Track flows of technology metals

Recycling cannot meet the demand for rare metals used in digital and green technologies, warns Andrew Bloodworth. A more holistic approach is needed.

Demand for metals is growing rapidly as global populations burgeon and millions of people in emerging economies aspire to a Western lifestyle. The variety of metals we use has also expanded as technology has advanced. As a result, historic fears regarding metal scarcity and resource depletion have returned in the past 10 years.

Concerns focus on the future supply of metals such as indium, rare earths and tellurium that are critical in delivering new digital and low-carbon energy technologies. In 2009 the issue came to global prominence when China reduced its exports of rare earth elements, as the Beijing Government sought to maintain supply to their rapidly expanding domestic manufacturing sector.

Geopolitical and socio-economic risks – such as territorial disputes in Asia or labour relations in southern Africa – can interrupt supply because technology metals are produced in very few locations. Commercial barriers compound the issue. Investment in these materials can be risky because they are difficult to extract and the markets are small, complex and volatile compared to those for common 'industrial metals' like iron, copper and aluminium.

To secure supplies of critical metals for future technology the scientific, industrial and policy communities must work together. The numerous metal 'criticality' assessments that governments have commissioned fall short. They identify key issues, but also generate lots of sterile argument as to whether or not a particular metal is 'critical'. The solutions they point to are generic and of little practical use.

Prominent amongst these broad-brush responses has been the implication that technology metal supply security in Europe and the UK can be achieved largely through recycling. Whilst recycling is very important for managing stocks of common industrial metals, its application to technology metals is more complex. Some materials are impractical or impossible to retrieve after use.

More primary resources will be needed to meet rising demand and replace lost technology metals. To find new reserves, the geological processes that concentrate these metals need to be understood. And to increase efficiency of use, avoid unnecessary substitution and unintended environmental impacts, the flows of individual metals need to be mapped, from the ground to end of use.

Rare resources

Demand for technology metals has exploded in the past 40 years. Eighty percent of cumulative global production of gallium, rare earth elements, platinum group metals and indium has taken place since 1980 (Hageluken et al, 2012). This growth looks set for the foreseeable future if technology develops as expected (Graedel and Erdmann, 2012)**.**

Most technology metals are mined in only a few places. In 2011, for example, 72 per cent of global cobalt came from the Democratic Republic of Congo and 57 per cent of indium originated from China (see Figure**).** They are produced in low volumes. In 2011 just 72900 tonnes of tungsten was extracted globally, compared to 45.2 million tonnes of aluminium and 1.5 billion tonnes of crude steel (BGS, 2013).

Some studies have concluded that scarcity and depletion of technology metals are unavoidable as rising consumption will outstrip current reserves (Ragnarsdottir, 2008). These apocalyptic forecasts fail to take into account that geological reserves are dynamic, expanding as metal prices rise and extraction of lower grade ores becomes economically viable, and contracting as prices fall.

Reserve levels also vary with the development of scientific and technical knowledge related to discovery, extraction and processing. A combination of price pressures and technical advances has kept global reserves of most metals steady or growing over the past 50 years (Crowson, 2011).

Because technology metals were of limited economic interest until recently there was little imperative to look for them. Consequently their distribution in the Earth and the natural processes that concentrate them are poorly understood.

As knowledge improves, we will be able to reappraise old mining areas and explore new frontiers. Former mines of south west England may hold promise for tungsten, and a significant deposit of heavy rare earths was recently identified at Norra Karr in Sweden.

Recycling is not enough

Secondary metals, recycled from defunct products, provide valuable supplementary resources. However, secondary stock will never meet growing demand. And recycling has technical limits.

From mobile phones to motor vehicles, technology metals are used in myriad applications. Up to 60 different metals go into the manufacture of microprocessors and supporting circuit boards (Gunn, 2013), usually in tiny quantities, often in combinations that are not found in nature.

Whether or not a metal can be recovered at the end of the life of the device depends on the element's value, concentration and accessibility when combined with other materials (Reck and Graedel, 2012). Precious metals — platinum group metals and gold — are, unsurprisingly, the main target in processing of used circuit boards. Lower value copper, antimony and indium may be recovered at the same time. But metals like tantalum, gallium, germanium and rare earths are oxidized and lost in the smelter slag (Hageluken et al, 2012).

