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Prediction of Recyclable Resource Potential Distribution in China's New Energy Vehicle Industry

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Abstract: The rapid development of China's new energy vehicle (NEV) industry has led to a high demand for key raw materials in power batteries, with a continuous high dependence on imports, posing certain supply risks. As domestic NEVs gradually enter the retirement phase, recyclable resources have become crucial for China. Therefore, analyzing and predicting the potential distribution of recyclable resources in China's NEV industry can effectively support the capacity layout and optimization of the power battery cascade utilization and recycling industry. Research results show that in 2023, China's recyclable lithium, cobalt, and nickel metal resources were 65,000 tons, 12,000 tons, and 106,000 tons, respectively, mainly distributed in provinces such as Guangdong, Guangxi, Shandong, Henan, and Zhejiang. By 2035, China's recyclable lithium, cobalt, and nickel metal resources are expected to grow to 695,000 tons, 305,000 tons, and 2.49 million tons, respectively, with the distribution remaining largely consistent with 2023. It is recommended that provinces plan their recycling industries based on the distribution of NEV recyclable resources to avoid overcapacity or shortages. Enterprises can also plan production lines according to the distribution of key metal resources to ensure efficient utilization of capacity.

Keywords: New energy vehicles, power batteries, key metals, recyclable resources.

1. Research Background

Driven by national policies and market forces, the NEV industry has developed rapidly.In 2024,China's NEV production and sales reached 12.888 million and 12.866 million units, respectively, representing year-on-year growth of 34.4% and 35.5%. As the world's leading manufacturer, exporter, and user of power batteries, China has a high demand for key raw materials in power batteries. However, domestic resources are relatively scarce, with most materials needing to be imported, resulting in high dependence on foreign supplies. In 2023, China's dependence on foreign lithium, cobalt, and nickel metals was 73.7%, 98%, and 94.1%, respectively, indicating certain supply risks. As domestic NEVs gradually enter the retirement phase, retired power batteries can yield recyclable materials such as lithium, cobalt, and nickel, which have high recycling value and significant potential. This can effectively reduce China's dependence on foreign lithium battery metal resources and mitigate supply risks for key raw materials. By analyzing the current stock and distribution of NEV resources in China and predicting future scenarios based on power battery market trends, this study forecasts the volume and distribution of NEV recyclable resources, providing support for the capacity layout and optimization of China's power battery recycling industry to ensure efficient resource utilization. [1-3].

2. Research Methodology

2.1. System Boundaries and Research Framework

The geographical scope of the study is mainland China, excluding Hong Kong, Macau, and Taiwan. The research objects include passenger vehicles and commercial vehicles, covering pure electric vehicles and plug-in hybrid electric vehicles. Based on the Gompertz curve model, elasticity coefficient method, and Weibull distribution, a regional NEV ownership prediction system was constructed for the period 2024-2035, forecasting the ownership of NEVs in 31 provinces. Considering battery technology trends, the study predicted the battery capacity per vehicle and the material types of power batteries, building a model to analyze the distribution of recyclable resources from NEVs nationwide. This provides a reference for enterprise capacity planning, layout, and recycling decisions.

2.2. Calculation Methods

(1) Regional NEV Ownership Calculation

Historical data from developed countries such as the United States, Europe, and Japan show that a country's per capita passenger vehicle ownership follows an "S" curve, characterized by rapid growth, slow growth, and stabilization as the economy develops. The Gompertz curve model, a commonly used S-shaped nonlinear fitting curve, has been widely applied in passenger vehicle ownership prediction.

(2) Key Metal Resource Distribution Calculation

The distribution of recyclable resources from NEVs is related to EV ownership, battery capacity per vehicle, battery material composition, and material intensity. The specific parameters for these factors are explained in Section 3.

3. Key Parameters and Scenario Settings

3.1. Average Power Battery Capacity

The average capacity of power batteries increases with advancements in battery technology and improvements in vehicle range. From 2014, the average battery capacity of NEVs in China showed an upward trend, rising from 44 kWh to 49 kWh. With the growth in plug-in hybrid vehicle sales, the average battery capacity stabilized at 47 kWh starting in 2022. As battery technology advances, the average battery capacity per vehicle is expected to gradually increase, reaching 50 kWh by 2030 and 53 kWh by 2035.

