

## Critical metals for low carbon technologies: can future supply be ensured?

A large and varied group of metallic elements are essential in the delivery of a low carbon economy and their continued supply needs careful consideration by industry and policymakers.



Wind turbine generators can contain several hundred kilogrammes of rare earth metals

**As the global population and economy expand, metal resources are being used at an ever-increasing rate. Managing these resources efficiently is imperative. The availability and sustainability of a large and disparate group of metallic elements that are critical in delivering new low-carbon energy, transport and digital technologies are the focus of particular concern from industry and policy-makers.**

## **What are critical metals and why are they important?**

**Meeting challenging greenhouse gas reduction targets will require very large-scale uptake of low carbon technologies. Critical metals (sometimes also known as “technology” or “strategic” metals):**

- Are essential functional constituents of many low-carbon or “green” technologies, particularly in energy, transport and digital systems.
- Include rare earths such as neodymium and dysprosium, used in high-strength magnets in electric vehicles and wind turbines. Platinum-group metals perform crucial catalytic functions in fuel cells and exhaust systems. Tellurium is used as a semiconductor in photovoltaic panels. High-capacity batteries in electric vehicles and mobile devices rely on lithium and cobalt.
- Tend to be used in relatively small quantities, but this is generally in highly specialised applications where they have no effective substitute.
- Are often only available as by-products of the mining of other metals.
- Can be at risk of disruption of supply.

## **How scarce are these metals and what factors affect the security of their supply?**

**Although most critical metals are relatively rare and are unevenly distributed in the Earth’s crust, it is very unlikely that we will physically run out of any of them in the foreseeable future. However:**

- Many critical metals were of limited economic interest until recently and there was little imperative to look for them. Consequently their distribution in the Earth and the processes that concentrate them are poorly understood compared to “industrial metals” such as iron, copper and aluminium.
- Because they are generally produced in low volumes (hundreds or thousands of tonnes) compared to industrial metals (millions or billions of tonnes) production of individual critical metals is often limited to a few locations where they are by-products of the extraction of other metals. This production concentration increases vulnerability to supply disruption through factors such as geopolitical disputes, resource nationalism, conflict or natural disasters.
- By-product status of many critical metals means that continued availability is dependent on the continued supply/demand for other, unrelated metals.
- Commercial investment is often risky and commercial developments slow to come on stream because their extraction and processing is technically difficult, gaining necessary permits can be difficult, and markets for these materials are relatively small, complex and volatile.
- Critical metals such as tungsten and tantalum may originate from small-scale “artisanal” mines linked to civil conflict in some parts of Africa. As a consequence, ethical and regulatory issues may impact on the supply of these metals.

## Why can't we obtain what we need by recycling?

**Critical metals recycled from end-of-life products could provide a valuable supplementary resource which may require less energy to recover than those from primary sources. However:**

- In a world of increasing resource use, the stock of secondary critical metal available from material in the human environment will always be insufficient to meet growing demand, even if efficiency is very high.
- There are socio-economic and technical barriers to the recycling of critical metals. These materials have numerous applications in a very wide range of products. Some products in which they are used have long lives. Effective recycling requires big changes in social attitudes to disposal and implementation of efficient collection systems.
- Critical metals are often highly dissipated because, within an individual product, they are present only in small quantities that are uneconomic to recover.
- Manufactured products put metals together in combinations that are not found in nature. This can present fundamental thermodynamic obstacles to critical metal recovery.
- Whether or not a critical metal is recovered at the product end-of-life depends on its intrinsic value, concentration and technical recyclability when combined with other materials in the device.

## What impacts do the extraction and use of these metals have on the environment?

**Because critical metals are vital to the function of many low carbon energy and transport technologies, they deliver major environmental benefits whilst these devices are in use. Recovery of critical metal as a by-product of industrial metal mining is resource efficient and reduces the overall environmental impact by combining some processes. However, there are environmental impacts associated with their extraction and processing:**

- Many critical metal deposits are low grade. For example, platinum group metals are typically mined from deposits which only contain about 5 parts per million platinum and palladium.
- Some critical metals occur in complex ores which make their separation difficult. For example, isolation of individual rare earth elements from a typical rare earth concentrate is a very complex process involving many stages of treatment with chemicals which are potentially harmful to the environment.
- Occurrence in low grade and/or complex ores makes production of some critical metals very energy-intensive.
- Processing of critical metals may also produce waste streams which can pose a threat to the environment if they are not properly managed. For example, processing of some types of rare earth ore may produce waste which is mildly radioactive.

## What actions are needed from policymakers to ensure a secure and sustainable supply of raw materials for a low carbon economy?

### **Policy makers should:**

- Accept that physical exhaustion of critical metals is not a major problem: together, primary material in the Earth and recycled resources comprise an abundant resource.
- Acknowledge the resource implications of major global uptake of low carbon technologies. Growing demand for critical metal cannot be met by recycling alone and Earth resources will be needed for the foreseeable future.
- Recognise that future access to unevenly distributed and/or dissipated resources is a major challenge.
- Support research into the origins, transport and deposition of critical metals in the Earth's crust, thus helping to find new resources and process them efficiently.
- Develop supply security policies based on a holistic understanding of critical metal flows through our environment.
- Ensure national statistical agencies gather metrics on production, consumption and recycling of individual critical metals to underpin sustainable resource management.
- Promote effective fiscal and regulatory interventions in the supply chain for secure and sustainable sourcing, resource efficiency and to minimise environmental impacts.
- Avoid over-reliance on a restricted number of technologies which rely on the same small group of materials which may be vulnerable to supply disruption.

## What actions are needed from manufacturers to ensure a secure and sustainable supply of raw materials for a low carbon economy?

### Manufacturers should:

- Understand which metals are critical to their production process.
- Develop strategies to manage critical metal supply risks dominated by human factors.
- Recognise where the supply of a particular critical metal is a by-product of another metal.
- Understand the critical metal supply chain, including alternative primary and recycled sources, and stockpiles.
- Understand the fate of critical materials in the recycling loop/circular economy and develop better strategies for their recovery.
- Work with their supply chain to ensure metal traceability.
- Design low carbon technology for maximum resource efficiency: do more with less, work with consumers to maximise product longevity, build with re-use, disassembly and recycling in mind.

## Further information

This policy and practice note was written by **Andrew Bloodworth, Gus Gunn and Evi Petavratzi (British Geological Survey)**. It draws on the following NERC-support research: **BGS national capability; three Security of Supply of Mineral Resources catalyst grants; Critical Metals: Science for a Secure Supply knowledge exchange project**. It was also informed by EU-funded research, including **Minerals Intelligence Network for Europe (Minerals4EU); EU raw materials statistics on resources and reserves (Minventory); Development of a sustainable exploitation scheme for Europe's Rare Earth ore deposits (EURare)**. Research collaborators include **Exeter University (Camborne School of Mines), Cambridge University, Imperial College, Leicester University, National Oceanographic Centre**.

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