Q & A: Recycling electronic waste could be a golden opportunity

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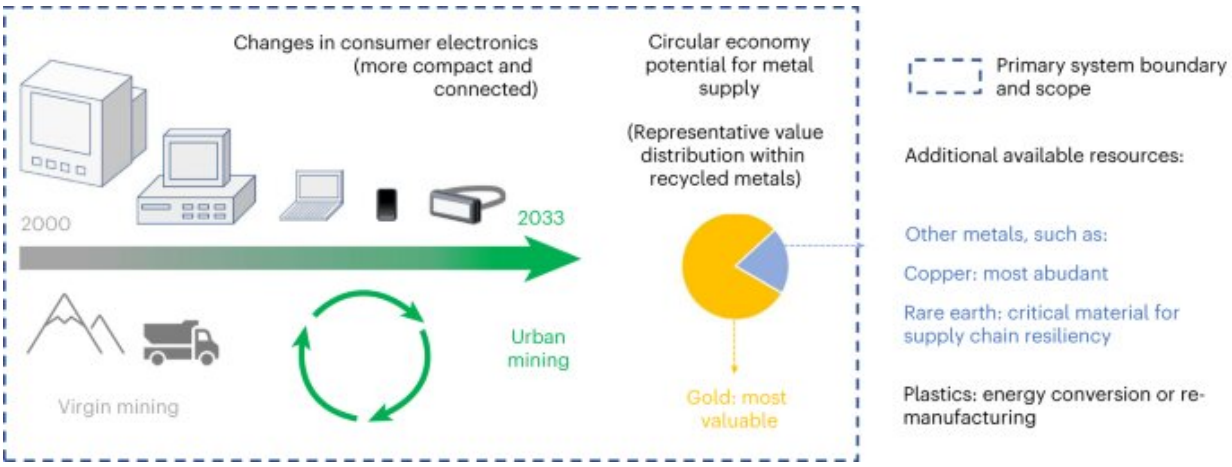

Scope and system boundary of this study. Credit: *Nature Sustainability* (2022). DOI: 10.1038/s41893-022-00983-9

By 2033, more than 1 billion laptops, cellphones, and other electronic devices could be entering the U.S. waste stream each year.

That's according to a new study in *Nature Sustainability* that projects a dramatic increase in the amount and complexity of U.S. waste electronics in the decade ahead. If not properly recycled, this influx represents a growing cause for environmental concern as it contains many toxic materials, according to study coauthors Peng Peng and Arman Shehabi, two scientists at the Department of Energy's Lawrence

Berkeley National Laboratory (Berkeley Lab).

However, with better end-of-life management, Peng and Shehabi's work shows electronic waste could also represent a source of valuable metals, namely gold, that could benefit the future economy by offsetting increasing demand for virgin mining.

In this Q&A, the researchers discuss the scale of the U.S. electronic waste problem as well as the potential of diverse management solutions across the country.

Peng Peng is a research scientist in the Sustainable Energy Systems Group in the Energy Analysis and Environmental Impacts (EAEI) Division at Berkeley Lab.

Arman Shehabi is a staff scientist in the EAEI Division of the Energy Technologies Area at Berkeley Lab.

Q. How big of a problem is electronic waste now?

Arman: The amount of electronics that are being discarded is increasing rapidly and in some ways that makes sense if you think about it intuitively. We just have more and more electronic devices in our lives. Many of them have short lifetimes. In our estimate, we saw that just in the U.S. alone projections were showing that there is a ballpark of a billion devices that will be discarded every year in the U.S. by the end of the decade.

One of the big issues is we don't really have a system in place or the infrastructure in place to properly take these electronics apart and reuse the different components that are in them, so they are really just being landfilled or shipped off to another country to recycle. A lot of times that recycling process is not done with proper health regulations and

could be exposing people to some of the toxic materials in those electronics.

Peng: If you look at the increase in the amount of electronics from like, say 2010 to right now, the amount being generated in a global setting has doubled.

