wide electronics recycling program is now managed by the Electronic Products Recycling Association (EPRA) (previously ESABC). EPRA is responsible to their stewards for implementing and executing a program for handling electronic waste in a way that is consistent with EPRA standards and the requirements of the EPRA Stewardship Plan. As an industry-funded organization, the over 1600 stewards in this program include major and minor producers and retailers of electronic products in BC. Since the start of operations in 2007, EPRA's recycling program has been delivered by Encorp Pacific (Canada), a non-profit organization under contract by EPRA that operates under the name Return-It™ Electronics.

The Canadian Electrical Stewardship Association (CESA) manages ElectroRecycle, BC's small appliance and power tool recycling program. CESA is a not-for-profit product stewardship agency of manufacturers, brand owners, and retailers of small appliances, power tools, sewing machines, sports and leisure equipment. It offers companies the opportunity to become a member in an industry-governed and -operated recycling program that will meet their legal obligations under provincial regulations. CESA has contracted the BC-based Product Care Association to perform day-to-day operations of the ElectroRecycle program.

BC's recycling of major appliances is managed by the Product Care Association under contract from the Major Appliance Recycling Roundtable (MARR), a not-for-profit stewardship agency created to implement a stewardship plan for end-of-life major household appliances in the province on behalf of the major appliance "producers."

The Canadian Wireless Telecommunications Association (CWTA) manages the province's cell phone recycling program, Recycle My Cell, a national industry initiative to keep mobile devices out of local landfills. CWTA is the authority on wireless issues, developments, and trends in Canada, and represents cellular, personal communication services (PCS), messaging, mobile radio, fixed wireless, and mobile satellite service providers as well as companies that develop and produce products for the industry.

Products Covered

The first phase of BC's Return-It Electronics program, the public-facing brand for the EPRA program in BC, was launched in 2007 and includes electronic items such as televisions, computers, computer monitors, keyboards, mice and other peripherals, printers, and laptops. On July 1, 2010, the second phase of the program was launched, and the list of acceptable electronics expanded to include stereos, VCRs, cameras, telephones and other personal electronics, and the batteries used in these products.

Phase III, managed by CESA and not part of the Return-It program, was launched on October 1, 2011 and was the first program of its kind in North America. Although, in the beginning, only small appliances were accepted for recycling, in July 2012, amendments made to the Recycling Regulation prompted the expansion of CESA's accepted product list to include motorized kitchen countertop appliances, microwaves, weight measurement devices, garment care appliances, desk and table-top fans, personal care appliances, and exercise machines to include electrical tools, such as hand-held power tools and bench-top and free-standing power tools, sewing machines, sports and exercise equipment (like treadmills), arts, crafts and hobby devices. A full list of materials covered by the program can be found at http://www.cesarecycling.ca/products.

With the launch of Phase V on July 1, 2012, the list of eligible products expanded further to include large appliances, electrical and electronic power tools, medical devices, automatic dispensers, lighting equipment, toys, leisure and sports equipment, monitoring and control instruments, IT and telecommunications equipment, and accessories for use with any e-waste product. Some but not all of these devices are covered by EPRA; others are covered by CESA and MARR.

The Major Appliances Recycling Roundtable (MARR) stewardship plan is the first and only approved stewardship plan for major appliances in BC. The MARR program accepts major household appliances powered by 120- or 240-volt input power that have been designed for

use in residential homes, including those that use natural gas or propane for heating purposes. Also included in the program are appliances used in or sold for industrial, commercial, and institutional applications that have the same fundamental design features as major household appliances.

All mobile and wireless devices that connect to a cellular or paging network, including all cell phones, smartphones, wireless personal digital assistants (PDAs), external aircards, and pagers are recovered under Recycle My Cell. Headsets, chargers, and other accessories are also accepted by this program.

Mandated Performance Standards

As noted in Section 5(1)(a) of the BC Recycling Regulation, the director may adopt performance requirements when he or she considers it appropriate. Approval of 12 core performance indicators as an alternative to the recovery rate for the EPRA program was granted by the director on July 9, 2010.

According to EPRA BC's 2012–2016 stewardship plan, the program aims to maintain a 3-year rolling average of a minimum of 18,000 metric tonnes of program material collected per year beginning with the year 2011. The program has also set a target with regards to public access to collection sites and collection events. Specifically, its goal is to achieve 90% coverage on a 3-year rolling average. With respect to public awareness, the program seeks to maintain a 3-year rolling average of 65% awareness of the program beginning in 2011.

Like EPRA, CESA has a set of targets relating to collection sites, public awareness, access, and collection. The target for public access for 2011 (part 1 of the program) was 95%. CESA data shows this target was achieved.

Recycle My Cell has set no quantifiable targets. However, the CWTA has identified several performance indicators that can be used to evaluate program success, including volume of cellular devices recovered, annual survey data on consumer awareness and likeliness to participate in a mobile device recycling program, website traffic and call volume to toll-free numbers, representative surveys of retailer participants to determine satisfaction, and media pick-up statistics.

Supporting Regulatory Framework

The province-wide "Return-It" electronics program for EPRA BC's program began under the *Environmental Management Act* and was created in response to an amendment to the provincial *Recycling Regulation*, which demanded that the electronics industry take responsibility for its products at the end of their life cycle. In December 2006, the Ministry of the Environment approved the British Columbia Stewardship Plan for End-of-Life Electronics, and the program became operational on August 1, 2007.

Under the BC *Recycling Regulation*, obligated "producers" (usually first importers to the province including manufacturers, distributors, and retailers) must have a product stewardship program in place and approved by the minister by July 1, 2012. To be approved, the program must include a province-wide collection system through which consumers can discard their end-of-life products free of charge. In addition, it must include a system for recycling the products that are collected.

CESA received approval for its stewardship plan for small appliances from the BC Ministry of Environment. The plan is governed by a board of directors consisting of ten individuals (six represent manufacturers or the brand owners of small appliances and four represent retailers of small appliances and electrical products). The board is also observed by the Canadian Hardware and Housewares Manufacturers Association (CHHMA), the Association of Home Appliance Manufacturers Canada (AHAM Canada), and the Retail Council of Canada (RCC).

The MARR stewardship plan received government approval on June 29, 2012. It is governed by a board of directors of major appliance manufacturers and retailers who are appointed by the Association of Home Appliance Manufacturers (AHAM) Canada and the Retail Council of Canada (RCC).

Recycle My Cell received regulatory approval on November 10, 2009 and is governed by the requirements of BC's *Recycling Regulation*.

Collection Systems and Rates

The EPRA British Columbia program has grown to encompass a wide network of permanent collection sites where consumers can drop off electronics for responsible recycling without charge. Although collection models vary from the return-to-retailer to the mail-back or contractor-take-back option, most e-waste is collected through a network of Return-It depots managed by Encorp Pacific or through various programs operated by regional governments, not-for-profit organizations, or provincial governments. While most products added to the program in July 2012 have been incorporated into the existing collection model, some of them will require the implementation of new service delivery models in order to be recycled.

As of December 2011, EPRA BC's collection network had expanded to more than 120 depots providing 97% of the province's population with convenient access to collection sites. In those locations falling outside the catchment and driving-range criteria for a depot, regular e-waste collection events are held during which consumers can bring in their waste electronic equipment free of charge.

The amount of material collected under the EPRA program has increased annually by an average of 20% or more. By December 2012, the program had collected 21,963 kg of waste electronic equipment (or 4.8kg per capita). The following table shows the total tonnes collected in BC in 2012, and the rates for four more of the 12 core performance indicators.

Table 6: Performance indicators, British Columbia, 2012

INDICATOR	
Tonnes collected	21963
Kilograms per capita	4.8
Collection sites	142
Population awareness (%)	75
Cost per tonne	$1,208

The CESA collection network includes 142 advertised collection facilities (as of August 15, 2013) and 14 unadvertised collection facilities. In 2012, over 2 million kg of electronics were recovered by CESA stewards.

As for Recycle My Cell, there are currently 554 drop-off locations in 83 communities across the province. In 2011, members recovered a total of 107,506 devices: 30,771 were collected through members' RMC initiatives (23,195 via drop-off locations and an estimated 7,576 using the mail-back option offered by several RMC partners) and 76,735 through various internal initiatives.

Funding Mechanism

The Return-It program is funded through revenues generated from an environmental handing fee (EHF) paid at the point of purchase by consumers. One hundred per cent of program revenue is used for the purposes of program administration and the collection, transportation, and responsible recycling of regulated end-of-life electronics, including historic and orphaned wastes. Table 7 shows prior and current EHFs for Phase I, II, and V products run by EPRA.

Table 7: Fees, British Columbia, 2013

CATEGORY	FEE
Desktop computers	$5.50
Portable computers	$1.20
Display devices ≤ 29 inches	$9.00
Display devices ≥29 inches	$31.75
Computer printers	$6.50
Computer peripherals	$0.90
Desktop computer scanners	$6.50
Personal or portable audio/ visual playback or recording systems	$0.40
Home audio/visual systems	$3.50
Home theatre in a box (HTIB) systems	$6.00
Vehicle audio/visual systems	$2.75
Non-cellular phones and answering machines	$0.85

ElectroRecycle, the program covering small appliances managed by CESA, is funded by the application of a recycling fee on the sale of new products brought into BC by manufacturers and retailers. The recycling fee covers all program costs, including the collection, transportation, and recycling of electrical products. Recycling fees were determined by CESA based on industry-best practices and other factors including the following:

- Total product weight per category
- Costs of program administration
- The cost of collecting and recycling a particular product
- Product sales and forecasts

The program is designed so the cost of managing the waste within one category of product is not subsidized by the fees paid within another category. Fees will be reviewed during the first two years of program operation and will be readjusted if necessary. The EHF for these products ranges from 50 cents a unit for time and weight measurement devices to $10.00 for a large microwave oven.

Similar to the programs of EPRA and CESA, the MARR program is funded by an administrative program fee (APF) charged on the purchase of new major household appliances in BC. All fees collected are used by MARR to cover the costs associated with implementing the MARR stewardship plan. These fees, collected from consumers, will be reported and remitted to MARR by MARR participants (manufacturers, distributors, retailers) who have registered with MARR to fulfil their regulatory

obligations. The EHF for products covered by the MARR program is $1.25 for major cooling appliances and $1.10 for other major appliances.

In contrast to other electronics, wireless devices are recycled without a fee to consumers. The Recycle My Cell (RMC) program is funded by various cell phone companies. The CWTA has internalized the cost of the RMC program; there are no visible fees levied on the purchase of cell phones.

Alberta

Alberta Recycling Management Authority (Alberta Recycling), Recycle My Cell (RMC)

Who is Responsible?

Initiated in October 2004 and launched in April 2005, Alberta's electronic recycling stewardship program has the distinction of being the first of its kind in Canada. Unlike the programs of the other provinces, Alberta's program is run by the Alberta Recycling Management Authority (Alberta Recycling), a not-for-profit association responsible for administering the province's tire, electronics, and paint recycling programs. Whereas other provinces have industry-funded organizations (IFOs) created through the actions of EPSC, RCC, and EPRA, Alberta's program was initiated by the provincial government.

CWTA, in conjunction with its members, is responsible for managing Recycle My Cell.

Products Covered

Phase I electronics currently accepted for recycling include visual display devices (e.g., televisions, computer monitors), CPUs, keyboards, cables, mice, speakers, printers, laptops, notebook computers, and tablets. Details regarding program expansion to include 250 new products are expected in the near future.

Mobile devices are covered under the Recycle My Cell program.

Mandated Performance Standards

Alberta Recycling's 2013–2016 business plan includes targets for the collection and processing of currently eligible (Phase I) electronic waste. The target for 2013–2014 is to collect and process over 16,000 tonnes of electronic waste, equating to over 4 kg per capita and a 45% capture rate.

CWTA has set a public accessibility target for the RMC program, which is to increase the number of Recycle My Cell drop-off locations by 1% per year from 2012 to 2015. It has also identified target collection rates increasing 4 to 5% each year up to 2015, when the target is a 37% collection rate.

Supporting Regulatory Framework

This province-wide program is regulated under the Environmental Protection and Enhancement Act and the *Electronics Designation Regulation*. The law was signed in 2004 and came into force on October 1 of the same year. Fees were implemented on April 1, 2005. The regulations define electronics as a designated material for the purposes of Part 9, Division 1 of the act and the *Designated Material Recycling and Management Regulation*.

In addition to being governed by provincial regulations, Alberta Recycling and its operations are regulated by a number of legislative bylaws, including the *Electronics Recycling Bylaw*. First approved in September of 2004, the bylaw has undergone several amendments to ensure that Alberta Recycling remains accountable to the Minister of Environment and Sustainable Resource Development and the residents of Alberta.

Recycle My Cell received government approval on June 10, 2011, when the Alberta government signed a memorandum of understanding (MoU) with the CWTA.

Collection Systems and Rates

Under Alberta Recycling, consumers can return designated end-of-life electronics free of charge to any of the province's 344 collection sites. Alternatively, electronics may be dropped off at more than 90 collection events held annually across Alberta. For materials not accepted by the program, such as radios, VCRs, and DVDs, some private recycling companies will recycle these electronics for a fee. Eco Stations, recycling depots, and other local waste-reduction events may also collect these electronics for responsible recycling.

E-waste collected at municipal collection sites is transported to one of the province's 6 registered electronics processors to be reduced to commodity state (plastics, metals, glass). From here, they are re-manufactured into new products. Registered processors are required to ensure that all waste electronics capable of storing data or personal information are physically

destroyed before being shipped to pre-approved companies (located nationally and internationally) for further processing and manufacturing into new products.

Table 8 shows the total amount of material processed (in tonnes) by the Alberta Recycling program, as well as the rates for five other performance indicators.

Table 8: Performance indicators, Alberta, 2011–2012

INDICATOR	
Tonnes collected	15768
Kilograms per capita	4.4
Collection sites	325
Collection events	94
Population awareness (%)	81
Cost per tonne	$1,117

As for the province's cell phone recycling program, RMC has 456 drop-off locations in 78 communities. In 2011, a total of 113,579 devices were recovered through the program: 30,958 were recovered through members' RMC initiatives (25,012 via drop-off locations and an estimated 5,946 using the mail-back option) and 82,621 through various internal initiatives. Its collection rate for 2011 was 27%.

Funding Mechanism

Since 2005, Alberta Recycling has been funded by end users through a one-time, non-refundable environmental fee placed on the sale of new, designated electronics. The fee, which ranges from $1.20 to $10 (depending on the item), is charged at the point of sale and appears as a separate item on the customer's receipt. All fees are remitted to Alberta Recycling and are used to cover the costs of collecting, transporting, and recycling end-of-life electronics; developing research into new recycling technologies; and raising awareness and support for the program. After registering with Alberta Recycling, members of the retail and manufacture supply chain are responsible for collecting and remitting the fee to Alberta Recycling in addition to filing regular remittance reports. Table 9 shows current environmental fees for different products categories under the Alberta Recycling program.

Table 9: Fees, Alberta, 2013

CATEGORY	FEE
Desktop computers	$$4.40
Portable computers	$1.20
Display devices ≤ 30 inches	$4.00
Display devices ≥30 inches	$10.00
Computer printers	$4.80
Desktop computer scanners	$4.80
Floor-standing printing devices	$4.80
Floor-standing copiers or multifunction devices	$4.80
Label, barcode, and card printers	$4.80

In contrast to other electronics, wireless devices are recycled without a fee to consumers through the RMC program, which is funded by the CWTA and various cell phone companies.

Saskatchewan

Saskatchewan Electronic Products Recycling Association (EPRA; formerly the Saskatchewan Waste Electronics Equipment Program or SWEEP), Recycle My Cell

Who is Responsible?

On February 1, 2007, the Saskatchewan Waste Electronic Equipment Program (SWEEP) was established as North America's first industry-led electronic stewardship program. On April 1, 2013, Saskatchewan joined a number of other provinces (British Columbia, Manitoba, Québec, Nova Scotia, and Prince Edward Island) in transitioning to the Electronic Products Recycling Association (EPRA), a national, not-for-profit organization established to harmonize the operation and management of electronics stewardship programs across the country. Despite the transition, day-to-day management of the SWEEP program will remain unchanged.

Under the regulations, EPRA is responsible for managing industry-led and government-approved electronic products recycling programs throughout the province on behalf of industry stewards. Though EPRA is responsible for overall management, the operational aspects of the program are managed by SARCAN Recycling, a non-profit recycler run by the Saskatchewan Association of Rehabilitation Centres (SARC), under contract from EPRA.

The CWTA is responsible for managing the RMC program.

Products Covered

SWEEP was implemented in two phases. Products included in Phase I of the program, launched on February 2007, include televisions, computer monitors, keyboards, mice, and other peripherals, printers, and laptops. In April 2010, the list of designated products was expanded to include Phase II products. Products in this category include audio-visual and consumer equipment, vehicle audio and video systems, and non-cellular phones and answering machines.

