MAGAZINE (/TAXONOMY/TERM/60) FEATURE (/TAXONOMY/TERM/114)

RARE EARTH RECYCLING: HOW CAN WE KEEP OUR GADGETS SUSTAINABLE?

By Libby Peake (/profile/libby-peake) | 6 June 2017 | Add a Comment (/article/rare-earth-recycling-how-can-we-keep-our-gadgets-sustainable-11904#disqus_thread)

PRINT E-MAIL SHARE

Our reliance on rare earth elements in our gadget-hungry world is growing, but their supply is far from secure. Libby Peake learns about the environmental costs of mining the materials and increasing efforts to recycle them

Think of virtually anything that symbolises modern life – whether it be electronic gadgets, transportation like aircraft or cars (of both the electric and petrol-powered variety), advanced medical equipment like MRI scanners, fibre-optic cables allowing instantaneous global communication, or even nuclear reactors and the wind turbines and solar cells that we hope will replace them – and it's likely to be enabled by at least a few rare earth elements (REEs).

(https://resource.co/sites/default/files/rare-earths-electronics.jpg)

The REEs are comprised of the 15 lanthanide metallic elements – the ones that can be found below the main body of the periodic table (numbers 57-71, for the chemistry geeks) – plus scandium (21) and yttrium (39), which tend to be found in rare earth compounds and ores and have similar chemical characteristics.

These elements display unique magnetic, luminescent and catalytic properties, which have made them indispensible to most modern-day technology. Despite the name, however, the rare earths aren’t generally rare (cerium and neodymium, for instance, are roughly as plentiful as copper or nickel), but are found in such low concentrations in the earth’s crust that extracting them is an incredibly difficult, expensive and dirty process.

Because the rare earths occur together and are so similar to each other, displaying only very small differences in solubility and chemical formation, refining them is very complicated, typically involving dissolving large bits of natural ore in batches of industrial acids thousands of times to enable the chemical filtering of the elements. The process generates vast amounts of toxic and radioactive liquid waste, resulting in extensive environmental degradation and plenty of health hazards for those working the mines and processing facilities, which goes some way to explaining China’s dominance of the rare earth scene: more developed nations are less willing to accept the environmental and human toll associated with their production.

Dr Eric Schelter, who is researching ways of recycling rare earths at the University of Pennsylvania (more of which in a moment), notes: “Everybody’s heard of blood diamonds, but maybe people haven’t heard of blood cobalt or tantalum or lithium for that matter.”

But there is increasing awareness of the devastating human and environmental cost of mining these essential materials. In 2015, **BBC journalist Tim Maughan visited rare earth mines in Baotou in Inner Mongolia** (https://www.bbc.com/future/story/20150402-the-worst-place-on-earth), an autonomous region in northern China that supplies most of the world's rare earths, and described it as 'hell on earth'. Visiting the tailings 'pond' where the mining waste is dumped, Maughan added: "[N]othing prepared me for the sight. It's a truly alien environment, dystopian and horrifying. The thought that it is man-made depressed and terrified me, as did the realisation that this was the byproduct not just of the consumer electronics in my pocket, but also green technologies like wind turbines and electric cars that we get so smugly excited about in the West."

Despite the West's reliance on REEs, though, nearly all of them currently come from China, with the country producing 95 per cent of the world's supply as of 2010. Its dominance was aided by the fact that, in the 1990s, China undercut world prices, which meant that many mines in other countries were forced to shut. With growing demand for the elements, however, China announced restrictions on the export of rare earths in 2009, citing (perfectly plausible) environmental concerns and prompting a diplomatic row with the likes of Japan, the EU and US. Eventually, the World Trade Organisation ruled that China had broken free trade agreements, forcing the country to drop its restrictions. The development, however, saw the reopening of some shuttered mines, including the Molycorp's Mountain Pass Mine in California, and forced many countries to increase efforts to secure reserves of these critical materials.

In a **2013 briefing paper** (https://www.europarl.europa.eu/RegData/bibliotheque/briefing/2013/130357/LDM_BRI(2013)130357_REV1_EN.pdf), the EU (which has very few rare earth deposits – in Sweden, Germany and possibly Ireland), for instance, noted: 'The supply-demand balance, in the near future, shows important differences among REEs but it is generally characterised by under-supply. Tensions are

(https://resource.co/sites/default/files/RARE%20EARTH.jpg)
A satellite image of the Bayan Obo mining district, China

particularly likely for five REEs (neodymium, europium, terbium, dysprosium and yttrium) for which demand is expected to grow by up to 30 per cent. Only for lanthanum is a surplus expected.'