Recycling of technology metals is most economically attractive where the metals are highly concentrated, such as in manufacturing scrap. Around 70 percent of the indium used in the production of flat screen displays, for example, finds its way into scrap which is then recycled (Jackson and Mikolajczak, 2012).

To identify supply constrictions and resource inefficiencies requires measuring technology metal stocks and understanding how they flow through the whole chain – from mining to concentration, extractive and process metallurgy, manufacturing, use, re-use, re-cycling, dispersal and disposal (Allwood and Cullen, 2012).

Quantification of losses may reveal where interventions can be made. For instance, improving recovery technology at tungsten mines would increase the amount of the metal in the ore that ends up reaching the smelter, just 75% for tungsten in contrast to 90% for gold. Addressing technological barriers to resource efficiency is a focus of initiatives such as the European Innovation Platform on Raw Materials, a network of partnerships between European countries directed at increasing the availability of raw materials across the region.

In theory over 90 percent of platinum group metals used in autocatalysts can be recovered. In practice only 50-60 percent is actually retrieved from European scrap cars because many vehicles are exported second-hand to places without recycling facilities. A full analysis of metal flows could show whether a scheme to retrieve these lost converters would be more effective than others which have been proposed which aim to recover these metals from road sweepings Autocatalysts contain about 0.2 per cent platinum group metals; road sweepings less than 1 part per million (Jackson et al, 2007).

Mapping the full life cycle of critical metals is challenging, however. The volumes are low; extraction, processing and recycling are handled by just a few organisations; and commercial confidentiality can make data and contacts hard to find.

Secure supply

In the past five years, the response to concerns over securing supplies of technology metals has evolved from near panic over physical depletion and Chinese geopolitical muscle-flexing, to a dangerous assumption by some policy makers that recycling is the panacea. A more holistic approach is needed.

The ‘one size fits all’ notion that recycling is always good and material from primary sources is always bad needs to be challenged. Large-scale adoption of low-carbon technologies such as photovoltaics and electric cars will accelerate demand for lithium, rare earths, gallium, tellurium and germanium. Much of this growth will have to come from primary sources.

Primary and secondary sources must be considered as part of one system. Once that system is understood in its entirety, interventions can be targeted to improve efficiency and reduce environmental impacts.

Basic statistical data are vital. Industrial supply chains and governments need to use metrics related to technology metal stocks and losses to track flows. Better dialogue between producers, processors, consumers and recyclers will be needed.

Policy makers must take into account how we use and combine technology metals and the impact that this has on the economic and environmental viability of recycling them.

The benefits of securing supplies of technology metals are clear. Improving the efficiency and reducing the environmental footprint of extraction and processing of these metals from primary sources is a major opportunity for industry and researchers.

