A new source of raw materials: prosperity trash

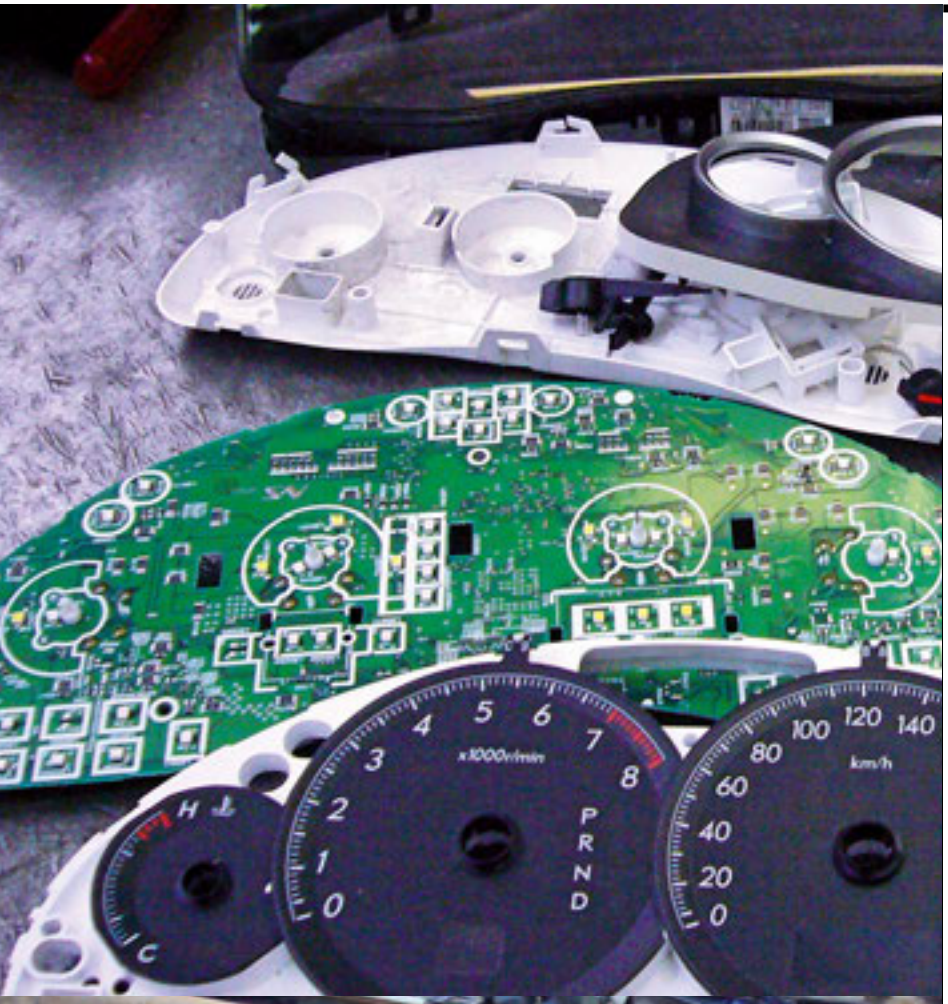
A constant wave of new functions on cell phones and home electronics soon renders them obsolete – and turn working devices into e-waste. Empa is addressing the issue of so-called secondary raw-material extraction or "urban mining", as it is commonly referred to – namely, the transformation of consumer waste into a source of raw materials.

