Research and Reporting on Design Elements that have Reduced the Environmental Footprint of Electronics Products in Canada

2009 Design for Environment (DfE)

Authored by the Green Electronics Council for:

Electronics Product Stewardship Canada | **Recyclage des produits électroniques Canada**

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BY THE GREEN ELECTRONICS COUNCIL

2008 Design for Environment (DfE) Reporting

Research and Reporting on Design Elements that have Reduced the Environmental Footprint of Electronics Products in Canada

Green Electronics Council for EPSC

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Note from EPSC's Chair

With this release of our second report on Designing for the Environment, the Canadian electronics industry continues to maintain its high standard of co-operation. This report joins other key co-operative efforts, including the highly acclaimed Recycling Vendor Qualification Program, which has been an innovative component to developing an effective, responsible approach to managing end-of-life electronics.

Since its founding in 2003 by Electro-Federation Canada (EFC) the Information Technology Association of Canada (ITAC) and leading consumer electronics and information technology manufacturers, EPSC has an established reputation for working to design, promote and implement sustainable solutions for Canada's electronic waste. EPSC is proud to see four industry-led environmental stewardship programs now operating in Canada. With Ontario set to join the programs already operational in British Columbia, Saskatchewan and Nova Scotia, the successful partnership approach that EPSC has used since its inception is clearly an effective one. We have demonstrated that industry can work with all levels of government to create and operate programs that ensure safe end-of-life programs for electronics.

In addition to EPSC's concern for products at the end of their lives, this report also visibly indicates that our member companies are investing significantly in the environmental performance of their products throughout their lifecycle. Their commitment to the investment required in the initial research and development, which may take several years to bring to full implementation, is remarkable. From the design stage, through manufacturing, marketing and delivery, our companies are working to create products that leave a much smaller environmental footprint. As a result, our customers have a wider range of electronic products that can be used more efficiently and can be recycled in a more environmentally responsible manner.

This document provides a summary of the findings from the research EPSC commissioned the Green Electronics Council to conduct. The complete report is available at www.epsc.ca. This is just one more example of EPSC's dedication and commitment to working together on behalf of all of its member companies, and to provide accurate and timely information to the Canadian public.

Lloyd Bryant
Acting Chair
Electronics Product Stewardship Canada (EPSC)

Foreword

Electronics Product Stewardship Canada (EPSC) hired Green Electronics Council (GEC) in September 2008 to research and report on Design for Environment (DfE) of electronics goods that are sold in the Canadian market.

The purpose of this report is to identify key trends and advances in environmental design. These DfE initiatives study well-known areas such as energy use and reduced use of environmentally sensitive materials. Other important areas seeing positive improvements include design for expandability, design for better management at end-of-life and use of recycled materials.

Based on GEC's research in the electronics industry, this report is divided into five key areas:

1. Environmentally Sensitive Materials
2. Environmentally Preferable Materials Selection
3. Energy
4. Design for End-of-Life
5. Product Expandability

The information presented in this report is based on secondary research conducted over several months by a team of environmental professionals assembled by GEC.

Founded in 2005, GEC is a non-profit organization established to work with all stakeholders in the electronics eco-system with the intention of "re-designing society's relationship with electronics" by:

- Developing market-based incentives for improved practices
- Building the capacity of individuals and organizations to reduce the life-cycle impacts of electronic products
- Conducting research

GEC assembles virtual teams for research of this type, comprising key industry professionals with germane and specialized knowledge. The following team prepared this EPSC report:

- *Mark Schaffer*, President, Schaffer Environmental, was the project manager in addition to leading the research in the Energy and Product Expandability Sections
- *Pamela Brody-Heine,* Principal, Eco Stewardship Strategies, led the research on Environmentally Sensitive Materials and Materials Selection
- *Anne Peters*, President, Gracestone Inc., led the research on Design for End-of-Life
- *Maria Kelleher*, Principal, and *Janet Robins,* Senior Researcher and Consultant, Kelleher Environmental, provided input on regulatory and procurement drivers in the Canadian marketplace
- *Wayne Rifer*, Manager of EPEAT™ Operations*,* Green Electronics Council, was the project's technical advisor

Executive Summary

Design for the environment (DfE) trends yielding positive environmental benefits are occurring throughout the electronics industry in a number of ways:

1. Participation by the industry in global voluntary initiatives such as environmental labels and programs, and cooperative industry standards, such as EPEAT™, ENERGY STAR, EcoLogo™ and Bluetooth
2. Leadership in environmental standard setting by industry organizations, such as Institute of Electrical and Electronics Engineers, Inc. (IEEE), International Electrotechnical Commission (IEC), ECMA International and International Electronics Manufacturing Initiative (iNEMI)
3. Design shifts and creative inventions, such as the use of new and converging technologies that yield both performance and environmental benefits, such as the move to LEDs and multifunction devices
4. Product changes due to consumer demand and requirements, such as smaller, thinner, less-material-intensive products
5. Meeting and, in some cases, exceeding, regional regulatory requirements and applying those requirements to products worldwide, such as Restriction of Hazardous Substances (RoHS) and provincial take-back schemes

It is encouraging that these trends integrate environmental benefits – along with product performance improvements in standard product design and business practices – while meeting marketplace demands.

Product design has changed significantly and quickly in recent years due to the mounting availability and economic viability of new materials, processes and technologies that offer environmental advantages. Additionally, environmental programs and ecolabels are more widely developed and used than ever, especially in Canada. These voluntary tools identify best practices to minimize adverse environmental impact during material selection, product and component design, product use and the end-of-life (EOL) phase. Purchasers' access to products through these programs and ecolabels is very strong in Canada, further amplifying a market-driven incentive for manufacturers to "go green." Industry's ability to provide products that meet both marketplace and green imperatives depends upon its flexibility to take rapid advantage of these new developments, and being recognized by purchasers for being able to do so. The purchaser is providing positive feedback to the environmental design and functionality requirements, which in turn promotes more innovative environmental product design in a timely fashion.

During the past three years, Canadian consumer electronics and information technology manufacturers have worked co-operatively to develop and implement industry-led recycling programs. Since its inception in 2003, Electronics Product Stewardship Canada (EPSC) has used a successful partnership approach, demonstrating that competing industry players can work together effectively, and with other stakeholders, to create and operate programs that ensure that e-waste is collected and recycled safely.

While continuing on its substantial progress in developing the capability to deliver end-of-life (EOL) programs, the electronics industry has also turned its attention to DfE programs. DfE-related trends and advancements can be grouped into five major areas:

1. Environmentally Sensitive Materials
2. Environmentally Preferable Materials Selection
3. Energy
4. Design for End-of-Life
5. Product Expandability

Within each of these areas, which were the focus of this research, voluntary industry-wide initiatives are improving the design of electronics and information technology products well beyond what is required by regulation.

Perhaps the most successful example of developments in the DfE area for some consumer electronics is the widespread adoption of EPEAT, which encompasses the five key DfE areas. A multi-stakeholder group that included industry, government, purchasers and activist organizations developed this voluntary program between 2003 and 2006. The industry's active support was one of the key factors that led to EPEAT's success. EPEAT is part of the *Canadian National Master Standing Offer for IT equipment*. EPEAT recently partnered with the leading Canadian voluntary environmental procurement program, EcoLogo™, to make it easier to certify and promote green electronics. In Canada, over 3 million notebooks, desktops and monitors that meet EPEAT's criteria were sold in 2007.

Within each of the key DfE areas outlined above, the research found trends that indicated improving product environmental design. Together, these trends contribute significantly to positive environmental outcomes.

Environmentally Sensitive Materials: The electronic industry has made significant strides in moving away from the use of Cathode Ray Tubes (CRTs) over the past two decades. The availability and viability of new materials and technologies has facilitated the reduced use of environmentally sensitive materials, especially lead in CRTs as flat panel displays are replacing CRTs, and mercury in mercury-bulb backlit liquid crystal displays (LCD) as light-emitting diode (LED) technologies that are mercury-free are becoming more common.

However, there is a distinction between the leading companies and the many small- to medium-sized manufacturers and suppliers. Work still needs to be done to improve practices in smaller companies with little-known brands, who have less capacity for innovation, less ability to influence their supply chain, and often less transparency with the public or regulators.

Environmentally Preferable Materials Selection: Industry efforts focus primarily on two areas – dematerialization and "alternative" materials. The dematerialization (using less material overall) of products occurs due to multiple trends. The availability of newer, smaller products or subassemblies such as flat-panel technologies replacing CRTs is an example of how new technology can change what and how much material is needed to meet users' needs. Consumers far prefer flat-panel display technology, because it takes up much less space, uses fewer materials, generally consumes less power, and generates less heat during use. As a result, the enclosure (for a laptop or a television, for example) can be smaller and lighter. An example of this trend is well illustrated by the evolving design of televisions. Twenty years ago, a 32" TV might weigh over 45 kg (100 pounds) due to its CRT; today, that 32" TV is only 9-14 kg (20 - 30 pounds) (or less) thanks to LCD technology. Besides less production of primary materials, this dematerialization also yields dividends in reduced transport impacts throughout the product lifecycle and reduced product packaging.