Cell phones are recovered under the RMC program.

Mandated Performance Standards

Although there are no mandated performance standards identified in the legislation, EPRA-Saskatchewan has chosen to adopt the EPRA key performance indicators that have been adopted by other electrical and electronic stewardship programs across Canada, including Atlantic Canada Electronics Stewardship (ACES), the Electronics Stewardship Association of British Columbia (ESABC), and Ontario Electronic Stewardship (OES).

The CWTA has not set any quantifiable performance targets. However, success of the RMC program is evaluated using a suite of performance indicators including volume of cellular devices recovered, annual survey data on consumer awareness and likeliness to participate in a mobile device recycling program, website traffic and call volume to toll-free numbers, representative surveys of retailer participants to determine satisfaction, and media pick-up statistics.

Supporting Regulatory Framework

EPRA Saskatchewan is regulated under the *Saskatchewan Environmental Management and Protection Act* (2002) and the *Waste Electronic Equipment Regulations,* signed into law on February 1, 2006. Over 690 manufacturers, retailers, and other stakeholders are stewards of the program, which received government approval in accordance with Saskatchewan's product management program.

RMC was formally recognized as a stewardship program for the recycling of cell phones in Saskatchewan on November 12, 2009. Although the CWTA has no formal obligation to the Ministry of Environment, it chose to report voluntarily on the RMC program's status for the 2011 calendar year.

Collection Systems and Rates

Since launching in Saskatchewan in 2007, EPRA Saskatchewan's collection network has expanded tremendously. As of 2012, there were 24 collection events and 72 depots in 63 communities across the province, all run by SARCAN Recycling and its community-based organizations. These depots accept all of the electronic and electrical equipment designated under the program, at no charge to the consumer. Thus far, the program has diverted more than 14,700 tonnes of waste electronics from landfill. (See Table 10 for 2012 performance.)

Table 10: Performance indicators, Saskatchewan, 2012

INDICATOR	
Tonnes collected	3425
Kilograms per capita	3.24
Collection sites	72
Collection events	24
Population awareness (%)	87.5
Cost per tonne	$1,760

Industrial, institutional, and commercial users in Regina and area can also arrange to have their electronic waste picked up by the Regina Food Bank. After collection, electronics are shipped to one of four processing centres: KIN Enterprises in Prince Albert, Saskatchewan; the Saskatchewan Abilities Council in Yorkton, Saskatchewan; Estevan Diversified Services in Estevan, Saskatchewan; and eCycle Solutions in Airdrie, Alberta.

Cell phones and other mobile devices can be returned to any of CWTA's 140 drop-off locations in 40 communities throughout the province. In 2011, a total of 40,582 devices were recovered under the RMC program: 11,953 were recovered through members' RMC initiatives (11,677 devices through RMC drop-off locations and another estimated 276 using the mail-back option) and 28,629 through various internal initiatives.

Funding Mechanism

The program is funded entirely through revenue generated from the environmental handling fee (EHF) charged to consumers on the sale of new electronic equipment. This fee is collected by retailers and by obligated industry stewards and remitted to EPRA to finance the program and manage it in their name. The amount of the fee is determined based on the numbers of units sold in or into the province. In general, retailers pass the EHF on to the consumer at the point of sale, and it is displayed as a

separate fee on a consumer's receipt. Whether charged wholesale or retail, EHFs in Saskatchewan range from $0.40 to $23.25 per unit sold. The EHFs for all products covered by the program are listed in Table 11.

Table 11: Fees, Saskatchewan, 2013

CATEGORY	FEE
Desktop computers	$15.00
Portable computers	$3.00
Display devices ≤ 29 inches	$9.25
Display devices ≥29 inches	$23.25
Computer printers	$8.00
Computer peripherals	$1.10
Desktop computer scanners	N/A
Personal or portable audio/ visual playback or recording systems	$0.40
Home audio/visual systems	$3.50
Home theatre in a box (HTIB) systems	$6.00
Vehicle audio/visual systems	$2.75
Non-cellular phones and answering machines	$0.85

In contrast to other electronics, wireless devices are recycled without a fee to consumers through the RMC program, which is funded by various cell-phone companies in partnership with the CWTA.

Manitoba

End-of-Life Electrical & Electronic Equipment Recycling Program, Electronic Product Recycling Association (EPRA), Recycle My Cell

Who is Responsible?

When it first began, Manitoba's e-waste recycling program was run by the provincial government. Green Manitoba launched the E-Waste Roundup program on May 1, 2011. The transition to an industry-run program occurred on August 1, 2012, when E-Waste Roundup transitioned to a regulated EPR program under EPRA Manitoba. EPRA Manitoba is currently authorized to operate the end-of-life electrical and electronics equipment stewardship program in Manitoba and is responsible for delivering the program in a manner that ensures the safe collection and recycling of waste electronics.

The stewardship program for Manitoba follows a shared responsibility model whereby manufacturers, retailers, consumers, and government each plays a role. At present, more than 380 manufacturers, retailers, and other stakeholders are registered stewards of the EPRA Manitoba program plan.

Formally recognized within the province on March 25, 2009, Manitoba's cell phone recycling stewardship program, Recycle My Cell, is managed by the CWTA in conjunction with its members.

Products Covered

Manitoba's e-waste stewardship program consists of three designated product categories. The program, launched on August 1, 2012, covers televisions, computers, computer monitors, keyboards, mice and other peripherals, laptops, printers, and audio-visual and consumer equipment. One new product, the countertop microwave, is categorized as Phase III and has been added.

Cell phones and other mobile devices are recovered separately through RMC.

Mandated Performance Standards

EPRA Manitoba proposes to adopt the same core suite of indicators adopted by other electrical and electronic stewardship programs across Canada. This consistency will not only facilitate assessment of program performance over the years but also enable performance to be assessed relative to that of other provincial programs.

The CWTA has not set any quantifiable performance targets. However, RMC program performance is evaluated using a suite of indicators including volume of cellular devices recovered, annual survey data on consumer awareness and likeliness to participate in a mobile device recycling program, website traffic and call volume to toll-free numbers, representative surveys of retailer participants to determine satisfaction, and media pick-up statistics

Supporting Regulatory Framework

Manitoba's end-of-life electrical and electronic equipment stewardship program is regulated under the *Electrical and Electronic Equipment Stewardship Regulation* (2010) of the Waste Reduction and Prevention Act.

The original plan for RMC was granted government approval in May 2009. The revised plan outlines how the program meets the requirements of Manitoba Conservation, as described in the *Electrical and Electronic Equipment Stewardship Regulation*. The memorandum of understanding that exists between Manitoba Conservation and CWTA requires the CWTA to report on the program's status on an annual basis by March 31.

Collection Systems and Rates

EPRA Manitoba collaborates with various organizations, including retailers, charitable organizations, waste collection companies, and municipalities, to provide collection services for designated products. Designated electronics can be dropped off at any one of the 38 approved e-waste collection depots across the province at no charge to the consumer. However, some collectors may offer additional services, such as data destruction or home pick-up, for a fee. These fees are the responsibility of the person or organization dropping off the electronics.

Although it continues to emphasize the importance of recycling, Manitoba takes a comprehensive approach to waste management by stressing the significance of *first* reusing and then recycling. The EPRA Manitoba program seeks to manage only those electronic products that have exhausted their potential for reuse. As for electronic items that have not yet reached the end of their useful lives, residents are encouraged to donate them to family members, friends, or local charitable organizations. For example, Computers for Schools (CFS) Manitoba will accept electronics that are in working condition and meet its minimum standards. CFS refurbishes computers and related equipment donated by governments, businesses, and the general public, and then distributes this equipment across Canada to schools, libraries, and registered non-profit learning organizations.

Since becoming operational on August 1, 2012, EPRA Manitoba collected over 1,349 metric tonnes of end-of-life electronics in the first six months of operation. The province has not mandated a specific recovery or collection rate.

Cell phones and other mobile devices can be returned to any of the 131 RMC drop-off depots located in 29 communities. In 2011, RMC recovered 22,464 devices: 6,192 were recovered through members' RMC initiatives (5,503 via drop-off locations and another estimated 689 using the mail-back option) and 16,272 through various internal initiatives.

Funding Mechanism

The program is financed by consumers through an environmental handling fee (EHF) charged on the sale of new electronic equipment.

EHFs are remitted to EPRA Manitoba by the obligated stewards of designated products that have joined the program as a member to discharge their legal responsibilities and ensure compliance with the regulation. All revenues generated from the EHF go towards the costs of collection, handling, and recycling; communication and public education; recycler evaluations, administration, compliance, and enforcement over and above government measures; and continuous research and improvement. A full list of EHFs by product category is shown in Table 12.

Table 12: Fees, Manitoba, 2013

CATEGORY	FEE
Desktop computers	$15.00
Portable computers	$3.00
Display devices ≤ 29 inches	$9.25
Display devices ≥29 inches	$23.25
Computer printers	$8.00
Computer peripherals	$1.10
Desktop computer scanners	N/A
Personal or portable audio/ visual playback or recording systems	$0.40
Home audio/visual systems	$3.50
Home theatre in a box (HTIB) systems	$6.00
Vehicle audio/visual systems	$2.75
Non-cellular phones and answering machines	$0.85
Microwave ovens < 1 cubic foot	$7.50
Microwave ovens > 1 cubic foot	$10.00

Ontario

Ontario Electronics Stewardship (OES)

Who is Responsible?

Ontario Electronic Stewardship (OES), a not-for-profit industry organization, manages the Waste Electrical and Electronic Equipment (WEEE) program and is responsible for collecting fees from obligated stewards to finance the operation of the program. OES was established by leading retail, information technology, and consumer electronics companies to execute the program, with oversight by Waste Diversion Ontario (WDO). The WDO, a non-crown corporation created through the *Waste Diversion Act* (2002), monitors the program's performance and reports directly to the Ontario Ministry of the Environment.

Products Covered

Ontario's Waste Electrical and Electronic Equipment program was launched on April 1, 2009, and, initially, it covered electronics including televisions, computers, computer monitors, keyboards, mice, and other peripherals, printers, and laptops. It is worth noting that Phase I also includes hard drives, making Ontario the only province that accepts them for recycling. Phase II of the program was launched in April 2010, expanding the list of acceptable electronics to include audio-visual and consumer equipment, cell-phone products, desktop scanners, non-cellular phones and answering machines, vehicle audio and video systems, home theatre in a box systems, and portable and home audio devices.

Ontario is one of only two provinces in which cellular phones are covered by the main program and not separately through Recycle My Cell.

Mandated Performance Standards

Although there is no mandated performance standard, the program specifies targets for collection, reuse, and recycling for all eligible products. For example, it aims to collect 84,732 tonnes of Phase I and II products combined for the program year ending March 2015. This target would equate to a collection rate of 87% for desktop and portable computers, 74% for display devices, 47% for other Phase I and Phase II products, and an 80% collection rate for floor-standing copiers and printers.

The program plan also includes recycling targets. These are defined as specific percentages of [the] products available for collection.[7] By 2014, it aims to achieve recycling targets of 78% for desktop and portable computers, 67% for display devices, 42% for other Phase I and II products, and 72% for floor-standing copiers and printers.

The program has also set an overall reuse target of 10,188 tonnes of products available for collection by 2011. More specifically, reuse targets have been established for different product categories, for example, desktop and portable computers (37.5%), display devices (3%), other Phase I and II products (8%), and floor-standing copiers and printers (52%). It is anticipated that these targets will be met through the means of an electronics materials exchange program.

Supporting Regulatory Framework

Ontario's Waste Electrical and Electronic Equipment program was established in response to the Ontario Minister of Environment's requests for an e-waste diversion program in 2004 and 2007. Designated waste electronics and the designated industry funding organization, OES, are regulated under the *Waste Electrical and Electronic Equipment Regulation* (2004) under the Waste Diversion Act (2002).

Collection Systems and Rates

Consumers can return their end-of-life electrical and electronic equipment free of charge to any of the province's more than 440 permanent collection sites or to one of the 228 collection events held across Ontario. As of 2012, 85% of the province's population lived within 25 kilometres of a collection depot. These depots include retailers, businesses, non-profit organizations, and municipal facilities that have entered into agreement with OES.

In 2012 alone, Ontario residents recycled more than 75,000 tonnes of e-waste, more than was handled by any other program in Canada. This amount represented a 45% increase from the previous year. Table 13 shows the tonnes collected and rates for five other performance indicators.

[7] "Electronic Waste Recycling Program, Ontario," Environment Canada, last modified July 12, 2013, accessed August 16, 2013, http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=DB5C8F07-1.

Table 13: Performance indicators, Ontario, 2012

INDICATOR	
Tonnes collected	75,702
Kilograms per capita	5.61
Collection sites	444
Collection events	228
Population awareness (%)	67
Cost per tonne	$1,105

Funding Mechanism

Ontario's Waste Electrical and Electronic Equipment program is funded by fees paid to OES by industry stewards (identified as brand owners and first importers) for the proper management of their electronic and electrical equipment in Ontario. Retailers may choose to charge an environmental handling fee (EHF) at the point of sale of new products or, alternatively, to include the fee in the price of the product.

Stewards remit fees to OES based on their share of the annual cost to operate the program. Fees cover program costs to collect, transport, consolidate, and process waste electronics, as well as the cost of providing financial incentives for service providers: about 90% of the fees are used in this way. In addition, 10% of program funding is used for public education and awareness and for program management and execution.

Table 14: Fees, Ontario 2013

CATEGORY	FEE
Desktop computers	$$3.00
Portable computers	$1.50
Display devices ≤ 29 inches	$12.25
Display devices ≥29 inches	$39.50
Computer printers	$10.35
Computer peripherals	$0.75
Personal or portable audio/ visual playback or recording systems	$0.75
Home audio/visual systems	$7.10
Home theatre in a box (HTIB) systems	$7.10
Vehicle audio/visual systems	$4.00
Non-cellular phones and answering machines	$1.50
Floor-standing printing devices	$173.75
Floor-standing copier or multifunction devices	$173.75
Cellular devices and pagers	$0.05

Québec

Association pour le recyclage des produits électroniques (ARPE)

Who is Responsible?

In May 2012, RECYC-QUÉBEC entered into agreement with EPRA requiring the organization to implement and manage, on behalf of its stewards, a program for the recovery and recycling of electronic products. Resulting from this agreement was the establishment of the Association pour le recyclage des produits électroniques (ARPE)–Québec (in English, this translates as the Electronic Products Recycling Association [EPRA]–Québec). As an industry-led, non-profit organization, ARPE-Québec is made up of the producers (manufacturers), distributers, and retailers of electronics marketed and sold in the province.

Products Covered

Phase I of program implementation, launched on July 14, 2012, covers various electronic equipment, including televisions, computers, computer monitors, printers, scanners, computer keyboards, mice and other peripherals, cell phones, and non-cellular phones. Québec is one of only two provinces where cellular phones are covered by the main program and not separately through RMC.

On July 1, 2013, the list of eligible products expanded to include video game consoles and peripherals, floor-standing servers and routers, personal or portable audio/video systems, vehicular audio/video and navigation systems, home theatre in a box systems, and GPS devices.

Mandated Performance Standards

The province of Québec has set minimum recovery rates for Phase I and Phase II materials, and these must be achieved on an annual basis. (The recovery rate is defined as the "quantity of products actually recovered during the year, that is, the quantity of products returned to drop-off centres or recovered through a collection service ... that were forwarded to a treatment or storage centre during the year" divided by the "quantity of products marketed during the reference year for that subcategory of products."[8]) The minimum recovery rates, which will become effective as of 2015, are as follows:

PRODUCT CATEGORY	MANDATED MINIMUM RECOVERY RATE
Desktop computers, laptop computers, display devices, printers and scanners, video game consoles.	40%, to be increased by 5% per year until a 65% rate is attained (excluded are computer peripherals)
Cellular, satellite, wireless, and conventional telephones. Computer peripherals, portable A/V players, and routers, servers, and hard drives.	25%, to be increased by 5% per year until a 65% rate is attained (excluded are mercury lamps)

In addition to these recovery targets, the same suite of key EPRA performance indicators adopted by other provincial programs will also be identified in Québec.

Worth noting is the fact that while all jurisdictions have penalties/sanctions for non-compliance by obligated producers, Quebec's is the only provincial program for end-of-life electronics that includes financial penalties to producers for missing collection targets. These penalties, outlined in Table 15 are set to become effective five years after program commencement.

Supporting Regulatory Framework

Québec's end-of-life electronics recycling program is regulated by the *Regulation Respecting the Recovery and Reclamation of Products by Enterprises* under the *Environment Quality Act*. This regulation mandates the industry-led collection and recycling of a range of electronic products in the province. It was signed on June 15, 2011 and came into force on July 14, 2012.

