***Will Carbon Neutrality Alleviate China’s Energy Security Concerns? – The Strategic Importance of Critical Metals in Batteries***

Yufan Du1,2, Jie Li3, Yuan Xu1,2,\*

1 Department of Geography and Resource Management & Institute of Environment, Energy and Sustainability, The Chinese University of Hong Kong, Hong Kong, China; 2 Shenzhen Research Institute, The Chinese University of Hong Kong, Shenzhen, China; 3 Urban Development and Disaster Risk Management, East Asia and Pacific Region, the World Bank

## Overview

How carbon neutrality may reshape energy security concerns weighs greatly for all major energy importing countries, including China. Large-scale electrification and energy transition as a crucial pathway will potentially alter the strategic importance of different resources. This study examines three key battery-related metals – lithium, cobalt, nickel – in China’s carbon-neutral future by calculating their foreign dependency ratios and import costs and then compare them with those of crude oil, natural gas, and uranium. Scenario analysis shows that China’s foreign dependency of the metals could exceed 80% in many scenarios in 2030 and 2050 with import costs likely reaching USD 135 billion in 2030 and USD 265 billion in 2050. Their strategic importance in 2050 represented by their import costs can be equivalent to the 2016-2020 average level of oil and natural gas, if unfavorable conditions happen simultaneously, specifically high metal intensity, low recycling rates, and high metal prices. Hence for China, carbon neutrality might replace conventional energy security concerns about oil and natural gas with new concerns about battery-related metals, especially considering the much higher geographic concentration of metal imports. However, we find that recycling is the most important factor in reducing overseas reliance and import costs of the metals. In low-demand scenarios with optimistic recycling rates, their foreign dependency could be substantially reduced or even completely alleviated, indicating that efficient and large-scale recycling of end-of-life batteries has great potential to strengthen energy security and reduce the monetary costs in China’s carbon-neutral future.

## Methods

Future demand, domestic production, recycling, foreign dependency, and monetary costs for import (the “key indicators” hereafter) of battery-related metals are difficult to predict because of rapidly evolving battery technologies, various battery types in different applications, and subsequently different metal compositions within the batteries. To account for a spectrum of possible outcomes under different circumstances, scenario analysis is conducted for the key indicators above towards 2030 and 2050.

Because of the projected dominance of Li-ion batteries in future battery applications, estimations are based on the assumption that all batteries used in the future scenarios of this study are Li-ion batteries. The future demand, recycling, foreign dependency, and monetary costs for the import of lithium, cobalt, and nickel are estimated from 72, 12, and 7 different scenarios, respectively. Each scenario is a unique combination of sub-scenarios for consumer electronics, electric vehicles, and electrochemical energy storage. These sub-scenarios comprise different data sources and different growth pattern assumptions of the variables based on historical data. Estimations of the key indicators for each year under each scenario from 2020 to 2050 are conducted. The annual average value and standard deviation of the key indicators in all scenarios are calculated for each year.

Two different methods are used for calculating the future demand, recycling, foreign dependency, and monetary costs for importing the metals. The first method directly uses existing future projections in literature for specific years (e.g., 2030 or 2050) and constructs estimated values for the remaining years based on linear simulation. For example, if we have historical electrochemical energy storage capacity data that ends in the year 2021 and direct future projections from literature in 2050, the estimated value for each year between 2022 and 2049 is calculated assuming linear growth from 2021 to 2050. The second method is applied when direct projections are not available in the literature. When only historical data is available, we construct different scenarios by assuming different growth patterns of the variables (e.g., linear growth, flat growth, etc.) to cover as many possibilities as possible.

## Results

China will be more heavily dependent on overseas lithium under carbon neutrality targets without recycling. Demand for lithium is projected to increase rapidly towards 2030 and 2050 under all scenarios, despite relatively large standard deviations due to significant variations of demand projections. The average lithium demand is estimated to increase by approximately 3 times in 2030 and 8 times in 2050 compared to the 2020 level. China’s foreign dependency of lithium – under the no-recycling scenario – is projected to stay between 84% to 87% towards 2030 and 2050 from the 2020 level of 75%.

The demand for cobalt in China is projected to increase in the coming decades as well, with an average foreign dependency of 96.5% and 89% in 2030 and 2050 assuming no recycling. The declining trend of foreign dependency is largely a result of the general projection that cobalt intensity of Li-ion batteries would decrease with the development of new low-cobalt battery technologies (IEA, 2021).

Nickel demand is estimated to experience an increasing trend in general despite a slight decline from 2025 to 2035, which is largely a result of projections on lower nickel content of batteries (e.g., Li-ion batteries being replaced by Ni-MH batteries). On average, China’s nickel demand in 2050 is estimated to reach more than 1.5 million tons, with the foreign dependency of 72.8% under a no-recycling scenario.

## Conclusions

We conclude that the future strategic importance (as represented by the import costs and foreign dependency ratios) of the three key battery-related metals can be as important as oil and natural gas for today’s China, if the unfavorable conditions happen simultaneously, especially high metal intensity, low recycling rate, and high metal prices. Even the most optimistic estimation suggests that the three metals have much greater strategic importance than uranium for nuclear energy, another crucial technology under carbon neutrality. Accordingly for China, carbon neutrality may replace conventional energy security concerns about oil and natural gas with new concerns about critical metals in Li-ion batteries, especially considering the much higher geographic concentration of metal imports.

Furthermore, our results also suggest crucial factors that may alleviate the new security concerns. Increasing the collection rate of end-of-life batteries and the metal yield rate of battery recycling has the most significant impact in reducing the foreign dependency and import cost of the key battery-related metals and, in some scenarios, completely alleviates China’s current reliance on imports. In the optimistic recycling scenario, the foreign dependency and associated monetary cost of the three metals in 2050 is estimated to decrease by 61% to 76% on average compared to the no-recycling scenario. In some low-demand scenarios of metal demand, the total demand for the metals can be fully met through recycling and domestic production without any import from overseas. Considering China’s relatively scarce reserve of the three metals, efficient and large-scale recycling of end-of-life batteries has great potential to strengthen the feasibility and reduce the required financial resources to achieve its carbon neutrality target.

Metal intensity and battery density are also key variables in determining the strategic importance and financial resources required for lithium and cobalt under carbon neutrality targets, despite lower impact compared to recycling rate. A 10% change in the two variables results in a change of the import cost for lithium and cobalt by around 5% to 20%, indicating the importance of more advanced battery technologies for a carbon-neutral China.

Metal prices, as shown by the result of the sensitivity analysis, greatly and directly affect the import cost of the battery-related metals. Strategic storage of the three metals, therefore, will play a crucial role in managing the risk of unforeseeable metal price shocks as a result of geopolitical conflicts. This is especially important for countries like China that currently are and are estimated to be heavily reliant on the import of battery-related metals in the coming decades. Although the technical feasibility, spatial requirement, and cost of storing lithium, cobalt, and nickel is to be further evaluated, the relatively low demand for the metals compared with crude oil makes strategic storage a potentially appealing and feasible option for securing future metal demand. Sharing more similar chemical properties with battery-related metals and relatively low usage compared with crude oil, China’s current strategic storage of uranium can be used as a reference for the potential storage of lithium, cobalt, and nickel in the future when their demand is projected to soar under the carbon neutrality target.

## References

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