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Role of metal recycling in decarbonization

- **The electrification needed if the world is to transition to net zero emissions will depend on far greater use of critical minerals and metals than is currently the case.**
- **With mines unlikely to be able to meet demand for metals such as copper, cobalt, lithium and nickel, metals recycling has the potential to scale up to fill the gap.**
- **The metals recycling industry is expected to grow significantly over the next years, providing possible opportunities for investors.**

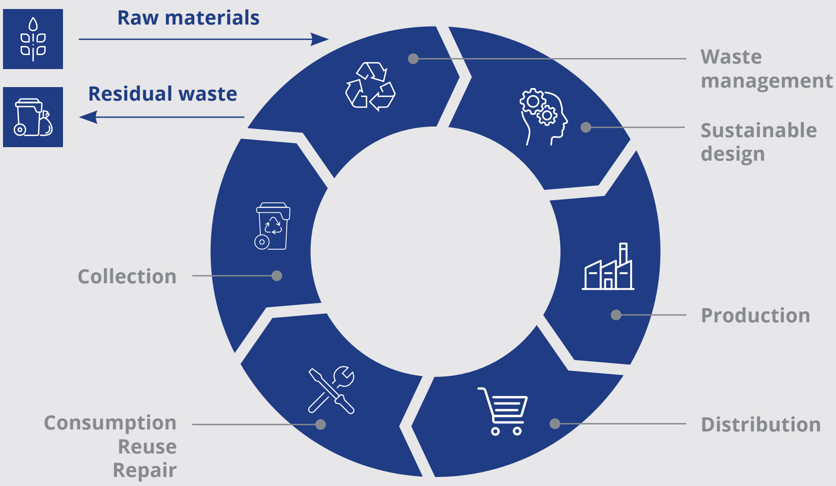
Introduction

Electrification and renewable energy are increasing demand for the minerals and metals that are essential for electrical components and renewable technologies. As they do so, mines are unlikely to supply enough critical metals such as copper, cobalt, lithium and nickel, leading to a risk of shortages in critical metals.

This looming shortage is focusing minds on the circular economy, or specifically, the potential for recycling of metals to bridge the gap between primary supply and demand. To illustrate this, a successful scale-up of

Explaining the circular economy

As opposed to linear economy, the concept of circular economy focuses on closing the consumption loop. Unlike the traditional linear economy, the circular economy concept focuses on sharing, leasing, reusing, repairing, and recycling when closing the consumption loop. It also emphasizes designing products in ways that minimize waste and pollution during their lifecycles:



Linear economy

Resource Extraction → Production → Distribution → Consumption → Waste

Chart 1: Critical minerals for various clean energy technologies

	Copper	Cobalt	Nickel	Lithium	Rare Earths	Chromium	Zinc	Platinum Group	Aluminum
Solar Photovoltaic	High								High
Solar Thermal	Moderate		Moderate			High	Moderate		High
Wind	High		Moderate		High	Moderate	High		Moderate
Hydro	Moderate					Moderate	Moderate		Moderate
Biofuels	High						Moderate		Moderate
Geothermal			High			High			
Nuclear	Moderate		Moderate			Moderate			
Grid	High								High
EVs & Batteries	High	High	High	High	High				High
Hydrogen			High		Moderate			High	Moderate

■ High Importance ■ Moderate Importance

Source: International Energy Agency

recycling could lower the need for new mining activity by 25-40% by 2050, according to an estimate from the International Energy Agency (IEA). More specifically, it could reduce new mine development needs by as much as 40% for copper and cobalt, and close to 25% for lithium and nickel. According to IEA's Announced Pledges Scenario, the market value of recycled energy transition minerals could grow fivefold, reaching USD 200 billion by 2050.

While it's widely appreciated that mining companies will need to expand existing mines and open new ones to help electrify the global economy, the need for greater recycling capacity is less well understood. However, this appears likely and could offer an opportunity for the sector to grow profitably.

