Raw materials for a truly green future

Meeting global emission reduction goals will require the large-scale deployment of renewable energy infrastructure and electric vehicles. Ensuring a fair and sustainable supply of the required critical primary and secondary raw materials will be essential to a greener future.

During an international summit on climate last month, Joe Biden committed to reduce US greenhouse gas emissions by 50% by 2030 (the baseline is 2005 levels). The UK and the European Union have similarly ambitious targets of 68% and 55% reductions, respectively; other countries, including Japan, Canada and Brazil, also announced a step up of their targets at the summit.

Key to a shift towards a green economy is the deployment of renewable energy infrastructure and electric vehicles. Electric cars provide an instructive case study for the challenges ahead. Global sales rose by 43% in 2020 to more than 3 million, and projections show that in 20 years there will be between 300 and 500 million electric vehicles on the roads. To support this growth, we will need more critical raw materials — in particular rare earths, lithium and cobalt — than ever before.

For electric cars to be truly green, the raw materials they require need to be sourced sustainably. There are three ways to reach this goal: reuse materials where possible; recycle them into secondary raw materials when they reach the end of their useful life; and ensure any primary raw materials are sourced in a fair and sustainable way. Eventually, the aim is to transition to a fully circular economy, in which all new materials will come from reusing and recycling.

Electric cars use critical raw materials mainly for their motors and batteries. An electric car's motor comprises a fixed component generating a magnetic field that sets in motion a moving part, generally a permanent magnet based on rare earth elements. Rare earths are not actually rare, but they are considered the most critical of raw materials because of their combined importance and supply risk. In a Comment in this issue, Koen Binnemans argues that we need to seriously ramp up rare earths recycling to establish a sustainable and reliable supply of these critical materials. Owing to the low cost of permanent magnets, recycling is not always economically profitable. Other incentives will need to be introduced.

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Most electric cars run on Li-ion batteries, which require substantial amounts of both Li and Co. Mining these elements is far from what we would call 'green'. Most Co comes from mines in the Democratic Republic of the Congo, where the issue of pollution is compounded by concerns about human-rights violations. Owing to the large amounts of water its mining requires, the extraction of Li has a big impact on regions with scarce water resources (most Li comes from Australia, Chile and Argentina). Richard Herrington reflects on how we can secure acceptable sources for the raw materials we require to transition to a green economy in a Comment in this issue.

Ideally, in the long term we want to fully move away from primary raw materials, and derive the components we need from recycling, creating value from waste and ensuring supplies. Strategies to recycle batteries to recover critical metals are discussed in a Comment in this issue by Anke Weidenkaff.

While we reduce our reliance on primary raw materials, we must establish politically, environmentally and socially sustainable ways to source the raw materials we need to meet our emission reduction goals. Moving forward, it will be important to take into account sustainability, and not only performance, when designing new materials. Materials scientists can contribute to the creation of solutions to enable a true circular economy. Policymakers will also have to play their part.