The paper added that 'bringing a new mine on-stream is a complex and long-term project', taking 10 to 15 years, and suggested that most countries have placed rare earths on their critical or risk list. Indeed, REEs came top of the British Geological Survey 'Risk List 2012', which gave them a relative supply risk index of 9.5 out of 10.

Despite the pressure on the supply of these vital elements and the increasing recognition of their critical nature and environmental cost, however, recycling of rare earth elements has been virtually non-existent. There are several reasons for their low recycling rate. The first is that, unlike the precious metals found in electronics, the quantities of rare earths in each application, are normally very low – with each smartphone containing, for example, just 50 milligrammes of neodymium and 10 milligrammes of praseodymium. The elements are also often combined in a way that makes them difficult to separate (just like when they are found in the ground) and in some cases, as with the rare earths in touch screens, they are distributed throughout the material at the molecular scale.

Moreover, the typical method currently employed in developed nations for recycling used electronics – namely shredding and grinding gadgets into a powder from which to extract component materials – means that the rare earths, already in such tiny concentrations, are normally lost. This is especially true if there is ferrous material present, as the rare earths with magnetic properties will adhere to iron-containing substances. Indeed, a recent study from the Materials Innovation Institute in Delft in the Netherlands found that shredding hard drives for recycling resulted in a 90 per cent loss of the rare earth neodymium, used along with dysprosium in powerful magnets for the hard disk drives, with the researchers noting: "The large losses of material incurred while shredding the material puts serious doubts on the usefulness of this type of recycling as a solution for scarcity."

Even when recycling is attempted, it can be either too expensive or environmentally-damaging to justify: pyromettallurgical methods that separate out elements through heating electronics to very high temperatures, for instance, require vast amounts of energy. The most common method currently employed for rare earth recycling, meanwhile – liquid-liquid extraction, which involves dissolving the waste in strong acids before extracting the rare earths with a series of solvents – very closely mirrors the method for extracting them from ore, and can take several weeks. University of Pennsylvania researcher Zeke Cole explains: “They just run tonnes and tonnes of solvents past one another in a continuous fashion. It uses up huge amounts of energy and there’s a lot of liquid waste generated from that process.”


(https://resource.co/sites/default/files/phones_1.jpg)
Rare earths are contained in many of our everyday gadgets

And if that list isn’t long enough, another problem, following the lifting of China’s export restrictions, is that rare earth prices have fallen again, making many budding attempts at recycling founder on the basis of cost. Belgian chemical company Solvay, for instance, acquired the French company Rhodia, which had been developing rare earth recycling applications in the automotive, lighting and electronics industry, but noted in a 2015 update on the rare earth recycling initiatives it had inherited: ‘Now that REEs are back to more normal prices, most of these [recycling] initiatives are unprofitable.’ It added that the company would only focus recycling efforts on ‘the most valuable REEs’ going forward, and that ‘due to the REE market dynamics, [sourcing outside of China] will remain a small portion of REE raw materials’.

Nonetheless, research into recycling is ongoing, especially in countries like Japan and the US, where dependence on rare earths is high (the UK has also recently launched its Critical Raw Material (CRM) Closed Loop Recovery programme, managed by the Waste and Resources Action Programme (WRAP), funded by the EU’s LIFE programme, which aims to increase collection of used electronics and includes REEs in its goal of increasing CRM recycling by five per cent by 2020). In the US, the Department of Energy’s Critical Materials Institute (CMI) is exclusively focused on lessening the country’s reliance on China for rare earth metals, and has made some progress with different recycling methods, including those using supercritical carbon dioxide, ionic liquids, and electrochemical methods.

A particular success that the institution has been shouting about has come in the form of a two-stage liquid metal extraction process that uses those very minor differences between the solubility properties of the different elements to separate out rare-earth metals. In CMI's liquid extraction method, scrap metals are melted with magnesium, because, as CMI scientist Ryan Ott explains: "Magnesium has good solubility with rare-earths, particularly with neodymium, and poor solubility with the other components of magnets, like iron and boron."

Rare earths with lighter atomic weights, like neodymium, bind with the magnesium and leave the iron scrap and other materials behind before being recovered from the magnesium through vacuum distillation. In the second step, another material is used to bind with and extract the rare earths with heavier atomic weights, like dysprosium. "Extraction of the heavier rare earths was always the difficulty of this process, and those materials are the most valuable. So finding a way to do that successfully was the key to making it more economically viable as a large-scale recycling method", Ott concludes.