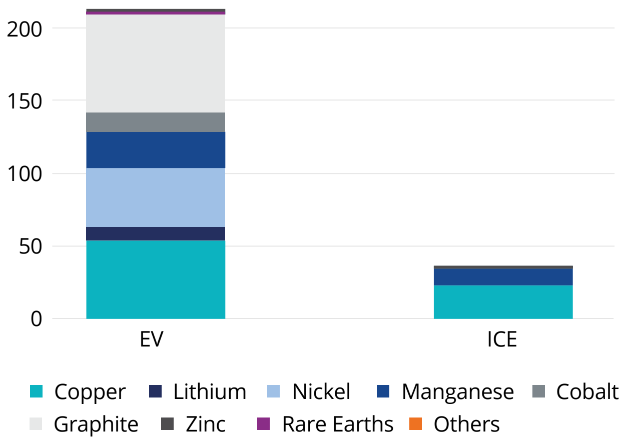
Material demands of energy transition

It is barely a secret nowadays that electrification of the global economy would require an enormous amount of minerals. According to the IEA, if the world pursues a path to net zero emissions by 2050, demand for minerals could increase ninefold. Even in a scenario that only reflects governments' currently stated decarbonization pledges, demand is forecasted to double already by 2030.

Where, specifically, will demand come from? The table below shows that clean energy technologies – from wind turbines and solar panels, to electric vehicles (EVs) and battery storage – require a wide range of minerals and metals. The type and volume of mineral needs varies widely across technologies.

Broadly speaking, the technologies needed for electrification are mineral hungry. For instance, EVs consume about six times more minerals than combustion engine cars (ICEs):

Chart 2: Minerals used
kg/vehicle



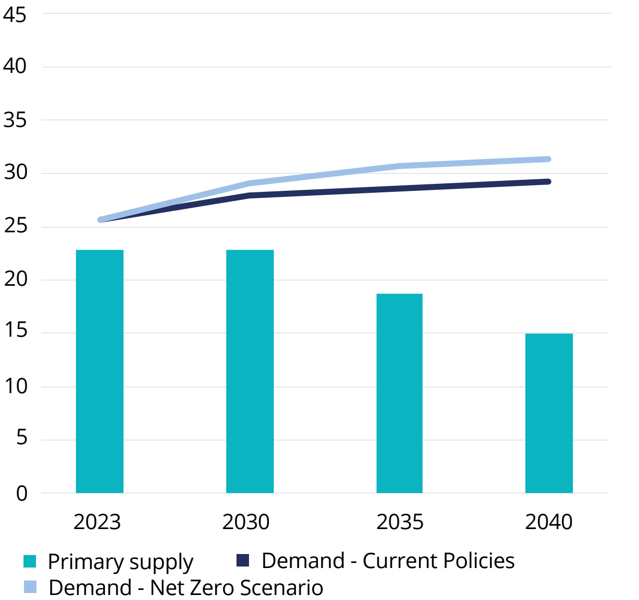
Source: IEA (2021), The Role of Critical Minerals in Clean Energy Transitions, IEA, Paris

Likely medium-term supply shortages

Against the rising demand backdrop, supply side of the equation remains uncertain.

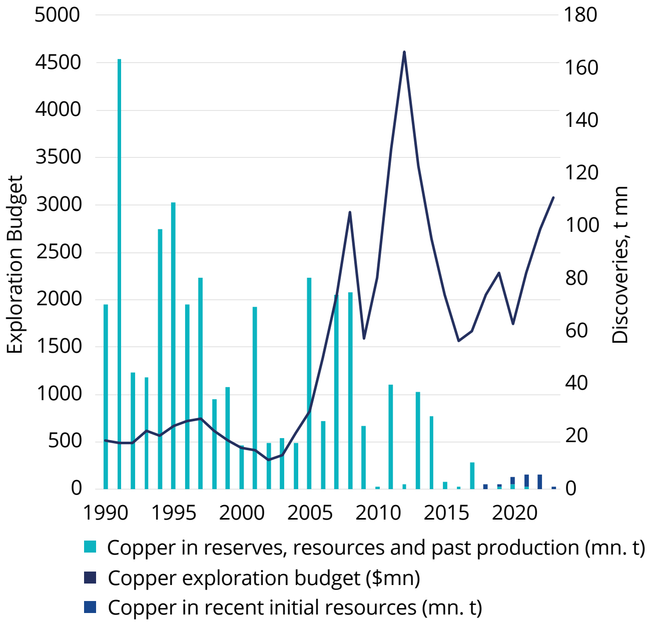
The prices of critical metals have been volatile in the past few years as demand for them has risen but so too has supply. They tripled in the two years from January 2020, only to relinquish most of that gain in 2023, according to the IEA Energy Transition Mineral Price Index. Demand