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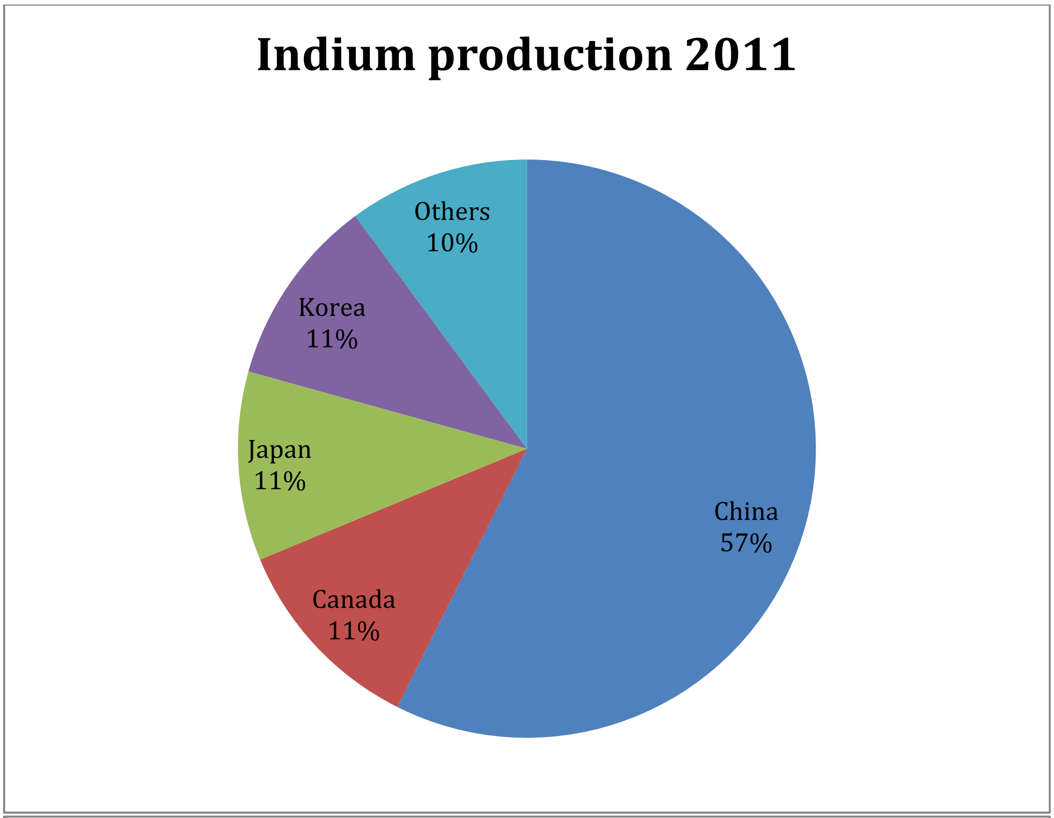
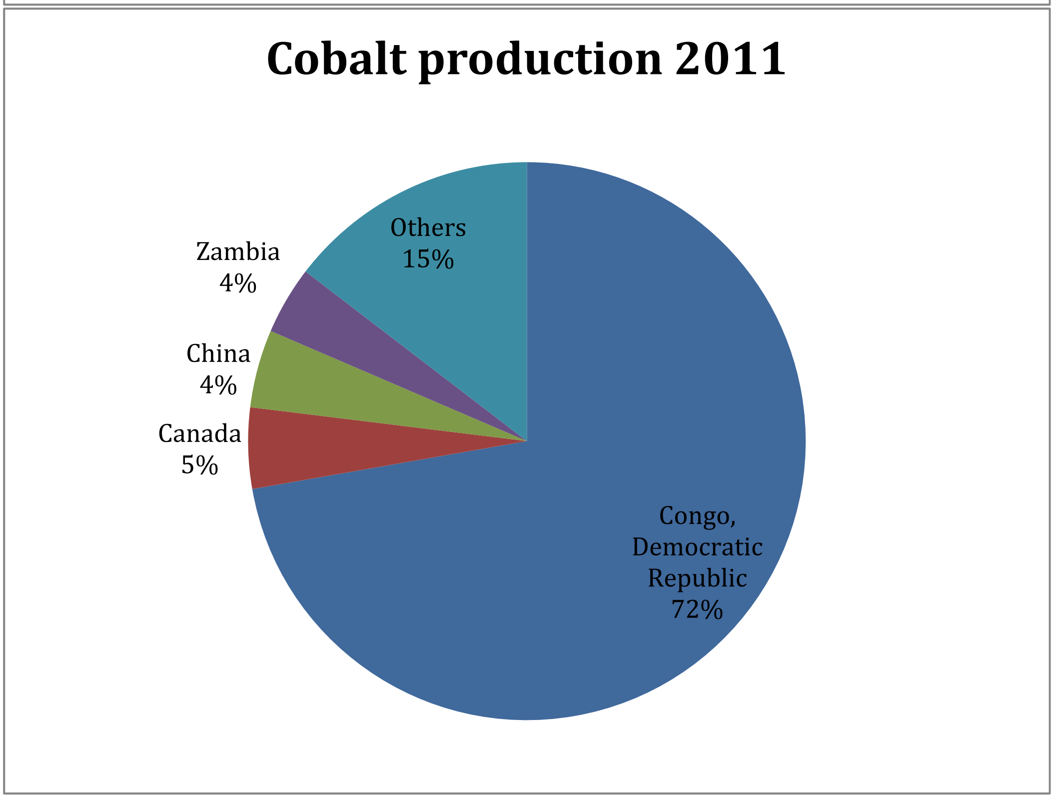

Indium production 2011
Others
10%
Korea
11%
Japan
11%
Canada
11%
China
57%


Cobalt production 2011
Others
15%
Zambia
4%
China
4%
Canada
5%
Congo,
Democratic
Republic
72%