While dematerialization is a common practice in the industry, the use of post-consumer recycled content and bio-based/renewable materials remains more of a challenge. Looking to the future, materials engineered from recovered and renewable/bio-based materials, as well as the development of nanomaterials and nanotechnologies, will impact the type, size and number of materials potentially utilized in new industry designs. While these state-of-the-art technologies can always produce more environmental challenges, the investigation and mitigation of these challenges are playing a growing role in the technology development process.

Energy: Industry has been, and continues to be, a partner in the development of ENERGY STAR and other voluntary energy-management programs such as the 80 Plus Program and the Climate Savers Computer Initiative (CSCI). These engagements will only increase over the next few years as EPEAT and ENERGY STAR expand into more products and more restrictive management levels for off, standby and use phase energy.

The next challenge for the electronics industry will be to identify more than off or standby mode power limits. The evolution will be identifying true product efficiency and the tools to measure this are already being investigated for computers. By developing them, other benchmark tools may become available to define product efficiency for additional consumer devices such as televisions, displays, and printers.

Design for End-of-Life: Due to EPEAT, EcoLogo™ and other voluntary environmental ecolabel programs, the design of electronics products has become more streamlined than in the past. Fewer screws, more snap-fit parts, as well as fewer different types of materials are found in these products. These design changes make them easier to recycle at end-of-life. Additionally, manufacturers are providing more transparent information on how products can be disassembled either for recycling or for upgrading and life extension by end-users.

Although there are many drivers aiding in designing for end-of-life, there are still challenges. As such, industry groups, key trade associations, national-level agencies and authorities in North America and Europe, and various non-governmental organizations (NGOs), are all looking for solutions to break down the barriers to designing products that can be more efficiently managed at end-of-life. Strategies for breaking down these barriers are many, and include changes in governmental policies, purchasing mechanisms, voluntary collaborative industry work groups, and continued research into all aspects of increasing EOL design.

Product Expandability: Industry has worked together to establish common specifications for key aspects of electronics product design and functionality, by establishing non-competitive means to communicate with one another to establish cross-industry standards. The standards resulting from pan-industry work were prompted through market demand for increased interoperability of electronic devices, and have given rise to a number of universally adopted standards. Additionally, industry has formed agreements such as the Digital Living Network Alliance (DLNA), where manufacturers are designing an array of electronic products that communicate and function efficiently with one another, giving rise to a more streamlined digital lifestyle for consumers. Though much work remains to be done to expand these efforts in cross-generational and cross-brand functionality of components and systems, they have already effectively lengthened the life of products through upgradability and refurbishment, and by decreasing production and EOL disposal of proprietary connectors and cables.

As well, the convergence of functionality in devices has given rise to further opportunities in dematerialization. Customer demand and market pressures for smaller, lighter multi-functional devices have resulted in new classes of products. Netbooks, smartphones and multi-function printer devices are examples of converging multiple features into a single device – typically smaller than any one of the previous "single function" devices. The demand for more of these devices, with even more functionality, smaller form factors, lower energy use per function and lessened material use, will continue into the future.

1. Introduction

1.1 Background to the Study

Consumer electronics in general, and information technology in particular, play a major role relative to global efforts to create a sustainable relationship with the environment. IT makes a significant positive contribution to human sustainability by empowering people worldwide with enhanced communication, increasing the efficiency of the economy in meeting human needs, and providing the foundational tools for planning, controlling, optimizing and monitoring environmental impacts.

While Canada has a small market share of the global consumer electronics market, representing only 1% of world sales, it plays a key role as a leader advocating environmental sustainability. Canada is noteworthy in that its electronics industry, through Electronics Product Stewardship Canada (EPSC), works closely with governments at the federal, provincial, and even municipal level to promote sustainable management of consumer electronics throughout production, use and EOL stages. Industry joins regulators and policy-makers regularly in both informal and formal idea-generating and decision-making settings to ensure communications are clear, stakeholders understand one another's agendas, and that industry continues to exceed public expectations for enhanced environmental performance.

EPSC was created in 2003 as a not-for-profit organization working to design, promote, and implement sustainable solutions for appropriate management of Canada's electronic waste. Led by industry, EPSC works with many key stakeholders, including provincial regulators, academia, electronics recyclers and others, to design, promote and implement sustainable solutions for appropriate management of Canada's electronic waste. EPSC is the environmental voice for the electronics industry in Canada. As product stewardship programs grow across Canada, EPSC seeks to stay in the forefront of initiatives from regulators and program managers. EPSC has been instrumental in establishing industry-led EOL electronics management programs in Saskatchewan, Ontario, BC and Nova Scotia. DfE is of key concern to EPSC as one of the ways in which electronics stewards can improve long-term performance, and reduce the long-term environmental footprint of electronics products in Canada.

EPSC issued a Design for Environment report in 2006. In 2008, EPSC hired Green Electronics Council (GEC) to prepare a more detailed and updated Design for Environment report (DfE). This report is intended to serve as a resource for authorities to reference regarding the Canadian electronics industry's efforts in the DfE arena, and as a reference for those considering potential legislation focused on DfE improvements. This report builds on and enhances the work done in a similar 2006 EPSC report, "Designing for the Environment[1]."

For specific examples of companies that are working towards making a significant difference in the five key environmental areas, see Appendix A.

[1] www.epsc.ca/dfe/

2. Green Procurement Initiatives in Canada

2.1 The Context

Research into green procurement initiatives in Canada highlights some promising trends. Increasingly, government purchasing agencies and consumers are recognizing the influence of their purchasing power. The Canadian federal government alone buys about $20 billion in all goods and services, more than the total operating budgets of many smaller countries. It is estimated that the federal government purchases between 32,000 and 37,000 notebooks and 70,000 to 80,000 desktop computers annually. Purchasing agencies can exert strong influence on the environmental integrity of products by incorporating environmental preferences in their tendering specifications.

The Canadian government, as well as provincial and local governments, recognizes the importance of harmonizing environmental attributes requested of electronic manufacturers with other jurisdictions, especially the United States. For this reason, the federal government's purchasing agency, Public Works and Government Services Canada (PWGSC) has adopted EPEAT and ENERGY STAR standards in its notebook, desktop and server tender specifications. These environmental criteria play a major role in the evaluation process

EPEAT is now specified in the *Canadian National Master Standing Offer for IT Equipment*, and many Canadian agencies and jurisdictions, including PWGSC, are incorporating green specifications and/or EPEAT into their IT tender documents. Some jurisdictions specify EPEAT Silver standards for all desktop and notebook purchases, at a minimum, and have done so since 2007.

2.2 EPEAT in Canada

EPEAT is an environmental purchasing program that explicitly covers the US and Canada, though it is now being expanded internationally. Table 1 shows the unit sales of EPEAT-registered products in 2007.

Table 1: 2007 Unit Sales of EPEAT Registered Products[2]

Region	Desktops	Notebooks	Monitors	Integrated Systems	Total
Canada	983,029	561,096	1,606,612	0	3,150,737
USA	12,403,405	10,375,874	18,883,816	1,196,621	42,859,716
Rest of World	22,478,991	13,219,158	28,218,926	59	63,917,134
Total	35,865,425	24,156,128	48,709,354	1,196,680	109,927,587

Sales of EPEAT-registered desktop computers in Canada were 172,000 in 2006; as shown in Table 1 above, this increased over fivefold to sales of 983,000 in 2007.

[2] Environmental Benefits report 2007, www.EPEAT.net.

EPEAT was designed and created by a multi-stakeholder process. Industry's initial and ongoing support of EPEAT has been strong, and is based chiefly on two benefits that it offers to the industry:

1. EPEAT establishes a common framework for measuring the effectiveness of industry's DfE efforts. Industry promotes EPEAT because it can help to harmonize DfE requirements and standards so that all of industry, as well as standard setters and users, can share a common language and set of goals.
2. EPEAT provides a clear measure of environmental performance for industry competition. That is, it is a shared incentive that rewards industry efforts for continuous improvement. Industry participated in the setting of tough standards, especially in the optional criteria that are now the market-place distinguishers.

Table 2 provides a summary of the environmental benefits from purchasing of EPEAT-registered products in Canada in 2007.

Table 2: Environmental/Cost Benefits of 2007 Canada Purchasing[3]

Benefit Category	Savings
Energy	1.34 billion kWh
Primary Materials	2.4 million metric tons
Air Emissions	5.54 billion kg
GHG Emissions	105 million kg
Water Emissions	11.6 million kg
Toxic Materials	91,400 kg
Hazardous Waste	3.56 million kg
Cost Savings	$116 million

2.3 EcoLogo™ and Other Green Procurement Standards

The other ecolabel that covers electronics in North America is EcoLogo™. It encompasses a broad list of electronic products and peripheral electronic devices, such as printers (laser and ink jet), photocopiers and facsimile machines. EPEAT and EcoLogo™ have signed a cooperative agreement that establishes EcoLogo™ as a certifier of EPEAT products. This agreement will allow IT products to be registered with either environmental program based on the common, harmonized standard – IEEE 1680.

Other initiatives underway include the ENERGY STAR program, which has been modeled on the United State's ENERGY STAR program, ensuring that all technical specifications are the same for Canada and the United States. The Energy, Air and GHG Emissions environmental benefits in Table 2 are mostly from the inclusion of ENERGY STAR as part of EPEAT. Canada has been pursuing an action plan for standby power that would target consumer electronic products, and has encouraged its NAFTA trading partners to pursue similar standards.

