'Urban mines': How to unlock our electronic junk's potential

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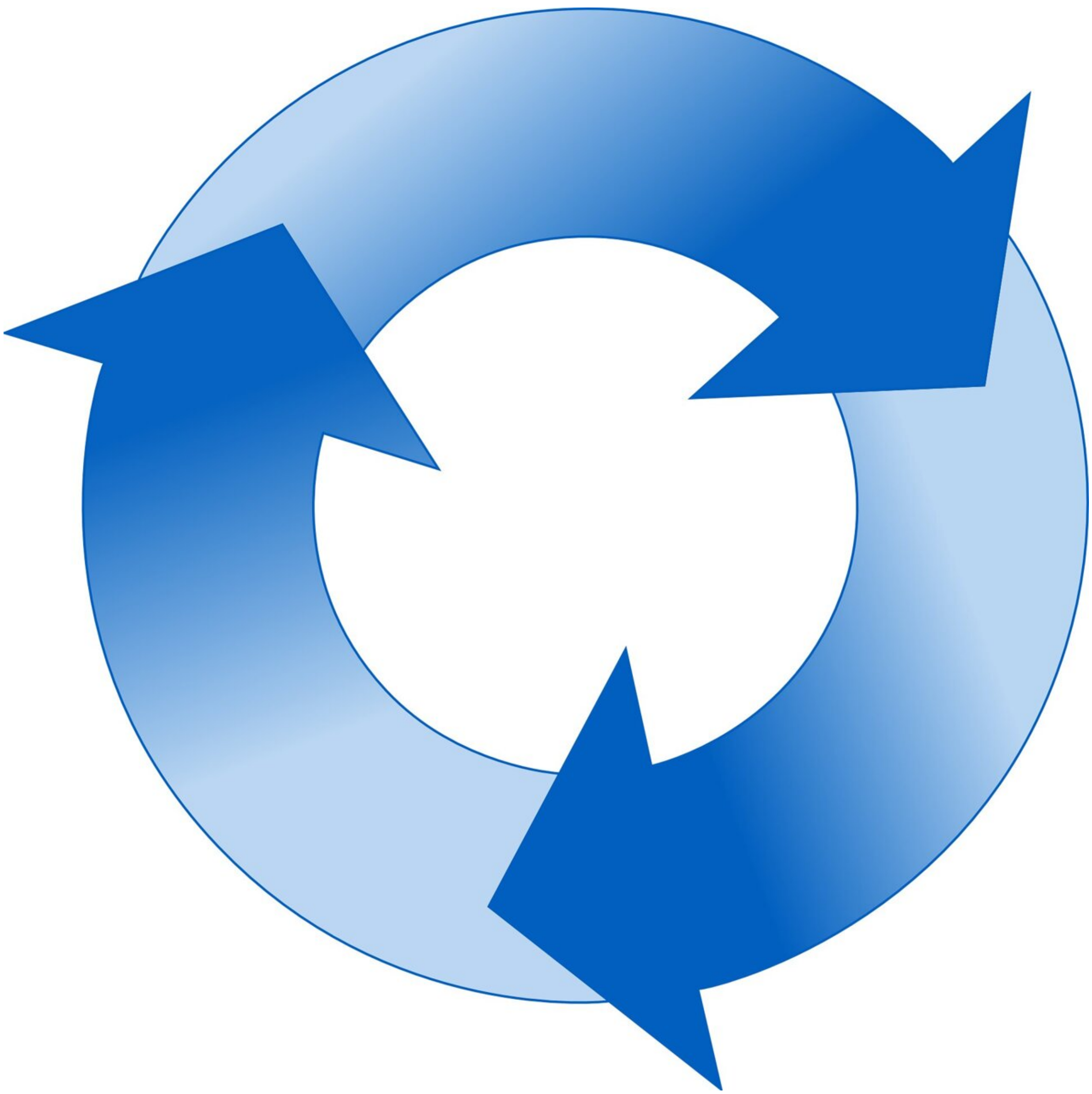

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Instead of developing new mining infrastructures, what if we recovered the metal deposits contained in the electronic objects we no longer use, such as smartphones or computers? There are very good reasons for focusing on the potential of these "urban mines", also known as secondary mines to distinguish them from the "primary" mines where resources in the ground are exploited directly.

A strategic challenge for the European Union

Not only would these alternative resources address a shortage of mining infrastructure, they could also help to slash electronic waste, otherwise known as "e-waste". The fastest-growing waste stream in the world, electronic junk wreaks havoc on ecosystems around the globe and poses a major threat to health by leaching toxic substances into the land and water, especially in Asia.

Better recycling electronic items could also reduce mining's high environmental impact. In fact, for some metals, recycling is more energy efficient than mining. Extracting aluminum through recycling, for example, requires 10 to 15 times less energy than primary production.

The issue is especially important as several of the recyclable metals are critical resources for the European Union's twin transitions to a digital and net-zero economy. Deposits such as lithium, cobalt, nickel and rare earths are essential for the production of electronics, electric vehicles and renewable energy components such as solar panels. Yet they are barely exploited in the bloc and exposed to a high risk of supply tensions. To this end, since 2011, the European Union has assessed and released every three years a list of critical raw minerals that should constitute a priority for urban mining.

