© Pieter Hugo. Courtesy of Stevenson, Amsterdam/ Cape Town/ Johannesburg, Yossi Milo, New York and Priska Pasquer, Cologne

INTO THE E-WASTES

Jodie Lea Martire ventures into the "global tsunami" of e-waste as part of our ongoing series on recycling industries.

The United Nations says the world is drowning under a "tsunami of e-waste": the unnatural by-product of our digital age. The term "e-waste" is generally understood as comprising any broken or obsolete item with a battery, plug or power cord. It is generally considered hazardous because it often contains toxic substances or additives: mercury, lead, cadmium, PVC, flame retardant chemicals, and more.

The world's e-waste problem is growing rapidly, driven by a global increase of "electrical and electronic equipment" (EEE) purchases of 2.25 m tonnes per year. In 2019, the world generated 53.6 m tonnes of e-waste, only 17.4% of which was recycled.

Australian e-waste reached 539,000 t in 2018-2019—an average of 21.3 kg per person per year—with 40% coming from households. Only 9% to 11% of our e-waste was properly recycled in 2019, compared to around 50% of general waste, and only 2% of our lithium-ion batteries did the full circle.

But e-waste isn't just about sending your old phone to Mobile Muster (which, if you're not familiar with it, is the Australian phone industry's collective recycling scheme). The Global E-waste Monitor identifies six categories of EEE that later become waste (and that's just domestic items):

- Temperature exchange equipment (e.g. fridges, freezers, air conditioners);
- Screens and monitors;
- Lamps and light bulbs;
- Large equipment (white goods, PV panels);
- Small equipment (vacuums, medical devices, power tools, e-cigarettes); and
- IT and telecommunications equipment (phones, computers, routers, GPS devices).

The good news is that 90% of e-waste can be recycled—including 98% of computers and televisions! So where is Australia at?

How is e-waste recycled?

Industry standard AS/NZS 5377, which applies in both Australia and New Zealand, sets out the process for safe handling and recycling of e-waste.

Waste materials are delivered by (or collected from) offices, councils and homes to the recyclers' warehouse. Items are initially sorted into categories by hand, and components like batteries, glass, toner, printer cartridges, polystyrene, cardboard and cords are isolated. Hand pickers remove computers' motherboards, RAM, hard drives and optical drives for resale, and disassemble circuit boards, metals, plastics and copper.

What remains is mechanically shredded

Cover image: The permanent error of Agbogbloshie

Over the course of 2009 and 2010, photographer Pieter Hugo travelled several times to Accra, the capital of Ghana, to document the disposal of e-waste at the Agbogbloshie scrap market. The photos he took became an exhibition entitled *Permanent Error*, which debuted at New York gallery Yossi Milo in 2011. The photo on the preceding page—of which our cover image is a details—is taken from the exhibition, and we're both delighted and honoured to publish it in *Renew*!