[3] Environmental Benefits report 2007, www.EPEAT.net.

2.4 Clean Production and Toxics Related Legislation in Canada

Canada has also implemented numerous programs promoting clean production and responsible management of electronics products. In 2006, Canada launched the Chemical Management Plan with a mandate to categorize 23,000 toxic chemical substances[4] in order to identify substances to which the human population is most likely to be exposed, as well as those which are persistent, bio-accumulative, and/or inherently toxic to humans or the environment. Currently, 4,300 chemical substances have been identified as needing a more thorough examination. Five hundred of these were considered to have the greatest potential for causing harm, and are receiving highest priority for study.

Under the *Canadian Environmental Protection Act* (CEPA), the federal government has authority to set limits and restrictions on new or additional uses of chemicals, including the establishment of regulations, guidelines, codes of practice, or other mechanisms to reduce the environmental and/or human health impacts of the substance. Recently, two materials contained in consumer electronics – mercury and brominated flame retardants – have been targeted as high-risk toxic materials requiring special attention and restrictions. The province of Ontario announced a Toxics Reduction Strategy in late November 2008 that will initially target a defined list of chemicals including Bisphenol A and lead-related compounds.

2.5 Canadian End-of-Life Electronics Programs and Design For Environment Requirements

Canadian provinces and territories are predominantly responsible for waste management policy setting, with the federal role in waste management limited to toxics, transboundary and international issues. Canadian provinces and territories have embraced the concept of Extended Producer Responsibility (EPR) for managing a variety of materials, with new programs being considered and implemented each year. EPR programs targeting a selected list of EOL electronics have been implemented in British Columbia, Saskatchewan and Nova Scotia to date. A program will be implemented in Ontario, in April 2009.

Many of the provincial EPR regulations or program plans for electronic waste include DfE elements and/or mandate product reuse and refurbish targets. The government of British Columbia requires that the electronic Producer Responsibility Organization (PRO) showcase industry design for environment initiatives as part of its reporting requirements. The Ontario Waste Electrical and Electronic Equipment (WEEE) Program Plan sets reuse targets, and requires the PRO to provide examples and analysis of reduction activities undertaken by industry, including DfE initiatives. Nova Scotia's electronic stewardship program requires brand owners to incorporate DfE in their planning process and requires Atlantic Canada Electronics Stewardship (ACES, the provincial electronic product stewardship program) to report on DfE improvements across the industry.

[4] Requires every new chemical substance made in Canada or imported from other countries since 1994 to be assessed against specific criteria.

3. Environmentally Sensitive Materials

3.1 Context

Computers, televisions, monitors, notebooks, printers and other types of electronic equipment used at home, in the workplace and in schools have traditionally contained materials or substances that raise concern due to their hazardous constituents. These materials include lead found in CRT monitors and printed circuit boards, chlorinated plastics in cable wiring, brominated flame retardants (BFRs) in circuit boards and plastic enclosures, mercury in the lighting in some flat panel displays and other heavy metals. This is of concern because these substances and others found in electronics have been linked to adverse human health effects and environmental impacts. These products, when managed improperly at end-of-life (particularly in overseas informal recycling sectors found in some developing nations), can pose risks to human health and the environment.

In response to policy mandates, regulations and other market drivers – as well as growing public concern over the environmental impacts of electronics, and advancements in research and development of less harmful alternatives – the electronics industry has made significant strides in moving away from the use of these substances over the past two decades. This section discusses the positive movement made in reducing adverse impacts of materials of concern in electronic products manufacturing.

3.2 Mercury

In electronic products, mercury is primarily used in CCFLs, in the backlighting flat-panel displays of monitors, laptops and televisions.

During use, mercury is well sealed within an electronic product; however mercury-containing components require special EOL handling. Mercury is a neurotoxin that affects the brain and nervous system, particularly in the early years of life as a child's brain is developing. Mercury is one of the six substances regulated through Restriction of Hazardous Substances Directive (RoHS), although mercury lamps are exempt (see Section 3.6 for a discussion of RoHS and other regulations).

The Canadian federal government has responded to the need for mercury management by developing diverse policies and program initiatives. Mercury is identified in Schedule 1 of CEPA 1999 (List of Toxic Substances). It has been targeted for reduction and has been designated a Track 2 substance requiring life cycle management[5] to bring levels back to naturally occurring levels of mercury.

A separate process under CEPA is assessing options to address mercury in products. A Discussion Paper containing various approaches was released in December, 2007.

Under the Canadian Council of Ministers of the Environment (CCME), three Canada-wide Standards (CWS) for mercury have been signed. These standards target waste dental amalgam, fluorescent lamps and emissions from incinerators. The CWS for mercury-containing lamps calls for a reduction in the average mercury content of lamps sold in Canada. From a 1990 baseline,

[5] Because mercury is considered a naturally occurring substance, element or radionuclide, it is excluded from the Track 1 substance list requiring virtual elimination.

the numeric target was a 70% reduction by 2005 and a total reduction of 80% by 2010. This CWS also includes a commitment for jurisdictions to assess the feasibility of recycling/recovery of lamps, and to implement initiatives to encourage these types of activities, when appropriate. As well, mercury was targeted in the recently announced Ontario Toxics Reduction Strategy in November 2008.

EPEAT includes three criteria addressing declaration, reduction and/or elimination of mercury. GEC estimates that for 2007, EPEAT purchases resulted in a reduction of almost 295 kg of mercury, equivalent to the amount of mercury needed to fill over 482,000 household fever thermometers.

A few leaders in the electronics industry have recently made commitments to phase-out mercury use in LCD displays, primarily by switching to LED backlighting. LED backlights are known to be mercury-free and very recyclable. Compared to CCFL technology, which most LCD displays use today, LED displays are much more energy-efficient. Several manufacturers have already begun selling mercury-free, LED backlit televisions, monitors and notebook products.

3.3 Other Heavy Metals

The electronics industry has been working diligently to meet the RoHS requirements for restricted substances, including the three other heavy metals, in addition to mercury; lead, cadmium, and hexavalent chromium. Lead and hexavalent chromium have been designated "toxic substances" and placed on the List of Toxic Substances in Schedule 1 of CEPA 1999. Under this listing, the government of Canada has the authority to regulate and authorize other instruments to prevent or control the use and/or release of these substances.

For substances that are designated "toxic" under CEPA 1999 and added to the *List of Toxic Substances*, Environment Canada and Health Canada must propose prevention or control instruments for managing the substance, which will reduce or eliminate risks to human health and the environment posed by its use and/or release.

Lead: CRTs can contain up to 2 to 3 kilograms of lead, and circuit boards can contain some of this metal. Exposure to lead can cause brain damage, nervous damage, blood disorders, kidney damage, and developmental damage to a foetus.

Most major manufacturers are transitioning to flat-panel displays (FPDs), which do not require the use of lead. FPDs are thin (generally less than 4 inches), lightweight video displays used in a variety of applications, including laptop computers, desktop computer monitors, televisions, and microdisplays. FPDs are predicted to replace CRTs in almost every application in North America, particularly in desktop computer monitors and television sets. By 2008, devices that contain FPDs were projected to account for nearly 85 percent of the total U.S. demand for display products; by 2013, the percentage is predicted to reach 94 percent.[6] Worldwide, the move from CRTs to FPDs in monitors and televisions continues, with many manufacturers making commitments to no longer produce CRT televisions in many of the world's markets.[7]

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[6] King County, 2007. Literature Review Flat Panel Displays: End of Life Management Report. Prepared By: King County Solid Waste Division, Updated Report, April 24, 2008

[7] http://economictimes.indiatimes.com/News_by_Industry/Sony_to_exit_CRT_TV_business_in_India/articleshow/3843040.cms

Lead solder was widely used by industry, prior to the RoHS directive and other regional restrictions on lead. Lead was used due to its temperature range and reliability, as well as cost, primarily in the manufacture of printed circuit board assemblies. The switch to lead-free solder has not been simple and still faces many challenges. Not only do lead solder replacements generally require higher reflow temperatures in manufacturing, thereby using more energy; there are also concerns over the reliability of solder joints and the thermal stability of electrical laminates. Other unforeseen technological challenges have also occurred, most notably with "tin whiskers" (unintended growths of tin on the surface of circuit boards that cause short circuiting). These issues are requiring changes to manufacturing processes, are introducing other exotic or potentially hazardous materials (such as silver), are using more energy, and are causing higher defect and scrap rates – all of which impact negatively on the environment. It should be noted that the environmental and technological impacts of banning one material and its potential replacements should be better understood and evaluated before being regulated. Industry continues to test "lead-free" solder alternatives.

Cadmium: This heavy metal is found in some batteries, electronic contacts and switches; persists in the environment; and accumulates in living organisms. One common usage has been in plastics, as a stabilizer or colouring agent. Over three-quarters of EPEAT-registered products meet an optional criterion indicating that these products have concentrations of cadmium less than half the threshold level defined in RoHS (note that there is an exception for cadmium attributable to recycled content).