Collection Systems and Rates

Consumers can return their old electronics for recycling, free of charge, by dropping them off at one of seven eco-centres located throughout the province. Alternatively, they can bring them to any of the 450 drop-off points throughout the province. The drop-off points range from eco-centres and retailers to community centres. In general, in-store collection depots accept all types of obligated products, regardless of where they were purchased. However, some retailers may place restrictions on certain products or restrict the daily quantity of products that can be dropped off.

Retail stores (e.g., small or large, corporate or independent) operated by a program steward can become an approved ARPE-Québec drop-off point by joining the Return to Retail (R2R) Incentive Program. The R2R Program enables retailers to work with processors verified by the Recycler Qualification Office (RQO), so materials are transported and recycled in an environmentally and socially responsible manner.

In line with the waste management hierarchy, the ARPE-Québec program views source reduction (including reuse) as preferred over recycling. In light of this, it is designed to manage only those unwanted electronics that can no longer be reused. For electronics that have not yet exhausted their reuse potential, ARPE-Québec encourages consumers and IC&I generators to consider donating them to family, friends, or local charitable organizations.

Funding Mechanism

Like other provinces, Québec funds its program by the application of an environmental handling fee (EHF) on the purchase of new designated electronic products marketed in Québec. Québec is unique in the fact that EHFs must be included in the product's price. Nonetheless, the retailer

Table 15: Penalties to be applied in 2018, Québec

CATEGORY	PENALTY
Desktop computers	$10/unit
Portable computers	$2/unit or equivalent weight
Display devices ≤ 29 inches	$15/unit
Display devices ≥29 inches	$15/unit
Computer printers	$5/unit or equivalent weight
Desktops computer scanners	$5/unit or equivalent weight
Personal or portable audio/visual playback or recording systems	$1/unit or equivalent weight
Home theatre in a box (HTIB) systems	$4/unit or equivalent weight
Non-cellular phones and answering machines	$0.50/unit or equivalent weight

may choose to indicate the amount of EHFs included in the product's price for information purposes.

The full list of EHFs is outlined below in Table 16. Phase I products have been subject to EHF since October 1, 2012. EHFs on Phase II products will be effective as of August 1, 2013.

Table 16: Fees, Québec, 2012–2013

CATEGORY	FEE
Desktop computers	$7.50
Portable computers	$1.65
Display devices ≤ 29 inches	$12.25
Display devices ≥29 inches	$42.50
Computer printers	$8.75
Computer peripherals	$1.25
Desktop computer scanners	$8.75
Personal or portable audio/ visual playback or recording systems	$0.45
Home audio/visual systems	$3.75
Home theatre in a box (HTIB) systems	$7.25
Vehicle audio/visual systems	$3.25
Non-cellular phones and answering machines	$1.15
Floor-standing printing devices	$42.50
Floor-standing copier or multifunction devices	$42.50
Label, barcode, and card printers	$8.75
Cellular devices and pagers	$0.10

[7] Québec, Regulation Respecting the Recovery and Reclamation of Products by Enterprises, R.S.Q., c. Q-2, r. 40.1, http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=3&file=/Q_2/Q2R40_1_A.HTM.

Nova Scotia

Electronic Products Recycling Association (EPRA; formerly Atlantic Canada Electronics Stewardship or ACES), Recycle My Cell

Who is Responsible?

Operating under the EPRA as of August 1, 2012, Atlantic Canada Electronics Stewardship (ACES) is responsible for the development and implementation of Nova Scotia's industry-led and government-approved electronics recycling program. ACES is a non-profit association representing more than 550 brand owners, manufacturers, retailers, and other stakeholders committed to collecting and recycling e-waste in a responsible manner. The program itself is operated by EPRA and managed by the Resource Recovery Fund Board (RRFB), a not-for-profit organization that also administers Nova Scotia's bottle, tire, and paint recycling programs.

As for cellular devices, Recycle My Cell was formally recognized as the official cellular phone stewardship program within Nova Scotia in October 2008.

Products Covered

Nova Scotia was the first province in Atlantic Canada to develop and implement a program to deal effectively with electronic waste. Launched in two phases, the program accepts electronics in a variety of categories. Products collected during Phase I, which came into effect on February 1, 2008, include laptop and desktop computers and peripherals, printers, monitors, and televisions. Products collected during Phase II, effective as of February 1, 2009, include audio-visual and consumer equipment, fax machines, non-cellular telephones and answering machines, vehicle audio and video systems, home theatre in a box systems, portable and home audio equipment, computer scanners, telephones, and cell-phones products (excluding cell phones).

Cell phones are collected separately under the RMC program.

Mandated Performance Standards

There are no provincial targets or mandated performance standards for the electronics recovered under either program. Nevertheless, EPRA and the CWTA have proposed several performance indicators to evaluate ongoing program success, including volume of cellular devices recovered, annual survey data on consumer

awareness and likeliness to participate in a mobile device recycling program, website traffic and call volume to toll-free numbers, representative surveys of retailer participants to determine satisfaction, and media pick-up statistics.

Supporting Regulatory Framework

The program is legislated under the *Solid Waste-Resource Management Regulations* made under Section 102 of the *Environment Act (*1994–1995). Because of these regulations, the majority of electronics have been banned from disposal in Nova Scotia landfills since 2008.

The RRFB was established under these same regulations and is contracted by EPRA to manage the program.

The RMC program, which officially launched in January 2009, is also regulated under the *Solid Waste-Resource Management Regulations*. Under Section 18O(1), industry stewardship programs are required to report on their respective programs on an annual basis by June 30.

Collection Systems and Rates

There are currently 108 independently owned and operated Enviro-Depots located in 36 communities throughout Nova Scotia. Each owner or operator is required to sign a standard agreement form with RRFB Nova Scotia to become a registered Enviro-Depot™.

Residents and businesses may bring their end-of-life electronics (excluding cell phones) directly to any of 37 Enviro-Depots free of charge. As of 2011, 96.8% of the population lived within 30 kilometres of a drop-off centre. Cell phones are collected through RMC and can be dropped off at any of the province's 108 drop-off locations or returned through the mail using the prepaid mailing option.

The Enviro-Depots collect recyclable materials and sort them for a handling fee prior to shipping them to a central processing facility. All drop-off centres accept large volumes of unwanted electronics. However, for quantities of 25 units or more, it is necessary to book an appointment with the drop-off centre. When making an appointment, the customer must inform a drop-off centre staff member of the number of pieces being dropped off.

Nova Scotians recycled 4,734 tonnes of electronics (excluding cell phones) in 2012 (4.99kg/capita). This is a 9% increase from 2011. Table 17 shows the total collection and rates for four other performance indicators for the province of Nova Scotia.

Table 17: Performance indicators, Nova Scotia, 2012

INDICATOR	
Tonnes collected	4734
Kilograms per capita	4.99
Collection sites	37
Population awareness (%)	79
Cost per tonne	$1,315

As for cell phones, a total of 29,706 devices (16 tonnes) were recovered through the RMC program in 2011; 6,708 were recovered through members' RMC initiatives (5,678 via drop-off locations and an estimated 1,030 using the mail-back option) and 22,998 through various internal initiatives.

The EPRA Nova Scotia program is designed to manage only those electronic products that cannot be reused. Residents are encouraged to donate electronic items that have not yet reached the end of their useful life to family members, friends, or local charitable organizations.

Funding Mechanism

This program is funded by revenues generated through EHFs applied to the sale of designated new electronics products in Nova Scotia. A list of product categories, along with their specific fee rates, is shown in Table 18.

Table 18: Fees, Nova Scotia, 2013

CATEGORY	FEE
Desktop computers	$10.50
Portable computers	$2.10
Display devices ≤ 29 inches	$11.50
Display devices ≥29 inches	$40.00
Computer printers	$6.50
Computer peripherals	$0.90
Desktop computer scanners	$6.50
Personal or portable audio/ visual playback or recording systems	$0.40
Home audio/visual systems	$$3.50
Home theatre in a box (HTIB) systems	$6.00
Vehicle audio/visual systems	$2.75
Non-cellular phones and answering machines	$0.85

In contrast to other electronics, wireless devices are recycled without a fee to consumers through the RMC program, which is funded by various cell-phone companies.

New Brunswick

Recycle My Cell

Who is Responsible?

As of April 9, 2009, residents of New Brunswick can recycle their used wireless devices through the Recycle My Cell program, a national industry initiative managed by the Canadian Wireless Telecommunications Association (CWTA) in conjunction with its members (wireless manufacturers and service providers).

Despite overwhelming support from residents for an electronics recycling program, New Brunswick remains the only Maritime province that does not have one in place. The closest the province comes to a comprehensive e-waste recycling program is an initiative in Moncton, where the Westmorland-Albert Solid Waste Corporation accepts end-of-life electronics from residents of Westmorland and Albert counties and ships them to Toronto for recycling. Other places in the province provide electronics recycling services that remove some components from electronics for reuse purposes. For example, Fundy Region Solid Waste, part of the Fundy Regional Service Commission, recycles computers and ships them to Resnet Recyclage in Edmundston, a non-profit organization that disassembles some electronics to salvage working components and recyclable materials. Resnet also refurbishes electronics and donates them to low-income families and non-profit groups.

Other solid waste commissions and public service groups offer collection events for e-waste. Funding is provided via the Environmental Trust Fund

Products Covered

With the exception of mobile devices, New Brunswick has not designated any electronic products as being subject to a product stewardship program.

The RMC program covers all mobile and wireless devices that connect to a cellular or paging network, including all cell phones, smartphones, wireless personal digital assistants (PDAs), external aircards, and pagers. Headsets, chargers, and other accessories are also accepted.

Mandated Performance Standards

Although specific targets have yet to be set out, CWTA has identified several performance indicators used to evaluate program success, including volume of cellular devices recovered, annual survey data on consumer awareness and likeliness to participate in a mobile device recycling program, website traffic and call volume to toll-free numbers, representative surveys of retailer participants to determine satisfaction, and media pick-up statistics.

Supporting Regulatory Framework

RMC is a voluntary program overseen by the province's Environment and Local Government department.

Collection Systems and Rates

RMC utilizes a return-to-retail model for device recovery. New Brunswickers can return mobile devices and accessories to any of the province's 80 drop-off collection sites, regardless of where the device was purchased. Collection depots can be found in 29 communities throughout the province, and include retail stores, municipal waste depots, not-for-profit organizations, and other third-party agents not affiliated with current RMC members. Alternatively, consumers can return their devices through the mail using a prepaid mailing label.

Donated devices are sent to a recycling plant to be refurbished or disassembled for scrap. Of the 7,113 devices recovered in 2011 in New Brunswick, approximately 97% were sent for recycling while 3% were sent for refurbishment and reuse. Out of the total number, 1,906 were recovered through RMC initiatives while another 679 were recovered through the mail-back option offered by several RMC partners. An additional 5,207 devices were recovered through various internal initiatives.

Funds from the sale of refurbished phones and scrap materials are donated to national and local charities, including the World Wildlife Fund, Tree Canada, and New Brunswick food banks.

Funding Mechanism

There is no fee to consumers for recycling their wireless devices through the RMC program. RMC is funded by various cell phone companies, including Bell, Dell Canada Inc., GEEP Inc., Greentec International®, LG Electronics, Lynx Mobility, Motorola Mobility, MTS, Nokia Corporation, Research in Motion (RIM), Rogers Communications, Samsung, SaskTel, Sims Recycling Solutions, Sony Mobile Communications, Tbaytel, TELUS, Vidéotron, and Virgin Mobile Canada.

Should a comprehensive electronics stewardship program become available, the province's Minister of Environment and Local Government is advocating for a hidden fee instead of the visible environmental handling fee (EHF) adopted by other provinces. A fee table has yet to be determined.

Newfoundland and Labrador

Electronic Products Recycling Association (EPRA)
Newfoundland and Labrador, Recycle My Cell

Who is Responsible?

Launched on August 1, 2013, the province's new e-waste program takes an extended producer responsibility (EPR) approach, meaning that electronics manufacturers will be responsible for their products from the point of production through to end-of-life recycling. The program will be operated by EPRA in conjunction with manufacturers, retailers, provincial and municipal governments, and consumers. The Multi Materials Stewardship Board (MMSB), established in 1996, will continue to coordinate recycling in Newfoundland and Labrador, however.

Recycle My Cell has been responsible for managing Newfoundland and Labrador's cell phone recycling stewardship program since it received formal recognition within the province on July 28, 2009. The program is run by CWTA in partnership with cell phone service providers, handset manufacturers, and recycling companies.

Products Covered

The EPRA program launched covering two phases. Phase I products include items such as televisions, computers, computer monitors, printers, scanners, video game consoles, and computer keyboards, mice, and other peripherals. Phase II products include audio-visual equipment, cell-phone products (excluding cell phones), desktop scanners, non-cellular telephones and answering machines, vehicle audio and video systems, home theatre in a box systems, and portable and home audio systems.

The RMC program covers mobile devices and accessories, including all mobile devices that connect to a cellular or paging network (e.g., cell phones, smartphones, wireless PDAs, external aircards, and pagers). Headsets, chargers, and other accessories are also accepted.

Mandated Performance Standards

There are no provincial targets or mandated performance standards for the electronics recovered under either the EPRA or RMC program. However, EPRA will report on the same key performance indicators as do its sister programs in other provinces, and the CWTA has proposed several performance indicators to evaluate the program, including volume of cellular devices recovered, annual survey data on consumer awareness and likeliness to participate in a mobile device recycling program, website traffic and call volume to toll-free numbers, representative surveys of retailer participants to determine satisfaction, and media pick-up statistics.

Supporting Regulatory Framework

The *Waste Management Regulations* (2003) under the *Environmental Protection Act* (2002) governs the disposal of e-waste in Newfoundland and Labrador. On November 2, 2012, the provincial government announced amendments to the regulations in order to introduce an industry-led electronic-waste recycling program. Under this regulation, electronic manufacturers are given 120 days to submit to the MMSB a detailed stewardship plan describing their proposed recycling program for the province.

Collection Systems and Rates

By the end of the first year of operation, it is expected that 19 permanent collection depots will be established throughout the province. In addition, by the end of year two, there will be annual collection events implemented in 31 communities.

With regards to cell phones, consumers can return their devices to any of RMC's 74 drop-off locations in 32 communities (most of these locations are affiliated with carrier member programs). In 2011, a total of 18,622 cell phones (9 tonnes) were recovered through RMC; 5,417 were recovered through members' RMC initiatives (4,812 devices through RMC drop-off locations and an estimated 605 using the mail-back option) and 13,205 through various internal initiatives.

Funding Mechanism

The program will be funded through revenue generated from EHFs levied on the sale of new products in the designated categories. Newfoundland and Labrador will be following the ACES model with a similar fee structure. Table 19 displays EHFs for the different product categories covered by the program.

Table 19: Fees, Newfoundland, 2013

CATEGORY	FEE
Desktop computers	$10.50
Portable computers	$2.50
Display devices ≤ 29 inches	$12.25
Display devices ≥29 inches	$42.50
Computer printers	$7.75
Computer peripherals	$1.05
Desktop computer scanners	$7.75
Personal or portable audio/ visual playback or recording systems	$0.45
Home audio/visual systems	$4.00
Home theatre in a box (HTIB) systems	$7.20
Vehicle audio/visual systems	$3.25
Non-cellular phones and answering machines	$1.00

Prince Edward Island

Electronic Products Recycling Association (EPRA; formerly Atlantic Canada Electronics Stewardship or ACES), Recycle My Cell

Who is Responsible?

PEI's province-wide electronics stewardship program came into effect on July 1, 2010 and is managed by EPRA. The cellular phone stewardship program, on the other hand, is managed through the RMC program under the CWTA. RMC received formal recognition within the province on April 7, 2009.

Products Covered

Launched in two phases on July 1, 2010, the stewardship program includes products such as televisions; computers; computer monitors, keyboards, mice, and other peripherals; printers; laptops; audio-visual equipment; desktop scanners; non-cellular telephones and answering machines; vehicle audio and video systems; home theatre in a box systems; and portable and home audio systems.

Mobile devices and accessories are covered under the RMC program.

Mandated Performance Standards

No quantifiable targets or performance standards have been set under either program; however, EPRA will report on the same key performance indicators as do its sister programs in other provinces, and several performance indicators have been proposed by the CWTA to evaluate the program, including volume of cellular devices recovered, annual survey data on consumer awareness and likeliness to participate in a mobile-device recycling program, website traffic and call volume to toll-free numbers, representative surveys of retailer participants to determine satisfaction, and media pick-up statistics.

Supporting Regulatory Framework

The *Materials Recycling Regulations* under the *Environmental Protection Act* governs the disposal of e-waste in PEI. These regulations require brand owners to join a government-approved product management program. Under the memorandum of understanding that exists between the CWTA and the Department of Environment, Labour and Justice, the CWTA is required to report on the program's status by March 31 of each year.

