Comment

PER-ANDERS PETTERSSON/GETTY

An open-pit copper mine at the Mutanda works run by Glencore in the Democratic Republic of the Congo.

COVID-19 disruptions to tech-metals supply are a wake-up call

Ata Akcil, Zhi Sun & Sandeep Panda

The pandemic has temporarily closed mines, factories and borders and destabilized flows of cobalt, lithium and other metals that are crucial for batteries, wind turbines and solar panels.

Solar panels, wind turbines and batteries need silicon, cobalt, lithium and more to convert and store energy. Access to these elements, known as technology metals, is crucial for combating climate change. Some 3 billion tonnes of metals and minerals will be needed to decarbonize the global energy system by 2050, the World Bank estimates[1]. Supplies were stretched before COVID-19. Now, the tech-metals sector is in disarray.

The pandemic has partly or wholly closed hundreds of mines, smelters and refineries (see go.nature.com/3ehkn9g). Metals production will be at least one-third lower this year than last, with an estimated potential loss worldwide of almost US$9 billion in revenue.

South American and African mines have been hit the hardest. Peru stopped producing iron and tin completely in April and is still trying to get back to 80% of former levels. South Africa's mines, including those for platinum-group metals, were closed in March and have run at half capacity since May – levels that are financially unviable in the long run.

Industrial demand for metals has fallen in the global slowdown[2]. Factory and border closures have disrupted international supply chains, too. For example, lockdowns in China interrupted supplies of almost half of the world's battery materials earlier in the year. The city of Wuhan, where the virus was first reported, is a major manufacturing hub for vehicles and batteries. Its plants were shut from the end of January until April.

Metals markets are volatile as a result. Prices are expected to fall by 13% on average this year[2], with decreases ranging from 0.5–4.5% for platinum, copper and aluminium, to 11% for zinc and 17% for nickel. By contrast, some scarce materials face price spikes and fierce competition to secure supplies[3–5]. These include rare earth elements (such as cerium, yttrium, lanthanum and neodymium), which are used in computer chips, mobile phones, batteries and magnets. Demand for them is soaring because many countries want to boost their renewable-energy sectors to stimulate and decarbonize their economies[6].

Governments and researchers must work together to secure world supplies of technology metals. Steps include: supporting the mineral and mining sector through the pandemic; tightening regulations for the import and export of metals and sustainable extraction practices; and increasing the recycling rates of metals from electronics waste.

Pressingly, more research and development is needed to make it easier and cleaner to produce metals, and to recover them from products that have reached the end of their useful life.

Valuable materials

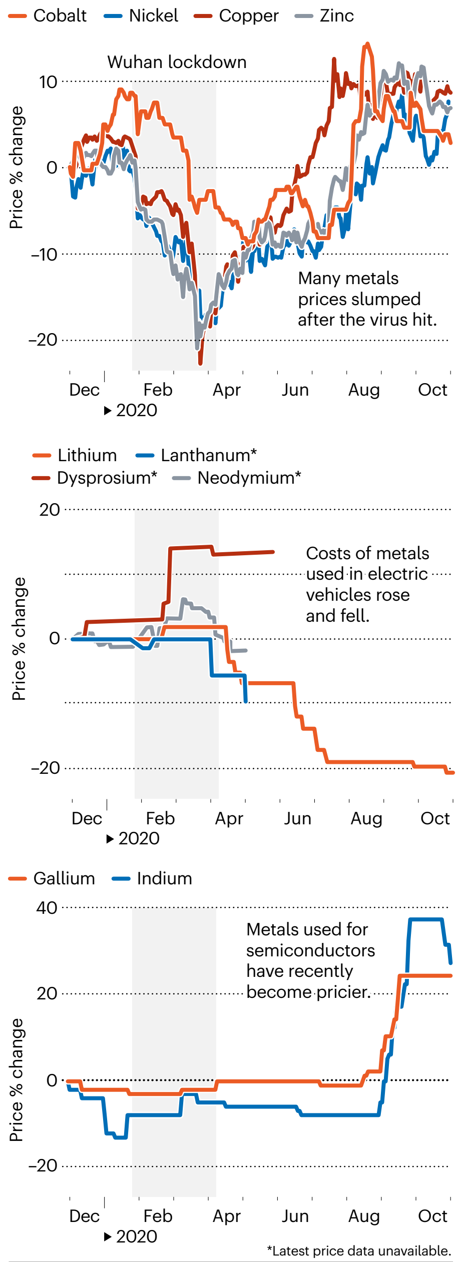
More than 30 metals are crucial for green-energy technologies. Aluminium and copper are most in demand, for turbine blades, wires and electrodes, for example. Cobalt, lithium, nickel and iron are key ingredients in batteries. For instance, more than 60% of mined cobalt goes into rechargeable batteries. Rare metals such as indium and gallium are widely used in electronics components, such as transistors and computer chips. Neodymium and dysporium are used in magnets.