Hexavalent chromium: This heavy metal can sometimes be found in screws, metal railings, and metal casings/frames of chassis, hard drives, optical drives and power supplies. Given RoHS restrictions, and voluntary standards such as EPEAT, much of the industry is working to eliminate hexavalent chromium from their products.

Arsenic: This heavy metal is added during the manufacturing of the high performance glass used in LCDs, to prevent the formation of defects. Several manufacturers have announced plans to eliminate the use of arsenic in their displays.

3.4 Flame Retardants

Brominated flame retardants (BFRs), which are one family of chlorinated flame retardants, are frequently used in various types of products for the purpose of fire safety. They are commonly found in enclosure casings and circuit boards in the electronics industry. Although they are quite effective as flame retardants, BFRs' ability to persist in the environment has raised concern over their use and effect on human health. Many major manufacturers have risen to the challenge of eliminating BFRs in their products and are working to expand the availability of safe and suitable alternatives.

In addition to the two primary drivers for DfE with respect to environmentally sensitive materials, regulatory and legal requirements, customer requirements such as ecolabels and green procurement specifications, and advocacy organizations have all substantially influenced manufacturers' moving towards eliminating halogenated materials, primarily BFRs and Polyvinyl Chloride (PVC). One notable effort is that of Greenpeace and its *Guide to Greener Electronics*[8]. The guide ranks the 18 top manufacturers of personal computers, mobile phones,

[8] www.greenpeace.org/international/campaigns/toxics/electronics/how-the-companies-line-up

televisions and games consoles according to their policies on toxic, recycling and climate change.

Some manufacturers have developed timelines to eliminate all use of BFRs; however, not all of these companies have publicly released roadmaps on how they plan to get there.[9]

EPEAT, EcoLogo™ and other prominent global ecolabels have incorporated criteria that specify and promote the removal of brominated flame retardants.

3.5 Polyvinyl Chloride and Chlorinated Plastics

Polyvinyl chloride (PVC) is a chlorinated plastic that it is widely used by the electronics industry, mainly as an insulator and coating for electrical cables, as well as in packaging. However, throughout its lifecycle, from the use of hazardous raw materials during the manufacturing stage through the addition of various chemical additives, such as plasticizers to make it flexible and soft, to its EOL disposal, PVC presents environmental problems and human health concerns.

Viable alternatives to PVC exist for most applications, and a number of companies have already voluntarily phased it out of a wide range of their products, with stated goals of total phase-out by 2009. Many of the voluntary ecolabels to which the electronics industry registers products require that large plastic parts are free of PVC.

3.6 The Market Context

The electronics industry's efforts to reduce the use of materials of concern come from three major forces:

1. Many of the leaders in the electronics industry have made voluntary and public commitments to restrict use of certain environmentally sensitive materials, often at the encouragement of Environmental Non Government Organizations (ENGOs).
2. Regulatory and legal requirements are directing industry's use of these substances of concern.
3. The marketplace has tools of its own emerging that enable customers to efficiently purchase greener products through use of ecolabels and green procurement specifications such as EPEAT, Blue Angel, TCO, and organization-specific schemes like Wal-Mart's Green Supply Chain and Electronics Scorecard.

There are a myriad of global regulations and legislation targeting the use of certain substances in electronics products such as:

- European Union's Restriction of Hazardous Substances (RoHS)
- European Union's Registration, Evaluation, Authorization and Restriction of Chemical Substances (REACH)
- China's Management Methods on the Prevention and Control of Pollution Caused by Electronic information Products (Chinese RoHS)
- Japan's Green Procurement Survey Standardization Initiative
- Korea's RoHS

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[9] www.cleanproduction.org/library/electronicManufacturers.pdf

- Norway's Hazardous Substances in Consumer Products (as of December 2008, under review by Ministry of Environment)
- Canadian Chemical Management Plan
- Various U.S. state-level legislation incorporating restricted substance requirements

Although there are some commonalities between some regulations, each is unique, with varying requirements. The lack of harmonization of global regulations on restricted substances is a key concern of the industry.

The Government of Canada has chosen to take immediate action on five substance categories confirmed to be harmful to the environment and to human health in the long run, moving toward prohibiting most uses, including polybrominated diphenyl ethers (PDBEs). It will also be establishing the Virtual Elimination List under CEPA 1999, and adding the first substances to that list, which will include tetraBDE, pentaBDE and hexaBDE congeners.

Most procurement programs and tools include some kind of chemical or materials specifications or restrictions. Many reference either EPEAT, which requires RoHS compliance, or RoHS itself. In addition, ecolabels such as TCO, Blue Angel, IT Eco Declaration, Japan PC Green Label, Korean Eco-Label, and Taiwan Green Mark typically include restricted substances requirements.

3.7 Conclusions

The efforts of industry leaders to reduce and eliminate materials of concern are notable and to be commended. The electronics industry has made significant strides in moving away from use of these substances over the past two decades. This has been achieved through advancements in research and development of less toxic alternatives, as well as in response to policy mandates, and public interest in the environmental impact of electronics.

There is, however, a distinction between the leading companies and the many small- to medium-sized manufacturers and suppliers. Work still needs to be done to improve practices in smaller companies that produce little-known brands, since they have less capacity for innovation, less ability to influence their supply chain, and often less transparency with the public or regulators. Additionally, there are still many opportunities for all manufacturers to eliminate hazardous substances from electronics.

4. Environmentally Preferable Materials Selection

4.1 Context

With technical advances taking place on an ever-escalating basis, it is critical for the electronics industry to address the environmental impact throughout the entire life cycle of their products. More companies are recognizing the importance of materials selection. The goal is to design and manufacture electronics products so the resources needed to manufacture those products are minimized, the use of recycled and/or renewable materials is maximized, and new material blends and types are thoroughly evaluated for health and environmental safety prior to use.

4.2 Dematerialization

Dematerialization is key to reducing the environmental impact of the electronics industry. Simply put, dematerialization means making smaller products that provide the same or more functions as their larger ancestors. It's a way of having products deliver more functions with less material. Section 7 discusses in more detail the move to convergence of more functionality within electronic devices.

There are five main drivers for dematerialization: purchaser requirements; the increasing costs of raw materials; the increasing costs of transportation costs along the entire supply chain; the need for manufacturers to have greater control of their supply chains to ensure materials meet voluntary and regulatory requirements; and the general trend of consumer demand for miniaturization of certain products.

Manufacturers have introduced new technologies, as they become available, that allow for dematerialization of products. For example, the manufacture and sale of products in recent years has shifted from desktops to notebooks and from CRTs to FPDs. This has resulted in the dramatic decrease in material use per unit. A typical FPD uses little more than half the weight of materials in a conventional CRT screen, and requires approximately 60% less energy in use. The weight difference between desktops and notebooks is even more remarkable – typically an 80% reduction. Combined, a notebook with an additional flat screen display represents only one-third of the weight of a desktop with a CRT.

4.3 Packaging Optimization in Canada

Consumer packaging is subject to extended producer responsibility legislation in Ontario and Quebec, and stewardship and funding programs are in place in other provinces through a variety of mechanisms. Several provinces are in the process of developing EPR legislation targeting consumer packaging. Most ecolabels also address concerns with packaging, including appropriate marking, recyclability and reusable systems.

In recent years, industry has tended to use less packaging, while balancing the need to deliver the product without damage to the purchaser. Packaging engineering throughout the industry has worked to achieve the same goal along different paths. The use of moulded pulp, reduction in foams, and the move to more completely paper-based packaging solutions are some of the common trends being seen today.

4.4 Post-Consumer Recycled Content

Post-consumer recycled content means a product is using recycled material that has been recovered from the post-consumer waste stream (as distinguished from a post-industrial or "in plant" waste stream, which has historically been recycled).

Manufacturers' use of post-consumer materials such as plastics and papers in making new products and packaging is an example of "closing the loop." Closing the loop ensures that demand for post-consumer content materials continues from manufacturers, to keep the collection infrastructure for post-consumer materials thriving. This in turn reduces the extraction of virgin resources, resulting in significant environmental benefits through reduced logging and drilling for oil and gas, transportation energy use – and dramatic reductions in the negative greenhouse gas impacts associated with virgin resource extraction.

Similar to the German ecolabel, Blue Angel, which includes criteria for recycled plastic content for electronic products, EPEAT contains three criteria that specifically reward use of post-consumer recycled plastic content. Plastics recyclers reported in 2008 that, due to EPEAT, the demand for their material has increased significantly. However, ensuring a high-grade, consistent, and sufficient supply of post-consumer material is challenging. In October 2008, less than 5% of EPEAT-registered products declared conformance with the optional criterion, specifying that the product contained an average post-consumer recycled plastic content of 10% or greater. And only 3% declared to another criterion specifying a minimum post-consumer recycled plastic content of 25%.

Another challenge associated with "closing the loop" for plastics in electronics products is the BFR content used in plastics for fire safety. As described in Section 3.4, BFRs are commonly found in electronics products' enclosure casings and circuit boards. Although quite effective as flame retardants, BFRs' ability to persist in the environment has raised concern over their use and effect on human health. Some electronics manufacturers are voluntarily phasing out use of some or all BFRs. TCO, EPEAT and other ecolabels also contain criteria rewarding restricted use of BFRs. Due to a historic and widespread use of BFRs, it can be very difficult to find a reliable source of post-consumer plastic that is free of BFRs. Consequently, there is tension between assuring products are free of BFRs and maximizing use of post-consumer recycled plastic. It is important to note, however, that the plastics recycling industry is actively working to bring to market technology that would separate BFRs from recovered, post-consumer plastic.