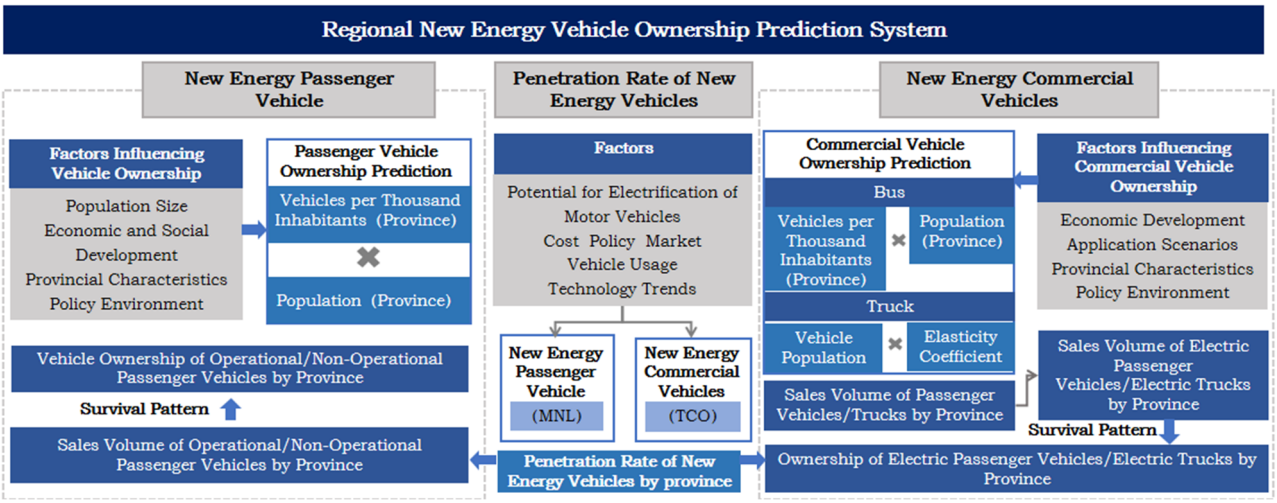

Figure 1. Region New Energy Vehicle Ownership Prediction System

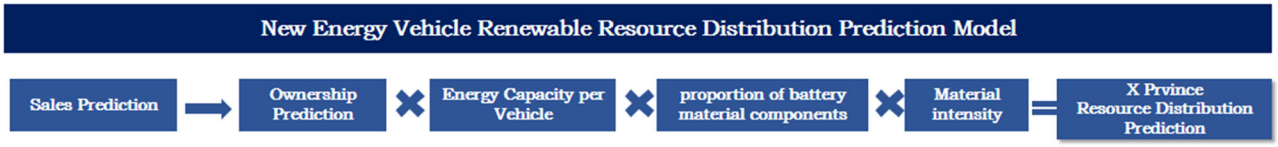

Figure 2. New Energy Vehicle Renewable Resource Distribution Prediction

Table 1. Average Battery Capacity per Vehicle (kWh/vehicle)

Year	Average Battery Capacity
Before2014	44
2020	49
2025	47
2030	50
2035	53

Data analysis of different battery types shows that the battery capacity of ternary batteries is gradually increasing, while that of lithium iron phosphate (LFP) batteries shows an initial rise followed by a decline.