Chart 3: Committed production and projected demand for Copper



Sources: IEA (2024), Critical Minerals Data Explorer, IEA, Paris https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer

Chart 4: Copper Discoveries, 1990 - 2023



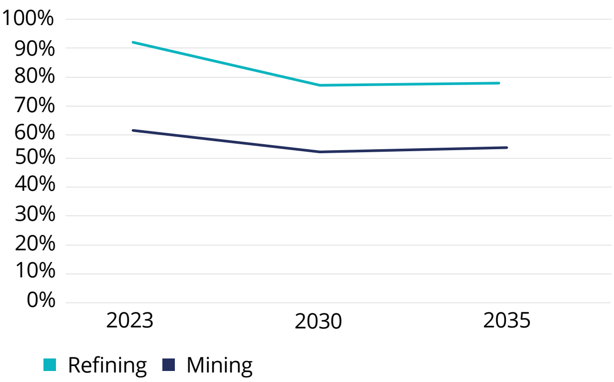
Source: S&P Global Market Intelligence (2024)

was robust but there was an increase in supply, which caused 2023's price weakness. Ironically, though, the price reduction only compounds the danger of a longer term shortage of supply. That's because it's likely to deter mining companies from investing to expand mining capacity. Looking forward, the likely picture is one of a shortfall in supply for some metals and excessive concentration risks for others. Take copper and lithium. IEA estimates that already by 2035 the supply from announced mining projects would meet only 57% (Chart 3) and 69% of requirements respectively.[1]

At the same time, balances for nickel and cobalt are in much better shape when accounting for prospective projects.

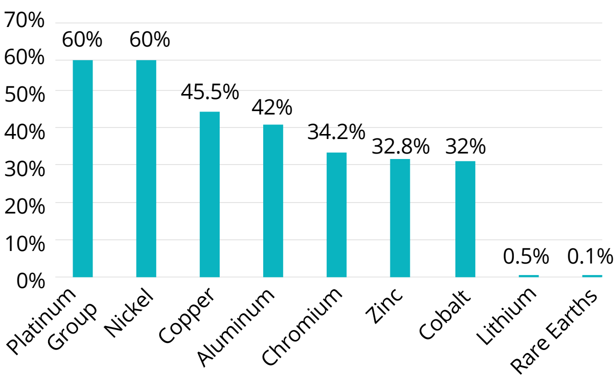
Turning to graphite and rare earth elements, problems are already emerging as trade tensions escalate between the United States and China, which controls supply. There is no overall shortage globally, but over 90% of battery-grade graphite and 77% of refined rare earths (Chart 5) originate from China. Given these imbalances, recycled metals have an opportunity to play a crucial role in the energy transition.

Chart 5: Share of China in Rare Earths sector, %



Source: IEA (2024), Critical Minerals Data Explorer, IEA, Paris https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer. Data for 2030 and 2035 represents IEA forecasts.

Chart 6: End-of-life recycling rates for select metals



Source: IEA (2021), The Role of Critical Minerals in Clean Energy Transitions. Data used: Henckens (2021); UNEP (2011) for aluminum; Sverdrup and Ragnarsdottir (2016) for platinum and palladium; OECD (2019) for nickel and cobalt.

[1] Using the IEA's current policies scenario as of 31 Dec 2024

Recycling's potential

Circularity can play a pivotal role in closing the supply gap. Metals are particularly well suited to recycling. They do not lose their intrinsic properties during the process, meaning that they can be used and re-used many times without loss of quality or functionality. Further, there is ample scrap metal to be recycled.