Collection Systems and Rates

Residents of PEI may bring designated electronic items free of charge to the province's annual collection event or to any of the six Island Waste Management Corporation's approved drop-off locations across the island. In 2012, 99.6% of the province's population lived within 30 kilometres of a drop-off centre.

Cell phones are managed through RMC and can be returned to any of the 27 drop-off centres within the province. Alternatively, consumers may choose to return their cell phones using the program's mail-back option.

For the year of 2012, 649 tonnes of used electronics were recovered in PEI through the EPRA program, equivalent to 4.44 kg/capita. Table 20 shows the rates for the five performance indicators.

Table 20: Performance indicators, Prince Edward Island, 2012

INDICATOR	
Tonnes collected	649
Kilograms per capita	4.44
Collection sites	6
Population awareness (%)	69
Cost per tonne	$1,393

The CWTA captured 2,423 mobile devices in 2011; 715 were recovered through members' RMC initiatives (610 via drop-off locations and an estimated 105 using the mail-back option) and 1,708 through various internal initiatives.

Funding Mechanism

PEI's e-waste stewardship program is funded by an EHF that is charged at the point of sale on the purchase of new designated products. PEI industry stewards who register with EPRA must remit these fees to the organization. The fees on electronics, which are solely used to cover the actual costs of running the program, range from $0.04 all the way up to $40, depending on the item. Table 21 provides a complete list of EHFs for all product categories.

Table 21: Fees, Prince Edward Island, 2013

CATEGORY	FEE
Desktop computers	$10.50
Portable computers	$2.10
Display devices ≤ 29 inches	$11.50
Display devices ≥29 inches	$40.00
Computer printers	$6.50
Computer peripherals	$0.90
Desktop computer scanners	$6.50
Personal or portable audio/ visual playback or recording systems	$0.40
Home audio/visual systems	$3.50
Home theatre in a box (HTIB) systems	$6.00
Vehicle audio/visual systems	$2.75
Non-cellular phones and answering machines	$0.85

Mobile devices can be returned free of charge. The CWTA has internalized the cost of the RMC program and thus there are no visible fees levied on the purchase of cell phones.

National Performance of WEEE Collection Programs

In order to provide a reasonable analysis of program performance on a province-to-province basis, we must consider a number of variables. These include, for example, the level of convenience, economies of scale, and population density, all of which can affect program performance.

Consider, for instance, Ontario's program, which has the lowest cost per tonne. Ontario has the overall highest performance rate in Canada; it collected more material in 2012, both per capita and in total, than any other province. This success is likely attributable to the density of Ontario's population, as well as to the fact that it has the widest network of collection sites and events, making the recycling of electronics more convenient for consumers. Ontario's list of products covered is also longer than the lists of other programs (with the exception of Québec), which could be another reason for the program's high performance. Despite its high collection rate, only 67% of the province's population is aware of the program—the lowest awareness rate in Canada.

Though it represents only 3% of Canada's population, Nova Scotia's per capita collection rate was the second highest in the country, following Ontario. This ranking was reached despite the fact that Nova Scotia has significantly fewer collection sites and events than do most other provinces. One plausible explanation is the province's relatively high level of population awareness.

At the other end of the scale, Prince Edward Island's program has the lowest collection rate and a relatively high cost per tonne. This situation is understandable given its tiny population of less than 150,000 people (representing only 0.5% of Canada's population) and the fact that it has fewer collection sites and events than any other jurisdiction.

At 87.5%, Saskatchewan had the highest level of population awareness. Nevertheless, the cost of its program, which is about $1,760 per tonne, was the highest in the country. These figures can be explained by the province's low collection rate (total and per capita) and the fact that it represents less than 4% of the country's population.

As for Manitoba, Québec, New Brunswick, and Newfoundland, program performance cannot be assessed at this time, either because the program has been operational for less than one year or because it has yet to launch.

Table 22 shows the data for the 6 core performance indicators for each province with an established program.

Table 22: Performance indicators, National, 2011–2012

INDICATOR	BC (2012)	AB (2011–12)	SK (2012)	ON (2012)	NS (2012)	PEI (2012)
Tonnes collected	21,963	15,768	3,425	75,702	4,719	605
Kilograms per capita	4.8	4.4	3.24	5.61	4.97	4.14
Collection sites	142	325	72	444	37	6
Collection events		94	24	228	2	1
Population awareness (%)	75	81	87.5	67	79	69
Cost per tonne	$1,208	$1,117	$1,760	$1,105	$1,269	$1,393

Part V: Costs of Recycling WEEE

Financing Mechanisms

In Canada, electronic products stewardship programs minimize or eliminate the industry's financial responsibility and pass it on to consumers in the form of a front-end or back-end fee. Many different financing models exist, so knowing how a program is funded is critical to understanding the design and operation of e-waste take-back systems as well as the potential for program success.

Environmental Handling Fee (EHF)

An environmental handling fee (also called an electronic handling fee, an advance disposal fee, or an advance disposal surcharge) is an industry developed and imposed fee charged per unit collected by the obligated steward (OEM, distributor, supplier, or retailer). EHFs provide manufacturers incentives for modifying design to reduce the environmental burden of their products by shifting the costs associated with product end-of-life management to the producers, and in turn consumers, rather than having these costs be the responsibility of governments and taxpayers.

Final users, when purchasing a new product, accept full responsibility for the entire life cycle of the product, including getting the product to a collection depot for recycling. The fee is not a government tax, nor is it a refundable deposit. All revenue generated from EHFs funds the recycling program, including its administration, depot operation, public education, and the collection, transportation, storage, and recycling of collected electronics. All fees collected stay within the individual program. For example, funds from EHFs collected in Ontario go only towards covering the costs of OES. Moreover, each program is designed so that the cost of managing products in one category is not subsidized by fees paid in another.

In each province that uses the EHF model, sales taxes (e.g., the harmonized GST in Ontario) are applicable to the EHF.

How are EHFs determined?

Since EHFs are intended to reflect the actual cost of recycling a particular item, they are not uniform across product categories and will vary depending on a myriad of factors. The size, weight, and quantity of e-waste diverted from landfill for recycling is one factor affecting EHFs. For example, the EHF on a cellular phone is much lower compared to that on an office photocopier because the latter is much more expensive to recycle. Another factor taken into consideration when setting an EHF is whether a product is made up of little or many recyclable components. A product with few recyclable components or that is more difficult to disassemble will have a higher EHF than a product with many recyclable components or that is easy to take apart. EHFs can also vary depending on the total product weight per category, the costs of program administration and of collection and recycling, as well as the actual and forecasted amount of product in the market (i.e., product sales and forecasts). To ensure that EHFs are set at appropriate levels, they are regularly reviewed and adjusted.

Visible vs. hidden fees

Manufacturers or retailers most often have a choice of how to raise the necessary funds. On one hand, they can choose to make the fee hidden. In this case, fees paid by brand owners on products are passed on in the supply chain to the consumer at point of purchase with the fee incorporated into the product's price. On the other hand, they may choose to display the fee as a separate charge applied at the retail point of sale. Visible fees can act as an educational tool because they send a clear signal at the point of purchase to consumers that there are environmental and financial costs associated with recycling e-waste. Regardless of which model is adopted, the EHF is charged only once in the supply chain.

Table 23 presents EHFs by province as of May 2013. Entries of N/A represent product categories that a particular province does not collect or for which no fee is charged.

System Costs

Managing WEEE is costly. From an operational standpoint, costs are incurred for collection, which requires a series of procedures to ensure that the safety and health of all staff handling WEEE materials is maintained. Consolidation and transportation and finally processing of WEEE also incur net costs, even after processors sell off their commodities to downstream or end-use markets.

Collection and Handling Costs

The greatest costs to the system are payments that must be made to the collectors, transporters, and processors of the collected WEEE. Some provinces, such as Ontario, publish the values of collection, transportation, and processing incentives. In some other provinces, the fees paid out per tonne for these services can be determined by dividing the total fees paid out by the number of tonnes processed.

Table 24 shows the net per tonne cost of collection, transportation, and processing in each province where the number is available or can be determined from financial

Table 23: Fees for WEEE in Canadian provinces, 2013 **Effective August 1, 2013

CATEGORY	BC	AB	SK	MB	ON	QC	NS	NFL**	PEI
Desktop computers	$5.50	$4.40	$15.00	$15.00	$3.00	$7.50	$10.50	$10.50	$10.50
Portable computers	$1.20	$1.20	$3.00	$3.00	$1.50	$1.65	$2.10	$2.50	$2.10
Display devices ≤ 29 inches	$9.00	$4.00	$9.25	$9.25	$12.25	$12.25	$11.50	$12.25	$11.50
Display devices ≥ 29 inches	$31.75	$10.00	$23.25	$23.25	$39.50	$42.50	$40.00	$42.50	$40.00
Computer printers	$6.50	$4.80	$8.00	$8.00	$10.35	$8.75	$6.50	$7.75	$6.50
Computer peripherals	$0.90	N/A	$1.10	$1.10	$0.75	$1.25	$0.90	$1.05	$0.90
Desktop computer scanners	$6.50	$4.80	N/A	$8.00	N/A	$8.75	$6.50	$7.75	$6.50
Personal or portable audio/visual playback or recording systems	$0.40	N/A	$0.40	$0.40	$0.75	$0.45	$0.40	$0.45	$0.40
Home audio/visual systems	$3.50	N/A	$3.50	$3.50	$7.10	$3.75	$3.50	$4.00	$3.50
Home theatre in a box (HTIB) systems	$6.00	N/A	$6.00	N/A	$7.10	$7.75	$6.00	$7.20	$6.00
Vehicle audio/visual systems	$2.75	N/A	$2.75	$2.75	$4.00	$3.25	$2.75	$3.25	$2.75
Non-cellular phones and answering machines	$0.85	N/A	$0.85	$0.85	$1.50	$1.15	$0.85	$1.00	$0.85
Floor-standing printing devices	N/A	$4.80	N/A	N/A	$173.75	$42.50	N/A	N/A	N/A
Floor-standing copiers and multifunctional devices	N/A	$4.80	N/A	N/A	$173.75	$42.50	N/A	N/A	N/A
Label, barcode, and card printers	N/A	$4.80	N/A	N/A	N/A	$8.75	N/A	N/A	N/A
Cellular devices and pagers	N/A	N/A	N/A	N/A	$0.05	$0.10	N/A	N/A	N/A

Table 24: Collection and handling costs by province, 2012

COSTS	BC	AB	SK	ON	NS	PEI
Net collection costs per tonne	$141	$130	$100	$150	$71	$59
Net transportation costs per tonne	$106	$50–$200	N/A	$50–$120	$74	$40
Net processing costs per tonne	$379	$700	N/A	$150–$600	$230	$273
Total per tonne	$626	$880–$1030	N/A	$350–$870	$375	$372

records. Costs should not be directly compared with each other, as each program may have different operating parameters.

Overall, total net costs of programs have been decreasing. This decrease is partially because the fees paid out to processors have been dropping. In BC, the average fees paid out to processors per tonne fell from an average of $687/tonne to $379/tonne, a reduction of 45%. In Ontario, OES dropped the range of fees paid out to processors from $450–$850/tonne to $150–$650/tonne. These cost declines may be explained by a number of factors, which include more Canadian processors competing with each other, better economies of scale, improved markets for commodities and a harmonized service agreement being administered by EPRA.

They may also be attributable to the fact that selection criteria for processors has shifted from one that previously placed emphasis on the importance of a high recycling rate to one that prioritizes costs. For example, according to the final revised program plan (OES, July 2009), the processor "recycling rate" accounted for 50% of the selection score and the costs only 30%. In 2011, OES released a new set of selection criteria, increasing the importance of cost to 55% of the total score, while reducing recycling efficiency (i.e., the recycling rate) to only 20%.

Who Pays for WEEE Collection and Recycling?

Canada's e-waste stewardship programs attempt to offset these costs, which were traditionally picked up by consumers directly or by ratepayers, through municipal property taxes. This shift in the cost burden promotes free collection for all generators of WEEE.

Nearly all Canadian WEEE programs rely on consumer-based fees or "eco-fees" to generate the funds to pay for the programs. For the most part, these funds are originally levied by the program operator (by province) and are paid by the EEE steward (usually the brand owner or first importer). In most cases, these eco-fees are passed on directly to the retailer and then the consumer.

However, in some jurisdictions, namely the province of Québec, all associated fees, including "eco-fees," are required to be embedded in the product price. So although there may be no visible fee attached to the product, in most cases, producers will increase the shelf price accordingly.

Part VI: Social, Economic & Environmental Impacts

WEEE Recycling and Jobs

In 2012, the Coalition for American Electronics Recycling (CAER) commissioned research to quantify the number of jobs associated with waste electronics recycling in the United States.

Surveys were sent to 21 of 67 CAER members, a sample representing over half of all physical CAER-affiliated recycling operations. The employment activity was broken down into six activities: de-manufacturing, shredding, administration and management, asset recovery and information technology asset disposition (ITAD), glass cleaning, and other.

The study found that total throughput of WEEE recycling operations in the United States is roughly 1.2 billion pounds (equal to over 544,000 tonnes). These operations employ approximately 6,850 people with an estimated payroll of $250 Million (USD), which translates to approximately 12.6 full-time equivalent (FTE) employees per thousand tonnes of material at an average of roughly $36,500 per FTE.

Transposing those numbers to the Canadian WEEE recycling situation, we find that Canadian programs cumulatively collect roughly 121,000 tonnes of material. Recycling that tonnage is estimated to create over 1,500 FTE jobs in this country.

WEEE Recycling and the Recovery of Materials

Another positive aspect of WEEE recycling is the recovery of valuable materials that can be reused. In order to determine the volume of this material, we need to estimate the unit weight of common electronic products and their composition by weight. Only then can we estimate the quantity and value of each material recovered.

Unit Weights of Common Electronic Products

In this report, the unit weights used are determined by the best available source. Table 25 shows the unit weights used.

Composition of Electronic Products by Weight

The United Nations University's *2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment:*

Table 25: Unit weights used in this report

CATEGORY	UNIT WEIGHT IN KG
Desktop computers	9.8
Portable computers	2.6
Printers and fax machines	8
Floor-standing printers, copiers, or multifunctional devices	60
Computer peripherals	0.6
Monitors CRT	15.7
Monitors FPD	5.1
TV < 19 inch CRT	9.9
TV < 19 inch FPD	3.4
TV 19–29 CRT	27.7
TV 19–29 FPD	10.5
TV 30–45 CRT	58.8
TV 30–45 FPD	24.5
TV 30–45 RP	48.3
TV > 45 inch CRT	61.4
TV > 45 inch FDP	31.6
TV > 45 inch RP	67.5
Display devices > 45 Inches	76.4
Computer scanners	3
Personal or portable audio/video devices	0.7915
Home audio/video devices	6.46
Non-cellular telephones & answering machines	1
Cellular or smart phones and pagers	0.1
Small appliances	1
Large appliances	55

Sources for unit weights include the Alberta Recycling Management Authority; the Environmental Protection Agency; G. Gaidajis, K. Angelakoglou, and D. Aktsoglou, "E-waste: Environmental Problems and Current Management," *Journal of Engineering Science and Technology Review* 3, no. 1 (2010): 193–199; and, for scanners, the average weight of 6 different scanners found for sale online.

Final Report provides average composition, by weight, of IT and telecommunications equipment (including computers, printers, photocopiers, and cellular and fixed telephones), CRT computer monitors and television sets, FPD computer monitors and television sets, and audio/video devices.

The following pages provide for each category of WEEE a pie chart showing the dominant materials that make up a piece of electronic equipment, by weight, as a percentage of the weight of the item. A separate table for each category shows the materials that make up less than 1% of the item's weight

IT and telecommunications equipment

These products are mostly made up of plastic and steel. There is also a significant amount of copper, iron, and aluminum. Figure 7 shows the composition percentages for the major materials.