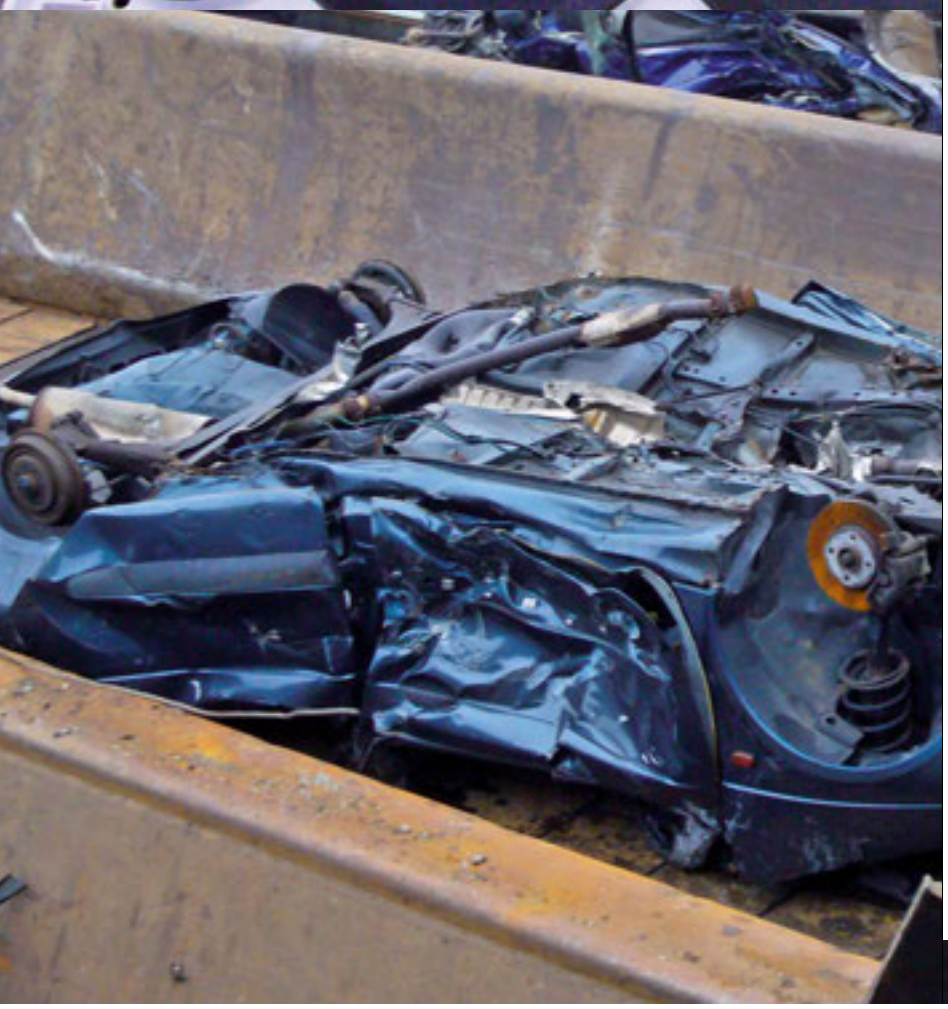
TEXT: Anna Ettlin / PICTURES: Empa

The demand for materials for highly specialized applications is on the rise. Take electronics, for instance, which are becoming increasingly smaller and more powerful: an ordinary cell phone contains around 50 different metals, including some rare ones such as tantalum, indium, platinum and palladium. And many are classed as critical: for geological, political or technical reasons, their long-term availability is unsure and could even become severely limited in future.

The focus in the procurement of these critical metals is increasingly shifting towards "urban mines", namely discarded products, which harbor the coveted materials. Electrical and electronic devices often contain much higher concentrations of valuable materials than even the most productive mines. All too often, however, high costs and the technical complexity of the recycling process stand in the way of the systematic exploitation of these urban mines.

Empa is conducting research in various areas of urban mining. First of all, the institute is investigating which metals are found in which devices and components and in which quantities. Then: which recycling processes produce the highest possible yield? And is this reclamation worth it from an ecological and economic perspective? Three current projects illustrate the range of the research. For instance, Empa researchers are studying the prerequisites for recycling the extremely rare metals indium and neodymium in Switzerland. A second project is devoted to an urban mine that has lain fallow thus far: car electronics. And the results should eventually benefit developing countries, which have to deal with growing mountains of sometimes hazardous e-waste.





Too good for the scrap press

The fact that cell phones and computers are recycled is almost taken for granted in Switzerland nowadays. In modern households, however, electronics are no longer solely found in the office or living room, but also in the garage: in cars. Every year, 100,000 cars are scrapped in Switzerland – and the same number is exported and eventually ends up on the scrap press abroad. And all of them are jam-packed with electronics: GPS and stereo systems to increase comfort; numerous sensors and chips to monitor safety and energy consumption. Back in 2010, electronics already constituted a third of every new car's material value. This proportion will continue to rise with the increasing "electrification" of transport.

Consequently, a modern car contains about as many metals as a cell phone, including some rare elements such as gallium and the rare earth metals dysprosium and lanthanum. "Of the roughly 50 different metals, up to 20 could be recovered," says Rolf Widmer from Empa's Technology and Society Lab. Today, recycling is primarily limited to three metals: iron, aluminum and copper. All the others are lost when the disused cars are scrapped.

Empa is looking for solutions together with the Federal Office of the Environment (FOEN), the Foundation Auto Recycling Switzerland (SARS), the Association of the Official Car Collection Proprietors (VASSO) and other industrial partners. "First of all, we want to characterize the cars as an urban mine," explains Widmer. This should improve the management of this valuable source of raw materials. Although, according to Widmer, the recycling infrastructure is already in place for the second largest urban mine in Switzerland, consumer electronics, this is not yet the case for car recycling. The Empa researcher sees enormous potential here: "Could car recyclers learn from electronics recyclers? Might car electronics even be incorporated into electronics recycling by dismounting them on their way to the scrap press?"