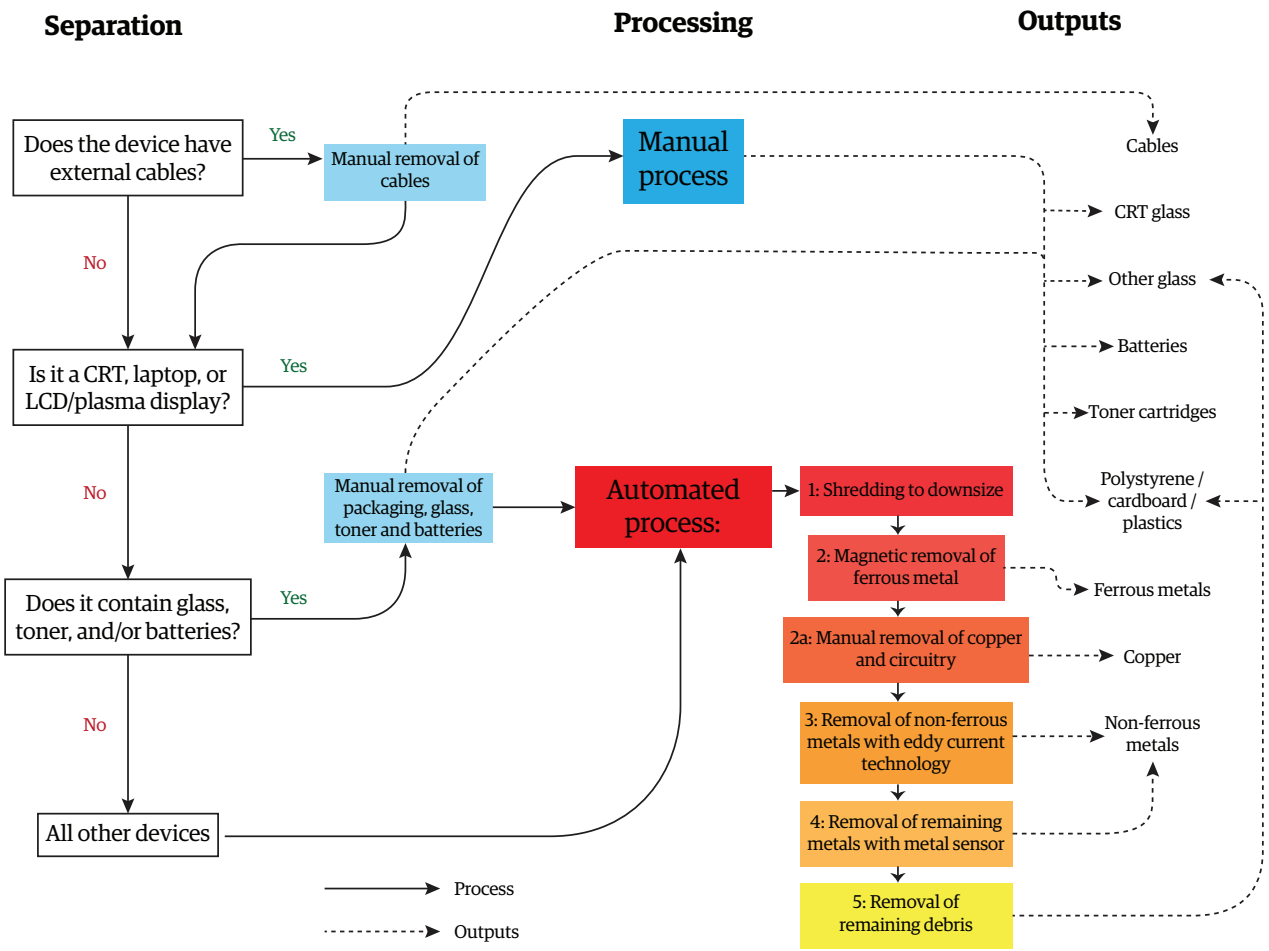
Permanent Error was instrumental in bringing the world's attention to how at least some of the e-waste dumped by first world countries onto the third world is "disposed" of: some parts set aflame and melted down to yield the valuable copper within—along with carcinogenic smoke and ground pollutants—and others simply discarded en masse to create a new landscape of smashed monitors and forgotten technology.

Hugo's work in Agbogbloshie is photojournalism as activism: his portraits are startling and deeply moving, depicting workers doing their best to simply go about their business in a blasted hellscape of smoke, flame and refuse. The more abstract images are equally arresting: Hugo's lens picks out keyboards and monitors sinking slowly into the earth, buried under layer after layer of dust and ash—not decomposing, as organic matter would, but simply disappearing from view, to leach out their component chemicals over the course of thousands of years.

A decade later, the images remain as striking—and, sadly, as relevant—as ever: despite efforts to clean the area of toxic pollutants and/or encourage safer e-waste disposal procedures, Agbogbloshie remains one of the world's largest informal e-waste dumps.

If you'd like to see some more of the photos from *Permanent Error*, there's a selection online at Hugo's website: pieterhugo.com/PERMANENT-ERROR.

— *Tom Hawking*



The basic e-waste recycling process: items are shorn of cables, separated into those recyclable by automatic or manual processes, and broken down into various outputs.