Figure 7: Composition of major materials in computers, printers, photocopiers, and cellular and fixed telephones

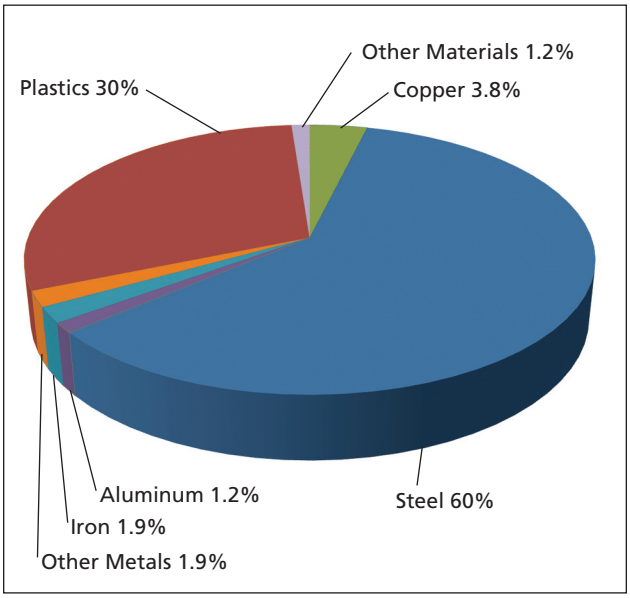


Table 26: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of computers, printers, photocopiers, and cellular and fixed telephones

MATERIALS	PERCENTAGE OF WHOLE
Tin	0.09%
Gold	0.002%
Silver	0.011012%
Nickel	0.08%
Cadmium	0.005%
Zinc	0.10%
Lead	0.03%
Antimony	0.005%
Cobalt	0.0061%
Chromium	0.02%
Manganese	0.0004%
Palladium	0.001%
Glass and Ceramics	0.6%
Bromine	0.04%
Arsenic	0.00003%
Beryllium	0.0001%
Bismuth	0.001%
Chlorine	0.0002%

CRT computer monitors

The glass and lead CRT screen and cone dominate the weight of a CRT computer monitor. Figure 8 shows the major materials in a CRT computer monitor, and Table 27 lists the materials that make up less than 1% of the whole monitor.

Figure 8: Composition of major materials in CRT computer monitors

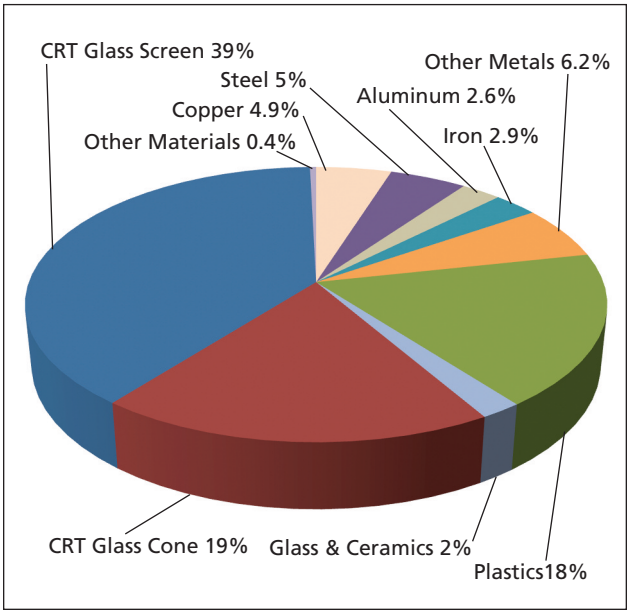


Table 27: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of CRT computer monitors

MATERIALS	PERCENTAGE OF WHOLE
Tin	0.01%
Gold	0.0001%
Silver	0.001%
Nickel	0.06%
Zinc	0.18%
Lead	0.10%
Antimony	0.02%
Cobalt	0.001%
Chromium	0.03%
Palladium	0.00003%
Bromine	0.0003%
Bismuth	0.0065%

Flat panel display computer monitors

Like most other consumer electronics, FPD monitors are primarily made from plastic and steel. There is a significant amount of glass and ceramics as well.

Figure 9: Composition of major materials in FPD computer monitor

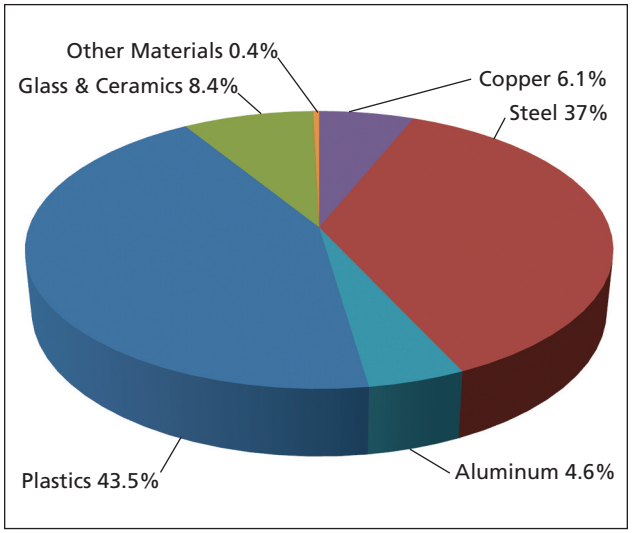


Table 28: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of FPD computer monitors

MATERIALS	PERCENTAGE OF WHOLE
Tin	0.01%
Gold	0.004%
Silver	0.01%
Nickel	0.07%
Zinc	0.02%
Mercury	0.0001%
Iron	0.04%
Lead	0.05%
Antimony	0.003%
Chromium	0.002%
Palladium	0.001%

CRT television sets

Most of the weight of CRT television sets, like that of CRT monitors, is the leaded glass in the cone and screen.

Figure 10: Composition of major materials in CRT television sets

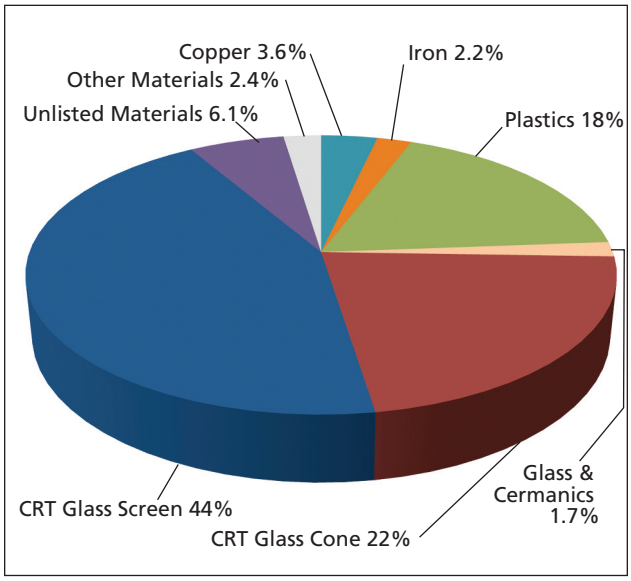


Table 29: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of CRT television sets

MATERIALS	PERCENTAGE OF WHOLE
Tin	0.05%
Aluminum	0.8%
Gold	0.0006%
Silver	0.01%
Nickel	0.04%
Zinc	0.02%
Lead	0.09%
Antimony	0.02%
Cobalt	0.0008%
Chromium	0.01%
Palladium	0.0003%
Other Metals	0.1%
Bromine	0.08%
Bismuth	0.002%
Chlorine	0.01%

Flat panel display television sets

Figure 11: Composition of major materials in FPD television sets

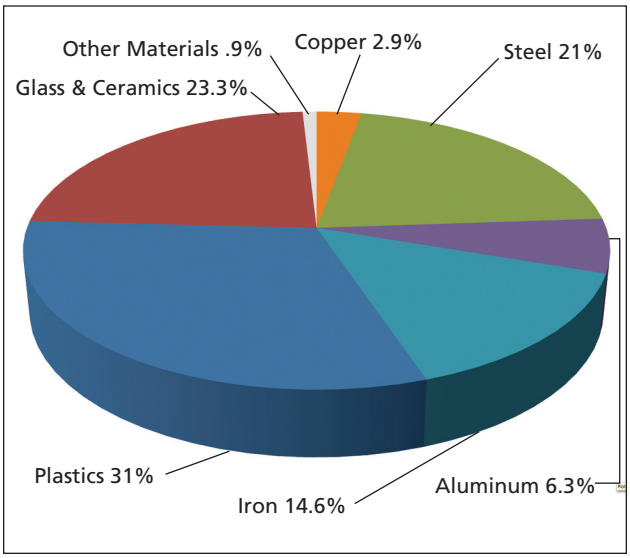


Table 30: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of FPD television sets.

MATERIALS	PERCENTAGE OF WHOLE
Tin	0.065%
Gold	0.0004%
Silver	0.002%
Nickel	0.011%
Zinc	0.081%
Mercury	0.0003%
Lead	0.043%
Antimony	0.003%
Chromium	0.002%
Palladium	0.003%
Other metals	0.767%

Audio/video devices (personal or portable and home or vehicular devices)

Figure 12: Composition of major materials in audio/video devices

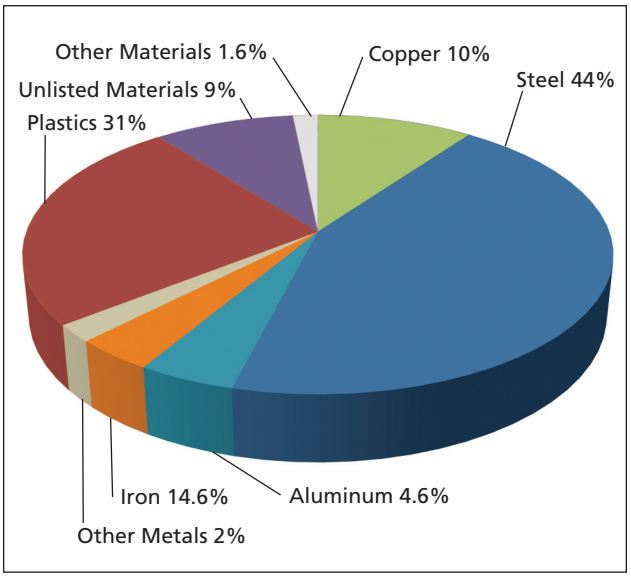


Table 31: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of CRT television sets

MATERIALS	PERCENTAGE OF WHOLE
Tin	0.041%
Gold	0.0004%
Silver	0.003%
Nickel	0.022%
Cadmium	0.003%
Zinc	0.080%
Lead	0.054%
Antimony	0.006%
Cobalt	0.003%
Chromium	0.001%
Manganese	0.0002%
Palladium	0.0001%
Glass and Ceramics	0.607%
Bromine	0.009%
Bismuth	0.0015%
Chlorine	0.026%

Total Recycled Materials by Type

Collectively, Canadian WEEE recycling programs recovered over 121,000 tonnes of electronics in 2012. To determine estimates for the amount of each material collected, we have used reliable and recent composition estimates.

Applying these composition ratios to WEEE collected in all the provinces provides estimates of the materials collected on a national level. Note that these estimates do not take into account what is actually recycled; rather, they identify how much material is potentially recoverable in the amount of WEEE collected.

Table 32: Estimated materials, in tonnes, in WEEE collected in Canada

MATERIALS	TONNES IN RECOVERED WEEE
Copper	6,211
Steel	30,280
Tin	55
Aluminum	2,389
Gold	0.92
Silver	7.5
Nickel	54
Cadmium	2.2
Zinc	92
Mercury	0.0036
Iron	3,120
Lead	84
Antimony	13
Cobalt	3
Chromium	14
Manganese	0.16
Palladium	0.36
Other Metals	3,110
Plastics	27,448
Glass and Ceramics	1,811
CRT Glass Cone	14,134
CRT Glass Screen	28,391
Others	4,645
Bromine	48
Arsenic	0.01
Beryllium	0.04
Bismuth	3
Chlorine	12

Value of Collected WEEE

Many of these materials are valuable. The following chart shows the estimated value of some of the WEEE material collected annually in Canada, as well as the amount of each material recovered (in tonnes). Note that these values are for pure forms of the materials listed and do not reflect the prices that a recycler would receive for sales of the materials, let alone any costs associated with processing WEEE in the first place.

Table 33: Estimated value of WEEE material collected annually in Canada

MATERIAL	TONNES IN RECOVERED WEEE	VALUE OF MATERIAL ($USD) PER TONNE	VALUE OF MATERIAL IN COLLECTED WEEE
Copper	6,211	$6,724.03	$41,763,350
Steel	30,280	$680.00	$20,590,666
Tin	55	$20,260.27	$1,107,510
Aluminum	2,389	$1,741.63	$4,159,956
Gold	0.92	$45,697,467.00	$42,092,163
Silver	7.5	$701,599.86	$5,261,527
Nickel	54	$13,690.57	$744,189
Cadmium	2.2	$2,040.00	$4,490
Zinc	92	$1,807.77	$166,299
Mercury	0.0036		$0.00
Iron	3,120	$163.00	$508,627
Lead	84	$2,006.19	$169,243
Antimony	13	$10,350.00	$134,898
Cobalt	3	$30,996.68	$106,663
Chromium	14	$2,420.00	$35,010
Manganese	0.16	$2,300.00	$357
Palladium	0.36	$23,457,210.00	$8,410,439
TOTAL VALUE			**$125,255,387**

Each individual piece of electronic equipment contains some but not all of these materials. Table 34 shows the value of the materials in average electronics individually and the total value of all listed materials (as of June 2012 values).

Table 34: Estimated total value of all the materials available from individual units of different types of common e-waste, with the most valuable components listed separately

E-WASTE CATEGORY	COPPER	STEEL	GOLD	SILVER	PALLADIUM	ESTIMATED TOTAL VALUE OF ALL MATERIALS
Desktop computers	$2.50	$4.01	$8.45	$0.79	$1.65	**$17.98**
Portable computers	$0.66	$1.06	$2.24	$0.21	$0.44	**$4.77**
TV 19–29 CRT	$6.78	0	$8.07	$1.93	$1.63	**$19.45**
TV 30–45 FPD	$4.80	$3.45	$4.35	$0.27	$18.9	**$35.52**

Elements and Substances of Concern in WEEE

Note: The following section uses definitions created by the Ad-hoc Working Group on Defining Critical Materials, a subgroup of the Raw Materials Supply Group of the European Commission's Enterprise and Industry Directorate General. The working group classifies materials based on economic importance and supply risk. If a material is of high economic importance, and the supply is at risk due to any one of a number of factors, that material will be considered critical. Some of the factors that will see the supply of a material declared as "at risk" are low substitutability, low recycling rates, or production concentrated in countries with risky political-economic stability, which means that its supply could be suddenly shut off by some political or economic problem in the country that dominates production.

Antimony is found in small quantities in the printed circuit boards of most electronic devices and display devices, especially CRT displays and televisions sets. It is used as a flame retardant.

Breathing high levels of antimony for a long time can irritate the eyes and lungs and can cause problems with the lungs, heart, and stomach. Tests on animals have shown that breathing high levels of antimony can cause damage to the lungs, heart, liver and kidneys. Fertility issues were also noted in animals exposed to high levels over a longer period.

Although some studies have shown lung cancer in rats exposed to antimony, there are no studies that show conclusively that antimony is carcinogenic to humans.

The Ad-hoc Working Group on Defining Critical Materials defines antimony as a "critical raw material." There are no effective substitutes, supply is dominated by China, and there is a low recycling rate.

Arsenic is found in very small quantities in the transistors of some computers and technological equipment. Arsenic in the environment can combine with oxygen, chlorine, or sulfur to form inorganic arsenic compounds.

Ingesting or breathing low to medium levels of inorganic arsenic can cause warts, sore throat, irritated lungs, or other problems, and ingesting high amounts of arsenic can result in death.

The International Agency for Research on Cancer (IARC) and the US Environmental Protection Agency (EPA) have both determined that inorganic arsenic is carcinogenic to humans.

Barium, found in CRT screens, can accumulate in water and aquatic organisms. Humans exposed to barium, usually through contaminated drinking water, can suffer gastrointestinal disturbances and muscle weakness. High levels of ingestion over a long period of time may lead to kidney damage.

The IARC has not classified barium as to its carcinogenicity.

Beryllium, used in trace quantities for the circuit boards of information technology electronics, can be quite harmful if high levels of it are airborne. About 1–15% of all people occupationally exposed to beryllium in the air become sensitive to it and may develop chronic beryllium disease (CBD), an irreversible and sometimes fatal scarring of the lungs.

Ingesting beryllium by swallowing has not been shown to cause negative effects in humans, but tests on animals have resulted in ulcers that may have been caused by beryllium exposure.

The IARC and the US EPA have both determined that beryllium is a human carcinogen.

EC's working group rates beryllium as a "critical raw material" because 99% of world production is in the United States and China, there is a low recycling rate, and it is difficult to find a substitute for the material.

Cadmium is found in printed circuit boards, semi-conductors, copy machines, batteries, and possibly older CRT screens. Lungs can be severely damaged by breathing in high levels of cadmium. Eating or drinking cadmium can irritate the stomach. Long-term exposure can cause a build-up of cadmium in the kidneys, potentially resulting in kidney disease.

The IARC has determined that cadmium and cadmium compounds are human carcinogens. The EPA has listed cadmium as a possible human carcinogen.

Chromium is found in trace amounts in nearly all WEEE. The greatest concentrations are in CRT display devices. Chromium is found in different compounds, the most harmful of which is chromium VI, more commonly known as hexavalent chromium.

Ingestion of chromium VI is linked to irritation of the nose and other breathing issues. In laboratory tests, animals exposed to chromium VI have shown damage to their reproductive systems and sperm.

The IARC and the EPA have both determined that chromium VI is a human carcinogen.

