The complete e-waste recycling process

The amount of e-waste generated around the world in recent years has exploded, driven by changes in technology, planned obsolescence, changes in media and storage types (tapes, CDs, HDs, SSDs etc.), and easier accessibility through decreasing costs. As the availability and use of electronics increases across the globe, e-waste has become the fastest-growing waste stream in the world.

E-waste refers to any electronic devices that have reached the end of life. Unfortunately, many of the items that are labeled as “e-waste” are in fact not, since old devices that are no longer wanted but still working (or suitable for repair) can be donated, reused, or refurbished.

The most common types of e-waste

The term e-waste covers a huge range of products, with the most common categories by weight being:

Small Equipment

- vacuum cleaners
- microwaves
- ventilation equipment
- toasters
- electric kettles
- electric shavers
- scales
- calculators
- radio sets
- video cameras

- electrical and electronic toys
- small electrical and electronic tools
- small medical devices
- small monitoring and control instruments

Large Equipment

- washing machines
- clothes dryers
- dish-washing machines
- electric stoves
- large printing machines
- copy equipment
- solar panels

Temperature Exchange Equipment

- refrigerators
- freezers
- air conditioners
- heat pumps

While these groups of items are growing by weight, individuals and businesses looking at how to process e-waste are likely to be more concerned with small IT and telecommunication equipment, which includes cell phones, GPS devices, routers, modems, computers, printers, telephones, etc. Through miniaturization, they show up as a smaller part of the waste stream, however, the circuit boards and batteries within these products are a big contributor to the many problems e-waste creates.

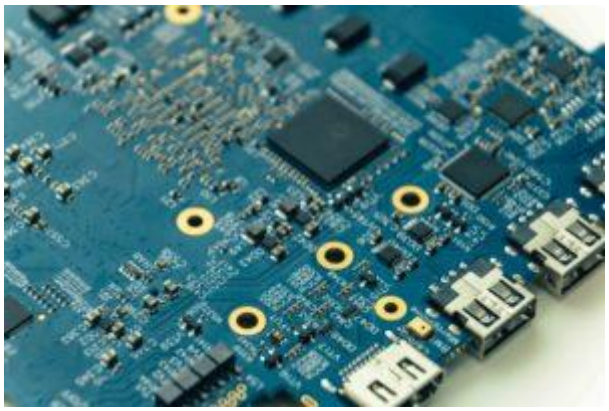
Source: Roadrunner

Why is electronic waste recycling important?

Before looking at how electronic waste is recycled, it's important to know why. Sustainable waste management helps to offset the negative impacts of waste while also providing a number of benefits, mainly through keeping materials in circulation.
Municipalities across the US, and indeed the world, are pushing for greater awareness of the problem and urging businesses across all industries to take greater responsibility for their e-waste products. This has a knock-on effect, and through producer responsibility, consumers have more choice when it comes to recycling (or reusing) e-waste products.
Today, e-waste management is not keeping pace with our consumption, so the importance of recycling e-waste on large scale cannot be underestimated. Unless we improve our management systems, we will soon be surrounded by broken electronics.

The problems with not recycling e-waste

Improperly managed e-waste, including that which is sent to landfills and incinerators, can release toxic chemicals into the ground, air, and water supplies.
Just some of the pollutants that can be released through e-waste mismanagement are:



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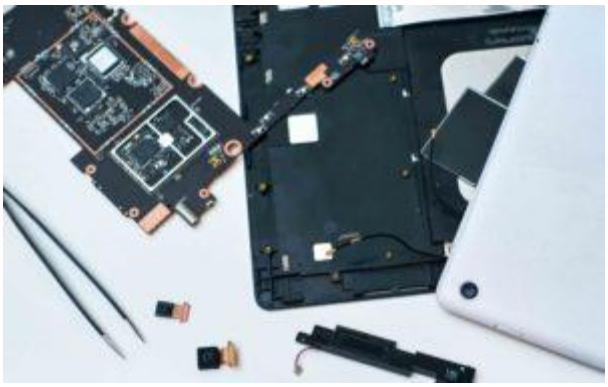
  - Lead
  - Barium
  - Phosphor
  - Beryllium
  - Cadmium
  - Mercury
  - Brominated dioxins
  - Polycyclic aromatic hydrocarbons

These toxic materials, and in particular heavy metals such as mercury and cadmium, can cause damage to ecosystems, build

up in food chains, and have direct and immediate effects on human health.

