Part VI: Social, Economic & Environmental Impacts

WEEE Recycling and Jobs

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

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

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

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

WEEE Recycling and the Recovery of Materials

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

Unit Weights of Common Electronic Products

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

Table 25: Unit weights used in this report

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

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

Composition of Electronic Products by Weight

The United Nations University's *2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment: Final Report* provides average composition, by weight, of IT and telecommunications equipment (including computers, printers, photocopiers, and cellular and fixed telephones), CRT computer monitors and television sets, FPD computer monitors and television sets, and audio/video devices.

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

IT and telecommunications equipment

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

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

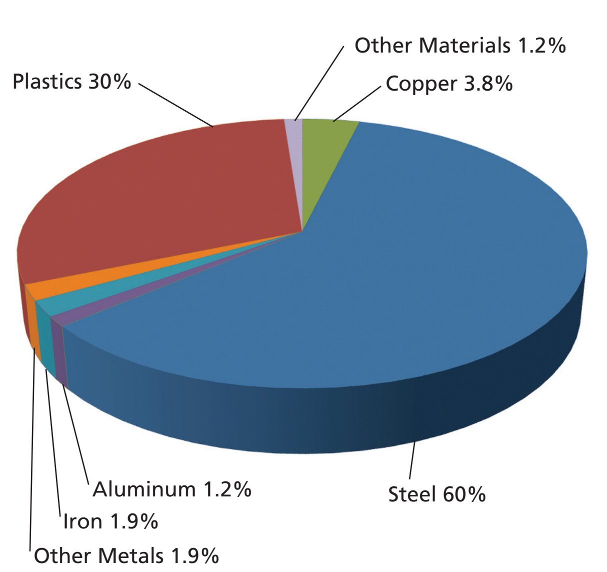

Table 26: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of computers, printers, photocopiers, and cellular and fixed telephones

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

CRT computer monitors

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

Figure 8: Composition of major materials in CRT computer monitors

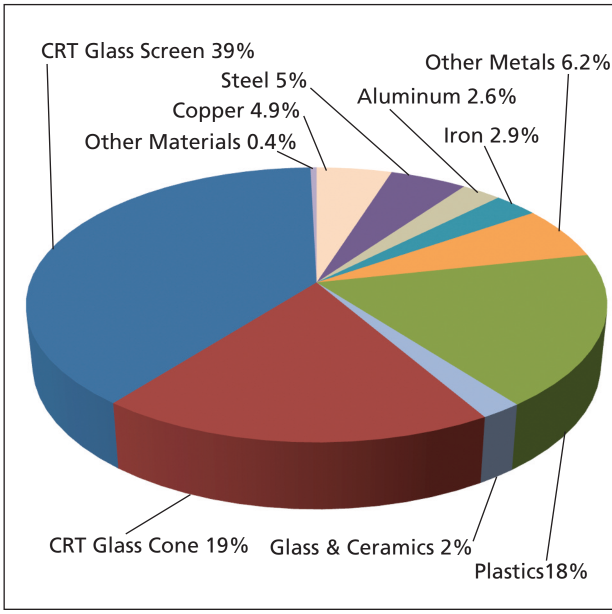

Table 27: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of CRT computer monitors

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

Flat panel display computer monitors

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

Figure 9: Composition of major materials in FPD computer monitor

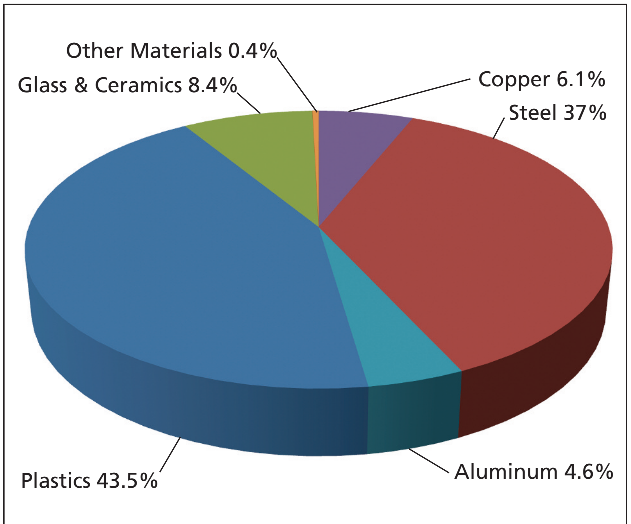

Table 28: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of FPD computer monitors