Cobalt is in some batteries and the hard drives of consumer equipment. It is naturally occurring and can be beneficial to humans at low levels. High levels of exposure to cobalt can cause negative effects to the heart, lungs, skin, liver, and kidneys.

Tests on laboratory animals have shown that cobalt may be linked to cancer. The IARC has determined that cobalt and cobalt compounds are possible human carcinogens.

Cobalt is defined as a "critical raw material" by the EC's working group. Production is concentrated in the Democratic Republic of Congo, and there are limited options for substitution.

Copper is used as conductive cabling in nearly all electronic devices. Humans are regularly exposed to low levels of copper. High levels of exposure, however, can cause irritation of the nose, mouth, and eyes, as well as vomiting, diarrhoea, stomach cramps, nausea, and even death.

The EPA has determined that copper is not classifiable as to its human carcinogenicity.

Because of its high value, most copper is recovered from WEEE and recycled.

Lead is considered to be one of the greatest potential sources of toxicity in WEEE. It has been nearly eliminated from new products because of directives or agreements such as the RoHS Directive and California's WEEE provisions, but there are still tremendous quantities of lead in existing electronic devices, particularly in CRT screens, and this lead will eventually enter the waste stream. The EPA estimates that over 1 billion CRT PC's and television sets were sold in the United States between 1980 and 2010, many of which are still in use or in storage and yet to enter the waste stream. And all of these will contain lead.

The EU's *2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment: Final Report* suggests that a typical 26 kg CRT television set has over 1 kg of lead oxide in the tube itself and an additional 24 grams of lead in the rest of the set.

Exacerbating the problem with leaded CRT displays is that, right now, the market value for leaded glass is so low that recyclers are stockpiling it rather than selling it to be repurposed. An article in *The New York Times* from March 18, 2013, estimates that, at present, there is roughly 660 million pounds of it stored in warehouses across the United States. [10]

In humans, lead toxicity affects the nervous system, primarily, but it can affect nearly every organ in the body.

Exposure to high levels of lead, either through breathing or swallowing, can damage the brain and kidneys. In pregnant women, it can cause miscarriage.

In children, lead can cause blood anaemia and brain damage. If unborn children are exposed to lead through their mothers, the results can include premature birth and decreased mental and learning abilities.

Though tests have proved inconclusive, both the IARC and the EPA have determined that lead is "probably" carcinogenic to humans.

Lithium, found in many rechargeable batteries, can cause symptoms such as nausea and vomiting if humans are exposed to mild doses, but, in high doses, exposure can lead to seizures and kidney failure.

There is no evidence that lithium exposure can lead to any form of cancer.

Manganese, also common in batteries, is an essential nutrient for humans. Exposure to high levels of manganese, for example in industrial settings such as factories, can lead to consequences for the nervous system, lung irritation, and reproductive system effects.

The EPA has concluded that there is not enough scientific information to determine if manganese is a human carcinogen.

Mercury, found in trace amounts in many electronics, particularly in LCD screens, can affect the nervous system and damage the brain, the kidneys, and a developing fetus. It has the ability to build up in the environment, for example, in fish, and be consumed by humans or other organisms eating fish with high levels of mercury.

The EPA has determined that mercuric chloride and methylmercury are possible human carcinogens. Laboratory tests on animals have shown that mercury increases incidents of tumours in rats and mice.

Nickel, which is present in most electronics and in some batteries, is an abundant natural element. Approximately 10–20% of the population is "sensitive" to nickel. The most common reaction to nickel for those allergic is a skin rash.

---

[10] Ian Urbina, "Unwanted Electronic Gear Rising in Toxic Piles," The New York Times, March 18, 2013, http://www.nytimes.com/2013/03/19/us/disposal-of-older-monitors-leaves-a-hazardous-trail.html.

People exposed to large amounts of nickel in industrial settings have reported bronchitis, reduced lung function, and adverse effects to blood and kidneys.

Tests have shown lung and sinus cancers in workers in refineries or processing plants who have been exposed to air containing high levels of nickel compounds. The EPA has determined that nickel refinery dust and nickel subsulfide are human carcinogens.

PBBs/PDBEs (polybrominated biphenyls and polybrominated diphenyl ethers) were commonly used to make the plastic housing for electronics flame retardant. Their use has been reduced greatly because of the RHoS Directive and California's WEEE provisions, but there are still many items containing PBB's entering the waste stream.

The IARC has determined that PBB's are possibly carcinogenic to humans.

Palladium, found in trace amounts in most electronic items, is widely used in multilayer ceramic capacitors for its resistance to corrosion.

Palladium on its own is regarded as having low toxicity, but palladium compounds, such as palladium chloride, are highly toxic and could cause bone marrow, liver, and kidney damage in humans. It has shown these results in laboratory tests on animals.

As part of the "platinum group" of metals, palladium is considered by the EC's working group to be a "critical raw material." The palladium that is used by EU countries comes mainly form two sources, South Africa and Russia.

PVC is a flame retardant plastic commonly used for cabling and housing in electronic products. The manufacture of PVC often creates toxic chemical pollutants such as dioxin, hydrochloric acid, and vinyl chloride.

People who work with vinyl chloride have been known to develop problems with their immune systems, nerve changes, and liver damage.

The US Department of Health and Human Services (DHHS) has determined that vinyl chloride is a known carcinogen.

Ruthenium is used as a corrosion-resistant hardener in electrical contacts and chip resistors. Ruthenium is one of the most rare metals on earth. Ruthenium has not been found to cause cancer, but its compounds should be regarded as toxic and potentially carcinogenic to humans.

Selenium can be found in some circuit boards and in the photosensitive drums of equipment such as photocopiers. Humans need small amounts of selenium to maintain proper health. High levels of exposure, though, can lead to neurological abnormalities such as numbness. Breathing selenium in the air can cause respiratory tract infection.

There is no evidence that selenium exposure increases the risk of cancer in humans.

Silver is found in small amounts in most electronic products. Because of the relatively high value of silver, it is usually extracted from WEEE and repurposed.

Exposure to air containing high concentrations of silver has been known to result in breathing problems and irritation to the lungs and throat. Some people have allergic reactions, such as a rash, when silver contacts their skin.

The EPA has determined that silver is not classifiable as to its human carcinogenicity.

Tantalum is a soft, corrosion-resistant metal used in some electronics as capacitors. Tantalum may cause eye and skin irritation or issues in mucous membranes and upper respiratory tracts if ingested, inhaled, or absorbed through skin.

The EC's working group defines tantalum as a "critical raw material." There are no substitutes that perform as well as tantalum, supply is dominated by the Democratic Republic of Congo, and there is a low recycling rate.

Thallium is used in some batteries and semiconductors. Exposure to high levels of thallium has been reported to cause nervous system effects and problems with the heart, lungs, and kidneys.

No study into the possible carcinogenic effects of thallium is available.

Tin, found in the lead-free solder used in many electronic devices made today, can combine with other chemicals to make compounds. When tin is released into the environment, metallic tin will quickly form inorganic tin compounds that cannot be destroyed naturally. Exposure to large amounts of inorganic tin compounds can lead to anaemia and liver or kidney problems.

There is no evidence that tin or tin compounds can cause cancer in humans.

Zinc is found in most electronic products, especially in monitors and televisions. Inhalation of large amounts of zinc as dust or fumes is known to cause a short-term disease called "metal-fume fever," but zinc is not classified as to its carcinogenicity.

Rare Earth Elements

There are several metals that are not yet a significant part of the electronic waste stream but are certainly going to be a larger part of the e-waste conversation in the future. Every iPhone or iPad, and most of the other smart phones and tablets that are dominating the sales of personal-computing electronics today, contain many of the elements that are called "rare earths."

The amounts of these elements in today's mobile devices are miniscule. This circumstance, combined with the fact that most of these devices are still in use today, means that the recycling industry has not yet found a way to make it economically viable to recycle these rare-earth materials.

According to SIMS Recycling Solutions President Steve Skurnac, "Rare earths come in very minute concentrations in electronic scrap," which means that recyclers need a high volume and super efficient processes to recover any reasonable amount of rare earths from electronics. The technology just isn't there to make it economically feasible for most recyclers.[11]

According to CNET's Jay Greene, writing in an article posted September 26, 2012, an iPhone (as well as most of the new mobile devices currently sold, further research confirms) contains the following Rare Earth elements:[12]

Cerium is used as a glass-polishing agent. Long-term exposure can cause lung embolisms, and cerium has been shown to be a threat to the liver when it accumulates in the body. Cerium will also accumulate in soil and water when it is dumped into the environment.

Dysprosium is an element used in the vibration system. It is not known to have negative effects on humans or the environment.

Europium is part of the screen. Europium is not known to pose threats to humans, plants, or animals.

Gadolinium is found in the screen, circuitry, and speakers of the iPhone. It is considered to be of low toxicity and poses no threat to plants or animals.

Lanthanum is found in the screen and the phone's circuitry. It has been found to have negative effects on lung function and, when inhaled, is linked with an increased risk of developing cancer.

Neodymium is used in the device's circuitry and speakers, primarily in magnets. Neodymium is not considered to be toxic but can be very irritating to the eyes. It can affect cell membranes in water animals that suffer from overexposure.

Praseodymium is another glass-polishing agent. Exposure to praseodymium can lead to negative effects on the lungs and liver.

Terbium is used in the vibration unit, speakers, and screen of the device. There is a possibility of eye or skin irritation if one comes into physical contact with terbium.

Yttrium is used in the coloured screen. It has been linked with an increased risk of developing lung cancer or of experiencing other lung issues when it is ingested by inhalation. When dumped into the environment, yttrium can accumulate in soil and water. It has been shown to cause damage to cell membranes in water animals, leading to them having reproductive and nervous system problems.

---

[11] *iFixit.org Blog*; "Why the iPad has to be Made in China," blogentry by Elizabeth, April 19, 2012, http://ifixit.org/1856/why-the-ipad-has-to-be-made-in-china/.

[12] Jay Greene, "Digging for Rare Earths: The Mines Where iPhones Are Born," CNET, September 26, 2012, http://news.cnet.com/8301-13579_3-57520121-37/digging-for-rare-earths-the-mines-where-iphones-are-born/.

Such extremely small amounts of these materials are present in these devices that, for now, it is not economically feasible to recycle them from the devices. The recycling industry or the electronics industry may be forced to change that as the worldwide market for mobile devices shifts.

Right now, most of these devices are still in use, either by a first or subsequent owner. But as the technology gets increasingly desirable with more functionality, many are replacing their devices with new ones. According to the EPA, the average lifespan of a new mobile device is only 18 months, and over 152 million mobile devices were disposed of in 2010.

The 2011 EPA report Electronics Waste Management in the United States Through 2009 predicts that, in the United States in 2012, consumers will have bought 36 million tablets, 81 million iPads, over 100 million smart phones, and 190 million iPhones. That adds up to roughly 400 million devices in that one year alone.

Worldwide, smart phone sales are expected to reach over a billion by 2015. In Canada, a report by the Media Technology Monitor, a research product of the CBC, estimated that, as of autumn 2012, 26% of the population owned a tablet, more than five times the number that owned one when a similar study was done in the spring of 2011.[13]

What all this means is that, with demand for these devices skyrocketing, demand for rare earth elements is going to increase as well. Many of these elements are not actually rare, but expensive and difficult to extract.

Global production of the elements ranges from 23,000 tonnes per year for cerium to only 10 tonnes per year for terbium.

In between are lanthanum (12,000 tonnes per year), neodymium (7000), praseodymium (2500), yttrium (600), gadolinium (400), and europium and dysprosium (100).

But there is more than just global production to be considered. The EC's working group considers this entire group of elements to be "critical."

Not only are rare earths in high demand for electronic devices, they are also needed for emerging technologies such as hybrid vehicle batteries. They are also difficult to recycle and to replace with a substitute material. But the primary reason that the entire rare earth group of elements is on the list of critical raw materials is that production is dominated by China, which has imposed export restrictions and quotas. These not only could but already have disrupted world supply.

Above that, the EC's working group considers China to be an "environmental risk country," meaning that there is a possibility that the country could impose new environmental regulations that could affect the supply by curtailing the mining industry. (Since the working group's report on critical materials, there is now some mining in the United States and Australia, which has slightly reduced China's share of world production.)

So we have materials that are highly sought after but extremely difficult to obtain, yet there are millions of miniscule amounts of them in our pockets and purses. The need to recycle these materials may define electronics recycling in the future.

[13] Michael Oliveira, "Tablet Ownership Canada: 1 in 4 Have One, and the iPad Is Still King," *The Huffington Post*, February 20, 2013, http://www.huffingtonpost.ca/2013/02/20/tablet-ownership-canada-ipad_n_2726499.html.

Part VIII: Policies, Regulations, and Conventions

Toxin Phase-Out Policies in Canada and Globally

As a consequence of the growing concern over the environmental and health problems caused by toxins contained in WEEE, many jurisdictions have started introducing policies designed to phase out the toxic materials in electronic products or to reduce the illegal transboundry movement of e-waste.

RoHS Directive

The European Union (EU) has been and continues to be a world leader in WEEE management. In 2002, it introduced the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive, which was designed to eradicate certain hazardous substances from new electrical and electronic equipment (EEE). Individual member states are expected to transpose the directive into their own national legislation to deal with WEEE.

Specifically, the purpose of the EU's RoHS Directive is to contribute to the protection of human health and the environmentally sound recovery and disposal of WEEE by restricting the use of lead, mercury, hexavalent chromium, cadmium, polybrominated biphenyls, and polybrominated diphenyl ethers in EEE, in concentrations exceeding the values adopted by the European Commission (0.01% by weight per homogeneous material for cadmium and 0.1% for the other five substances). Beginning in July 2006, manufacturers of EEE within the scope of the directive are responsible for ensuring that their products comply with these requirements.

The directive applies only to electrical goods placed on the market in the European Economic Area (EEA). These goods include large household appliances; small household appliances; IT and telecommunications equipment; electronic consumer equipment; lighting equipment (including light bulbs), electronic and electrical tools, toys, leisure, and sports equipment; and automatic dispensers. It does not cover fixed industrial-plant and large-scale industrial tools. Moreover, RoHS does not apply to individual components and sub-assemblies—only to the end products comprised of them.

On account of the broad scope of the RoHS Directive and the long list of products it affects, the European Commission acknowledges the fact that it may not be technically feasible to manufacture some products without the use of some restricted substances. In light of this, the directive includes provisions for exemptions where alternatives to restricted substances do not yet exist (e.g., mercury in some types of fluorescent lamps). In addition, two entire product categories have been exempted (medical devices and monitoring and control instruments) given that the reliability of alternative components has potentially life-threatening consequences.

It is estimated that the annual amount of waste not sent to landfill as a result of RoHS will be 89,800 tonnes of lead, 4,300 tonnes of cadmium, 537 tonnes of hexavalent chromium, 22 tonnes of mercury, and 12,600 tonnes of octabromodiphenyl ether (OctaBDE). In addition, it appears that the directive has significantly reduced the amount of hazardous substances released to air, soil, and freshwater, lessening toxicity to humans and the environment. The positive effects of this reduction are especially relevant for cadmium and hexavalent chromium.

Following the passage of the RoHS, several major international electronic firms, including Toshiba, Dell, Panasonic, Intel, Hitachi, Hewlett-Packard, and Apple, along with hundreds of their global suppliers, redesigned their products in order to become RoHS compliant and to continue to have access to the EU. What is notable is that these manufacturers are modifying their production systems not only for the products they sell in the EU but for their whole production lines, including products shipped to countries where no such laws exist. To demonstrate their progress in meeting the EU's regulatory requirements for their products, many companies now have "RoHS status pages" on their websites.

California WEEE Provisions

The United States does not have a national WEEE initiative. In the face of such inaction, many individual states have taken it upon themselves to enact e-waste legislation and put in place infrastructure for recycling WEEE. A striking example is provided by the state of California, whose statute represents a clear adoption of the European regulatory standard.

Coming into effect on January 1, 2007, California's RoHS regulations prohibit covered electronic devices from being sold or offered for sale in California if those devices are

prohibited from being sold or offered for sale in the EU due to the presence of certain hazardous substances (lead, mercury, cadmium, or hexavalent chromium) exceeding the established maximum concentration values.

Although modelled after the EU directive, California's RoHS regulations are much narrower in scope. For example, while the EU's RoHS Directive covers "electrical and electronic equipment," which, in effect, is any device that requires or generates an electric current for its function, California's list of "covered electronic devices" is restricted to specific video display devices. The directives are also different in that the RoHS Directive restricts the use of two brominated flame retardants, polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) in electronic devices whereas California's regulations do not. Another weak point in California's RoHS is that it applies only to those "covered electronic devices" manufactured on and after the date that the devices first became subject to the regulations. This limitation contrasts with the EU's RoHS approach, which subjects electronic devices to the regulations whether they were put on the market on or after the date the directive came into force, regardless of when the devices were produced.