Diagram: adapted by Renew from an original by 1-800-EWASTE.

into pieces as small as 100 mm, and sifted onto a conveyor belt. Ferromagnetic metals (i.e. steel and iron) are removed from the debris on the belt with electromagnets. Other metals (aluminium, brass and copper) are also extracted magnetically from non-metallic content, using eddy currents generated by a powerful electromagnetic rotor that spins continuously under the belt. The eddy currents created in the remaining metals cause them to be repelled from the magnetic rotor, which allows them to be separated from the other, non-metallic debris.

Finally, the remaining material is washed, which removes plastic and other substances, leaving only glass. The original EEE has now been broken down into units which can be on-sold as raw materials (metals, plastics and glass).

Some items require individual handling: old monitors and televisions that use cathode ray tubes (CRTs), for example, are complicated and difficult to break down safely. They include up to 1.8 kg of lead in their glass, which is toxic and can leach into soil and water (and humans). The process for breaking down these items involves removing the monitor front and extracting the CRT so the shell can be sent to join the main e-waste streams. The CRTs and screens are then shredded into fine dust, from which metal is removed using magnets and eddy currents. The glass is then washed to remove oxides, phosphors and dust, and the final sorting separates leaded from unleaded glass—both can make new screens.

But if less than 20% of global e-waste is recycled responsibly, what about the rest? The Global E-waste Monitor believes most is dumped, traded illegally or recycled dangerously. In the worst case scenario, it ends up in e-waste shanty towns such as Agbogbloshie in Ghana (see boxed text on facing page), or other similar places in China, India and Thailand, where people live amid piles of discarded electronics, rummage in tips with no protective gear, and melt cables over open fires to extract the valuable copper.

Some of this waste is from local markets, but significant amounts come from the rich world exporting their problems. Transporting e-waste abroad goes against the 1992 Basel Convention on the Control of Transborder Movements of Hazardous Wastes and Their Disposal—but nevertheless, 10% to 20% of first-world waste ends up being sent to non-OECD countries through white-collar criminal networks. The US-based Basel Action Network has GPS-tracked waste from the US, Canada, Europe and Australia to inferior, illegal disposal sites overseas.

What are the benefits of recycling e-waste?

Recycling e-waste has powerful benefits for people and planet. E-waste left in the sun heats up and releases toxic chemicals

and particulates into the environment and atmosphere: examples include toxic chemicals like brominated flame retardants and polychlorinated biphenyls (PCBs), along with extremely potent greenhouse gases like chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).

Even if it's not in direct sunlight, e-waste in landfill is terrible for the environment: a recent white paper from the Australia New Zealand Recycling Platform estimates that EEE is responsible for 40% of lead and 75% of heavy metals leaching from landfill into land and waterways. The equivalent of an estimated 90 m tonnes of CO_2 leaks out of fridges and air conditioners in scrapyards worldwide each year, and 23,000 t of Australian CO_2 emissions would be saved yearly if half the TVs in the tip had been properly recycled.

Of the 60+ elements present in e-waste, many have nasty effects on human bodies. As a sample, beryllium impacts nerves and inhaling it can cause beryllosis, an incurable lung disease; antimony affects digestion; chromium (especially in its hexavalent form) is carcinogenic and irritates the respiratory system; cadmium can decrease bone density and may cause osteoporosis; and lead accumulates in bones and teeth, slowly poisoning their unlucky owner. And that's not even looking at thyroid malfunction, weakened immunity and spontaneous abortions.

Wasted elements are literally a gold mine: up to 7% of the planet's gold may currently be sitting in e-waste, and at grades 40 times higher than the world's highest-grade mines. Recycling 1 m phones would access 15 t to 16 t of copper, 340 kg to 350 kg of silver and 24 kg to 34 kg of gold, while a 2018 study of "urban mining" in China found that it was 13 times cheaper to source copper, gold and aluminium from e-waste than from traditional mines. According to Global E-Waste Monitor, 2019's lost e-waste materials could be worth US$57 billion. In addition, sourcing precious metals from e-waste would reduce the staggering environmental impacts of mining, and the shameful human costs of sourcing "conflict minerals" from countries like the Democratic Republic of Congo.