The idea of a circular economy, that is finding ways to reuse the valuable materials in waste electronics, has been gaining a lot of interest recently, but one of the problems from a recycling perspective is that we don't really have good predictions of what the composition of that waste will be in the future because it is changing pretty quickly. There is lag between the type of devices being manufactured and the type of devices going into the waste stream which makes it difficult to predict the type of devices that will need to be recycled.

Q. How could the results of your study help address the electronic waste problem?

Peng: There are a lot of uncertainties associated with it, but what we showed is that the amount of gold that is essentially thrown away every year in electronics in the U.S. could be equivalent to the amount of gold that is mined in the country. We specifically looked at the value of extracting gold from electronics because gold is the most valuable metal you can get from them.

Arman: For our analysis we compiled various data sources to look at the sales of different electronics here in the U.S. We specifically focused on consumer electronics just because on a number basis that represents the largest stream of waste. We tied the projected growth in electronic sales to lifetime estimates for different electronic devices and studies that did tear downs of different electronics to get composition breakdowns of the

materials in those electronics.

And from that we were able to connect different electronic devices with different size integrated circuits, and then those different size integrated circuits with the heavy metal or gold composition of the circuitry.

Peng: Another important part of the paper was that we showed if theoretically in the United States all the virgin mining refineries were to start refining metals out of electronics, then they would have the productive capability of doing it. One potential problem however is the majority of U.S. gold refining facilities are located primarily in Nevada and Alaska.

Theoretically, we found that we could transport all the metals recovered from waste electronics to these refineries in Nevada or Alaska, but shipping them from all over the United States to those places actually creates a lot of economic and environmental burden. Our work shows that if we were to focus on building facilities across the nation to recover metals from these waste electronics in more diverse locations, we could actually reduce the environmental and economic burden associating with this transportation.

Q. Looking forward, what needs to be done to make your solution possible?

Peng: One of the issues we had while doing this research is that the disparities between different studies looking at what was in these electronics were rather large. So, depending on who did the experiments and what kind of brand, year of electronic used, etc., there could be dramatic differences between the amount of printed circuit board, plastics within the electronics, and gold or other metals within them.

To help us narrow down this uncertainty, it would be really helpful if electronic manufacturers would include the composition of what is in their electronics without exposing their intellectual property. Recyclers could then understand how much metal is in these electronics.

Arman: If each electronic device had sort of an ingredients label that could tell us what is in them it would make it easier to compile them and move them around the country to the ideal location for them to be refined, based on their content. Having manufacturers working a bit closer with the refiners from end to end on this process would also make it easier to make sure that they have the capacity to process the material and are optimizing their recycling facilities.

Another important area where there is an opportunity for future research is in terms of the type of refining that is being done now. Most of it is based on virgin mining and researchers need to continue making progress on more novel extraction techniques that might be better positioned for electronic recycling.

Q. What do you expect to happen if nothing else is done to address this issue?

Peng: So, I think if nothing is going to be done for this problem, we are definitely going to be facing a shortage of critical metal materials from virgin resources. And the environmental problem associated with waste electronics will just grow more and more complicated because all of these different electronic types are a lot smaller and more dynamic than they were 10 years ago. I think this could potentially be a very serious problem.

Arman: I think if nothing changes, we are going to see an increase in the amount of electronic waste that is generated in the United States, and

without the infrastructure to grow accordingly, that electronic waste is probably going to be shipped overseas or to other countries and that puts reliance on other countries to take care of our electronic waste. We also would be throwing away lots of valuable materials or just giving them away.

I think as we are moving more towards a digital society where we have more and more electronics in our everyday lives, the materials used to make electronics are going to become in higher and higher demand. So, if we can find a better way of extracting and keeping parts of those materials at their end-of-life, it is going to help allow the economy to grow while minimizing the strain on the environment.

More information: Peng Peng et al, Regional economic potential for recycling consumer waste electronics in the United States, *Nature Sustainability* (2022). DOI: 10.1038/s41893-022-00983-9

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