A final challenge associated with "closing the loop" for plastics is that the majority of plastic parts in electronics are produced in Asia, while post-consumer plastic is recovered where the consumers are – primarily in the developed world. This presents an added step of transporting the recyclate back to the point of product manufacture. Some types of plastics are re-used in the market countries in different applications, thus "closing the loop" through a different industry or product. However, as observed above, most flame retardants used in electronics are quite specific to electronics, and present health risks that complicate this common approach.

4.4 Renewable/Bio-based Materials

With the price volatility and supply of oil continuing to be of concern, along with a growing awareness of greenhouse (GHG) emissions associated with petroleum-based plastics, some manufacturers are exploring the use of renewable resources to reduce the net environmental burden in product materials use. Bio-based plastics (typically made from corn-derived polylactide acids or PLA) hold the promise of creating materials with the versatility of petroleum-based plastics but a lessened environmental footprint.

To date, however, bio-based plastics are not performing as well as conventional plastics in such areas as flame retardance, impact resistance, heat resistance, and mouldability. As a result, their use in products has been limited to a very small number of parts. In October 2008, there was only one product in the EPEAT Registry, out of more than 950, which declared to an optional criterion specifying that the product contains greater than 5% renewable/biobased plastic materials. In addition, most bio-based plastics are not compatible with the recycling processes used for petro plastics, which means they can actually contaminate and inhibit plastics recycling.

Finally, the optimal EOL treatment of many bio-based plastics is biodegradation in an industrial composting facility. This is not a common EOL treatment for many materials used in electronics, and requires careful identification, removal, and segregation of bio-based plastics from other materials – thus complicating an already complicated EOL treatment process.

The trend in industry at this time has been more on investigation of these technologies rather than implementation. However, some companies have implemented bio-based materials in packaging.

4.5 Nanomaterials

Nanomaterials are gaining a lot of attention for many applications. This section explains what nanomaterials are, and their potential use and impact in the electronics sector.

What it is: Nanotechnology is the process of engineering and using materials between 1 and 100 nanometers in size. It is attracting increasing attention in the electronics industry because nanomaterials perform with interesting new properties, due to their extremely small size. One nanometer is one-billionth of a meter. To get a sense of this scale, note that a human hair is 100,000 nanometers wide, while a smoke particle is 10,000 times greater than a nano-molecule.

Most electronics equipment made with nanomaterials uses carbon nanotubes, which are generally considered the basic building block of nanotechnology. Carbon nanotubes are over a nanometer in diameter but many times that size in length, and have conductivity properties like a wire or a semiconductor. As well, they are bendable, 100 times stronger than steel and 1/6th the weight, have low resistance when transporting current or heat, can emit light, and can be made from renewable sources such as corn stover or cellulose. Nanoelectromechanical systems (NEMS) are now used in electronics product manufacture to support the drive to miniaturize chips – one of the many frontiers that electronics design continues to explore to meet the Moore's Law imperative.[10]

The bright side: Nanotechnology has the potential to dramatically improve the performance and environmental impact of electronics equipment. Enhancing conductivity can reduce power usage; products may become stronger, lighter, and much more durable; and safer nanomaterials can be substituted for toxic materials with the same performance characteristics. As well, materials can be engineered to incredible tolerances and very detailed specifications, making EOL management easier because materials will be very well known.

[10] Moore's Law: processor capacity doubles in speed about every two years. www.intel.com/technology/mooreslaw

Issues and Concerns: Because nanotechnology is a newly emerging option in material design and specification, the environmental risks and benefits are not yet well known. Research on the impacts on human health and the environment of nanomaterials is at a very early stage. One concern is that the human health and environmental regulatory framework that has evolved in North America and Europe is based on traditional toxicity characteristics of materials. Because chemicals behave differently at the nano level, it is possible that legislations, regulations and processes such as CEPA, NPRI, ARET and CMP[11] in Canada (or the TRI in the EPCRA, RCRA, and CERCLA in the US[12]) will not encompass the performance of these materials throughout their life cycle. Consequently nanowastes from manufacturing or products containing nanomaterials reaching EOL will pose a human health and environmental risk in their EOL management. With hundreds of products on the market containing nanomaterials, research is needed to determine if existing EOL strategies for recycling, or even disposal, are appropriate for nanoscale wastes from electronics equipment. For example, the Toxicity Characteristic Leaching Procedure (TCLP) is widely used to determine the toxicity of materials, such as those in shredded circuit boards (which contain toxic substances such as lead, cadmium, etc.). However, it is not known if a TCLP test will accurately predict the toxicity of nanomaterials in those same shredded circuit boards.[13]

Canadian Status: In September 2007, Environment Canada issued an Advisory Note concerning notification obligations for manufacturers and importers of nanomaterials. The Advisory Note confirms that nanomaterials are subject to the same regulatory requirements as chemicals and polymers, and accordingly, manufacturers and importers of nanomaterials are required to submit a New Substances Notification package to Environment Canada prior to the manufacture in or import into Canada of new nanomaterials.

Nanomaterials manufactured in or imported into Canada that are not listed on the Domestic Substances List (DSL) are considered new substances. The nanoscale form of a substance is considered a "new" substance if it has a unique structure or molecular arrangement. Accordingly, new nanomaterials are subject to notification under the regulations.

However, nanomaterials present challenges to the current regulatory framework under CEPA 1999 due to their novel properties. The existing risk assessments used as part of current regulations governing traditional chemicals and polymers may not appropriately address these challenges.

Applications: In the electronics industry, much of the research and development of nano-level applications is occurring at the component level, with integrated circuit (IC) makers pushing for ever-smaller chips that are then purchased by brand owners for incorporation into their products.

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[11] *Canadian Environmental Protection Act* (CEPA) provides the authority for the development of regulations and programs such as the National Pollutant Release Inventory (NPRI), the Accelerated Reduction/Elimination of Toxics (ARET), and the Chemical Management Plan (CMP)

[12] Toxics Release Inventory in the Emergency Planning and Community Right-to-Know Act, 42 USC § 116 (2005); Resource Conservation and Recovery Act; Comprehensive Environmental Response, Compensation and Liability Act (Superfund).

[13] "Where Does the Nano Go? End-of-Life Regulation of Nanotechnologies," Linda K. Breggin and John Pendergrass, Project on Emerging Nanotechnologies, Woodrow Wilson International Center for Scholars, July 2007.

4.6 Emerging Materials

One notable electronics industry trend is the emergence of fashion-conscious "designer electronics" targeted for the mass market. Often these products are slim and sleek, and many companies are seeing the competitive edge by making these designer items greener. These products use innovative designs and/or materials such as:

- Single external casing made of a single material such as aluminium
- User-replaceable external casings
- Ultra-compact designs
- Use of novel materials such as leather or bamboo

4.7 Conclusions

More companies are working towards designing and manufacturing electronics products to minimize resources needed for manufacturing, and to increase the use of recycled and/or renewable materials. Drivers for material selection consideration are primarily market-driven and include: voluntary procurement through tools such as EcoLogo™, TCO, Blue Angel and EPEAT; market differentiators; and economic factors. Dematerialization is a common practice in the industry, while the use of post-consumer recycled content and biobased/renewable materials remains more of a challenge.

5. Energy

5.1 The Energy Context

Energy generation, demand, use, and management are now a routine topic in design departments, boardrooms, and legislatures globally – as energy prices fluctuate (inexorably trending upwards) and access to energy sources comes into question through depletion or for geopolitical, environmental impact, or other reasons. The energy consumption of electronics products during their use continues to be an area of focus for consumers, regulators, and the industry.

There are noteworthy efforts in voluntary standards development:

- ENERGY STAR is the leading voluntary energy standard used worldwide, and is widely cited in purchasing requirements across a broad range of product categories.
- Some efforts at voluntary energy efficiency standards development are multi-year progressive standards like the Climate Savers Computing Initiative (CSCI), while others are multi-purpose efforts that include sustainability requirements as well as energy efficiency, such as EPEAT.

Utilities in energy-constrained jurisdictions are providing incentives to consumers and businesses when they purchase targeted and specific "high efficiency products" (ENERGY STAR appliances and windows). These incentives are beginning to be offered to consumers on devices such as flat panel monitors and computers.

Canada and the US work very closely on energy-related issues, as they are considered effectively the same market. For this reason, both countries typically adopt common standards such as ENERGY STAR. The Information Technology Industry Council[14] (ITIC), American Electronics Association[15] (AeA), American Council for an Energy Efficiency Economy[16] (ACEEE) and Technology CEO Council[17] (TCC) have worked together over the last two years to deliver reports identifying opportunities to drive efficiency. In 2007, the Climate Group[18] released the SMART 2020 report[19] on behalf of the Global e-Sustainability Initiative (GeSI)[20]. This focused on Information and Communication Technology products' (ICT) ability to substantially reduce overall energy consumption, far more than the use-phase energy consumption of ICT products themselves.

Reports from the Technology CEO Council[21] and AeA (Europe Report[22]) are included in most industry communications concerning energy strategy and opportunities for improvement.