Additionally, by failing to reuse or recycle e-waste, new natural resources must be mined in order to manufacture electronics rather than recovering what is already in the economy. Precious metals are a crucial component of most PCBs (printed circuit boards), with gold, silver, platinum, and palladium all present and all becoming difficult to find. This has a massive ecological impact through the mining, transportation, and production required to source and extract valuable metals for “disposable” devices.



The benefits of recycling

e-waste

On the flip side, recycling e-waste allows for the recovery of materials such as gold, copper, glass, aluminum, lithium, plastic, and more. According to one study, the value of the raw materials in e-waste was roughly 55 billion euros in 2016. What’s more, these materials are returned to the supply chain for the production of new products, reducing the environmental impact, minimizing hazardous materials in the environment, and generally increasing the sustainability of the production of new electronics.

There is also a significant social and economic impact, with recycling and reuse accounting for 681,000 jobs in a single year, according to the EPA. Of course, e-waste is only a part of that, but as the fastest growing waste stream, it is likely to become increasingly significant as we become more reliant on digital devices.

What are the challenges of recycling e-waste?

In 2019, the United Nations reported that, by 2050**,** the global generation is set to reach 120 million tons of e-waste per year if our current systems do not change. However, the challenges associated with e-waste recycling programs and increasing diversion rates are not insignificant.
In fact, those chemicals, heavy metals, and other substances which are harmful to the environment can also create difficulties in the recycling process, and hazardous waste such as this must be carefully disassembled. This is especially problematic when e-waste is exported to developing countries where the people breaking down electronics are forced into extremely unsafe work environments in unregulated plants.

The methods used to process waste in these informal recycling facilities can also have severe environmental impacts and burning away plastics to recover metals without filters leads to an increase in emissions. While this does represent a significant concern, it can be avoided by ensuring your e-waste is handled by a reputable processor.
In addition to this, the range of different electronics makes dealing with “e-waste” as a single stream highly problematic, since recycling a fridge is very different from recycling a smartphone. Further still, even individual electronic products are often made of mixed materials such as plastic, metal, and glass. This poses a problem for recyclers, as separating these materials is difficult, costly, and time-consuming, especially compared to single-material products like cans and glass bottles.
Municipal and private electronic waste collections will specify what electronic items they will accept in their program as it differs across the US. For example, some programs may not accept appliances like microwaves or refrigerators but some ‘e-waste events’ held within communities may accept appliances

as part of a recycling program as they are made up primarily of metal or rigid plastic.

Despite the inherent challenges facing the recycling industry, there are systems in place that look to solve the e-waste problem. Here, we look at common, step-by-step processes of general e-waste recycling before going into the specifics of some of the items most frequently scrapped by businesses and homes.

E-waste recycling process flowchart

Collection Storage Sorting, Dismantling, Shredding Mechanical Separation Magnetic Water Recovery

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The e-waste recycling process

Step One — Collection

The first stage in the recycling process for e-waste is the collection of electronic products through recycling bins, collection locations, take-back programs, or on-demand collection services. The mixed e-waste is then taken to specialized electronics recyclers.

Best practice dictates that e-waste should be separated by type at this stage of the process, which is why many collection sites will have different bins or boxes for different items. This is especially important for e-waste containing batteries, which require special treatment and can be very damaging if mixed with other waste.

Step Two — Storage

While safe storage may not appear critical, it can prove very important. For example, the glass screens of Cathode Ray Tubes (CRT) TVs and monitors are highly contaminated by lead. In the past, they were recycled into new computer monitors, but the growth of new technology and subsequent

decline in demand for CRT products means much of this glass is now simply being stored indefinitely.

