

January 13, 2008

## The Afterlife of Cellphones

By JON MOOALLEM

### 1. Cellphones in Hell

Americans threw out just shy of three million tons of household electronics in 2006. This so-called e-waste is the fastest-growing part of the municipal waste stream and, depending on your outlook, either an enormous problem or a bonanza. E-waste generally contains substances that, though safely sequestered during each product's use, can become hazardous if not handled properly when disposed. Those products also hold bits of precious metals like silver, copper, platinum and gold.

The Belgian company Umicore is in the business of reclaiming those materials. It extracts 17 metals from our unwanted televisions, computers and cellphones and from more ominous-sounding industrial byproducts like drosses and anode slimes. Umicore harvests silver from spent photo-developing solutions collected at American big-box stores and sells it to Italian jewelers. The company describes its work as "aboveground mining."

Umicore has roots in actual mining. In the late 1800s, during the reign of King Leopold II, the firm mined copper in the African Congo and shipped it to a riverside smelter near Antwerp. Today the same property houses a sprawling, state-of-the-art \$2 billion smelter and refinery. Here, metals are recovered and processed. Then they are sold, sometimes to Asia, where they are used to manufacture brand-new electronics. It's a reshuffling of the colonial arrangement: an abundant resource is sent from richer countries to poorer ones, made into goods, then sent back. That resource is our garbage.

Umicore's smelter was burning furiously at 2,116 degrees Fahrenheit one afternoon last fall. Two heavy-set men in blue overalls sat in the control room, staring expressionlessly through heat-shielded windows. They were eye-level with the mouth of the smelter — a pit 13 feet wide by 46 feet deep. A conveyor belt fed shredded circuit boards and scrap into the fire in a dim, fast blur. I imagined the black-and-white television in my mother's basement, or my first blue [Nokia](#) cellphone — all the devices I'd gotten close to and outgrown — spilling out and squealing like lobsters in a pot.

The metals exit the smelter's base as a glowing sludge. It streams into another caldron the height of a house. From there, it moves into tanks of acid. The acid is electrocuted. As electricity flows through the mixture, copper accumulates on the tank's end plate. I watched a giant claw move across the ceiling, rip out the plate and, with a violent whack, cleave off a gleaming layer of 99.9 percent pure copper, with the unmistakable sheen of a new penny. It was thrilling to see something so clean and recognizable emerge from such an alien process.

After explaining the final stages, Thierry Van Kerckhoven, Umicore's e-scrap manager, handed me another of the end products from this process: a one-kilogram bar of gold. It felt the way I thought it would, based on what you see in the movies: substantial, mesmerizing. It was worth about \$24,000. "This gold is recycled gold," Kerckhoven said. "This gold is green gold."

Recycling feels good because we imagine it as just this kind of alchemy — which Umicore achieves with impressive environmental controls. The centerpiece is a monstrous gas-cleaning-and-filtration system that

captures and neutralizes enough of the carcinogenic and endocrine-altering chemicals produced from melting e-waste, according to Umicore, that the faint yellow emission finally released from its smokestack easily surpasses the [European Union](#)'s air-quality standards. (Martin Hojsik, who campaigns against toxics for [Greenpeace](#) International, notes that the process followed by Umicore and its few, similarly equipped competitors around the world is "not entirely clean" but still "the preferable solution" for recovering metals from e-waste.) Ultimately, by weight, only 1/2 of 1 percent of the e-waste Umicore takes in cannot be safely sent back into the world in a usable form. "There is often a discussion of separating what is valuable from what is toxic," Christian Hagelüken, Umicore's senior manager of business development, told me. "But sometimes they are the same thing."

This may never be more true than for cellphones. They are the most valuable form of e-waste. Each one contains about a dollar's worth of precious metals, mostly gold. And while single phones house far less hazardous material than a computer — an old, clunky monitor can incorporate seven pounds of lead — their cumulative presence is staggering. Last year, according to ABI Research, 1.2 billion phones were sold worldwide. Sixty percent of them probably replaced existing ones. In the United States, phones are cast aside after, on average, 12 months. And according to the industry trade group CTIA, four out of every five people in the country own cellphones.

