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King Abdullah Petroleum Studies and Research Center

Commentary

Can Circularity-Based Approaches Prevent a Cobalt Supply Shortfall?

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Key Points

- Electric vehicle batteries rely heavily on a small number of critical minerals, including cobalt. Cobalt metal prices have doubled over the past year as a result of a mismatch between supply and demand, particularly for electric car batteries (Hume 2022).

- Circularity-based approaches, including reducing and recycling, could alleviate the global and regional demand-supply mismatch, but the degree to which they could help was not assessed until recently.

- A 2022 study published in Nature Communications attempted to bridge this gap by modeling historical (1998–2019) and future (2050) global cobalt supply and demand with regional granularity (China, the U.S., Japan, the EU, and the rest of the world) (Zeng et al. 2022).

- Decreasing the cobalt content in batteries (reducing), including decreasing it all the way to zero (cobalt-free batteries), and recycling advances may greatly reduce long-term cobalt supply issues. However, despite all circularity-based attempts, a cobalt supply crisis appears to be unavoidable in the near to medium future (2028–2033), with ramifications for attaining global electric mobility ambitions. The findings are consistent with other studies that have also suggested that without an additional supply boost from unscheduled production and recycling, demand could outstrip current production capacities even before 2030 (Xu et al. 2020, Fu et al. 2020).

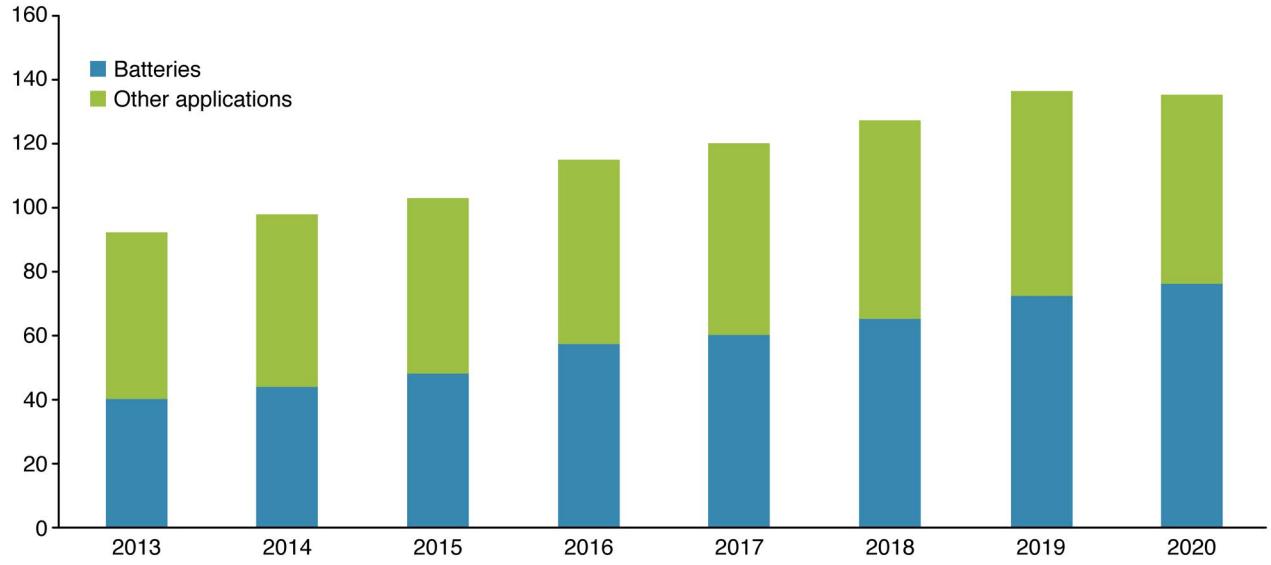
Graphical Abstract

Can a 3R framework of Reduce, Recycle, and Remove balance the supply and demand for cobalt in electric vehicle batteries?

