URBAN MINING AND CARBON NEUTRALITY: WILL BATTERY RECYCLING SUSTAINABLY SUPPORT CHINA'S DEMAND FOR CRITICAL METALS?

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Overview

Acknowledging the necessity and urgency to address climate change challenges, all major economies have committed to achieving carbon neutrality in the coming decades. Large-scale electrification coupled with energy transition towards renewables is key in this process, which would require rapid increase in the number of electric vehicles (EV) and battery storage capacity. Consequently, the demand for key battery-related metals, including lithium, cobalt, and nickel, is projected to increase. For countries like China with relatively scarce resources of these key battery-related metals, the imbalance between the metals' high demand and low domestic supply could raise energy security concerns in achieving carbon neutrality targets.

To address such challenges, battery recycling (i.e., urban mining) can be an increasingly important option to reduce China's foreign dependency of the key battery-related metals, lower expenditures on metal import, and ease energy security concerns. However, research on the cost efficiency of battery recycling and its economic comparison with mining remains limited. Whether urban mining could sustainably support China's battery metal demand towards carbon neutrality is a largely under-researched yet crucial question for China and other countries with similar resource endowment. This study aims to fill these research gaps.

Specifically, this research attempts to answer the following research questions:

- On China's battery recycling industry:
  - What is the market structure, industry chain, and characteristics of China's battery recycling market?
  - What is the cost components and future cost of battery recycling in China?
- On cost comparison between recycling and mining in China (from the perspective of recyclers and miners):
  - What is the unit cost of lithium recycling and mining in China, respectively?
  - What is the condition for cost parity (i.e., when the cost of battery recycling equals to the cost of mining) between recycling and mining in China?
  - When can China achieve cost parity between recycling and mining?
- Economic impact of battery recycling on EV consumers in China:
  - What is the lifecycle and per kilometer cost difference between EV and internal combustion engine vehicles (ICEV) considering the recycling value of batteries?
  - What is the lifecycle cost saving of EV from battery recycling for a typical EV owner?

Methods

This study carries out interviews with Chinese battery recycling companies to collect first-hand data on the cost and its detailed breakdown of recycling different types of lithium-ion batteries in China. This, together with data from academic literature and industry reports, enables quantitative analysis on the economic cost comparison between battery recycling and metal mining, as well as calculation of the cost-saving potential to electric vehicle owners from battery recycling. Data and information on the industry value chain, market characteristics, and challenges for China's battery recycling industry are also collected from the interviews, which is used to analyze the status quo, key characteristics, and possible future cost trajectory for battery recycling in China.

Scenario analysis is applied to quantitatively calculate the per metric ton cost of battery recycling and lithium mining in China under different market price and cost scenarios, hence facilitates economic comparison between the two in the Chinese context. Moreover, simulation analysis is conducted to find the best-fit curve for future

projection of battery market price, thus enables quantitative estimation of the cost parity conditions between lithium recycling and mining.

Furthermore, we carry out lifecycle analysis to calculate the per kilometer cost and lifecycle cost of EV and ICEV considering the battery recycling value. This enables our estimation of the cost saving potential for battery recycling to EV consumers.

Results

Based on first-hand data from interviews with Chinese recycling companies, we find that China's battery recycling market is currently loosely regulated, with the informal sector collecting 75%-90% of all retired batteries because of significantly lower regulation-induced cost. The industry is market-driven with high sensitivity to metal price fluctuations as the number of newly registered battery recycling companies is positively correlated with battery metals' market price.

For recycling companies, purchasing retired batteries consists of 70%-93% of total recycling cost, with ample room for further cost reduction as battery price continues to drop. Based on simulation results on future market price of lithium-ion batteries, when assuming stable costs of both battery recycling and mining technology, cost parity between lithium mining and recycling could be achieved in 2028. With continuous trend of price drop of batteries, recycling could become cheaper than mining after 2028, offering economic incentives for stronger policy support on battery recycling.

For EV consumers, battery recycling provides considerable cost savings thus economic incentives for further EV adoption. With national average annual travel distance (15,000 kilometers), battery recycling increases lifecycle cost saving of EV compared to ICEV by RMB 21,515-106,800 (24.69%-140.53%) depending on different lifetime and price of cars. Lifecycle cost saving of EV with high recycling value is 13.44%-51.79% higher than that in the low value scenario.

Conclusions

- Informal recycling huts control 75%-90% of all retired batteries in China due to much lower regulation cost hence 60% higher bid for batteries than "white-list" companies.
- Battery purchasing consists of 70%-93% of total recycling cost, with ample room for further reduction.
- Cost parity between lithium recycling and mining could be achieved in 2028 based on current recycling and mining costs, with recycling becoming cheaper than mining after 2028 with continuous drop of battery prices.
- Battery recycling increases average lifecycle cost saving of EV compared to ICEV by RMB 21,515-106,800 (24.69%-140.53%) depending on different lifetime and price of cars.
- Average lifecycle cost saving of EV with high recycling value is 13.44%-51.79% higher than in low value scenario.
- With high electrification rate and steady battery demand, battery recycling could sustainably support China's critical metal demand. However, sufficiently high metal price or subsidy is needed at the early stage.