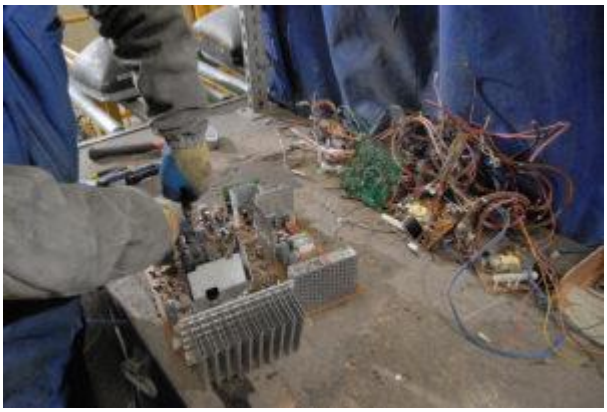
Step Three — Manual Sorting, Dismantling, Shredding

E-waste then goes through the initial stage of manual sorting, where various items (such as batteries and bulbs) are removed for their own processing. This is the stage at which some items may also be manually dismantled for components, reuse, or the recovery of valuable materials.

E-waste is then shredded into small pieces allowing for accurate sorting of materials, a key part of the process. Most electronics are a mix of materials, and breaking items down into pieces that measure just a few centimeters means they can be separated mechanically.

Step Four — Mechanical Separation

The mechanical separation of the different materials actually consists of several processes one after the other. The two key steps are magnetic separation and water separation.



Magnetic Separation

The shredded e-waste is passed under a giant magnet, which is able to pull ferrous metals such as iron and steel from the mix of waste. In addition to this, an eddy current may also be used, separating the nonferrous metals. These materials can then be diverted to dedicated recycling plants for smelting. Other materials such as metal-embedded plastic and circuit boards are also separated at this stage.

Water Separation

With a solid waste stream that now consists mainly of plastic and glass, water is used to separate the materials, further purifying for the separation of different plastics as well as hand-sorting obvious contaminants.

Step Five: Recovery

The materials, now separated, are prepared for sale and reuse. For some materials, such as plastic or steel, this means joining another recycling stream. Others may be processed onsite and sold directly alongside usable components separated in the early stages.

How the universal recycling process differs across common items

While this represents the general e-waste management recycling process, many items have their own unique processes. For example:

The Recycling Process for Batteries

Upon arrival at a site, batteries are sorted by chemistry—lead-acid, nickel-cadmium, nickel-metal-hydride, and lithium-ion. Combustible materials, such as plastic casings and insulation, are burned off, with a scrubber being used to capture polluting particles and gasses created during the incineration process.

The emptied metal cells are then chopped into pieces and heated until the metal liquefies, and non-metal components burn and gather on the top as a substance known as slag, which is scraped from the surface. At this point, some centers send unprocessed metal to specialized recycling plants. Other plants collect the metals during the liquification process since they settle in layers according to density. Cadmium vaporizes during this process and is collected through a condensation process.

The Recycling Process for Cathode Ray Tubes

Cathode Ray Tubes are considered one of the most troublesome types of waste to recycle. While many of their components can be broken down, they can contain as much as four pounds of lead per monitor/TV. This represents a significant threat, and the glass is so contaminated by this lead that it can't be added to normal glass recycling streams. While this outdated technology might not seem like a problem going forward, there remains a huge issue regarding recycling old items.

The E-waste Recycling Process for Computers and Laptops

The process for recycling laptops and computers is very similar to the general process outlined above. However, there is likely to be a greater focus on manual sorting and separation since computer components from broken machines can be combined into new computers with no extra resources.

What's more, the e-waste recycling process is also likely to include some sort of data destruction. This will be carried out digitally by wiping those hard drives that are reusable, or physically, by shredding them or using other data destruction methods. Businesses and individuals are increasingly concerned about data protection, and the shredding of confidential paper documents is already common practice.

Destroying data on hard drives is simply the 21st-century equivalent.

Finally, the Basel Convention identified e-waste as a problem back in 2002, and yet, we are only just at the beginning of a long journey towards an ideal zero e-waste world. Our digital world is here to stay, and if we continue to consume non-recyclable equipment at current rates without comprehensive reduction, reuse, and recycling programs in place, we will quickly deplete natural resources and create e-scrap on an unimaginable scale.
However, there is hope that we can strive for a more circular economy with e-waste, and both businesses and individuals can make a difference through conscientious consumption, reduction, and reuse, eventually pushing manufacturers towards more easily recyclable devices through producer responsibility programs.