Introduction

The transition to a net-zero carbon future necessitates the development and deployment of low-carbon technologies. These technologies, including batteries for electric vehicles (EVs) and energy storage, rely heavily on elements such as lithium, cobalt, and nickel. Between 1995 and 2019, the worldwide cobalt demand surged fivefold, and batteries accounted for approximately half of global cobalt usage in 2019 (Figure 1).

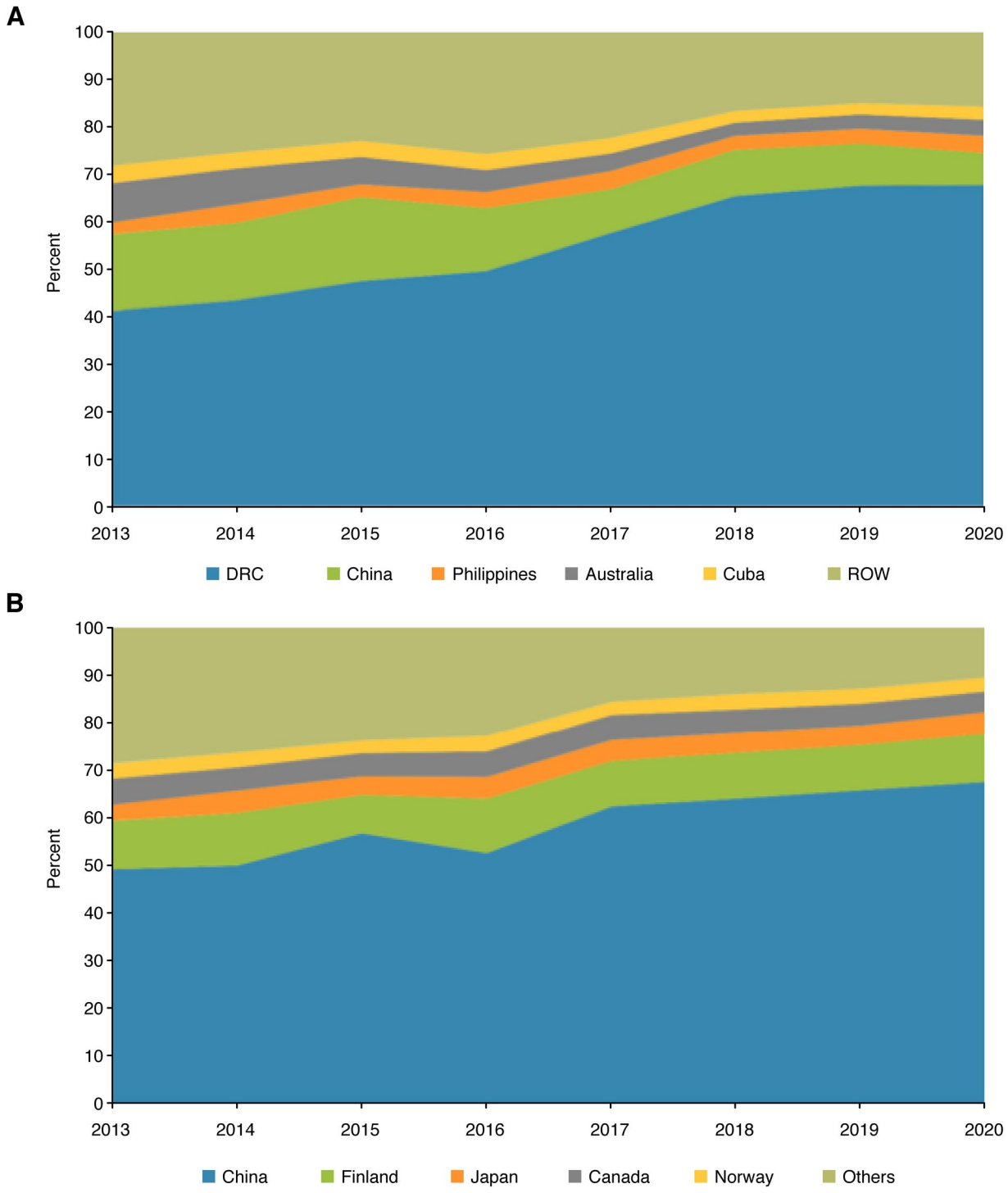
Figure 1. Consumption of cobalt, by application, 2013–2020 (kt).