Umicore estimates that, together with its competitors, it received only 1 percent of all phones that were discarded globally in 2006. "This of course is a lousy percentage," Hagelüken said. "Computers are also bad, but phones are the worst." Our obliviousness has mostly kept them from being recycled at all. When we do bother, we may not know, or be able to control, where the "recycled" phones go. Many enter a secondhand market in the developing world through a receding series of middlemen.

Reuse, we are told, is as green a virtue as recycling. But with e-waste all the old ecological dogmas start to become ambiguous. Cellphones represent only a part of the world's e-waste problem. But they are a key to understanding how complicated it is. They also embody the kind of high-tech products that we will be throwing away more of: easier to upgrade than repair, increasingly disposable-seeming but also deeply personal. As governments around the world, from the European Union to New York City, propose or pass laws to require the recycling of e-waste, there's little consensus about what recycling actually means. No matter how close our relationship with our phones has become — how faithfully we keep them with us, how we hold them to our faces and whisper into them — we rarely wonder where they go when they die.

## **2. Cellphones in Purgatory**

If we think at all about what to do with old phones, we may realize we can return them to the wireless industry. With the idea of extended producer responsibility gaining traction — the notion that businesses should manage the disposal or recycling of their products — most major carriers and manufacturers in the United States now run voluntary take-back programs. But because we stop wanting phones long before they're unusable, they also represent a kind of neglected value, there to be capitalized on. Seth Heine, who founded the company Collective Good in 2000, recognized this early.

Collective Good is a profitable business that, as the name suggests, Heine also sees as a vehicle for philanthropy. People send in their phones, and Collective Good sells the ones that still work into a global secondhand market. A portion of each phone's resale or scrap value goes to one of more than 500 causes — ranging from the Red Cross to the Humane Society to the Obama campaign — selected by the phone's donor. Used phones are sold to people overseas who can't afford new ones, and hazardous waste is kept out of landfills. "It's a self-cleaning oven," Heine says.

When I visited his office outside Atlanta a few months ago, Heine was introducing a new venture,

[GreenPhone.com](#), which pays donors directly for their phones. Mail a BlackBerry Pearl, for example, to GreenPhone, and Heine will cut you a check for \$65. And because Heine still isn't entirely comfortable with all the paper consumption this entails, GreenPhone also plants a tree for every check it writes.

Heine is 40, a whip-smart and mildly self-righteous environmentalist with an M.B.A. and a boyish love of sports cars. There's a lava lamp on his desk, but also, hanging behind it, a motivational poster that says VISION. Recently, he moved most of his operation to a larger facility in Colorado. But phones were still arriving at the small Georgia warehouse when I was there; they come in prepaid envelopes printed off the company's Web site or from collection boxes at every Staples and [FedEx](#) Kinko's in the United States. Each month, Heine receives 20,000 phones of at least 800 different makes and models.

They were scattered around the room: silver ones, a battered flip-phone with a sticker of a wolf on it. A store in Beverly Hills had been sending boxes of gold-plated, limited-edition Dolce & Gabbana [Motorola Razr](#) phones, turned in when customers traded up for something even newer. "That phone can't be more than six months old," Heine said at one point. Later, he handed an employee a Nokia with a note rubber-banded around it. It was something a friend gave him at dinner; that happens all the time, he said, "when you're the Fred Sanford of phones."

Heine's business succeeds or fails based on how well it can assess and then realize the value of each phone. "I refer to that as the pachinko machine," he told me. "You dump in a phone and it rattles around. It's got to come out somewhere at the bottom." The question is, where?

Phones beyond repair, or with little value, are dispatched to Umicore for their gold. But because acquiring the phones costs so much — all those individual, prepaid envelopes add up — recycling them must be subsidized by reselling the reusable ones. The most valuable handsets find their way to a room across the hall from the storeroom, where two employees sell them on [eBay](#). Most, however, are sold via private auction to a stable of about 20 different resellers. Some, once refurbished, will be sent to American consumers to replace broken phones under warranty or covered by insurance. But it's through the resellers, and the unfathomable network of resellers they sell to, that many also end up overseas, where the price of new phones can be prohibitively expensive.