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[14] www.itic.org/
[15] www.aeanet.org/
[16] www.aceee.org/
[17] www.cspp.org/
[18] www.theclimategroup.org/
[19] www.smart2020.org/
[20] www.gesi.org/
[21] "A Smarter Shade of Green," February 6, 2008, www.techceocouncil.org/
[22] "Advanced Electronics and Information Technologies: The Innovation-Led Climate Change Solution", September 17, 2007, www.aeanet.org/AeACouncils/Energy_Efficiency_Report_Launch_17September2007.asp

Voluntary standards are leading the way in energy management, although there has been a recent flurry in energy regulation regarding design and standby power usage.

5.2 Voluntary Standards

Many voluntary energy or energy-related standards exist in the market today. Table 3 summarizes the EPSC member companies that have adopted several of the most influential standards today. These standards are described briefly below.

Table 3: EPSC Member Companies Participation in Energy "Efficiency" Standards

EPSC Member Companies	EPEAT Member[23]	ENERGY STAR Partner[24]	Climate Savers Member[25]	80 Plus Qualified Computers[26]
Apple Canada Inc.	BofA*	Yes	No	No
Agilent Technologies	n/a	n/a	n/a	n/a
Brother International Canada	n/a	Yes	n/a	n/a
Canon Canada Inc.	n/a	Yes	n/a	n/a
CIARATECH	Yes	Yes	No	Yes
Dell Canada	BofA	Yes	BofD	Yes
Seiko-Epson	n/a	Yes	n/a	n/a
Hewlett-Packard (Canada) Co.	Yes	Yes	BofD	Yes
Hitachi Canada Ltd.	No	No	No	No
IBM Canada Ltd.	n/a	Yes	No	No
Lenovo Canada Inc.	Yes	Yes	BofD	No
LG Electronics Canada	Yes	Yes	No	n/a
Lexmark	n/a	Yes	n/a	n/a
Logitech	n/a	No	n/a	n/a
MDG Computers Canada Inc.	Yes	Yes	No	No
Microsoft Canada	n/a	Yes	BofD	n/a
Northern Micro Inc.	Yes	Yes	No	Yes
Panasonic Canada Inc.	Yes	Yes	No	n/a
Philips Electronics	Yes	Yes	No	n/a
Samsung Canada	Yes	Yes	No	n/a
Sharp Electronics of Canada Ltd.	n/a	Yes	n/a	n/a
Sony of Canada Ltd.	BofA	Yes	No	n/a
Sun Microsystems	No	Yes	Yes	No
Toshiba of Canada Ltd.	Yes	Yes	No	n/a

**Note: BofA means the member company sits on the Board of Advisors for EPEAT. BofD means the member company sits of the Board of Directors for Climate Savers.*

[23] http://www.epeat.net/Companies.aspx
[24] http://www.energystar.gov/index.cfm?fuseaction=estar_partner_list.showPartnerSearch
[25] http://www.climatesaverscomputing.org/about/member-directory/
[26] http://www.80plus.org/manu/buy.htm

ENERGY STAR and Ecolabels: ENERGY STAR is a program sponsored by the United States Environmental Protection Agency (EPA) and referenced worldwide. Natural Resources Canada had been developing similar standards on energy efficiency at the same time that ENERGY STAR was being developed in the US. Canada agreed to adopt the ENERGY STAR standards to promote harmonization, and to treat the Canada and US as one large market. ENERGY STAR products feature reduced energy consumption and improved efficiency performance. It is a voluntary standard, but is generally acknowledged as the leading standard for efficiency worldwide, and is generally considered a premier brand. The ENERGY STAR label is a requirement for many worldwide ecolabels such as TCO, Blue Angel, EcoLogo™, EPEAT and CSCI.

The ENERGY STAR program recently started reviewing and updating many of its criteria for electronics equipment such as televisions, computers, external power supplies, displays, imaging (printers) and computer servers. Manufacturers assure conformity through self-declaration and occasional spot-checks by ENERGY STAR.

Climate Savers Computing Initiative: CSCI[27] identified power supply efficiency requirements for computer and server applications. These efficiency points were identified in multi-year progressive phases, starting with compliance with ENERGY STAR. In addition, CSCI realized that just setting the bar was insufficient. Further requirements exist within the member's framework of CSCI that require the deployment of these high efficiency power supplies, in an increasing percentage of purchases over a multi-year basis. The combination of these factors has attracted the interest of many North American utilities, such as PG&E and Hydro Quebec. CSCI maintains a list of products whose manufacturers declare that they meet the standards, but there is no program for verifying the manufacturers' claims.

80Plus: 80Plus[28] is a collaborative effort with the Electric Power Research Institute[29] and operated by ECOS Consulting, which delivers third-party validation for power supply testing. The 80Plus organizations, in partnership with CSCI, have agreed and aligned test procedures and efficiency requirements to deliver these results. Power supply test results may be viewed on the 80Plus.org web site that provides manufacturer and model number of the power supply, along with pertinent efficiency and power factor information. Many consumer and computer manufacturers are utilizing this service to access utilities and rebate programs offered to offset the cost burden of high efficiency power supplies.

The Green Grid: The Green Grid[30] is an example of voluntary, "best in industry" collaboration and is designed to drive improved environmental performance of the data centre environment. The focus is at the data centre-level as opposed to efficiency for servers, other components of the data centre, or individual computers. The Green Grid collaboration encompasses and networks with globally significant efforts such as:

1. European Union Data Centre Code of Conduct
2. EPA's and Data Centre and Server Energy Star Standards

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[27] www.climatesaverscomputing.org/
[28] www.80plus.org/
[29] my.epri.com/portal/server.pt?
[30] www.thegreengrid.org/home

3. DOE's Save Energy Now
4. Climate Savers Computing Initiative

Green Grid's member groups and committees exist within North America, Europe and Asia. This activity places the Green Grid at the centre of data centre efficiency and metrics, establishing it as a significant force for energy efficiency and conservation.

5.3 Regulatory Standards

Energy-using Products Directive (EuP)

The Energy Using Products Directive, or the Ecodesign Requirements for Energy Using Product 2005/32/EC (EuP), is a European Union Directive aimed at integrating environmental aspects, specifically energy efficiency, into product design. The first of many implementing measures within the EuP, it establishes requirements for standby and/or off mode electric power consumption.

This directive specifically impacts electronics consumer and business equipment, including computers, displays, projectors, printers, and products with external power supplies (such as cell phones, PDA and MP3 players). Targets established for implementation are July 2010 at 1 Watt, and July 2013 at 0.5 watts. EMC Class A (servers and storage equipment) equipment is excluded from this directive. Compliance is through self-declaration, with conformity assured through issuance of the CE mark. Although based in Europe, the EuP Directive will have an impact on products designed, manufactured, imported and sold in Canada.

Standby Regulations

Canadian: Natural Resources Canada' s (NRCan's) Office of Energy Efficiency (OEE) is proposing to amend Canada's *Energy Efficiency Regulations* to prescribe certain products that use Standby Power as energy-using products, and to establish minimum energy performance standards for them. In particular the amendment will affect the following products:

- Compact Audio Products;
- Televisions;
- Video Playing/Recording Products;
- Computer Printers and
- Multi-Function Devices.

The regulations apply to products imported or shipped inter-provincially for sale or lease in Canada. NRCan are holding consultations on the proposed amendment in January, 2009 prior to publishing the proposed amendment wording in the *Canada Gazette*, Part 1.

Standby power is defined in the consultation document as the lowest level of electricity consumed by appliances which cannot be switched off (influenced) by the user and may persist for an indefinite time when an appliance is connected to the main electricity supply.

The State of California currently has an Appliance Efficiency Regulation which includes standby power limits for three consumer audio and video equipment categories (compact audio products, televisions and DVD players and recorders) and several other states plan to follow the California regulations. Canada is proposing an initial standard, effective in 2009, that will meet the current California limits for these products. The standards will be strengthened to a 1watt target in 2011.

A two-staged implementation is proposed for computer printers and multifunction devices with an eventual standard that is equivalent to the current ENERGY STAR criteria for these products by 2011.

Table 4: Proposed Tier 1 and Tier 2 Stand-by Power Limits

Product Type	Tier 1 (2009) Stand By Power Standard	Tier 2 (2011) Stand By Power Standard
Compact Audio Products	2W	1W
Televisions	4W	1W
Video Products	3W	1W
Printers (Small and Standard Size Format)	2W	1W
Multi-Function Devices	4W	2W

NRCan is proposing that the Tier 1 and Tier 2 energy efficiency performance standards for standby power apply to products manufactured after June 1st, 2009 and 1st June, 2011 respectively.

The regulations are expected to take effect in late 2009, after publishing in the Canada Gazette, Part 2. NRCan is not proposing mandatory EnerGuide labelling requirements. Dealers/importers would be required to report to NRCan verifying that the standby power requirements have been met prior to importing a product to Canada, or trading a product inter-provincially.

Worldwide: The definition of "Standby" in the International Standards IEC 62301 is now under consideration, and the committee draft proposed in November 2007 defines "standby mode" separately from "network-connected standby mode(s)." A significant shift is in process – countries that had voluntary standby limits are moving to mandatory requirements in legislation or regulation. Table 4 shows countries that have or will have standby regulations in force. Additionally, standby regulations are proposed for China, Brazil, Switzerland and Argentina.