Demand for these 'critical metals' is skyrocketing to meet renewable-energy goals. For example, the world's capacity from wind and solar sources needs to double to deliver half of global supply by 2035 under the Paris climate agreement (see go.nature.com/2jvjte7). More energy will need to be stored, meaning a greater need for vanadium, nickel, lithium and cobalt. Demand for these last two metals is expected to rise by up to fivefold from 2018 levels by 2050 (ref. 1). Other technology advances, such as 5G digital communications, are adding to pressures on these resources.

Supplies are controlled by a small number of companies and countries. Among the biggest mining corporations by revenue are, for example, Glencore in Baar, Switzerland; BHP in Melbourne, Australia; Rio Tinto in London; and Vale in Rio de Janeiro, Brazil (see go.nature.com/3ktnrme). China supplies around 90% of

METALS MARKETS

Prices of technology metals have been volatile since COVID-19 closed mines worldwide and factories in Wuhan from the end of January. Here are three trends.



SOURCE: SHANGHAI METALS MARKET

rare earth elements. Chinese and European companies control cobalt production in the Democratic Republic of the Congo (DRC), a nation that is also rich in copper and tin, tantalum, tungsten and gold. Australia and Chile dominate the production of lithium[4], whereas southeast Asian countries produce most nickel and China produces most graphite.

Regions that are reliant on imports are vulnerable to fluctuations in supplies, prices and political whims. Producers are not immune. For instance, in 2018 a policy change in the DRC triggered an economic cascade that suspended operations at one of the country's largest cobalt mines, Glencore's Mutanda mine. The government announced that it would treat cobalt as a strategic substance and increased its mining royalty from 2% to 10%. Price turbulence followed, exacerbated by falling demand for electric vehicles in China and bottlenecks in obtaining the chemicals needed to process the ore. Mutanda has been closed since last November, putting 20% of the world's cobalt production offline.

The world's biggest economies recognize the risks. For example, the US Department of Energy lists 35 critical materials for technologies[5]. The nation imports gallium mainly from China, the United Kingdom, Germany and Ukraine. For rare earth elements, it depends on China, Estonia, Malaysia and Japan[3]. It obtains lithium from Argentina, Chile, China and Russia, whereas cobalt comes from China, Norway, Japan, Finland and the DRC[5].

Similarly, the European Union has a list of 30 critical raw materials. Shortages of rare earth elements could, for example, derail the European Green Deal initiative to decarbonize Europe's economy by 2050 (ref. 7). China relies on imports, too – of lithium from Australia and Chile, nickel from South Asian countries, platinum-group metals from South Africa and Russia, as well as cobalt from the DRC.

The COVID-19 pandemic is exacerbating supply and demand problems. Wuhan's manufacturing shutdown and a 20% drop in the Chinese economy in the first quarter of this year initially drove down the prices of copper by 19.6%, nickel by 18% and cobalt by 7%. Prices have since been slowly rallying as some manufacturing has opened up. By contrast, prices of dysprosium and neodymium increased around February and March, because these metals were still highly sought after, whereas lithium and lanthanum experienced price drops around April (see 'Metals markets').

Markets are likely to remain turbulent for the next year at least, as the global economic slowdown depresses demand. Aircraft manufacturers (including Boeing and Airbus) and vehicle producers (such as Tesla, Volkswagen, Jaguar–Land Rover and Toyota) have shrunk production. Mining is still stalled across much of the world, with workers in Zambia, the DRC and South Africa subject to COVID-19 restrictions.

Three options

Governments can respond in three ways.

First: exploit other reserves. For example, improving access to deposits of rare earth elements in Brazil, Vietnam, Australia, Russia, India and Greenland would reduce reliance on China (see go.nature.com/385tusy). This is a long game– it would take at least 15 years for Europe to establish a supply chain for rare earth elements outside China, for instance[7]. And the environmental cost of developing mineral reserves is high: waste from mining can contain radioactive elements and other contaminants, and waste water from processing can release ammonia and heavy

NGUYEN HUY KHAM/REUTERS

Women sort electronics waste for recycling in a Vietnamese village.

metals. All the chemicals in minerals need to be considered for clean production.

Second: redesign technologies to use alternative materials. This needs to happen anyway. For example, cobalt is not abundant enough in Earth's crust to deliver all the batteries the world needs affordably, and it is often mined in poor social and ethical conditions. Manufacturers such as the US car maker Tesla and the battery firm CATL in China are pursuing alternative batteries that are cobalt-free. However, many replacements rely on nickel, which is carcinogenic, or iron (in lithium iron phosphate batteries), which are less efficient at storing charge. Solid state and sodium-ion batteries are other promising options.

Third: recycle. Spent batteries and obsolete devices have higher concentrations of metals than do ores, and so extraction from these is potentially more economical. Recycling shores up supplies, even if it cannot meet rising demand. It shrinks supply chains and logistical costs. Countries or regions that have strong technology sectors, such as the EU, the United States, China, India and Japan, produce most electronic waste and could reprocess it domestically[8]. There are economic, technical and regulatory barriers to overcome, however.