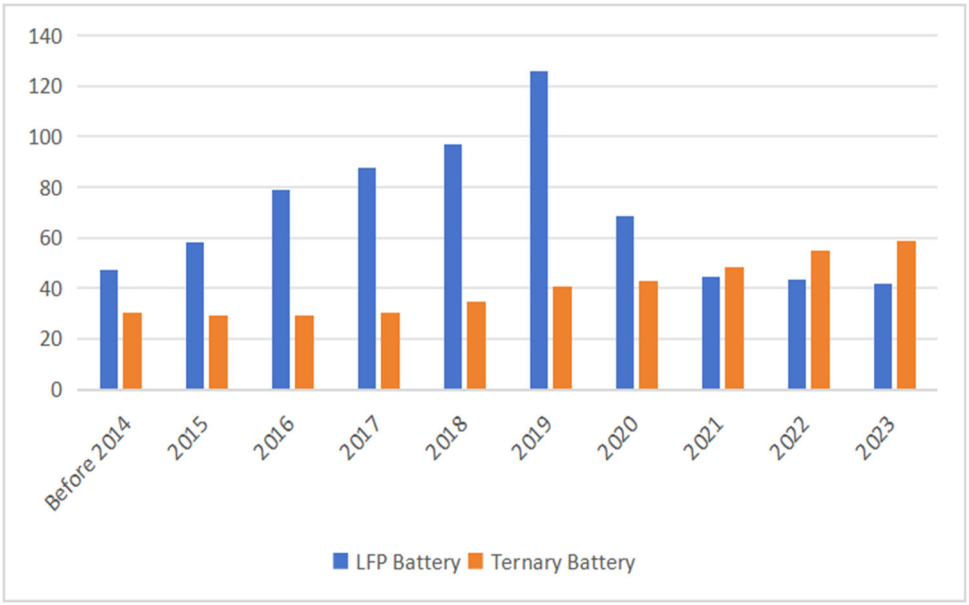

Figure 3. Changes in Battery Capacity per Vehicle by battery Type(2014-2023)

3.2. Power Battery Market Share

Before 2011, all Chinese electric vehicles used LFP batteries. Ternary batteries entered the EV market in 2012. From 2013 to 2023, the market share of LFP batteries first declined and then increased, while the share of ternary batteries first increased and then decreased. Among ternary materials, the proportion of high-nickel ternary cathode materials has gradually increased, exceeding 44% in 2023.

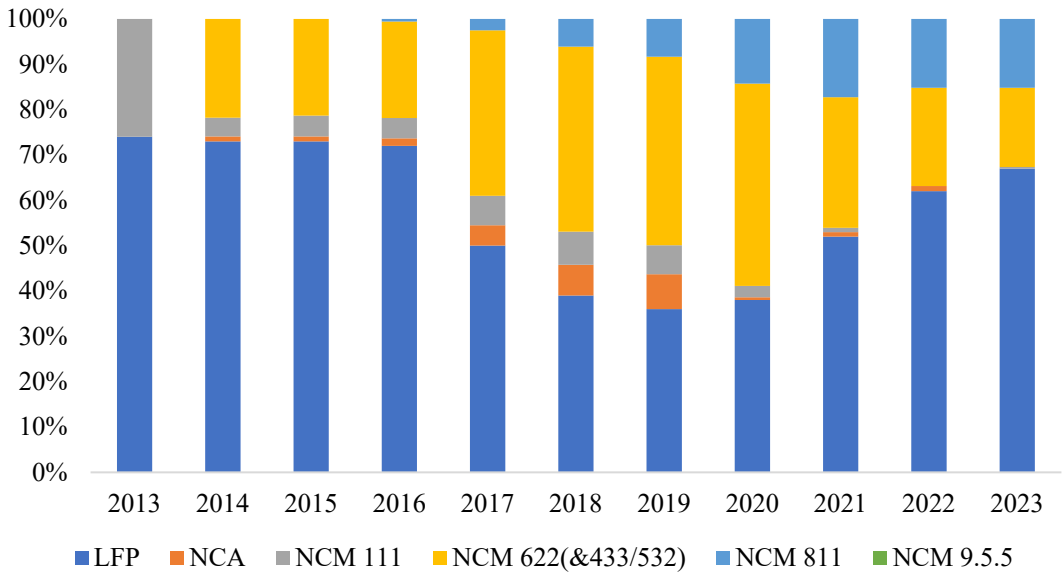

Figure 4. Historical Data on Power Battery Market

Using the 2023 Chinese power battery market as a baseline, a dominant scenario was set based on the growth trend of NEVs and the development direction of power battery technology. In the future, the share of LFP batteries is expected to gradually decline, while the share of ternary batteries will increase, with the proportion of high-nickel materials continuing to rise. By 2030, the share of high-nickel materials is expected to exceed 55%, reaching over 65% by 2035.