American wireless carriers like [AT&T](#) and [Sprint](#) offer new phones below cost, or free, as incentives to get customers to sign lucrative two-year service contracts. Users in much of the world don't purchase contracts, though. They buy chunks of prepaid minutes instead and can transfer their phone from one carrier to another more easily. Foreign carriers have no incentive to offer great deals. Phones we get free can cost upward of \$200 in Latin America or Africa — where customers have less to spend. "A lot of people in the developing world will never own a new phone," Heine says. They depend on our castoffs.

Ever-changing technology means that specific phones work only in specific networks, but relatively few are obsolete everywhere in the world. As one reseller says, "There's always a place to put the phone." Small-time entrepreneurs known as aggregators prowl the Internet cobbling together orders of thousands of a single make and model. "There are many, many thousands of us," Joseph Khan told me. Khan, who lives outside Los Angeles, works as a limousine driver but has a side business in phones. Recently, he claims, he purchased several thousand [Qualcomm](#) QCT-1000's for \$11 each and resold them in Ukraine for \$121 each. The QCT-1000 was introduced in 1996. "The battery is the size of a printer!" Khan says.

The need to refurbish or even significantly repair most phones is another reason vast quantities of them end up overseas — particularly in Asia, where cheap labor and replacement parts make the cost of fixing all sorts of phones with cameras and color screens and other features so low that many buyers do not even care if the phones turn on.

America's largest phone-recycling company, ReCellular, based in Michigan, sells millions of phones annually to 375 refurbishers in 40 different countries. Some of these refurbishers, Mike Newman, a vice president of ReCellular, told me, "are going to be highly sophisticated companies with really sparkling, huge plants," while others might consist of an entrepreneur with "10 small stores in the Dominican Republic who has, in the back of one of them, a place where 10 people are doing some refurbishing — just sitting on some benches and old tables, taking off the housings and fixing them." ReCellular handles the phones from most of the major recycling programs in America sponsored by wireless carriers, including [Verizon](#), Sprint and AT&T. It expects to receive seven million phones this year. Financially, according to Newman, the "backbone of these programs is the resale of usable phones."

It's hard to track ReCellular's or Collective Good's phones. But Jack Qiu, a professor at the Chinese University of Hong Kong who has studied the movement of used computers and phones in China, describes one route phones take. In Kowloon, in Hong Kong, Pakistanis and other immigrants (often asylum seekers) import phones from Europe by the shipping container. These are fixed or cannibalized for parts in stalls at a local market. In the past, Nigerians and other African exporters swept in to buy tens of thousands of phones at a time, particularly so-called "14-day phones" — those that have been returned under warranty and used little. But recently, Qiu says, the markets for these phones have become saturated in African cities. So the Nigerians, needing to take their business to poorer African villages, have been leaving Hong Kong for Chinese cities like Guangzhou, where they can purchase cheaper, more heavily used phones from the larger refurbishing companies there. Many Nigerians have learned Mandarin in order to do business in Guangzhou, Qiu says, and the city now has an African-style coffee shop.

Africa is one of the biggest markets for used phones. Seventy-five percent of all phones in the least-developed African nations are cellphones — and usage in many places is increasing by 30 or 40 percent per year. Their impact can not be overstated, particularly where roads are poor and settlements separated by great distances, places that land lines never reached and now have no reason to do so. Consequently, cellphones are not easily abandoned — and, when they are, someone somewhere is still likely to see some value in them. Jim Puckett, the coordinator of the Basel Action Network, a nongovernmental watchdog group that focuses on e-waste, visited Nigeria in 2005. He describes, at one Lagos electronics bazaar, repairmen sitting on dirt floors under shelves of scavenged parts, jury-rigging phones back together, over and over again, until the things are absolutely dead.

"I've never seen the real end," Qiu says. "I've seen landfills in China full of used computer parts, but I've never seen a single landfill of used mobile phones or phone parts." The Chinese themselves "retire" between 200 million and 300 million phones every year, he says. These phones are sold in places like India, Mongolia, Vietnam and Thailand. And from Thailand, they are sold to buyers in Laos, Cambodia, Bangladesh and Myanmar. In other words, the pachinko machine is global, and there are millions, or even billions, of phones still clattering down its channels.