Recycling rates are low: worldwide only 17% of electronic waste is collected and treated. Europe has one of the highest rates (around 40% in 2018; see go.nature.com/2tkqfgr), with roughly half (40–60%) of the metal produced in the region coming from scrap (see go.nature.com/3tyj22t). There's ambition to do more: the European Commission's Directive on Waste Electrical and Electronic Equipment has a goal of 65% from 2019. Yet few member states have the facilities to meet it.

In China, the recycling of spent lithium-ion batteries is beginning to supplement the supply of critical raw materials. China has made its electronics manufacturers legally responsible for recycling the products they make, or they are taxed to cover the costs.

Yet much scrap still goes straight to landfill or (sometimes illegally) to countries such as Nigeria, Ghana, Pakistan, Tanzania and Thailand, many of which have inadequate environmental and health and safety laws. Metals and other toxic substances, such as flame retardants, lead and cadmium, contaminate soil and groundwater and damage workers' health.

Recharge the sector

The following three steps need to be taken to stabilize the supply of critical metals.

First, political leaders should support metals and minerals industries and recycling in their post-pandemic stimulus packages. With demand for green-energy technologies surging, this sector is ripe to deliver revenue and jobs. Tax relief for mines would allow them to restart. Cross-border and domestic supply chains should be protected by ensuring that raw materials can be transported from mines to plants. Governments and banks should also target investment to recycling and reuse of tech metals, to reduce reliance on imports.

Second, researchers and manufacturers should develop a 'circular economy' for these materials[8,9]. Products need to be more eco-friendly, less energy-hungry, longer-lasting and easier to recycle and repair. Reuse of defunct products, recovery of materials and recycling of metals all need to be integrated into industry, along with cleaner production methods[9,10]. That will require public and private research to combine principles from metallurgical, chemical, environmental and biotechnical engineering.

Third, states should set up a global association under the United Nations' Sustainable Development Goals to support the critical-metals sector and renewable-energy technologies. Such a body would focus on the sustainable management of mineral-metal resources, including legal, financial, technological and environmental aspects. Priorities include revitalizing the international supply chain, boosting manufacturing, transferring recycling technologies and innovating in urban waste recycling and resource recovery.

A good model is the EU research network EIT RawMaterials, run by the European Institute of Innovation and Technology (EIT). In 2019, it established the Rare Earth Industry Association to bring academia and industry together to strengthen research and policies across the sector. Collaborators include the Association of China Rare Earth Industry, the Japan Society of Newer Metals and Europe's Critical Raw Material Alliance.

Materials are the lifeblood of the tech sector. As the world faces economic, environmental and social upheaval, it is ever more crucial to keep supplies flowing.

The authors

Ata Akcil is professor of engineering and technical senior expert for critical raw materials and **Sandeep Panda** is an assistant professor of mineral biotechnology in the Mineral-Metal Recovery and Recycling Research Group, Department of Mining Engineering, Süleyman Demirel University, Isparta, Turkey. **Zhi Sun** is professor of metal recycling at the National Engineering Laboratory for Hydrometallurgical Cleaner Production Technology, Institute of Process Engineering, Chinese Academy of Sciences, Beijing, China.
e-mails: ataakcil@sdu.edu.tr; sandeeppanda@sdu.edu.tr; sunzhi@ipe.ac.cn

1. Hund, K., La Porta, D., Fabregas, T. P., Laing, T. & Drexhage, J. *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition* (World Bank, 2020).
2. World Bank. *Commodities Market Outlook: Implications of COVID-19 for Commodities* (World Bank, 2020).
3. US Geological Survey. *Mineral Commodity Summaries 2020* (USGS, 2020).
4. Australian Government, Department of Industry, Innovations and Science, Australian Trade and Investment Commission. *Australia's Critical Minerals Strategy* 2019 (Commonwealth of Australia, 2019).
5. US Department of Energy. *Testimony of Daniel Simmons, Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy, Before the U.S. Senate Committee on Energy & Natural Resources, September 17, 2019* (US Dept of Energy, 2019); available at http://go.nature.com/3thsscc
6. Kim, T.-Y. & Karpinski, M. *Clean Energy Progress After the COVID-19 Crisis Will Need Reliable Supplies of Critical Minerals* (International Energy Agency, 2020).
7. EIT RawMaterials. *Position Paper on COVID-19* (EIT RawMaterials, 2020); available at http://go.nature.com/2jjmxbg
8. Işıldar, A. *et al. J. Hazard. Mat.* **362**, 467–481 (2019).
9. Sun, Z. *et al. ACS Sustain. Chem. Eng.* **5**, 21–40 (2017).
10. Sethurajan, M. *et al. Crit. Rev. Environ. Sci. Technol.* **49**, 212–275 (2019).