As electrification increases demand for critical metals, recycling could become essential as an additional source of supply that reduces reliance on new mines. IEA estimates that metals recycling could reduce new mine development needs by as much as 40% for copper and cobalt, and close to 25% for lithium and nickel. What's more, it's relatively environmentally sustainable and improves security of supply for countries importing minerals.

There are also major benefits for the environment, as mining and smelting are highly energy intensive. The European Commission estimates that aluminum recycling requires 95% less energy and emits 92% less CO_2 than production from ore, with 85% and 65% savings for copper, and 72% and 58% for steel, respectively. Recycling also uses significantly less water and emits less sulphur oxides and other air pollutants.

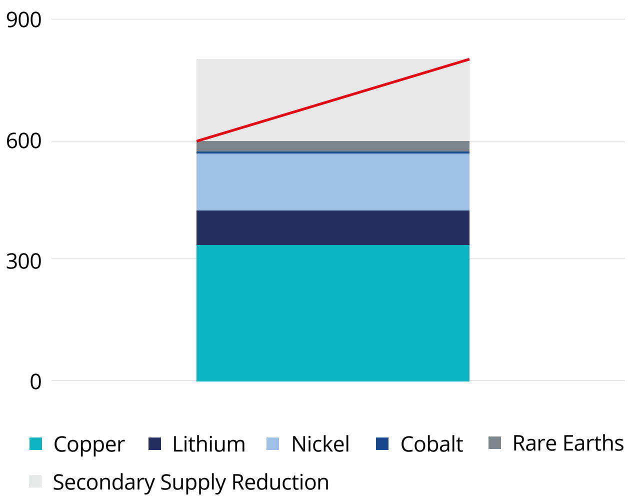
Many of the processes for recycling some of the critical minerals are already well-established. Consider metals recycling in Europe – a region that has modest natural deposits of minerals such as copper. Within the European Union, almost half (44%) of copper supply came from recycling at the time of a recent study.[2] What's more, the EU is a net exporter of recycled copper.

Turning to steel, making the metal from recycled scrap in electric arc furnaces is one of the few ways to produce it without emitting CO_2. Again, showing the potential for recycling, Turkey produces 72% of its steel this way and the United States produces 70%, according to the European Recycling Industries Confederation (EuRIC).[3] The EU makes about 45% of its steel this way.

On the other hand, lithium recycling is still at an early stage and faces significant hurdles. The main reason why lithium recycling is relatively uncommon is due to the complex battery format of lithium-ion batteries and evolving nature of battery technologies. Currently, most of the batteries are not designed with disassembly and recovery in mind and are disposed of in landfills, resulting in frequent leaks, underground fires and pollutant emissions. Nevertheless, it is anticipated that battery recycling will grow in importance as the first generation of EVs reaches the end of their lives. Battery recycling could meet 20-30% of lithium, nickel and cobalt demand by 2050, according to IEA estimates, depending on the collection rates. Similar issues plague rare earths recycling – they are normally used in smaller amounts and large costs associated with separating them pose a major barrier to wider recycling adoption.

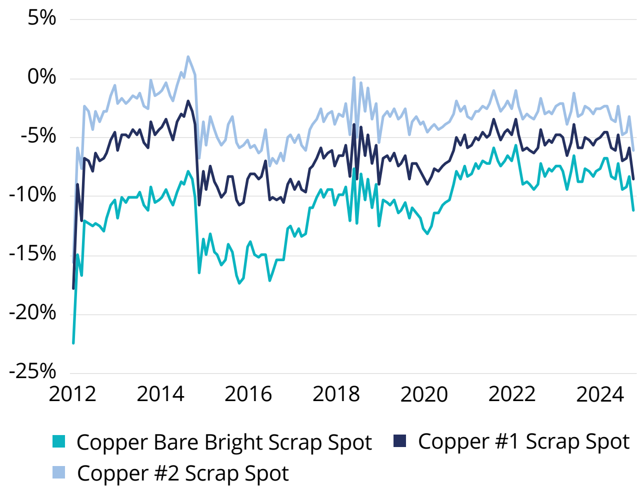
Recognizing the importance of recycling metals, countries are acting to incentivize metals recycling. Indeed, from

Chart 7: Mining capital requirements in 2040, $bn



Source: IEA (2024), Recycling of Critical Minerals, IEA, Paris. Analysis based on the Announced Pledges Scenario (APS), covering the announced ambitions and targets for emissions reductions by governments.