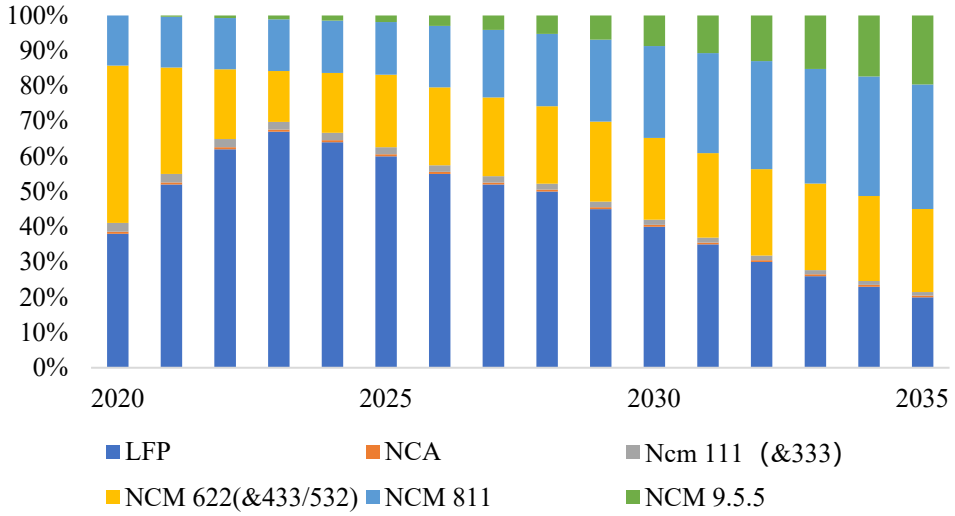

Figure 5. Forecast Data on Power Battery Market

3.3. Material Intensity

Material intensity refers to the mass of a specific metal required to store a unit of electricity in a battery (kg/kWh). Different cathode materials require different amounts of key metals. The parameters for several battery types involved in this study are set as shown in Table 2.

Table 2. Key Metal Consumption Intensity (kg/kWh)[1]

	Li	Co	Ni	Mn
LFP	0.86	/	/	/
NCM111	0.12	0.33	0.33	0.31
NCM523	0.12	0.20	0.51	0.19
NCM622	0.10	0.18	0.53	0.16
NCM811	0.10	0.08	0.65	0.08

4. Results and Discussion

4.1. NEV Ownership Prediction

For passenger vehicles: By 2025, the ownership of NEV passenger vehicles in central and southeastern coastal regions will exceed 2 million units. By 2035, most regions will have NEV passenger vehicle ownership exceeding 4 million units. In terms of distribution, population effects gradually dominate over economic effects, with provinces such as Henan and Shandong leading in NEV passenger vehicle ownership.

For commercial vehicles: By 2025, Guangdong Province's NEV commercial vehicle ownership will exceed 400,000 units. By 2035, central, eastern, and southern regions will have NEV commercial vehicle ownership exceeding 250,000 units, with Guangdong remaining in the top tier, exceeding 2 million units, showing significant growth. In terms of distribution, commercial vehicles are mainly influenced by economic effects, with population effects gradually becoming more prominent.

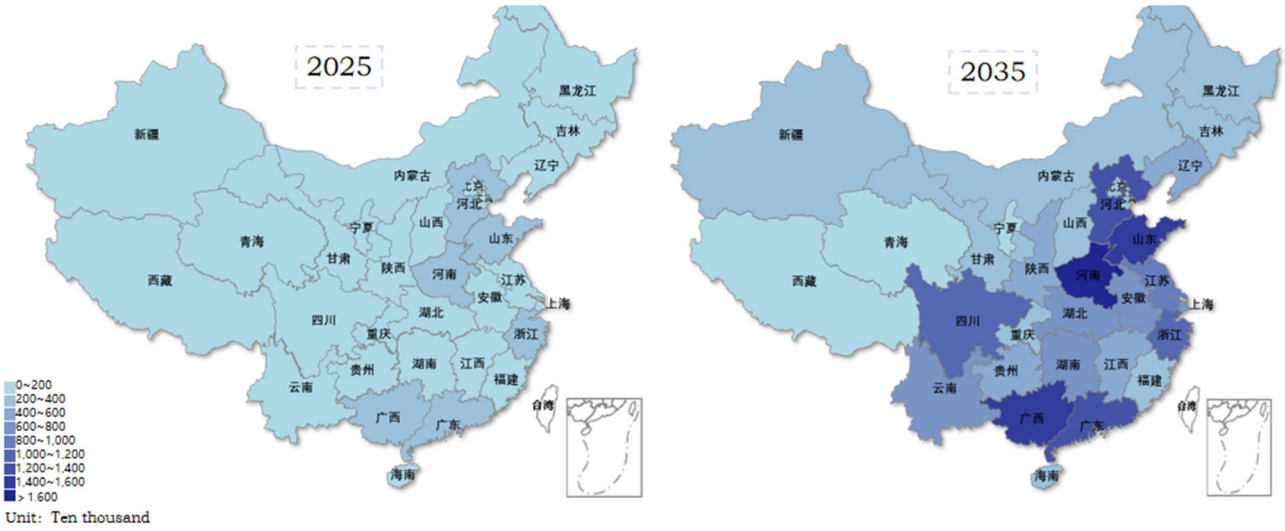

Figure 6. New Energy Passenger Vehicle Ownership Distribution Prediction

Figure 7. New Energy Commercial Vehicle Ownership Distribution Prediction

4.2. Power Battery Installation Scale Prediction

By 2030, the national power battery installation capacity is expected to grow to 660 GWh, exceeding 1,000 GWh by 2035, entering the TWh era. In terms of distribution, there will be no significant changes between 2025 and 2035, with provinces such as Guangdong, Shandong, and Henan leading in installation capacity, which will increase several fold.