Source: (Roskill 2021).

The rapid adoption of EVs is predicted to continue this trend in cobalt demand in the coming decades. Regarding the cobalt supply, global cobalt mining and processing are highly unevenly distributed. For example, in 2019, 70% of cobalt mining output came from the Democratic Republic of the Congo (DRC) (Figure 2a), while 67% of cobalt refining happened in China (Figure 2b). Such geographical dominance increases the criticality of cobalt to governments of major economies, including the U.S., the EU, Japan, and Australia, particularly in terms of its significance for the battery EV transition. All these factors taken together warrant research on potential demand-supply imbalances and supply-risk mitigation measures for these commodities.

Figure 2. (a) Production of cobalt feedstock, top five producing countries and rest of the world (ROW), 2013–2020 (%), (b) Production of refined cobalt, top five producing countries and ROW, 2013–2020 (%). DRC = Democratic Republic of the Congo



Source: (Roskill 2021).

Supply-risk mitigation measures include the circularity-based approaches of reducing, including decreasing the cobalt content all the way to zero (cobalt-free batteries), and recycling. Reducing, including the elimination of cobalt from EV batteries, has developed in recent years as cobalt prices have fluctuated, tripling between 2016 and 2018 (Figure 3), and environmental and social concerns over cobalt mining in the DRC have increased. In addition, EV battery recycling will become a secondary source of cobalt when batteries reach the end of their useful lives. Recycling accounted for 17% of the cumulative cobalt supply in 1998–2019 (Zeng et al. 2022).

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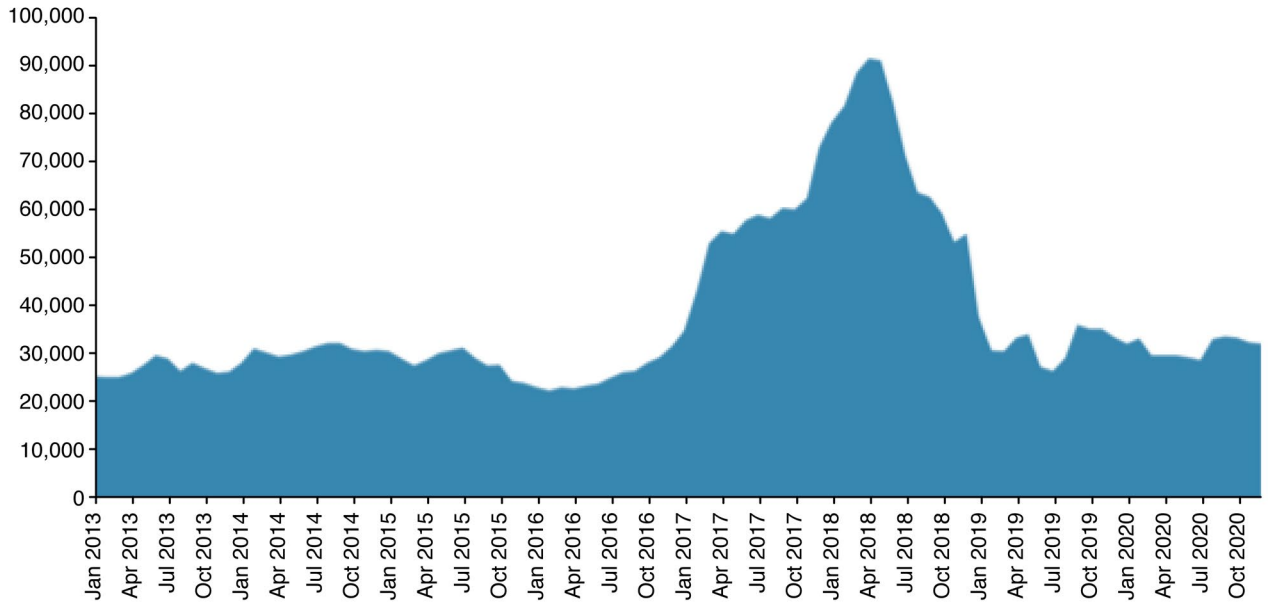
Figure 3. Cobalt metal prices, 2013–2020 (USD/tonne).