Tips for better e-waste recycling

- Try to buy refurbished electronics.
- Buy the right product for your needs, and only when you really need it.
- Choose environmentally responsible products and brands.
- Clean out your drawers and get rid of all your old phones!
- Inform yourself about local e-waste systems.
- Dispose of your e-waste responsibly, preferably with local neighbourhood projects.
- Choose reputable organisations when disposing of your e-waste. (In 2017-18, the Basel Action Network tracked e-waste from two Officeworks stores in Brisbane to Hong Kong.)
- Support businesses who work to eliminate e-waste.

Are there drawbacks to recycling e-waste?

One of the main issues with e-waste recycling is, unsurprisingly, the expense. In 2015 the Victorian Government reported that landfilling e-waste cost $150 to $250 a tonne, but recycling TVs and computers cost $500 to $1000 per tonne. (This, of course, is as much about how we account for externalities as anything else—the up-front cost of paying to recycle is easy to quantify, while the long-term environmental/societal effects of failing to do so are significantly harder to put a figure to.)

Dismantling e-waste effectively is a combined manual-mechanical process of identifying and separating up to 1000 different substances and components, and the people involved require training, experience and adequate pay for their labour. (We should note, though, that the same Victorian report stated that resource recovery employs 9.2 people per 10,000 t of waste, versus 2.8 workers for the same amount of landfill.)

There are other issues. One recycling company reports that 70% of tossed EEE still holds sensitive personal and business data, so e-waste poses an individual, corporate and even state security risk. And in environmental terms, stockpiled or abandoned e-waste is a serious hazard. In some rural areas of Australia, burning waste is still a routine process—definitely a no-no for e-waste. Lithium-ion batteries can be hard to find and extract, and have caused fires when ruptured during processing. Also, the Campbellfield, VIC factory of MRI e-cycle solutions—which was dangerously overstocked with e-waste and batteries—went up in flames in August 2020. After repeated warnings, the EPA suspended MRI's license—three months after the fire. Victorian firefighters claim the EPA did little to regulate MRI, which is seriously concerning given the factory was only 20 km from Melbourne's CBD.

How do we recycle e-waste in Australia?

Australia recycles e-waste through a combination of government, business and private-public systems. The major actors are customers, local councils, and privately run recyclers. We have one nationwide scheme which addresses e-waste; the National Television and Computer Recycling Scheme

(NTCRS) has been in place since 2011, and collected over 50 kt of TVs, computers and printers in 2016-17, 96% of which was recycled. The official NTCRS factsheet was last updated in 2015 (!), around the time the scheme's recycling targets were increased to meet public demand, but the National Waste Report 2018 states that "targets peak at 80% in 2026-27".

In late 2020, calls were made by NTCRS-accredited e-waste recyclers—such as the Australia and New Zealand Recycling Platform (ANZRP) and its TechCollect program—to expand the scheme to cover all electricals. According to TechCollect's CEO, Warren Overton, this will "ensure consistency, increase efficiency, reduce user confusion and make it easier for the Department for Agriculture, Water and the Environment...to monitor and enforce".

The NTCRS scheme was enabled by the Product Stewardship Act 2011, repealed in December 2020 and replaced by the Recycling and Waste Reduction (Consequential and Transitional Provisions) Act 2020—Australia's first-ever national waste legislation. The act is designed to enable smoother, more efficient product stewardship, as was the government's $20 m Product Stewardship Investment Fund, whose initial focus would be to expand and develop e-waste strategies. It's too soon to judge the effects of these initiatives.

State governments are also taking steps to keep e-waste out of landfill: the Victorian government, for example, has banned all e-waste from landfill since July 2019. Its pro-recycling program includes a $1.5 m community education campaign, and $15 m for upgrading and expanding the collection network (98% of Victorians will eventually be within a 30-minute drive of an e-waste drop-off).