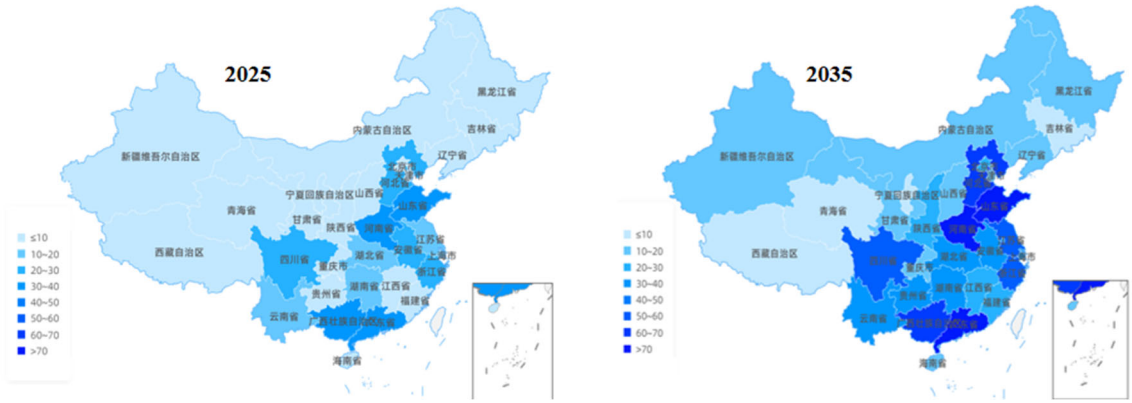

Figure 8. Power Battery Installation Capacity Distribution Prediction

4.3. Current Status and Prediction of Recyclable Metal Resources from NEVs

In 2023, China's recyclable lithium resources from vehicles reached 65,000 tons; recyclable nickel resources reached 102,000 tons; and recyclable cobalt resources reached 16,000 tons. Recyclable metal resources are mainly distributed in central and southeastern coastal regions. Due to the development of power battery technology, recyclable nickel resources are relatively abundant, while cobalt resources are scarce.