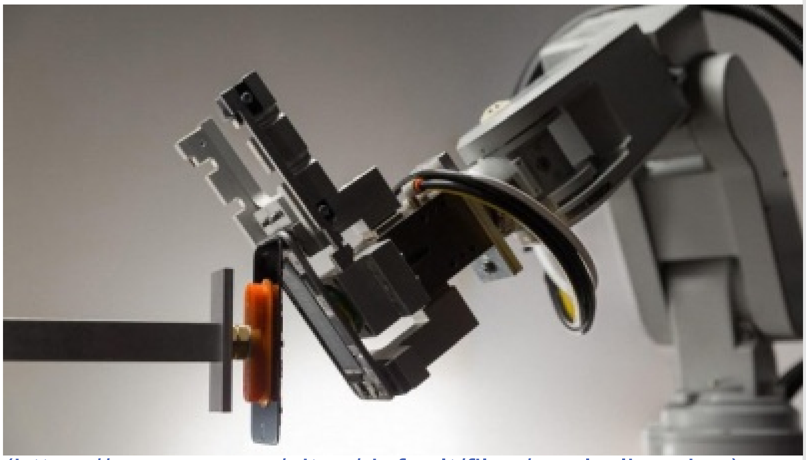
In another CMI project, researchers are using ionic liquids – or 'molten salts', which are often used as solvents and are considered safer than alternatives – to separate rare earth elements. Scientist Anja Mudring, who is leading the project, explains: "We are tuning the ionic liquids in such a way that they dissolve rare-earth oxides and then we're using electrodeposition, where electricity is run through a liquid to create a chemical change, to get the rare earth in metal form."

And outside the CMI, but still in the US, scientists at the University of Pennsylvania, as mentioned above, have been specifically researching how to separate the rare earths neodymium and dysprosium, used together in small, powerful magnets used in many high-tech devices. They have devised a method to chemically separate these two substances that they say is simple, produces little waste, and can be completed in a matter of minutes. Lead researcher Eric Schelter explains: "It is, in principle, easier to get the neodymium and dysprosium out of technology than it is to go back and mine more of the minerals they are originally found in. Those minerals have five elements to separate, whereas the neodymium magnet in a wind turbine generator only has two."

Graduate student Justin Bogart adds: "When we started, our goal was to make rare earth separations simpler and more efficient, and we have made strides towards just that. We have designed a way to separate the two metals by selectively dissolving the neodymium in a solution and leaving behind the dysprosium as a solid. This quick and easy method has allowed us to separate equal mixtures of the metals into samples that are 95 per cent pure."

Schelter concludes: “You can do this separation in five minutes, whereas the liquid-liquid extraction method takes weeks. A potential magnet recycler probably doesn’t have the capital to invest in an entire liquid-liquid separations plant, so having a chemical technology that can instantaneously separate these elements enables smaller- scale recyclers to get value out of their materials.”

More recently, Schelter’s team has been looking to apply the method to other rare earths and in December of last year published a paper in the *Proceedings of the National Academy of Sciences* that said that the method could potentially be extended to the entire series of REEs, though the paper recorded varying levels of success when the method was tried on combinations of six rare earths. Future research will look at improving the system as well as finding a cheaper and greener solvent (the benzene used is carcinogenic).

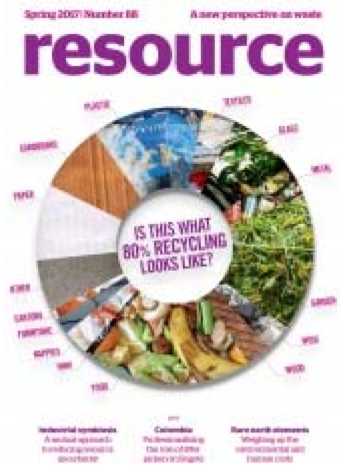


(https://resource.co/sites/default/files/apple-liam.jpg)
Apple has started using a 'Liam' robot to disassemble iPhones to recover components

And what’s more, the research doesn’t stop with recycling. Plenty of large corporations are also looking to recycle rare earths while others are looking to substitute them. Nissan has recently announced that it was able to lessen the use of dysprosium in the magnets in its Leaf electric vehicles by 40 per cent, while Tesla has gone one better and created a copper-rotor induction motor for its Model S electric vehicles that uses no rare earths.