There is also the independent Australian Battery Recycling Initiative; battery consumption is growing at 300% per year, yet we only recycle 2.7% of batteries. (As a comparison, some 70% of batteries are recycled in Europe.)

> *The Global E-waste Monitor believes [80% of e-waste] is dumped, traded illegally or recycled dangerously ... and 10% to 20% of first-world waste [is] sent to non-OECD countries.*

That last statistic is sadly representative of Australia's standing in the world: we do pretty poorly for a developed nation. (And, for that matter, even countries not traditionally considered "developed" put us to shame: India, for example, has higher recycling rates than we do.) Compared to our 9% to 11% of properly recycled e-waste, even the US hits 35%, while the EU tops the world with 42.5%. The EU has a Waste Electronic and Electrical Equipment (WEEE) Directive, whose core principle is extended producer responsibility—manufacturers, importers and sometimes distributors are responsible for the lifetime of their product, including collection and recycling. Japan, meanwhile, makes consumers pay for e-waste recycling—and still doubles our recycling rate (26% in 2019). However you look at it, we are lagging behind.

What is the future for recycling of e-waste?

A couple of Australian start-ups are addressing the e-waste challenge. The Centre for Sustainable Materials Research and Technology (SMaRT Centre) at the University of New South Wales developed an e-waste microfactory in 2018, which uses an electronic dismantler, a drone to identify and select circuit boards, and a hot facility that melts and extracts specific elements at the correct temperature.

Elsewhere, Envirostream in Melbourne has developed an all-in-one battery-recycling system that collects all battery types and recycles 95% of their components. Steel, copper and aluminium are returned to manufacturing, and the remaining mixed metal dust makes cathodes in new batteries. And TechCollect has joined forces with Australia Post so any Australian can "TechExpress" their e-waste to a safe recycling facility (at a cost of $14.95 for 22 kg of e-waste).

Overall, e-waste recycling in Australia needs to be convenient, efficient and trustworthy—and currently it is none of those. Our National Waste Policy Action Plan (2019) states that e-waste is a priority, but offers no strategies to deal with that priority.

How can we improve?

Waste analysts have plenty of ideas for how Australia can get its act together. Negotiating a workable EU-style extended producer responsibility scheme would force producers to commit to their product and take responsibility for it over its lifetime, rather than producing it as cheaply as possible to reap the maximum profit from its sale, without regard for long-term consequences. Such a scheme could also address the responsibilities of consumers (disposing of packaging correctly, for example) and other stakeholders (such as companies

Image (and previous page image) Ilya Cattel/iStockphoto

involved in the supply or waste management chains) to increase the program's scope.

There's also the fact that many devices these days are built to be disposable (and often to be disposed of well before the end of their functional life, due to enforced redundancy). Buyers need greater control over their own goods through "right to repair" legislation, allowing them to fix equipment without jeopardising their warranties (which are often voided by simply opening a product's casing). Combining this with viable product stewardship regulations—including mandated levels of recycled components in new products—could help cement good design into electronic devices, making them smoother and cheaper to recycle.

Adequate training—for example, a TAFE-style qualification in resource recovery—is needed to provide skilled workers to what should be a burgeoning industry. Existing legislation and systems could be expanded and connected with other local, state and federal waste laws and processes. Recycling targets should be updated for all kinds of e-waste and specified for other electrical products. Auditing and compliance should be strengthened on export, recycling and landfill.

Focus could be shifted to the small scale—small devices and local councils—to make big changes quickly. On the former point, consumers think of small electrical items as being desirable, affordable and disposable, so a solid public education campaign could result in strong improvements in recovering precious metals and components. And on disposability, since local councils are already responsible for domestic waste, they can hit their residents in the hip pocket for e-waste. One Dutch study showed that residents who paid a fee per item of waste, instead of paying an annual waste levy, tossed 50% less garbage in landfill. (They still threw away 1kg of e-waste per person—but at least they knew the true cost of disposing of it properly.)