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

CRT television sets

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

Figure 10: Composition of major materials in CRT television sets

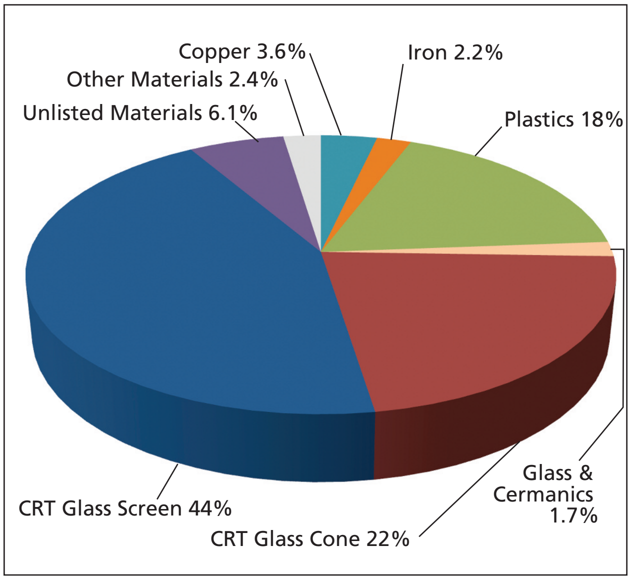

Table 29: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of CRT television sets

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

Flat panel display television sets

Figure 11: Composition of major materials in FPD television sets

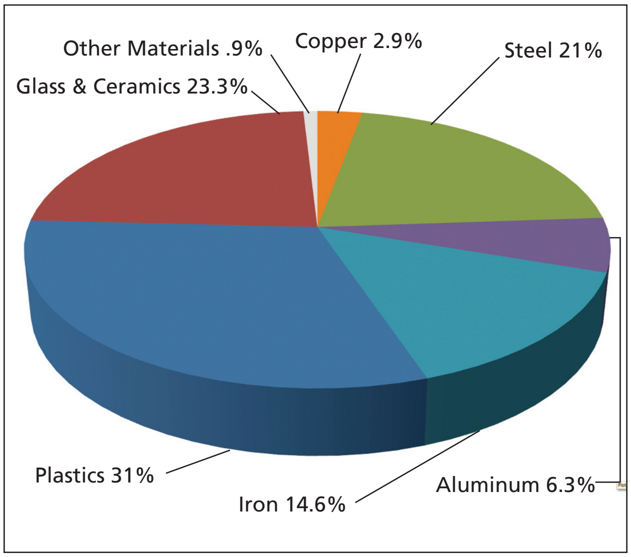

Table 30: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of FPD television sets.

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

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

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

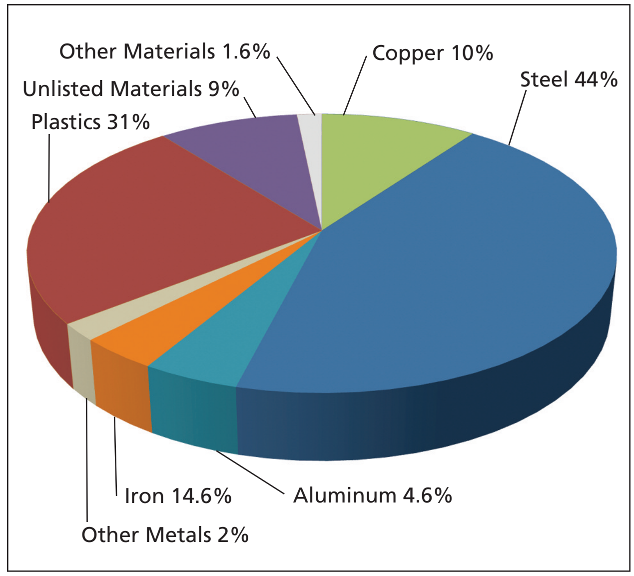

Table 31: Composition, expressed as a percentage of the whole, of materials making up less than one per cent of CRT television sets

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

Total Recycled Materials by Type

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

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

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

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

Value of Collected WEEE

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

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

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

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

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

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

Elements and Substances of Concern in WEEE

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

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

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

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

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

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

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

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

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

The IARC has not classified barium as to its carcinogenicity.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

In humans, lead toxicity affects the nervous system, primarily, but it can affect nearly every organ in the body. Exposure to high levels of lead, either through breathing or swallowing, can damage the brain and kidneys. In pregnant women, it can cause miscarriage.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Rare Earth Elements

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

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

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

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

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

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

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

Gadolinium is found in the screen, circuitry, and speakers of the iPhone. It is considered to be of low toxicity and not to be a threat to plants or animals.

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

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

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

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

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

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

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

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

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

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

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

What all this means is that, with demand for these devices skyrocketing, demand for rare-earth metals is going to increase as well. Many (but not all) of these elements are exactly as they sound, rare. Global production of the materials ranges from 23,000 tonnes per year for cerium to only 10 tonnes per year for terbium. In between are lanthanum (12,000 tonnes per year), neodymium (7000), praseodymium (2500), yttrium (600), gadolinium (400), and europium and dysprosium (100).

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

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

Above that, the EC's working group considers China to be an "environmental risk country," meaning that there is a possibility that the country could impose new environmental regulations that could affect the supply by curtailing the mining industry. (Since the working group's report on critical materials, there is now some mining is the United States and Japan, which has likely reduced China's 97% of world production.)

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

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