Table 5: Standby Regulations in Force by Country Today

Country	Year Enacted/In Force	Product Categories
Australia/New Zealand	2002/2010	Consumer Electronics, External Power Supply EPS
California	2004/2007	Consumer Electronics, EPS
Europe	2005/2010	Consumer Electronics, EPS
Japan	1998/1998	TV & Consumer Electronics
Korea	2005/2009	Consumer Electronics, EPS

United States	2007/2008	EPS

5.4 Embodied Energy

There appears to be growing interest in evaluating the amount of energy – often referred to as "embodied energy" – and other resources used in the manufacture of electronics products. Preliminary research suggests that perhaps 80% of the environmental impact (including energy consumption) of many electronics products occurs during their manufacture, rather than during their use. This is in stark contrast to earlier estimates, which were closer to 20%.

This perspective on energy associated with ICT seems to have escaped the notice of analysts focusing on energy use, probably for two main reasons. First, it is very difficult to quantify, and second, it appears on analyses of energy consumption as the consumption of "industry", and is not associated with electronics products per se. It seems likely that this perspective will gain traction in the near future because it implies very different priorities when trying to reduce the environmental impacts of electronics. Although there is little hard research available at this point, embodied energy is likely to be a topic of increasing interest in 2009 and beyond.

5.5 Conclusions

Industry has been and continues to be a partner in the development of ENERGY STAR and other voluntary energy-management programs. These engagements will only increase over the next few years as EPEAT and ENERGY STAR expand into more product sets and more restrictive management levels for off, standby and use-phase energy.

The next challenge for the electronics industry will be to identify more than off or standby mode power limits. The evolution will be identifying true product efficiency, which could be represented as "Useful Work Performed divided by Energy Consumed." The tools required for developing this important metric are already in development as part of the benchmarks for computers. ENERGY STAR, along with the industry, is reviewing the EEcoMark and SPECpower tools for defining computer and computer server efficiency. Once these tools are available, defining computer efficiency will be possible. By developing them, other benchmark tools may become available to define product efficiency for consumer devices such as televisions, displays and printers.

Finally, the embodied energy of electronics will likely become a topic of research and conversation in 2009.

6. Designing for End-of-Life (DfEOL)

6.1 Context

In a world of rapidly changing consumer and industrial information technology and communications products, the concept of designing products to be "better for the environment" is a relatively new one. While what it means for a product to be environmentally friendly is a broad and complex discussion, this section focuses on making products that will not have adverse effects on the environment as they reach the end of their useful life. "End of life" (EOL) of an electronics device is generally defined as the point when the original user can no longer use it. It does not mean the product is broken.

At an electronics product's EOL, several things can happen. In decreasing order of environmental preferability, the product can be:

- Reused by a second user
- Refurbished and upgraded (and then donated or resold)
- Dismantled for selective component re-use
- Recycled for recovery of materials
- Disposed in a landfill or incinerator (legally or illegally)

Environment Canada estimated the amount of e-waste disposed in Canada in 2005 to be 67,324 tonnes[31]. Since that time, a number of provincial EPR programs have diverted substantial amounts of e-waste from disposal to recycling. A description of these EPR programs is provided in Appendix B, Electronic Stewardship Programs in Canada.

Most EPSC member companies include some level of DfE principles in their design criteria. These principles include the items discussed in earlier sections (reduced use of environmentally sensitive chemicals, selecting materials for positive EOL management and environmental impacts, and design for energy efficiency), as well as principles centred on maximizing EOL environmental outcomes of electronics products.

EcoLogo™ has begun to address DfEOL in its certification program for electronics products. In 2007, the EcoLogo™ program released a final draft certification criteria document pertaining to notebooks and desktop computers. The document featured environmental and performance criteria that explicitly addressed design for recycling:

- Modular construction for components
- Inclusion of replacement/disassembly instructions
- Easy disassembly
- Identification of items with special handling needs
- Labelling of plastic parts; plastic parts greater than 25 g are one type of polymer
- Stipulations on manufacturer takeback programs, to ensure responsible reuse and recycling.[32]

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[31] Source Environment Canada website at www.ec.gc.ca/nopp/docs/rpt/itwaste/EN/summary.cfm
[32] www.greenercomputing.com/resources/resource/canadian-environmental-choice-program-computers-ecologo-certification and www.ecologo.org/en/certifiedgreenproducts/

The final draft document was circulated for comments to different stakeholder groups in August 2007. However, it was never finalized – largely because of the then-recent success of EPEAT addressing the same product types and the industry's desire for harmonized standards. Currently, the EcoLogo™ program has criteria for printers (laser and ink jet), facsimile machines and photocopiers.

The electronics industry has made progress in recent years in several aspects of designing products to be more easily managed at end-of-life. These include use of single-piece external cases that are easily removable, and compliance with a number of voluntary ecolabels (detailed below) that mandate, among other things, fewer different plastic types, avoidance of adhesives or welds, and the use of snap-fit fasteners.

A number of procurement tools, policies, and manufacture initiatives globally are driving better DfEOL of electronics. These include:

- Voluntary Procurement tools
  - The EcoLogo™ ecolabel originated by Environment Canada, features environmental criteria for printers (laser and ink jet), facsimile machines and photocopiers that include design for recycling and reuse.
  - EPEAT requires a number of specific criteria for which brand owners can get credit for designing products that are more easily recyclable and easy to disassemble. EPEAT's DfEOL criteria are the largest of its eight performance categories. 26% of the required and 19% of the optional criteria relate to DfEOL
  - Wal-Mart's recent announcement that, starting January 2009, it would require manufacturers supplying its goods to follow stricter environmental standards.[33]
- Policy initiatives
  - Provincial producer responsibility legislation requires reporting on DfE progress. It has been built into the regulations and program plans of three provinces involved in electronic stewardship: Ontario, British Columbia and Nova Scotia. Details of the requirements are provided in Appendix C, Design for the Environment Requirements in Canadian Electronic Stewardship Programs.
  - The EU was drafting updates to its 2006 Battery Directive in 2008, requiring that electrical equipment be designed to allow batteries to be "readily removed" for replacement or removal at EOL. In addition, it will require producers to provide details on safe battery removal.[34] This is likely to reduce the disposal of small electronics devices with hard-to-remove batteries.

[33] "Wal-Mart announces new ethical and environmental principles," Stephanie Rosenbloom, International Herald Tribune, October 22, 2008. www.iht.com

[34] "New EU directive pushes toward replaceable iPhone batteries," Prince McLean, October 7, 2008. www.appleinsider.com/articles/08/10/06/new_eu_directive_pushes_toward_replaceable_iphone_batteries.html

- Indirect drivers
    - Local landfill bans by jurisdictions throughout Canada (such as the province of Nova Scotia and Metro Vancouver) and worldwide, necessitates a flow of scrap electronics into reuse and recycling markets[35].
    - In Europe, the enactment of the Waste Electrical and Electronic Equipment (WEEE) Directive[36] in 2003 mandated brand owners and manufacturers to recycle electronics in EU countries. This forced the development of recycling strategies by brand owners who may have never previously considered recycling their products.
    - Through early Fall 2008, a thriving global industrial growth created strong market demand for secondary metals that can be extracted more easily from a ton of scrap circuit boards than from a ton of dirt or rock. Similarly, worldwide demand for scrap plastics created a strong market for this material. The recent economic downturn in late 2008 will result in a softening of all these markets for an unknown period of time.

Laws protecting private information in the health care, banking, education, and other sectors mean this data must be destroyed on the storage media when electronics reach end-of-life. This will drive the growth of both refurbishment, with data wiping, and increased recycling of destroyed data storage media such as hard drives.

At the September 2008 Sustainability Summit of the International Electronics Manufacturing Initiative (iNEMI), a prominent global industry group, electronics manufacturers' representatives identified four key needs in the areas of reuse and recycling of components: ease of disassembly, identification, cross-compatibility, and a lifetime indicator. For better materials reclamation from the e-waste stream that design could influence, iNEMI saw needs for cross-industry collaboration and for self-regulation on a common group of plastics, noting that only a few are dominant (such as ABS, PC and epoxy). This group is convening a number of industry-led symposia on all aspects of sustainability.[37]

6.2 Conclusions

Although there are many drivers aiding in DfEOL, there are still challenges. Industry groups, national-level agencies and authorities in North America and Europe, along with key trade associations and various NGOs, are all working to create solutions that will break down the barriers to designing products with more efficient EOL management. Strategies for breaking down these barriers are many, and include changes in governmental policies, purchasing mechanisms, voluntary collaborative industry work groups, and continued research into all aspects of increasing EOL design.

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[35] Many Canadian jurisdictions have placed bans on electronic equipment at the landfill or from being picked up at the curb including: Metro Vancouver, the Province of Nova Scotia and the Region of Waterloo, Ontario which, among others, has banned electronic waste including personal computers, printers and televisions from landfill; and the City of Toronto, which refuses to pick up waste electronics at the curb as part of its garbage collection service.
[36] Directive 2002/96/C of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment.
[37] www.nemi.org/cms; personal communication with iNEMI participants, Fall 2008.