Meanwhile, Apple, which recently announced a long- term aspiration to use only renewable and recycled materials in its products, has (some would say belatedly) recognised the value of disassembly. In 2016, it launched two lines of robots called Liam – one in California and one in the Netherlands – each capable of disassembling 1.2 million iPhone 6s per year to recover components for reuse. While the figure is a drop in the ocean compared to the 78.29 million phones it sold in the first quarter of 2017 alone, it is perhaps a step in the right direction.

As the Liam white paper notes: “For materials like rare earths, a recycled material supply does not yet exist at sufficient volumes, so discrete disassembly is the first step to enable a recycled materials market to be developed.”



[(/magazine/88)](/magazine/88)**This article was taken from Issue** [**88** (/magazine/88)](/magazine/88)

But progress in developing markets for recycled material has been moving forward at a much slower rate than advances in the technologies themselves, and success in this area can’t come quickly enough. Lately, plenty of players in the international community have been eyeing up the seabed as a potential source of REEs, potentially putting at risk its fragile ecosystems (that are already being significantly damaged by society’s inability to manage plastic!), with experts warning that extensive rare earth mining in that environment could have catastrophic impacts. As the world’s thirst for new technologies shows no signs of abating, efforts to recycle and replace the rare earths in our many, many gadgets are increasingly pressing.

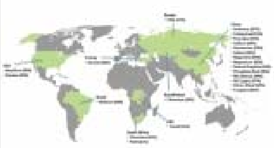
RELATED ARTICLES

(/article/apple-sets-sights-100-cent-recycled-iphone-11806)

Apple sets sights on 100 per cent recycled iPhone (/article/apple-sets-sights-100-cent-recycled-iphone-11806)

By Edward Perchard (/profile/edward-perchard) **| 24 April 2017 | Add a Comment** (/article/apple-sets-sights-100-cent-recycled-iphone-11806#disqus_thread)

Apple has pledged to work towards using 100 per cent recycled materials in its products, a commitment Greenpeace says puts pressure on the rest of the technology industry to follow suit.

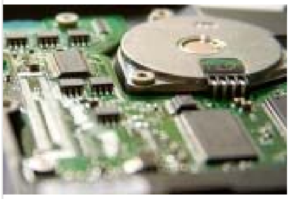


(/resource-

EC launches new critical raw materials analysis (/resource-use/article/ec-launches-new-critical-raw-materials-analysis)

By Annie Kane (/profile/annie-kane) **| 27 May 2014 | Add a Comment** (/resource-use/article/ec-launches-new-critical-raw-materials-analysis#disqus_thread) use/article/ec-launches-new-critical-raw-materials-analysis)

There are now 20 raw materials that are critical to the EU economy, finds European Commission report, up from 14 in 2010.



(/article/trials-improve-capture-diminishing-raw-materials-electrical-waste-under-way-11270)

Trials to improve capture of diminishing raw materials for electrical waste under way (/article/trials-improve-capture-diminishing-raw-materials-electrical-waste-under-way-11270)

By Edward Perchard (/profile/edward-perchard) | 27 July 2016 | Add a Comment (/article/trials-improve-capture-diminishing-raw-materials-electrical-waste-under-way-11270#disqus_thread)

Three companies have been selected to trial innovative ways to boost the recovery of critical raw materials from household electrical waste.

(/article/how-fairphone-creating-smart-phone-circular-economy-11361)

How Fairphone is creating a smart phone for the circular economy (/article/how-fairphone-creating-smart-phone-circular-economy-11361)

By Resource | 6 September 2016 | Add a Comment (/article/how-fairphone-creating-smart-phone-circular-economy-11361#disqus_thread)

Smart phones are increasingly designed to give up the ghost after a year or two, but Dutch company Fairphone is attempting to change that by putting the power back into the user's hands.