As it stands, both the Australian government and the average Aussie need a big push in the right direction. Three quarters of us know that phones can be recycled, but only 8% actually do anything about it. TechCollect surveyed 1000 Australians in capital cities and found that 43% are stockpiling old devices "in case" and 25% have simply binned their devices. We must do better.

Humanity's current levels of consumption and generation of waste are not sustainable in terms of resources, carbon emissions, environmental contamination and human health. E-waste is the fastest-growing waste stream worldwide, and our global total is likely to reach 74.7Mt by 2030. Effective recycling will make a significant impact, but it shouldn't be taken as permission to keep devouring the next must-have beeping-flashing-buzzing toy (for either kids or adults!). Our homes, workplaces, communities, institutions and governments must step up to the complexity of the e-waste challenge so our world is not ... e-wasted.

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RESOURCES

Standards Australia (note: downloading/accessing the standard will cost $125!)
bit.ly/3tLKw5G

Mobile Muster
mobilemuster.com.au

Recycling Near You
recyclingnearyou.com.au

Clean Up Australia
cleanup.org.au/e-waste

Case study: Green Collect

In 2019, social enterprise Green Collect diverted over 1m items from Greater Melbourne tips, with 60% of them reused and 35% broken down into recyclable materials. Around 20% of the total—around 2000 kg per month—was electrical goods and IT equipment: computers, printers, thumb drives, kettles, faxes, printers, floppy disks, cords... Basically, anything that has ever used power in an office.

Green Collect's business looks simple: it collects waste, mostly from office clean-ups and relocations, and saves 95% of it from landfill. Instead of hiring a skip, corporates, councils and government departments throw their unwanted items into Green Collect's boxes or cages. Everything is accepted except hazardous waste, and it is all removed, redistributed and repurposed.

It's what happens next that makes Green Collect a particularly interesting case study. As CEO Sally Quinn explains, "When we started over 15 years ago the focus was on recycling. Our work now prioritises maximising value through facilitating reuse, repair and remanufacture in ways that create significant environmental and social impact. We're dedicated to creating a circular economy ... creating new green jobs in sorting, testing, teardown and resale."

Those green jobs involve plenty of hard work. That work begins when the cages arrive at the warehouse: workers sort the material into almost 100 commodity categories. The three-person electricals team tests every powered item, even "extraordinarily exotic electrical items from the 1970s", and tag the roughly 50% that work as being functional. The team researches the item, looking into how it works, whether there's a market for it—and sometimes, first of all, what the item actually *is*. (Remember: none of these things come with manuals!) Working items are donated to community groups or sold through Green Collect's shops or their online channels (booming since Covid, by the way).

Image: Green Collect

Look, we *could* pretend to be sad to see a copy of Green Day's *Dookie* being consigned to the bin, but who'd be fooled?

Devices that can't be given the spark of life are then "pre-processed" so that environmentally sound local companies can do the "technical recycling" (i.e. running everything through a chipper and accessing the valuable elements). Cords are cut off, items dismantled into components, and pieces are sorted into two categories:

- "high-grade" e-waste: e.g. circuit boards that contain lots of precious metals; or
- "low-grade" e-waste: e.g. a memory stick: mostly aluminium, batteries, and wiring.

It's with unusual items like electronic whiteboards that Green Collect's adaptability in repurposing waste comes to the fore. Unlike other e-waste collectors, they're willing to take a whiteboard, crack out the small electrical part, cut off the cord, and recycle the rest of it (mostly steel). Quinn explains why: "We work with businesses and households to continually minimise waste and extract the highest value from tricky items that would usually go to landfill. [Our] key area of impact is in reducing workplace waste ... [via] new approaches that reduce the demand for natural resources."

Dominique Emery from Green Collect explains that the "most frustrating things" for this goal of reducing waste are cheap, single-use electricals—"the bottom of electrical innovation", the product of a linear economy that pays far too little attention to quality design for long-term use and reuse. As Emery says, "We want really well-designed systems and processes to keep items in circulation for as long as possible. What if landfill was just not an option?" — *Jodie Lea Martire*

Note: Renew used Green Collect's services when we moved office in January.