The fifth list, published in 2023, identified 34 critical metals, including rare earth elements, lithium, copper, and nickel. Unfortunately, the gap between the European Union's recommendations and urban mining practices is glaringly obvious.

A life cycle riddled with obstacles to recycling

An object's recovery potential is limited at every stage of its life cycle by technical, organizational, regulatory, and economic obstacles. From its very design, certain practices limit its metals' recyclability, such as the use of metals in particular alloys, since not all alloys can be recycled, or hybridisation, since composite materials are harder—not impossible—to recycle. For instance, for liquid food packaging, most cartons are made from cardboard and PolyAl, a blend of aluminum and polyethylene (a type of plastic).

For many years, the cardboard from food cartons was recovered and recycled, but not the PolyAl, leading to incomplete recycling. In this specific case, the companies Tetra Pak and Recon Polymers ultimately developed a separation process, opening a recycling plant specifically for PolyAl in 2021. But many other products continue to be difficult to recycle, precisely because this aspect was not taken into account at the design stage.

Dispersive uses, which involve using small quantities of metals in products to modify their properties, are another practice that evades recycling. Take silver nanoparticles: their industrial application ranges from the disinfection of medical equipment, water treatment, to odor prevention in textiles. Likewise, a few grams of dysprosium, a rare earth metal, may also be used to boost magnets' pull. In sum, some metals boast so many applications that it is impossible to ensure their circularity.

Electronic hibernation—abandoning our devices in the attic

Once objects have been designed and used, there is a second obstacle, which stems from consumers, who tend to hold on to their electronic objects, whether they work or not, rather than dropping them at a specific recycling facility. This phenomenon is known as *electronic hibernation*. As far back as 2009, a pioneering study estimated that American households stored an average of 6.5 hibernating electronic items in their attics and basements. This figure has increased exponentially over the years.

In 2021, a study conducted by Google identified seven key barriers preventing consumers from recycling their electronic devices:

- Low awareness of existing handoff options (recycling)
- Expectations regarding financial or social compensation
- Device nostalgia
- Desire to keep spare products
- Data retrieval factors
- Desire to ensure data removal
- Inconvenience of handoff options.

A more recent study conducted in Switzerland tempers these results slightly: 40% of respondents said they would be willing to part with their old cell phone for less than five dollars. However, it would be interesting to conduct the same survey in countries less wealthy than Switzerland.

Finally, the third stumbling block concerns collection systems and recycling infrastructures. In France, from where I write, most targeted waste channels (electronic waste, packaging, tires, etc.) are run by eco-organizations, private bodies that have either organizational or financial responsibility. These are regularly embroiled in controversy: analyses indicate that the material recovery of waste flows managed by eco-organizations is often suboptimal, in particular because of their profitability objectives.

Engaging engineers, designers, politicians, and consumers

Despite these obstacles, a number of initiatives aim to support companies in their eco-design efforts, including the cradle to cradle, which encourages companies to maintain "the quality of raw materials throughout the multiple life cycles of the product and its components."

Beyond such schemes, however, every participant in the value chain needs to examine their responsibility in waste:

- For engineers and product designers, this means adopting a more sustainable approach to design, taking into account the entire product life cycle right from the beginning of the design stage: it is the purpose of eco-design and eco-conception.
- Companies, meanwhile, need to take a longer-term approach rather than focusing exclusively on short-term profitability, particularly in a context of volatile metal prices.
- For consumers, this means greater awareness of the need to sort waste for disposal in specific channels, particularly electronic waste.
- And finally, governments and local authorities would do well to put in place regulations tailored to the sector's complexity, potentially including ambitious targets for specific recycling rates by type of metal, as well as some form of territorial planning to

better coordinate flows. Ensuring that recycling facilities more accessible is also a key factor in promoting good recycling behaviors.

The difficulty of moving toward a circular economy

We have not yet ventured to report metal recycling rates. One of them, the end-of-life recycling rate (EOL-RR), refers to the percentage of discarded metal that is recycled. Another indicator, the recycled content (RC), considers the proportion of recycled metal in total metal production.

Not surprisingly, these two indicators give very different recycling rates. For instance, chromium (Cr), copper (Cu) and zinc (Zn) have a life recycling rate of over 50%, which means that more than half of the quantities put into circulation are recycled. However, their recycled content is between 10 and 25%, as primary extraction of these metals is constantly increasing: the share of recycled metal in the total flows therefore remains low.

Consequently, even if we were able to achieve an optimal exploitation of urban mining deposits and high recycling rates for all metals (measured in EOL-RR), we would still be a long way from a circular economy, as demand for metals continues to rise exponentially. For instance, global production of copper (Cu) has almost doubled since 2000, rising from 14 to 25 million metric tons/year.

The effective recycling of metals contained in urban mines is therefore a necessary, but not sufficient condition for a truly circular economy. We will need to see a significant decrease in the volume of mineral resources used in industry before urban mining can partially replace, rather than add to, the exploitation of primary deposits.

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