The project, which should answer these questions, is currently under preparation and an international collaboration is already in the pipeline; other countries also want to improve their recycling of car electronics because the rolling urban mine is growing increasingly fruitful as transport becomes "smarter".

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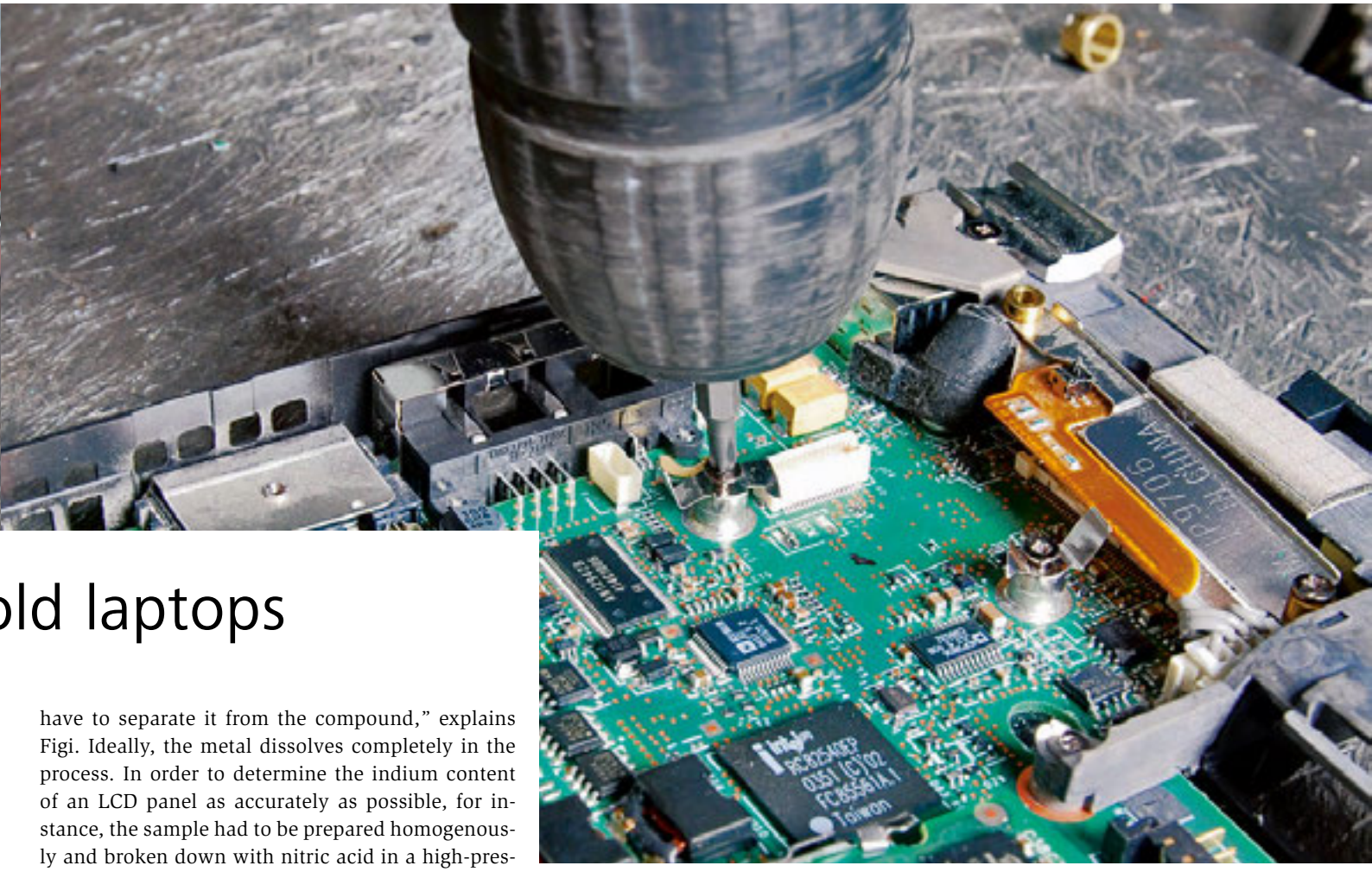
Rare metals from c

In Switzerland, electronic devices contained around two tons of indium and more than 80 tons of neodymium in 2009. Indium is found in LCD monitors, for instance, and neodymium in hard drive and speaker magnets. By now this figure is bound to be even higher. Nonetheless, neodymium and indium, like many other critical metals, are yet to be recycled.