In 2001, Basel Action Network filmed a documentary in Guiyu, China, a town overrun by shipments of old computers from recyclers in the United States and elsewhere. Guiyu's residents, including children, make their living sorting, dismantling and burning computer parts or bathing them in nitric and hydrochloric acids to recover precious metals. This not only mobilizes a device's hazardous constituents; it also creates new ones. The health consequences are immense; respiratory problems and elevated blood-lead levels in children are reportedly rampant in Guiyu and, around the time of BAN's visit, the nearby river contained up to 2,400 times the [World Health Organization's](#) acceptable threshold for lead.

In 2005, BAN found 500 shipping containers of electronics arriving in Lagos each month. Useless computers were being tossed into burning piles behind a marketplace. And the phones — no matter how many

ramshackle resurrections they experience — will at some point presumably meet the same fate, Puckett says. “It sounds like a cellphone’s just a little thing — if you burn it it’s not such a big deal,” he explains. “But we’re talking about mass volumes going to countries that have no infrastructure or ability to deal with it.”

Moreover, manufacturers now sell “ultra-low-cost handsets” — new, no-frills phones specifically for consumers in the developing world. Some cost less than \$20. These phones, says Badii Kechiche, a market analyst with Pyramid Research, are what really fuels the spread of phone usage across Africa — not the comparatively skimpy supply of our used ones. As a consequence, used cellphones — just rare enough to stay out of the planet’s globalized digital trash heaps so far — may come to be more like regular junk. “If ultra-low-cost handsets are coming in,” Kechiche says, “and they’re much cheaper or cheaper than refurbished handsets, what’s the point of getting a refurbished handset?” The people we rely on to take our garbage are not only losing their need for it. They’re becoming firsthand generators of that same garbage.

In a study published last year, 34 recent-model cellphones were put through a standard [E.P.A.](#) test, simulating conditions inside a landfill. All of them leached hazardous amounts of lead — on average, more than 17 times the federal threshold for what constitutes hazardous waste. Under a stricter state of California test, they also leached four other metals above hazardous levels.

The E.P.A. says modern American landfills are designed to keep toxics stewing inside from leaking out, so they don’t contaminate surrounding soil or drinking water. But landfills do fail, says Oladele A. Ogunseitan, an environmental-health scientist at the University of California, Irvine, and an author of last year’s study. More important, he notes, such landfills don’t exist in the developing world. In many places, garbage is tossed into informal dumps or bodies of water or burned in the open air — all dangerous ways of liberating and spreading toxics.

The electronics industry is greening significantly, though. E-waste take-back programs are starting to spread around the developing world. A landmark law, the RoHS directive, enacted by the European Union, requires all electronics manufacturers to drastically lower concentrations of hazardous substances, including lead, in their products. Nokia and [Sony Ericsson](#) are among those voluntarily phasing out other dangerous substances not covered by RoHS.

Still, according to Ogunseitan, there will always be risks, or at least unknowns, accompanying the improper disposal of such products. The compositions of consumer electronics evolve through long sequences of trial and error. “In a phone that you can hold in the palm of your hand, you now have more than 200 chemical compounds,” he says, citing the results of an analysis of one new cellphone. “To try to separate them out and study what health effects may be associated with burning it or sinking it in water — that’s a lifetime of work for a toxicologist.”

The laws governing the export of e-waste present their own difficulties. An international treaty restricting the movement of hazardous waste to the developing world, a 170-nation agreement called the Basel Convention, is ambiguous when it comes to electronics. Namely, when is an item repairable — and thus freely exportable as a reusable product — and when is it just hazardous waste? Nothing requires exporters to even test the products they ship. Consequently, exporting products for “reuse” is often used as a loophole to dump them. In any case, the United States has not ratified the Basel Convention.

Electronics recycling “has always been the used-car lot of the recycling world,” Seth Heine laments. With no clear standards to follow, he enforces his own. He claims to thoroughly assess the condition of all his phones. He’s also quick to send working phones with limited potential for reuse straight to Umicore rather than sell them for far more money to less scrupulous buyers in the secondhand market. Heine figures this means he is leaving \$150,000 on the table each year, easily. (Several environmental groups I contacted, including BAN,

singled out Heine for his integrity and seriousness about the environment.)