7. Product Design – Convergence, Expandability, New Devices

7.1 Market Context

Due to rapid changes in technology and the ever-growing demand by consumers for devices that offer ease of use and portability for today's lifestyles, devices' ability to communicate with each other has become an important feature. Additionally, devices that perform more than one function or allow users to perform activities that were once impossible are becoming more and more desirable.

The idea of expandability and connectivity is not new. For example, expandability for electronics products has been around many years, through the use of wired connections for external devices. What is new are a series of standards for both wired and wireless connectivity that the industry is adopting. These include Universal Serial Bus (USB) and Bluetooth. Voluntary standards and efforts such as Blue Angel, EPEAT and the Digital Living Network Alliance (DLNA) all promote the use of connectivity and expandability technologies.

Device convergence has also been around for several years, most notably in the imaging sector where multifunctional imaging equipment is common, combining printing, scanning, faxing and copying as well as the ability to create photographic quality "photo prints." Now, however, there are a wide variety of new, "essential" devices that provide multiple functionality. For example, smart phones provide email, web surfing, cameras, texting and phone capabilities. Some portable music players and gaming players, in addition to their main functionality, can play movies and connect to the Internet.

To date, the main driver for connectivity, expandability and the convergence of devices has been consumer demand. In addition, changes in technology have made new types of products more feasible and cost effective to produce, and therefore for customers to purchase. Environmentally, the desired impact is for better-connected devices with fewer wires and more compatibility, resulting in less obsolescence. The convergence of functions reduces both the resources and energy for production, transportation, energy consumption during use, and the EOL impacts – as a single device may now do the tasks that once took multiple devices.

7.2 Expanding Connectivity Options and Standards

Several industry-created standards already exist that directly or indirectly promote connectivity and product expandability. Additionally, there are opportunities for industry to be involved in the development of these standards. Table 5 shows four standards along with EPSC companies and their participation levels. Though these standards may not apply to each member company, due to the product sets of the standard, 100% of EPSC member companies are still involved in some way, either meeting the standard for their products via EPEAT or engaging in or using other standards, such as Bluetooth.

Table 6: EPSC Member Companies Participation in "Expandability and Connectivity" Standards

EPSC Member Companies	EPEAT Registered[38]	Bluetooth SIG level[39]	USB IF member[40]	DLNA Member Level[41]
Apple Canada Inc.	Yes	Associate	Yes	No
Agilent Technologies	n/a	Associate	Yes	n/a
Brother International Canada	n/a	Adopter	Yes	Contributor
Canon Canada Inc.	n/a	Associate	Yes	Contributor
CIARATECH	Yes	None	No	No
Dell Canada	Yes	Adopter	Yes	Contributor
Seiko-Epson	n/a	Associate	Yes	Contributor
Hewlett-Packard (Canada) Co.	Yes	Associate	Yes	Promoter
Hitachi Canada Ltd.	No	Adopter	Yes	Contributor
IBM Canada Ltd.	n/a	Associate	No	Promoter
Lenovo Canada Inc.	Yes	Promoter	Yes	Promoter
LG Electronics Canada	Yes	Associate	Yes	Promoter
Lexmark	n/a	Adopter	Yes	No
Logitech	n/a	Associate	Yes	No
MDG Computers Canada Inc.	Yes	None	No	No
Microsoft Canada	n/a	Promoter	Yes	Promoter
Northern Micro Inc.	Yes	None	No	No
Panasonic Canada Inc.	Yes	Associate	Yes	Promoter
Philips Electronics	Yes	Adopter	Yes	Promoter
Samsung Canada	Yes	Associate	Yes	Promoter
Sharp Electronics of Canada Ltd.	n/a	Associate	Yes	Promoter
Sony of Canada Ltd.	Yes	Associate	Yes	Promoter
Sun Microsystems	No	Adopter	Yes	n/a
Toshiba of Canada Ltd.	Yes	Promoter	Yes	Promoter

Expandability and its effect on DfE comes from voluntary efforts like EPEAT and the DLNA, which promote design characteristics to extend the life of products, or make them more compatible for consumers. For example, EPEAT has a mandatory requirement that registered products must be upgradeable, and specifically identifies USB as one way to meet this requirement. The DLNA promotes the interconnectivity of digital devices on a home network to make the sharing of digital media easier for consumers. It allows for the use of Bluetooth technologies, as part of the whole system, to provide this functionality. As both EPEAT and the DLNA have garnered much support from industry, the requirements of these voluntary efforts

[38] http://www.epeat.net
[39] http://www.bluetooth.com/Bluetooth/SIG/Membership/
[40] https://www.usb.org/members_landing/directory?complex_search_companies=1
[41] http://www.dlna.org/about_us/roster/

are changing how products are designed and their impact on the environment. For additional details, see Appendix D, Product Expandability Standards – Bluetooth, USB and DLNA.

7.3 Functional Convergence of Devices

A key trend in electronics product design over the past ten years has been the convergence of multiple functions or new function into a single product. This functional convergence has been made possible by many factors, not the least of which is the overall environmental improvements gained through energy use and resource reductions. Examples of new classes of products that now exist due to functional convergence include, but are not limited to:

- Multifunction imaging devices that print, copy, scan and fax documents
- Media or Entertainment PCs that combine the functions of a computer, DVR, and an HDTV
- Smart phones that combine phone functionality with Internet access - some also offer the functions of cameras, game players, portable video and/or music players
- Gaming systems that combine gaming with optical drives to play movies, have hard drives and Internet access that allows them to have some of the functionality of traditional computers

7.4 Future Trends

Electronic Paper/Digital Books: One of the more interesting technologies that is beginning to come to the market is a replacement for traditional digital displays. Sometimes called Digital Paper or Electronic Paper, the early generation of these displays is currently sold in book reader products from several different manufacturers.

This display technology replaces traditional LCD displays. It is more lightweight than the standard digital display, with a much higher resolution and viewing angle so that it more closely emulates the act of reading from paper.

Environmentally, it requires both less energy to manufacture and to run. It also has the potential to reduce both paper use and waste paper, as it is possible to print many images to an electronic paper display.

Current digital book readers are also providing a convergence of functionality for the user. Besides displaying books or even magazine and newspaper subscriptions, which obviates the need for printed material, these devices may also have the ability to play MP3 files or view PDF documents, and some provide limited connectivity to the Internet. As the design of future generations of these devices evolves, it is likely the line between a digital book reader and a notebook computer will disappear.

Ultraportable Notebooks and Netbooks: With increasing consumer demand for more mobile electronics device functionality, two very similar “new” classes of notebook computers have grown in popularity over the past two years. Ultraportable notebooks and their even smaller kin, netbooks, provide mobile computing in smaller forms, although with some limitations in functionality versus traditionally notebooks. Screen size is limited (generally under 10 inches for a netbook, slightly larger for the ultraportable), both devices are designed for power conservation and longer battery life, and the component parts (CPU, hard drive, memory) are chosen to optimize energy use rather than computing power. As technology progresses, however, it is likely energy optimization will still be possible, while providing more and more computing power. Designed for the highly mobile user, these PCs may not have optical drives and likely contain solid-state hard drives that allow for more durability.

Virtualization/Cloud Computing/Web Computing: Virtualization is the ability for one server to run multiple applications that previously needed dedicated servers. Thus, each application program has its own "virtual" server, but not its own physical server. Web and Cloud Computing refer to the increasing trend for applications and data to reside in a central location (a data centre) and to run from any computer over the web.

The technology industry is in the early stages of a big shift – one that will transform how we access information, share content and communicate. A new model of computing will drive this next wave. Instead of installing packaged software applications on their computers, people and businesses will use their web browsers to access a wide range of 'cloud services' available on-demand over the Internet.

The ability to distribute computing across data centres should facilitate more efficient use of existing data centres and reduce the need for more data centres to be built by organizations that embrace virtualization.

Ultraportable notebooks, smart phones, the greater adoption of thin-client systems that have the primary function of connecting to the web, and Cloud Computing centres will all be a growth area for the industry. The move to this type of interface, through a central computing location, will provide additional environmental benefits in dematerialization and energy use.

7.5 Conclusions

In the area of product expandability, there are several drivers today. Technology standards for connectivity such as Wi-Fi, WiMax, wireless WAN standards like 3G, USB and Bluetooth have been developed, widely adopted and supported by the electronics industry. Consumer demands for ease and connectivity is promoted and adopted by industry through the DLNA and similar organizations.

There has been an accelerating move over the past ten years to create products that are easier to use, with multiple functionalities. Printers, televisions, PCs and cell phones now have abilities far beyond the original vision when they were first introduced to the market. And industry continues to improve these devices, making them smaller, faster, more energy efficient and with a longer life, in addition to incorporating more features.

New technologies and ways to provide more functionality choices to consumers and business are always under consideration by the electronics industry. Current research on new technologies encompasses all aspects of environmental improvement, for both the end-user and the manufacturer.

The combination of technological improvements and developments, coupled with the consumer desire for more portable, smaller, faster and more interconnected devices, is having a net positive effect on DfE. Fewer resources are consumed in the manufacture of these devices, they use less energy and – because they are designed to industry-accepted standards (such as EPEAT and DLNA) – these devices work together and are upgradeable, promoting a longer useful product life.