Chart 8: Scrap discount to Comex copper price



Source: Bloomberg, data from April 2012 to December. Bare bright scrap represents the highest quality copper scrap (99.9%), Copper #2 scrap – the lowest (>94%).

[2] EuRIC Metal recycling factsheet. 2020.
[3] Circular steel: Powering a low-carbon, competitive and circular European steel industry. November 2024.

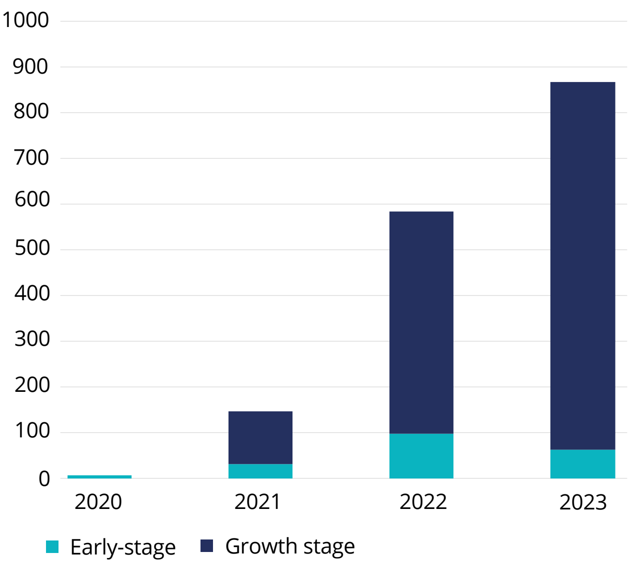
2022 to 2024 over 30 policy developments related to metals recycling have been introduced by governments, covering strategic plans, financial incentives and cross-border regulations.

However, despite the recent string of success, challenges still remain. Improper handling and exposure to other metals, like lead, or to non-metallic materials (oil, water or plastics), can reduce product quality, increase operational costs and even compromise employee safety and severely damage the local environment. This is reflected in the commercial scrap prices, where higher grades can trade close to the primary market, while lower scrap grades command a larger negative premium, reflecting related operating costs.

Increasing electronic waste complexity poses another challenge due to the complex mix of materials, some of them hazardous. Current technologies designed to address those issues have drawbacks, leaving a lot of room for innovation. On the other hand, sorting is one the fields where successful progress has been made due to the development of x-ray fluorescence (XRF) and spectroscopic technologies.

Chart 9: Venture capital investment in battery recycling and reuse

$mn



Source: IEA analysis based on Cleantech Group i3 database (2023)

Growing investment in metals recycling

Just as awareness of the potential for recycling to solve electrification's possible shortage of critical metals has grown, so some early-stage institutional investors are beginning to ramp up their investments. For instance, venture capital investment in the battery recycling has been steadily rising since 2020 (Chart 9).

For investors in stock markets, several publicly listed metals recycling companies are available. These include steel giant Commercial Metals, industrial metals specialist Sims, and the Belgian all-rounder Umicore, which offers recycling services for, among others, less commonly recycled minerals such as lithium, germanium, and rare earths. Other options include industrial waste recyclers like Befesa, which collects and processes steel dust and aluminum salt slags, reintroducing them into the metals supply chain. Investors in search of a more diversified approach could be interested in Circular Economy ETFs with holdings in metals recyclers.

Metals recycling is becoming a key in closing the supply gap for critical metals required for electrification of the global economy and eventual progression to net zero emissions. For businesses and investors in the sector, this could provide a tailwind.

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