Mike Newman told me that ReCellular supports establishing standards for exporting phones. But he also questions their effectiveness. A company could say it doesn't sell irreparable or untested devices to the developing world, but, "How does any company really know where their phones end up?" he asks. "Once you sell them, they're not your phones anymore." Newman claims that ReCellular tests all of its recycled phones anyway. But on the day we spoke, there were lots made up of hundreds and thousands of phones (even up to 15,000) listed for sale on ReCellular's Web site and labeled Bulk Beyond Economical Repair and Bulk Used/Untested. Newman would later clarify: these phones were not from recycling programs. They were returned under carrier warranty programs; ReCellular acquires and resells tens of thousands of these devices too every month and doesn't bother testing them.

Given this state of affairs, you can't help wondering if throwing your old phone in the trash, and into the high-tech sarcophagus of an American landfill, could end up doing less damage to the environment than recycling it. But that ignores yet another crucial part of the equation. As Heine explains, even though what he sells will probably be thrown out eventually, if a phone gets three or four more lives, "it's absolutely better for the environment than having to make three or four more phones — phones that wouldn't be recycled, either."

Reusing phones conserves natural resources, which reduces the environmental damage that comes with mining them. That damage isn't necessarily obvious. When I called Allen Hershkowitz, a senior scientist at the [Natural Resources Defense Council](#) who specializes in solid-waste issues, he was less interested in discussing the toxicity of old electronics than the costs of mining a particular metal, tantalum, to build the capacitors for new products. Tantalum comes from an ore called coltan. Control of coltan deposits was a factor in perpetuating Congo's civil war in the late 1990s, and the people mining it there now, Hershkowitz says, rely on "critically endangered" gorillas for food. Tantalum is one of the metals Umicore can't recover from e-waste.

Much of the world's gold and copper, meanwhile, is mined in open pits, which means it is leached out with cyanide or sulfuric acid. Using data from the [United States Geological Survey](#) and mining companies' own reports, Earthworks estimates that mining the gold needed for the circuit board of a single mobile phone generates 220 pounds of waste. The environmental nonprofit calls this "an extremely conservative" estimate.

What's more, the world's supply of these metals is finite. So even as the E.P.A. plays down the risks of throwing e-waste into landfills, it also urges us not to. Tim Townsend, an environmental engineer at the [University of Florida](#) who has studied the toxicity of mobile phones for the E.P.A., sums up the absurdity of just tossing this stuff away: "If we know these metals are, overall, bad for us, it doesn't make sense to keep digging them up from the earth's crust and bringing them into the biosphere while — at the same time — we're taking the ones we've already got and burying them."

As with most environmental issues, then, no option for getting rid of a phone is free of trade-offs, and nothing is as simple as we'd wish. But the truth is, few of America's phones are turned in for "recycling" in the first place. (It's unclear how few. The figure of less than 1 percent, put forward in a groundbreaking report on phone recycling by the nonprofit Inform five years ago, is still repeated. ReCellular estimates that it's more like 10 percent now.) While a phone's small size may give even normally conscientious consumers a dispensation to slip it into the trash, there seems to be a more typical solution, what ABI Research estimates nearly half of Americans do: stick the thing in a desk drawer and leave it there.

Every recycler I spoke with talked about "the drawer." It turns out to be the real purgatory for phones. Using predictions from Inform, the United States Geological Survey estimates that in 2005 there were already

more than half a billion old phones sitting in American drawers. That added up to more than \$300 million worth of gold, palladium, silver, copper and platinum. Heine says he still receives phones in prepaid envelopes addressed to the Kentucky tobacco barn where he started Collective Good in 2000. It tells him that people get motivated, take the envelope, then stick that in a drawer for a long time.

“As soon as [a phone] makes its way into the drawer, it’s hard to get people to dig it back out,” ReCellular’s Newman told me. I asked him how hard. “I have employees,” he said, “who have them in their desk drawers.”

### 3. Cellphones in Heaven

Given the intimate place of cellphones in our lives, why do we get rid of them so quickly?