Source: (Roskill 2021).

Findings

Zeng et al. (2022) showed that circularity-based approaches can help reduce the risk of a cobalt shortage in the long run. Even under the most optimistic scenario, a cobalt scarcity between 2028 and 2033 is probable due to the anticipated worldwide electrification of the passenger car sector. Although cobalt-free lithium ferrophosphate (LFP) batteries arrived on the market in 2020 and next-generation cobalt-free battery technologies are scheduled to be commercialized by 2030, the authors still forecast a demand-supply mismatch in 2028–2033. These results are similar to those of a prior study published in Nature Communication Materials, which also predicted that demand may exceed present production by 2025 (Xu et al. 2020). Overall, the findings indicate that increasing the primary cobalt supply would be critical to achieve global electric mobility ambitions. Other researchers have likewise estimated that a supply-demand balance (and even a supply surplus) can be realized only by increasing supply from previously unplanned production and recycling (Fu et al. 2020).

Challenges

The ability to increase the primary cobalt supply, though, remains uncertain and challenging due to price volatility (Sanderson 2021) and rising production costs (Li 2021). Short-term rebalancing of global and regional demand-supply imbalances continues to be particularly difficult owing to the lengthy lag between resource discovery and extraction (Alves Dias et al. 2018). Furthermore, as previously noted, the primary supply of cobalt remains vulnerable to various internal and geopolitical risks (Mayr 2018). These include civil wars and weak government systems in the countries that produce it as well as a fierce power struggle between China and the U.S. over access to the DRC's cobalt supplies (Searcey, Forsythe, and Lipton 2021). Finally, global unexpected event-induced short-term supply chain disruptions can also affect the cobalt primary supply, as was demonstrated by the COVID-19 pandemic (Roskill 2021).

Implications for Major Automotive Manufacturing Countries

The growing Chinese EV sector and battery production capacity will drive future cobalt demand in China, which is currently heavily dependent on foreign primary cobalt supplies.

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Currently, the EU and U.S. have reasonably secure cobalt supplies (59% of the global total reserve in 2019) relative to their modest levels of domestic battery manufacturing (Zeng et al. 2022). Additionally, their mining titans,

such as Glencore, control much of the foreign cobalt mining output (Roskill 2021, Cropley 2020, Century Cobalt 2018). This situation is expected to change, as the U.S. and EU intend to strengthen their local battery manufacturing sectors and as competition for foreign mining ventures increases (U.S. Department of Energy 2021, Edström 2020). Finally, China's dominance in cobalt processing is likely to be a continued cause for concern for the U.S. and EU.

The supply risk in Japan is greater than that in other areas because of Japan's limited local cobalt deposits and foreign ownership (Zeng et al. 2022). Consequently, Japan will likely maintain its current focus on the development of fuel-cell cars (cobalt-free cars) over electric cars to lessen its reliance on cobalt and possible supply difficulties.

In summary, recent research suggests that producing batteries with a lower cobalt content (reduce), including content reduced all the way to zero (cobalt-free batteries), and recycling advances may considerably minimize long-term cobalt supply difficulties. However, despite all the combined efforts to reduce, eliminate, and recycle cobalt, a cobalt supply crisis will likely be inevitable in the near to medium future (2028–2033), which will disrupt global goals related to electric mobility.

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