Empa is investigating whether it is worth doing something about this on behalf of the Federal Office of the Environment (FOEN) and the electronics manufacturer association Swico in the project e-Recmet, which places technical, organizational, economic and ecological factors under the microscope. “The project provides specific implementation recommendations for Swico,” says Heinz Böni, Head of Empa’s Technology and Society Lab. “It plugs major knowledge gaps that are also extremely important beyond Switzerland.”

Before the profitability and feasibility of recycling can be examined, you need to know exactly how much metal there is in the devices. Hence, Renato Figi from Empa’s Analytical Chemistry Lab devised new, standardized analytic methods for indium and neodymium. “In order to determine a metal’s exact concentration in a sample, we usually



old laptops

have to separate it from the compound," explains Figi. Ideally, the metal dissolves completely in the process. In order to determine the indium content of an LCD panel as accurately as possible, for instance, the sample had to be prepared homogenously and broken down with nitric acid in a high-pressure reactor at a temperature of 280°C and a pressure of 135 bar – a procedure with around 20 variable parameters that all had to be tested individually. According to Figi, however, it was worth the effort: "We now have a method that can be reproduced wherever you have the necessary lab equipment at your fingertips."

With the project on the brink of completion, Heinz Böni takes stock: "It's technically feasible to recycle indium and neodymium. And from an ecological perspective, it is even more favorable than their primary extraction from mines." So far so good, but: "Ultimately, the recycling costs will also come into play," he goes on. And these are currently higher than the market price of the metals. With a little help from the advance recycling fee, however, which Swiss consumers pay when they buy any device, we could already cover it today. "That would be a truly groundbreaking step," says Böni, "both in Europe and worldwide."

Video
Valuable scrap: recycling rare metals (in German)

http://youtu.be/53i8_BtDOg4

Indium

Use	Thin films, solders and alloys, composite materials, semi-conductors
Price per kilo	Approx. 700 CHF
Amount mined per year	Over 500 tons
Estimated reserves	11,000 tons
Concentration in primary mine	1 – 100 grams per ton
Concentration in components (LCD panel)	140 – 220 grams per ton
Amount contained in flat screens in Switzerland in 2009	2.1 tons

Neodymium

Use	Hard drives, engines, speakers, MRI
Price per kilo	Approx. 90 CHF
Amount mined per year	21,500 tons
Estimated reserves	110 million tons
Concentration in primary mine	1.2 – 17.6 kg per ton
Concentration in components (neodymium magnets)	320 – 640 kg per ton
Amount contained in hard drives and speakers in Switzerland in 2009	84 tons

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Fairness in recycling

Many of our raw materials come from developing countries. Standards and related labels guarantee the sustainability of their extraction. For instance, there are Max Havelaar bananas and fair-trade-certified goldmines. But gold is not just mined; discarded cell phones contain the precious metal in a form that is roughly 30 times more concentrated. Like many secondary raw materials, gold is recycled – even in developing countries. However, there are no standards or labels for reclaimed gold or copper, their reclamation is uncontrolled and done with methods that pose a hazard to both humans and the environment.

Consequently, Empa and the State Secretariat for Economic Affairs (SECO) have been working on a more sustainable e-waste recycling concept since 2003. The original "Swiss eWaste Program" managed to instigate improvements in India, South Africa, Colombia and Peru. The follow-up program "Sustainable Recycling Industries" (SRI), which is supposed to support the establishment of a sustainable e-waste recycling system in seven developing countries – now also including Ghana, Egypt and Brazil – over a period of four years was launched last year. Eco-inventory data centers are also being set up in India, South Africa, Egypt and Brazil. India is focusing on hazardous additives, such as flame retardants in recycled synthetic materials, while the disposal of old refrigerators is the priority in South Africa.

Contracts with the most important partners were signed recently. Now the realization is set to begin. Thanks to various projects, SMEs in the recycling sector should be given the incentive and opportunity to work more sustainably. As project leader, Empa brings its scientific expertise to the table, such as in the monitoring of pollutants, lifecycle analysis (LCA) and testing the efficiency and environmental burden of methods. "Despite the low costs and with the simplest of means," says Rolf Widmer, "it's quite a challenge to get the monitoring and analysis of pollutants up and running."

Industrialized countries like Switzerland are reliant on raw materials – increasingly on secondary ones, too. "Therefore, it's also important for these to be produced sustainably," stresses Empa researcher Heinz Böni. Results from the individual countries will thus be pooled regularly at the Global Roundtable for Responsible Recycling, based upon which a sustainability standard will then emerge for secondary raw materials.

Video
Empa's knowhow for better recycling in India (in German)

http://youtu.be/RMuGAmwgX1o