Sometimes we don’t have a choice. We switch to a new carrier and must buy a phone adapted to its particular network. (Late last year, Verizon announced it would eliminate this requirement.) Or we trade up for new features: first a camera, then an MP3 player, then a Web browser. [Apple’s iPhone](#) promised to put an end to this chase by combining everything in a single, graceful device. But the industry knows the iPhone is just a momentary milestone in its race to replace laptop computers entirely — and that we will follow, one revolutionary but not-quite-perfect device at a time.

Regardless, recyclers say that from their vantage point it’s obvious that most phones are retired because of psychological, not technological, obsolescence. “There’s some fashion driving all of this and, by its nature, fashion is not eternal,” says Mark Donovan of M:Metrics, which tracks the wireless industry. Phones were initially an afterthought, given out free so that customers had something to talk into after buying the real product, the service contract. But carriers learned, as Donovan puts it, that “if you deliver something cool, and if it’s a bit of a status symbol, people will pony up and pay cash for it.” He adds: “People want them to become more than an awkward gadget. People want it to be an expression of their personalities.”

Right now, there are roughly 470 models of phone for sale in the United States. About 16 new ones come out every month. Many are only slightly altered versions of existing phones, suggesting how easily we get bored — how we’ll crave something that slides, say, instead of flips open. (There are currently 46 styles of Motorola Razr; [Motorola](#) has, in fact, projected which colors and finishes we’ll find most attractive through the year 2009.) And we have the perfect incentive to get whatever we want every two years when our contracts are up and the discounts for new phones roll around. When I asked Iain Gillott, an analyst with iGR, what makes a person get a new phone, he told me, “They’re cruising through the Sunday paper, and they see a fabulous phone for 50 bucks and they say, ‘Well, I haven’t had a new one in 18 months.’ ”

Gillott estimates 50 to 60 percent of phones are replaced “because people get tired of the design.” Otherwise, consumers want a new feature — even, it seems, if there’s no real need for it; according to M:Metrics, 82 percent of those with Internet-enabled phones do not go online. Steven Herbst, a psychology researcher at Motorola, told me: “All that pressure to have the latest — something that people will be impressed by — is compounded by the fact that all of a sudden somebody is doing something with their mobile phone that you can’t do.” In other words, it’s because we’ve made phones such deep and indispensable extensions of ourselves that we dump them so quickly. Who can bear seeing himself as even slightly outdated or incapable?

“Somewhere during the last 100 years, we learned to find refuge outside the species, in the silent embrace of manufactured objects,” Jonathan Chapman, a young product designer and theorist at the University of Brighton, writes in his book “Emotionally Durable Design.” But designers and consumers have snared themselves in an unsustainable trap, Chapman told me, since our affection for many high-tech objects is tied

exclusively to their newness.

“The mobile phone occupies a kind of glossy, scratch-free world,” he says. Whereas a pair of jeans gains character over time, a phone does no such thing. “As soon you purchase it, you can only watch it migrating further away from what it is you want — a glossy, scratch-free object.” You might leave the plastic film over the display for a few days, just so you can take it off later and “give yourself a second honeymoon with the phone,” he says. But ultimately everything that first attracted you to it only deteriorates. You start looking at it differently. “It’s made of some kind of sparkle-finished polymer and it’s got some decent curves on it, but so what? The intimacy comes more from the fact that, within that hand-held piece of plastic, exists your whole world” — your friends’ phone numbers, your digital pictures, your music — and that stuff can be easily transferred to a new one. So you “fall out of love” with the phone, Chapman says.

Even the most idealistic visions of how e-waste should be recycled and reused take for granted that consumers and businesses will never reconsider why we are buying and discarding so many of those products, so quickly, in the first place. If the rush of castoffs isn’t likely to stop, we need to clear a proper path for it, considering all the inevitable compromises and costs along the way and delivering those products to as consequenceless a place as possible.

There is no heaven for cellphones. Wherever they go, it seems that something, somewhere, to some extent always ends up being damaged or depleted. The only heaven I came across was what Chapman described. It is an image in our heads — not of a place where we can send a used phone but one where we imagine each device when it’s brand-new, right before we first get our hands on it. That illusion of perfection, no matter how many times we see it spoiled, will always lure us into buying the next new phone and sending the last one careering on its way.

*Jon Mooallem, a contributing writer, last wrote for the magazine about the science and commerce of sleep.*

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