As with the EU legislation, California's RoHS regulations have an impact extending far beyond the borders of the state. Though it does not comprise as much of the electronics market as Europe, California has directly affected business practices because any product under the purview of its RoHS regulations that enters the state must be in compliance. In other words, national and regional regulations, for example those in Europe or California, have a worldwide affect because manufacturers do not make special models for different areas of the world. They will strive to make all new electronic and electrical devices compliant with all current legislation so as to enable sales in as many markets as possible.

Effectiveness of Toxic Substance Phase-Out Policies

In spite of these achievements, it is fair to say that the EU directive has not been as effective as anticipated. A major concern with RoHS has to do with enforcement. First, the directive takes a "self-declaration" approach in which goods are simply presumed to be in conformity because their producers have said so. Aside from random audits, investigation into whether a product is compliant with the requirements is warranted only when producer documentation is thought to be deficient. In general, there is no prescribed method to demonstrate compliance nor is there a requirement for certification. Under UK regulations, for instance, a producer is only required to develop and maintain sufficient documentation to demonstrate compliance. Another major issue with RoHS concerns exemptions. As previously stated, these are allowed when alternatives to restricted substances do not exist. There are currently 29 exemptions, and requests for others have been made. Long exemption processing times create problems for manufacturers; the uncertainty as to whether a substance will be exempted from the requirements has caused some manufacturers to halt certain product lines, while others continue to manufacture their products hoping that their applications for exemption will ultimately be approved. These issues aside, it is worth noting that the EU has made significant strides addressing the issue of WEEE compared to other jurisdictions.

National and International Regulations and Conventions to Control the Transboundary Movement of WEEE

Basel Convention

In an increasingly globalized world, concerns over the environmental impacts of international trade are growing. Particularly controversial is the international trade in hazardous waste, including e-waste, which has severe consequences for both the environment and human health. With the cost of local disposal on the rise as their governments impose stricter regulations to protect human health and the environment, players in industrialized countries in North America and Western Europe have been exporting more and more of their e-waste to developing countries in the South. In fact, it is estimated that anywhere between 50% and 80% of all waste electronics are sent to Asia for processing, where low-paid workers (without personal health or environmental protection measures) sort through discarded WEEE and processes it using a variety of low-tech methods, including manual disassembly and open burning.

A range of legislation has emerged in response to this problem, the most notable example of which is the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Adopted by the United Nations In March 1989 and entering into force in May 1992, the Basel Convention is the most significant multilateral environmental agreement (MEA) relating to e-waste and its management. It covers a wide range of waste material defined as "hazardous wastes" based on their origin, their composition, and their characteristics, as

well as two types of waste defined as "other wastes" (household waste and incinerator ash).
As of 2013, there were 180 signatories to the convention. Despite being a major actor, the United States has not yet ratified it.

The Basel Convention has several objectives related to the waste hierarchy of prevention, reduction, recovery, and final disposal, including (1) to reduce hazardous waste generation at its source, (2) to promote the environmentally sound management (ESM) of hazardous waste, (3) to advocate for disposal as close to the source as possible, and (4) to regulate and monitor the transboundary movements of hazardous waste.

For the waste deemed to require transboundary movement, the Basel Convention imposes numerous trade restrictions. For example, hazardous waste materials can be exported only if the exporting state lacks the capacity to deal with them in an environmentally responsible manner or if they are destined for recycling and recovery. If all these criteria are met, the shipment must still receive prior informed consent. In other words, prior to transboundary movement, an exporter must notify the destination country, as well as any intermediary countries, of its intent to trade in hazardous waste through a notification of consent.

In 1995, the UN made an amendment to the convention that outright banned the shipment of hazardous waste from developed to developing countries for any purpose. Although this amendment is undoubtedly an improvement, it is not in effect because it has not yet been ratified by the required three-fourths of the parties who accepted the convention. Canada, for example, has signed the Basel Convention but has not signed the amendment. Another major issue is that exporters are able to skirt the Basel Convention and its export and import regulations by claiming that the material is being exported for recycling or reuse and not for disposal. Another problem lies in the tracking of waste across national boundaries. Although it is estimated that more than half of all e-waste is exported to Asia for processing, there is no way to confirm this number because neither Statistics Canada nor the Canada Border Services Agency tracks this information. As a result of these loopholes, significant levels of WEEE, including hazardous materials, continue to be sent to developing nations.

Canadian Hazardous Waste Regulations

As noted, a number of jurisdictions have already begun to implement legislation to require that EEE be designed with less toxic materials. In Canada, the federal government is responsible for enacting e-waste regulations through toxic substance control legislation. Its approach to e-waste is twofold: to reduce the quantity of toxic material used in electronics and to reduce the release of toxic material at the end-of-life stage.

Although the federal government has not exercised its authority and specifically imposed regulations on the use of toxic substances in electronics, as has the EU and California, Canadian federal policy acknowledges and supports the international concerns about the use of toxics.

In Part 5 of the 1999 *Canadian Environmental Protection Act* (CEPA), Canada's federal environment minister has the power to implement regulations that ban or impose restrictions on products that contain substances noted in the act's "List of Toxic Substances" (Schedule 1). Several of the listed substances are substances commonly found in electronics, such as lead, mercury, hexavalent chromium, cadmium, polybrominated biphenyls, and polybrominated diphenyl ethers.

In addition to certain restrictions on listed toxic substances, Canada has put in place regulations designed to control the export and import of hazardous materials. Under Canada's *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations* adopted under Section 191 of the CEPA, hazardous waste and hazardous recyclable materials that are moved across international borders must be managed in a socially and environmentally responsible manner. The regulations maintain, for example, that hazardous material should be recycled and disposed of only at authorized facilities and that all transboundary shipments of these wastes must be tracked until they reach their final location. As well, written confirmation of disposal or recycling must be given.

Compared to markets in the United States or in EU nations, the Canadian market for electronics is much smaller; therefore, Canadian legislation controlling WEEE may not have as great a global impact on international business as regulations adopted in those countries. Nevertheless, it would be unfair to say that Canadian legislation has no influence on product design.

China's "Green Fence"

As the world's primary manufacturing country, China has an appetite for recycled raw materials, namely for metals, paper fibres, and plastics. The developed nations of the world have ample supplies to export to China. According to the US International Trade Commission (USITC), in 2011, exports from the United States to China of scrap copper, aluminum, ferrous metals, paper and paperboard, and plastic accounted for 11.3 billion in exports. This figure is

double that from 2006 and represents over 10% of all US exports to China. Other nations send enormous amounts of scrap there as well.

The low quality of the bales of collected materials, in terms of contamination, has forced China to institute a policy, known as the "green fence," regarding incoming shipments of scrap. In February 2013, the fence went up. Designed to keep contaminated materials out by imposing a limit of 1.5% contamination allowed in a shipment, the new initiative includes random inspection of all imported waste.

Early results show that the policy is having an effect. According to Plastics News, the first three months of enforcement saw more than 7,600 tons of recyclable materials rejected or sent back to suppliers and the import licenses of 247 companies suspended by customs officials.[14] Shipments of plastic alone are estimated to be down 5.5% in the first four months of 2013 (which includes January, before the fence went up).[15]

What this legislation means for shipments of WEEE to China is not entirely clear at this point. The fence is only supposed to stay up for 10 months, but it is possible that it will be extended beyond the month of November 2013. Clearly, waste electronics could hypothetically be held up in the port, or exporters from Canada and the United States may have to adjust primary collection or processing methods to ensure that loads will not be rejected and sent back.

Effectiveness of International Regulations on the Transboundary Movement of WEEE

Despite the good intentions of global agreements and conventions such as the Basel Convention, evidence suggests that WEEE containing hazardous materials continues to be exported from developed countries to developing countries. Loopholes exist in the regulations that allow for unscrupulous vendors to send the materials illegally and not get caught. The primary problems are of definition and enforcement.

Both the Basel Convention and the Canadian *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations* control the export and import of hazardous wastes going for disposal and recycling through a prior informed consent procedure. Shipments of electronics are controlled when the material meets the definition of hazardous waste under the Convention and some restrictions apply to certain used electronic materials sent for purposes of recycling (including reuse) between OECD countries.

Ostensibly, this policy is good, as it encourages reuse and it provides a channel for poorer countries to get some expensive electronic goods at low prices. The problem is that it remains fairly simple for a shipper to claim that a shipment is designated "for reuse", even if that may not be the case.

This problem is not new. When Basel was first introduced, the export of waste intended for disposal from OECD countries to non-OECD countries was reduced by 31% between 1990 and 1995. At the same time, waste designated for purposes of reuse increased by 32%.[16] There is no way to keep track of how much material that is labelled for reuse may have been shipped for actual disposal in the intervening years, but it is likely that it still happens. One of the primary reasons it is impossible to keep track of, let alone stop, this practice is that there is very little political will or funding to provide adequate monitoring and enforcement.

For example, it would be very difficult for Canadian authorities to develop a test to determine if a shipment of goods is, in fact, reusable. Some products or components are relatively easy to test, such as a cell phone. Others are more difficult, such as the individual parts of larger, integrated computer systems for businesses. Even if a set of testing protocols were developed, it would be unfeasible and impractical to test every single container destined for export. Even if it were possible to test all of these shipments, the ever-changing nature of electronic devices may render a set of test procedures invalid because of year-to-year differences in the goods themselves.

This is not to say that national and international regulations governing the transboundary movement of WEEE are entirely ineffective. Nevertheless, many challenges remain, including those created by the difficulties in defining the nature of e-waste and recycling as well as those related to enforcement. As these problems are addressed over time, the effectiveness of the regulations will increase.

[14] "US-based Recyclers May Gain from China's 'Green Fence,'" *Plastics News*, July 12, 2013, http://www.plasticsnews.com/article/20130712/NEWS/130719975/us-based-recyclers-may-gain-from-chinas-green-fence.

[15] Steve Toloken, "China's 'Green Fence' Makes Unprecedented Cuts in Recycled Plastic Imports," *Waste & Recycling News*, May 20, 2013, http://www.wasterecyclingnews.com/article/20130520/NEWS02/130529995/chinas-green-fence-makes-unprecedented-cuts-in-recycled-plastic-imports

[16] Djahane Salehabadi, *Transboundary Movements of Discarded Electrical and Electronic Equipment, Solving the E-Waste Problem* (StEP) Green Paper (Tokyo: United Nations University, March 2013).

Part IX: Closing Note

The last ten years has seen significant growth in WEEE collection and recycling. Canadian recyclers and refurbishers, both large and small, have expanded their reach by opening new facilities in new locations across the country. Many of these companies have also introduced new sorting technology to their processes and found new and better markets to take their sorted e-waste and further process it into raw materials that will replace virgin inputs. All provincial governments have, or are in the process of mandating, programs for WEEE, and consumers are showing an interest in participating in these collection programs, as demonstrated by the increasing tonnage of e-waste collected year after year.

But, most Canadians (whether from government, business, or the general public) will also agree that, while we have made great gains in this country, there is still a long way to go. Ensuring that all the facilities and workers that handle our e-waste, in Canada or abroad, maintain high operating standards with independent and regularly verified auditing is paramount and should be a priority.

As Canadians, we should do what it takes to make sure that the system in place is working the way it was intended to—and that no one, today or in the future, will be harmed by our e-waste.

Provincial Contact List

PROVINCE	CONTACT	PHONE/FAX/E-MAIL	LOGO
BRITISH COLUMBIA	Encorp Pacific (Canada) Neil Hastie Executive Director 206 – 2250 Boundary Rd. Burnaby, BC V5M 3Z3	Phone: (604) 473-2400 Fax: (604) 473-2411 E-mail: encorp@encorpinc.com	www.return-it.ca
BRITISH COLUMBIA	Canadian Electrical Stewardship Association Julie Robertson Member Inquiries 1321 Blanshard St. , Suite 301 Victoria, BC V8W 0B6	Phone: (710) 410-5070 E-mail: julie@cesarecycling.ca or info@cesarecycling.ca	www.cesarecycling.ca
BRITISH COLUMBIA	Product Care Association Mark Kurschner President 105 West 3rd Ave. Vancouver, BC V5Y 1E6 The Product Care Association is contracted to manage the MARR stewardship plan in BC.	Phone: (604) 592-2972 Toll Free: 1-888-252-4621 E-mail: contact@productcare.org or info@marrbc.ca	www.productcare.org www.marrbc.ca
ALBERTA	Alberta Recycling Management Authority Doug Wright, CEO 1310 Scotia Tower 1 10060 Jasper Ave. Edmonton, AB T5J 3R8	Phone: (780) 990-1111 Toll Free: 1-888-999-8762 Fax: (780) 990-1122 Toll Free Fax: 1-866-990-1122 E-mail: electronics@albertarecycling.ca	www.albertarecycling.ca
SASKATCHEWAN	SARCAN Recycling Kevin Acton Director of Operations 111 Cardinal Crescent Saskatoon, SK S7L 6H5	Phone: (306) 933-0616 Fax: (306) 653-3932 E-mail: contact@sarcan.sk.ca	www.sarcan.ca
SASKATCHEWAN	SWEEP/EPRA Saskatchewan Carl Flis Executive Director 2366 Ave C North Saskatoon, SK S7L 5X5	Phone: (306) 781-9337 E-mail: carl.flis@eprassociation.ca	www.sweepit.ca
MANITOBA	Electronic Products Recycling Association Dennis Neufeld Program Director 210 – 1600 Kenaston Blvd Suite 315 Winnipeg, MB R3P 0Y4	Toll Free : 1-888-527-9382 E-mail: dennis.neufeld@eprassociation.ca	www.recyclemyelectronics.ca/mb

PROVINCE	CONTACT	PHONE/FAX/E-MAIL	LOGO
ONTARIO	Ontario Electronic Stewardship Jonathan Spencer Executive Director 885 Don Mills Rd. Suite 400 Toronto, ON M3C 1V9	Phone: (416) 380-4545 Fax: (416) 380-4154 E-mail: customerservice@ontarioelectronicstewardship.ca	www.ontarioelectronicstewardship.ca
QUÉBEC	Association pour le recyclage des produits électroniques du Québec Dominique Levesque Executive Director E-3755 Boul Matte Brossard, QC J4Y 2P4	Toll Free: 1-888-557-8177 E-mail: info@recyclermeselectroniques.ca	www.recyclermeselectroniques.ca
QUÉBEC	RECYC-QUÉBEC Benoit De Villiers, President & CEO 141, avenue du Président-Kennedy, 8th Floor Montréal, QC H2X 1Y4	Phone: (514) 352-5002 Toll Free: 1-800-807-0678 Fax: (514) 873-6542 E-mail: info@recyc-quebec.gouv.qc.ca	www.recyc-quebec.gouv.qc.ca/
NEW BRUNSWICK	Resnet Recyclage Inc. Julie Lavoie General Manager 15 Jessome Ave. Edmundston, NB E3V 3K5	Phone : (506) 735-9140 E-mail: info@resnet.nb.ca	www.resnet.nb.ca
NEW BRUNSWICK	Westmorland-Albert Solid Waste Corporation P.O. Box 1397 Moncton, NB E1C 8T6	Phone: (506) 877-1050 Fax: (506) 877-1060	www.westmorlandalbert.com
NEWFOUNDLAND & LABRADOR	Multi Materials Stewardship Board Mike Samson CEO P.O. Box 8131, Station A St. John's, NL A1B 3M9	Phone: (709) 753-0948 Toll Free: 1-800-901-MMSB Fax: (709) 753-0974 E-mail: inquiries@mmsb.nl.ca	www.mmsb.nf.ca
NOVA SCOTIA	EPRA Nova Scotia (formerly Atlantic Canada Electronics Stewardship) Gerard MacLellan Executive Director 201 Brownlow Ave. Suite 44 Dartmouth, NS B3B 1W2	Toll Free: 1-877-462-8907 E-mail: gerard.maclellan@eprassociation.ca	www.recyclemyelectronics.ca/ns/
NOVA SCOTIA	Resource Recovery Fund Board Jeff MacCallum CEO 14 Court Street, Suite 305 Truro, NS B2N 3H7	Phone: (902)-895-7732 Toll Free: 1-877-313-7732 Fax: (902) 897-3256 E-mail: info@rrfb.com	www.rrfb.com

PROVINCE	CONTACT	PHONE/FAX/E-MAIL	LOGO
PRINCE EDWARD ISLAND	EPRA P.E.I. (formerly Atlantic Canada Electronics Stewardship) Gerard MacLellan Executive Director 201 Brownlow Ave. Suite 44 Dartmouth, NS B3B 1W2	Toll Free: 1-877-462-8907 E-mail: gerard.maclellan@eprassociation.ca	www.acestewardship.ca/pei
PRINCE EDWARD ISLAND	Island Waste Management Corporation Gerry Moore, CEO 110 Watts Ave. Charlottetown, PEI C1E 2C1	Telephone: (902) 894-0330 Toll Free: 1-888-280-8111 Fax: (902) 894-0331 E-mail: info@iwmc.pe.ca	www.iwmc.pe.ca
NATIONAL	Retail Council of Canada Diane Brisebois President & CEO 1881 Yonge St. Suite 800 Toronto, ON M4S 3C4	Phone: (416) 922-6678 Toll Free 1-888-373-8245 Fax: (416) 922-8011 Toll Free: 1-877-790-4271 E-mail: info@retailcouncil.org	www.retailcouncil.org
NATIONAL	Electronics Product Stewardship Canada Shelagh Kerr President & CEO 550 Bayview Ave. Suite 403 Toronto, ON M4W 3X8	Phone : (647) 351-7415. E-mail: shelagh@epsc.ca	www.epsc.ca
NATIONAL	Association of Home Appliance Manufacturers Canada Bruce Rebel Vice President 130 Albert Street Suite 1200 Ottawa, ON K1P 5G4	Phone: (613) 823-3223 E-mail: info@ahamcanada.ca	www.ahamcanada.ca
ALL PROVINCES (Except Ontario and Quebec)	Canadian Wireless Telecommunications Association (CWTA) Bernard Lord President 80 Elgin St. Suite 300 Ottawa, ON K1P 6R2	Phone: (613) 233-4888 Fax: (613) 233-2032 Toll Free (RMC support line): (888) 797-1740 E-mail: info@RecycleMyCell.ca or info@cwta.ca	www.recyclemycell.ca www.cwta.ca

Resources Researched for This Report

Part II: Recycling Performance Measurements

Bertolucci, Jeff. "How Much Ink Is Left in That Dead Cartridge?" *PC World*, November 2, 2008. http://www.pcworld.com/article/152953/printer_ink_costs.html.