0 Comments Resource Magazine Disqus' Privacy Policy 1 Login

Recommend Tweet Share Sort by Best

Start the discussion…

LOG IN WITH

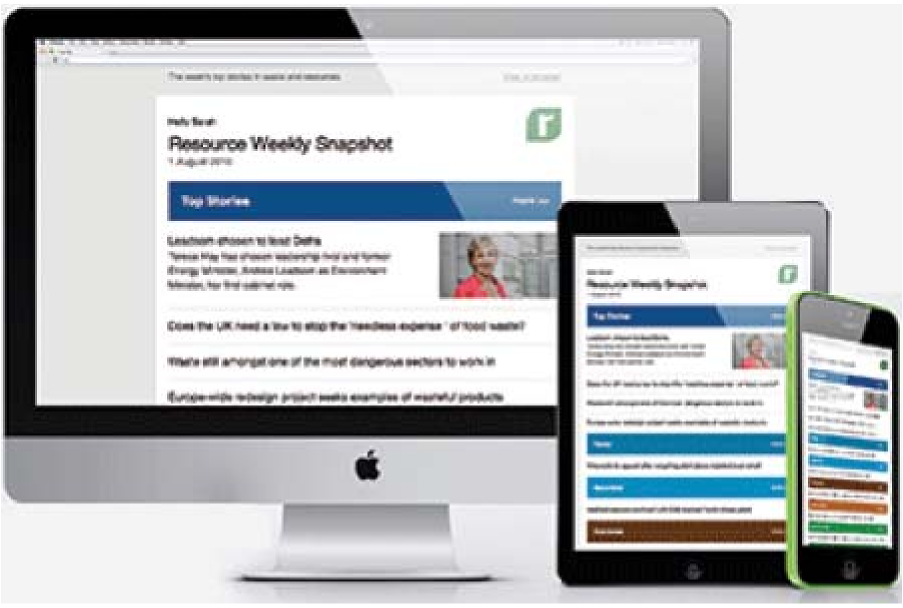
OR SIGN UP WITH DISQUS ?

Name

Be the first to comment.

Subscribe Add Disqus to your siteAdd DisqusAdd Do Not Sell My Data

NEWSLETTER



Weekly email newsletter

- The top stories in waste and resources
- Links to exclusive feature articles on the website
- Delivered to your inbox every Friday afternoon
- The best from Resource.co's industry-leading editorial team

Email*

First Name

Last Name

SIGN UP NOW

RELATED

Fly-tipping – the tip of the waste crisis iceberg

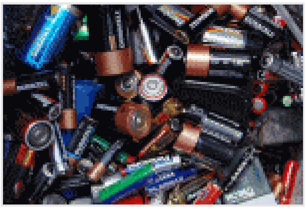
With fly-tipping reaching epidemic proportions in England, Nick Oettinger, Managing Director of The Furniture Recycling Group, looks at the issue, the underlying causes and what can be done to buck this socially and environmentally unacceptable trend.

60 per cent call for more 'on the go' can recycling

A recent survey carried out by Every Can Counts found that the UK public wants more can recycling facilities in public spaces, with 60 per cent calling for street recycling facilities.

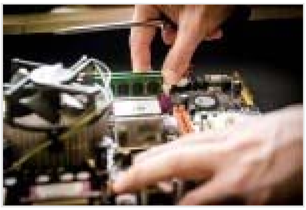
Government 'treating symptoms, not cause' of plastic pollution, says Green Alliance

A new report from think tank Green Alliance has criticised the government's plastics policy for 'failing to deal with the root of the problem'.



[UK misses battery collection target]

New figures from the Environment Agency (EA) have revealed that the UK has missed its battery collection target by 258 tonnes.



[Repair Café Conference to launch new Carbon Calculator]

A ‘Repair Café Carbon Calculator’ is set to be previewed at the UK’s first Repair Café Conference on 12 March in Farnham, Surrey.

POPULAR

[Budget 2020: Plastics tax set at £200 per tonne]

Chancellor Rishi Sunak has confirmed today (11 March) that a new Plastic Packaging Tax will be introduced from April 2022 to encourage producers to increase their use of recycled material.

[EU unveils Circular Economy Action Plan]

The European Commission has today (11 March) published its new Circular Economy Action Plan, outlining measures to ensure that products are designed to last longer and are easier to reuse, repair and recycle.

[60 per cent call for more ‘on the go’ can recycling]

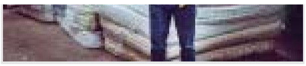
A recent survey carried out by Every Can Counts found that the UK public wants more can recycling facilities in public spaces, with 60 per cent calling for street recycling facilities.

[News in brief – 11/03/20]

A round-up of news from the waste and resources sector, including Renewi, Eunomia, PowerHouse Energy, Agrimax and J&B Recycling.

[Fly-tipping – the tip of the waste crisis iceberg]

With fly-tipping reaching epidemic proportions in England, Nick Oettinger, Managing Director of The Furniture Recycling Group, looks at the issue, the



underlying causes and what can be done to buck this socially and environmentally unacceptable trend.

SITEMAP

DIRECTORY

EVENTS

ABOUT

- EDITORIAL
- TERMS AND CONDITIONS
- PRIVACY POLICY
- CONTACT

ADVERTISE

LOGIN

GET IN TOUCH

Resource Media Limited, Create Centre, B Bond Warehouse, Smeaton Road, Bristol, Avon, BS1 6XN

0117 9030698

info@resource.uk.com