Deathe, Ashley L. B., Elaine MacDonald, and William Amos. "E-waste Management Programmes and the Promotion of Design for the Environment: Assessing Canada's Contributions." *Review of European Community and International Environmental Law* (RECIEL) 17, no. 3 (2008): 321–36.

UNEP International Resource Panel. *Recycling Rate of Metals: A Status Report*. Nairobi, Kenya: United Nations Environment Programme, May 2011.

Part III: WEEE Recycling

Arcadian Solutions for the EPEAT and the Green Electronics Council. *Comparison of Selected End-of-Life Electronics Processing Programs with the Requirements in the IEEE 1680 Series of Standards for End-of-Life Electronics Processing: Summary Report to Inform the IEEE 1680.1 Revision Working Group*. New York: Arcadian Solutions, December 2012. http://arcadiansolutions.com/wp-content/uploads/R008-EOLE-Comparison-2012-12-21.pdf.

Electronics Product Stewardship Canada (EPSC). *Recycler Qualification Program for End-of-Life Electronics Recycling*. Last modified October 27, 2010. http://www.rqp.ca/ESW/Files/Recycler_Qualification_Program_FINAL_10.10.27.docx.

European Commission. *Services to Support Member States' Enforcement Actions and Inspections Concerning the Application of EU Waste Legislation: Practical Manual on Permitting and Inspection of Waste Management Operations, Final Version*. Brussels: European Commission, 27 December 2011.

European Commission. *Services to Support Member States' Enforcement Actions and Inspections Concerning the Application of EU Waste Legislation: Guidance on Permitting and Inspection of Waste Management Operations, Final Version*. Brussels: European Commission, 19 January 2012.

Institute of Electrical and Electronics Engineers. *IEEE Standard for Environmental Assessment of Televisions*. New York: IEEE, October 2012.

US Environmental Protection Agency. *The Life Cycle of a Cell Phone*. Accessed July 23, 2013, http://www.epa.gov/osw/education/pdfs/life-cell.pdf.

Part IV: Quantifying the Benefits of WEEE Recycling

Morris, Jeffrey, Clarissa Morawski, H. Scott Matthews. *Measuring the Environmental Benefits of Ontario's Blue Box, MHSW, and WEEE Diversion: Final Report Submitted to Ontario Ministry of Environment.* Olympia, WA: Sound Resource Management, 19 May 2009. http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_108743.pdf.

Part V: Provincial Program Summaries

Program and Agency Websites

Alberta Recycling Management Authority (http://www.albertarecycling.ca/)

Canadian Electrical Stewardship Association (http://www.cesarecycling.ca/)

Canadian Wireless Telecommunications Association (http://cwta.ca/home/)

CBC, New Brunswick (http://www.cbc.ca/nb/)

Electronic Products Recycling Association (EPRA), Manitoba (http://recyclemyelectronics.ca/mb/)

Electronic Products Recycling Association, British Columbia (http://www.recyclemyelectronics.ca/bc/)

Electronic Products Recycling Association, Québec (http://recyclermeselectroniques.ca/eng/)

Electronic Waste Recycling Program (Alberta), Environment Canada (http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=9E378421-1)

Electronic Waste Recycling Program (British Columbia), Environment Canada (http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=D65DC132-1)

Electronic Waste Recycling Program (Nova Scotia), Environment Canada (http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=1531A374-1)

Electronic Waste Recycling Program (Ontario), Environment Canada (http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=DB5C8F07-1)

Electronic Waste Recycling Program (Prince Edward Island), Environment Canada

(http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=A56D5488-1)
Electronic Waste Recycling Program (Saskatchewan), Environment Canada (http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=2F16758B-1)
ElectroRecycle (http://www.electrorecycle.ca/)
Encorp Pacific (http://www.return-it.ca/)
Green Manitoba (http://greenmanitoba.ca/)
Major Appliance Recycling Roundtable (http://www.marrbc.ca/)
Mobile Device Recycling Program, Environment Canada (http://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=51FBEBFD-1)
Product Care (http://www.productcare.org/)
Product Stewardship: Electronic and Electrical Product Category, British Columbia Ministry of Environment (http://www.env.gov.bc.ca/epd/recycling/electronics/index.htm)
Recycle My Cell (http://www.recyclemycell.ca)
Retail Council of Canada (http://www.retailcouncil.org)
Return-It™ Electronics (http://www.return-it.ca/electronics/)
Saskatchewan Waste Electronic Equipment Program (http://sweepit.ca/)

Other Sources

Alberta Recycling. *Annual Report (2011–2012): The Promise of Responsible Environmental Stewardship*. Edmonton, AB: Alberta Recycling Management Authority, 2012. http://www.albertarecycling.ca/docs/annual-reports/alberta-recycling-annual-report-2011-12-final0F616AC5F353.pdf.
Association of Manitoba Municipalities. "E-waste collection in Manitoba." *Municipal Leader Special Report: The Greening of Municipalities* (Summer 2009): 32–33, full report 25–46. http://www.amm.mb.ca/documents/Leader_Summer2009_RICH.pdf.
"Electronic Products Industry Offers Quebeckers a Program for End-of-Life Electronics." *CNW: A PR Newswire Company*, July 19, 2012. http://www.newswire.ca/en/story/1009745/electronic-products-industry-offers-quebeckers-a-program-for-end-of-life-electronics.
Electronic Products Recycling Association (EPRA). *Annual Report 2012*. Mississauga, ON: EPRA, 2012. http://eprassociation.ca/ar/en/2012/EPRA2012 - Annual Report.pdf.
Ontario Electronics Stewardship (OES). "200,000 Tonnes Diverted: Ontario Surpasses Waste Electronics Reuse and Recycling Milestone." *Market Wire*, July 18, 2013. http://www.marketwire.com/press-release/200000-tonnes-diverted-ontario-surpasses-waste-electronics-reuse-recycling-milestone-1812524.
Ontario Electronics Stewardship (OES). *2012 Annual Report: Growing and Building Reforms for a Sustainable Future*. Toronto: OES, 2012. http://www.ontarioelectronicstewardship.ca/sites/all/files/annualreport/2012/index.html.
Ontario Electronics Stewardship (OES). "Ontarians Leading the Way with Electronics Recycling." *Market Wired*, April 23, 2013. http://www.marketwire.com/press-release/ontarians-leading-the-way-with-electronics-recycling-1782115.htm.
Ontario Ministry of the Environment. *Towards a Zero Waste Future: Review of Ontario's Waste Diversion Act, 2002*. Toronto: Ministry of the Environment, October 2008. http://www.york.ca/NR/rdonlyres/ifmwzwsvpxvl2c55b6h4zrc572j4pi5h34gguqfol3k5zbxomcupzgwfn4jlh7dqk6g5jqmsjnys6wsjtwdo3deepf/Jan+14+Review+att+3.pdf.
Recycle My Cell. *2011 Annual Report Submitted to the British Columbia Ministry of Environment*. Ottawa: Canadian Wireless Telecommunications Association, June 2012.
Recycle My Cell. *2012 Annual Report Submitted to the British Columbia Ministry of Environment*. Ottawa: Canadian Wireless Telecommunications Association, July 2013.
Saskatchewan Waste Electronics Equipment Program (SWEEP). *Annual Report 2012–2013*. Saskatoon, SK: SWEEP, 2013. http://www.sweepit.ca/images/About/Documents/AnnualReports/SWEEP_AnnualReport2012_WEB.pdf.
Ward, Susan. "Where to Recycle Computers in Canada." *About.com Guide*. http://sbinfocanada.about.com/od/environmentbiz/a/comprecycling1.htm.

Part VI: Costs of Recycling WEEE

Atlantic Canada Electronics Stewardship. *ACES Annual Report 2011*. Dartmouth, NS: ACES, October 2011.
Electronic Products Recycling Association. *EPRA Annual Report 2012*. Mississauga, ON: EPRA, December 2012.
United Nations Environment Programme. *UNEP 2009 Annual Report: Seizing the Green Opportunity.* Nairobi, Kenya: UNEP, 2010. http://www.unep.org/PDF/UNEP_AR_2009_FINAL.pdf.

Part VII: Social, Economic & Environmental Impacts

Abela, Maya, and Jacob Campbell. *E-Wasted Time the Hazardous Lag in Comprehensive Regulation of the Electronics Recycling Industry in the United States*. Udall Center for Studies in Public Policy Environmental Policy Working Paper No. 1. Tucson, AZ: University of Arizona, June 2010. http://www.greenbiz.com/sites/default/files/udall.center_epwp_abaya&campbell_june2010.pdf.

Agency for Toxic Substances and Disease Registry (ATSDR). *ATSDR Toxic Substances Portal*. http://www.atsdr.cdc.gov/substances/index.asp.

California Department of Toxic Substances Control. *Restrictions on the Use of Certain Hazardous Substances (RoHS) in Electronic Devices*. Sacramento, CA: DTSC, 2010. http://www.dtsc.ca.gov/hazardouswaste/rohs.cfm.

Carter-Whitney, Maureen, and Carolyn Webb. *Waste Bytes! Diverting Waste Electrical and Electronic Equipment in Ontario*. Toronto: Canadian Institute for Environmental Law and Policy (CIELP), 2008. http://cielap.org/pdf/EwasteOntario.pdf.

DMS Environment. *Jobs through Electronics Recycling: Membership Survey and Jobs Study of the Potential of the U.S. Electronics Recycling Industry*. Prepared for the Coalition for American Electronics Recycling. Windsor, VT: DMS Environment, January 2013. http://www.americanerecycling.org/images/CAER_Jobs_Study_Report_-_January_2013.pdf.

European Commission, Enterprise and Industry Directorate General. *Critical Raw Materials for the EU: Report of the Ad-hoc Working Group on Defining Critical Raw Materials*. Brussels: European Commission, 2010. http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report-b_en.pdf.

Gaidajis, G., K. Angelakoglou, and D. Aktsoglou. "E-Waste: Environmental Problems and Current Management." *Journal of Engineering Science and Technology Review* 3, no. 1 (2010): 193–199.

Graedel, T. E., Julian Allwood, Jean-Pierre Birat, Barbara K. Reck, Scott F. Sibley, Guido Sonnemann, Matthias Buchert, Christian Hagelüken et al. *Recycling Rates of Metals: A Status Report of the Global Metal Flows Working Group of the International Panel on Sustainable Resource Management of the UNEP*. Paris: United Nations Environment Programme, 2011. http://www.unep.org/resourcepanel/Portals/24102/PDFs/Metals_Recycling_Rates_110412-1.pdf

Greene, Jay. "Digging for Rare Earths: The Mines Where iPhones Are Born." *CNET*, September 26, 2012. http://news.cnet.com/8301-13579_3-57520121-37/digging-for-rare-earths-the-mines-where-iphones-are-born/.

ICF International. *Electronics Waste Management in the United States Through 2009 Executive Summary*. Prepared for the U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. Washington, DC: EPA, May 2011. http://www.epa.gov/wastes/conserve/materials/ecycling/docs/fullbaselinereport2011.pdf.

iFixit.org Blog. "Why the iPad Has To Be Made in China." Blog entry by Elizabeth, April 19, 2012. http://ifixit.org/1856/why-the-ipad-has-to-be-made-in-china/.

International Institute for Industrial Environmental Economics (IIIEE) at Lund University. *Designing Greener Electronic Products: Building Synergies between EU Product Policy Instruments or Simply Passing the Buck?* Brussels: European Environmental Bureau (EEB), 2010. http://www.eeb.org/?LinkServID=66030392-BF80-2CAC-B5335569F1526F90&showMeta=0.

Lenntech Water Treatment Solutions. *Elements*. http://www.lenntech.com/periodic/elements/index.htm.

Lundgren, Karin. T*he Global Impact of E-Waste: Addressing the Challenge*. Geneva: International Labour Organization, 2012. http://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_196105.pdf.

Oliveira, Michael. "Tablet Ownership Canada: 1 in 4 Have One, and the iPad Is Still King." *The Huffington Post*, February 20, 2013. http://www.huffingtonpost.ca/2013/02/20/tablet-ownership-canada-ipad_n_2726499.html.

Paul, Justin, and Gwenette Campbell. *Investigating Rare Earth Element Mine Development in EPA Region 8 and Potential Environmental Impacts*. EPA Document No. 908R11003. Washington, DC: Environmental Protection Agency, 2011.

Reuter, Markus A., Christian Hudson, Antoinette van Schaik, Kari Heiskanen, Christina Meskers, Christian Hageluken et al. M*etal Recycling: Opportunities, Limits, Infrastructure, A Report of the Working Group on the Global Metal Flows to the International Resource Panel*. Paris: United Nations Environment Programme, 2013.

Salehabadi, Djahane. *Transboundary Movements of Discarded Electrical and Electronic Equipment*. Solving the E-Waste Problem (StEP) Green Paper.

Tokyo: United Nations University, 25 March 2013. http://isp.unu.edu/publications/scycle/files/ewaste_flow.pdf.

Schluep, Mathias, Christian Hagelueken, Ruediger Kuehr, Frederico Magalini, Claudia Maurer, Christina Meskers, and Esther Mueller et al. *Recycling: From E-Waste to Resources. Sustainable Innovation and Technology Transfer Industrial Sector Studies*. Paris: United Nations Environment Program (UNEP), 2009. http://www.ewasteguide.info/files/UNEP_2009_eW2R.PDF.

Scoll, Jonathan P., and Julie M. Duckstad. *Cal RoHS: California Brings European Hazardous Content Regulation "Home" to U.S. Manufacturers*. Minneapolis, MN: Lindquist & Vennum, May 2008.

Toloken, Steve. "China's 'Green Fence' Makes Unprecedented Cuts in Recycled Plastic Imports." *Waste & Recycling News*, May 20, 2013. http://www.wasterecyclingnews.com/article/20130520/NEWS02/130529995/chinas-green-fence-makes-unprecedented-cuts-in-recycled-plastic-imports.

United Nations University. *2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment: Final Report*. Tokyo: United Nations University, 2007.

Urbina, Ian. "Unwanted Electronic Gear Rising in Toxic Piles." *The New York Times*, March 18, 2013. http://www.nytimes.com/2013/03/19/us/disposal-of-older-monitors-leaves-a-hazardous-trail.html.

"US-based Recyclers May Gain from China's 'Green Fence.'" *Plastics News*, July 12, 2013. http://www.plasticsnews.com/article/20130712/NEWS/130719975/us-based-recyclers-may-gain-from-chinas-green-fence.

Van der Voet, Ester, Reijo Salminen, Matthew Eckelman, Gavin Mudd, Terry Norgate, Roland Hischier et al. *Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles, A Report of the Working Group on the Global Metal Flows to the International Resource Panel*. Paris: United Nations Environment Programme, 2013. http://www.unep.org/resourcepanel/Publications/EnvironmentalChallengesMetals/tabid/106142/default.aspx.

Wäger, Patrick, Mathias Schluep, and Esther Müller. *RoHS Substances in Mixed Plastics from Waste Electrical and Electronic Equipment: Final Report*. St Gallen, Switzerland: EMPA Materials Science & Technology, 2010. http://new.weee-forum.org/system/files/documents/rohs20in20mixed20plastics_empa_final_2010200920171.pdf.