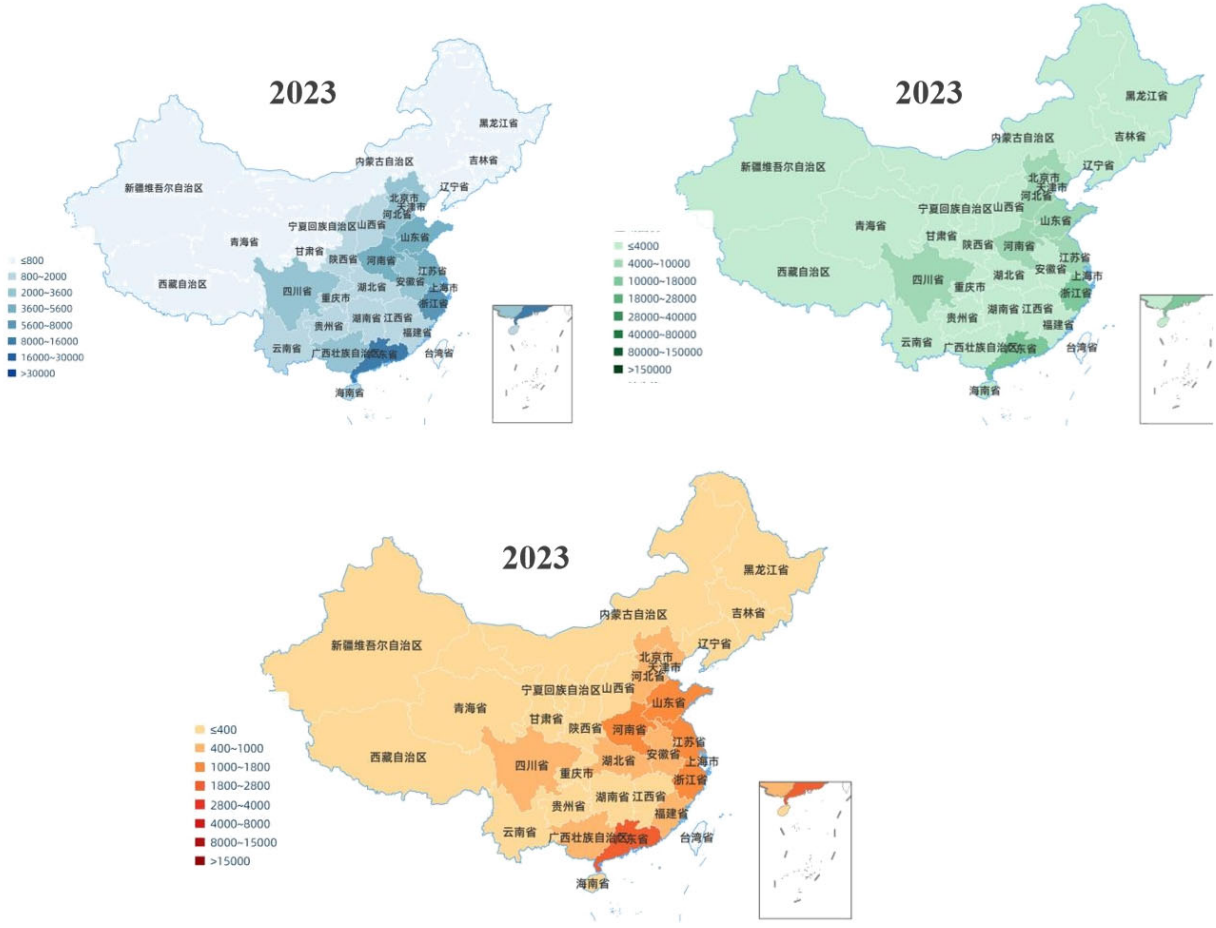

Figure 9. Distribution of Recyclable Metal Resources from NEVs in China (2023)

By 2025, China's recyclable lithium resources from NEVs are expected to reach 132,000 tons, mainly distributed in Guangdong, Guangxi, Zhejiang, Shandong, and Henan provinces, which form the first tier, with recyclable lithium resources exceeding 7,000 tons. By 2035, recyclable lithium resources will increase to 695,000 tons, with the distribution remaining consistent with 2025, and first-tier recyclable lithium resources exceeding 40,000 tons.

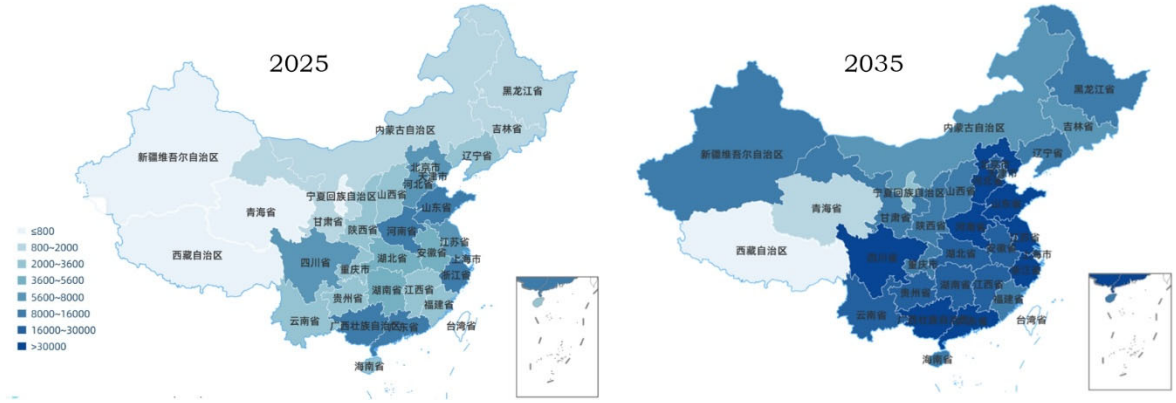

Figure 10. Prediction of Recyclable Lithium Resource Distribution from NEVs in China

By 2025, China's recyclable nickel resources from NEVs are expected to reach 212,000 tons, mainly distributed in Guangdong, Guangxi, Zhejiang, Shandong, and Henan provinces, which form the first tier, with recyclable nickel resources exceeding 10,000 tons. By 2035, recyclable nickel resources will increase to 2.49 million tons, with the distribution remaining consistent with 2025, and first-tier recyclable nickel resources exceeding 140,000 tons.

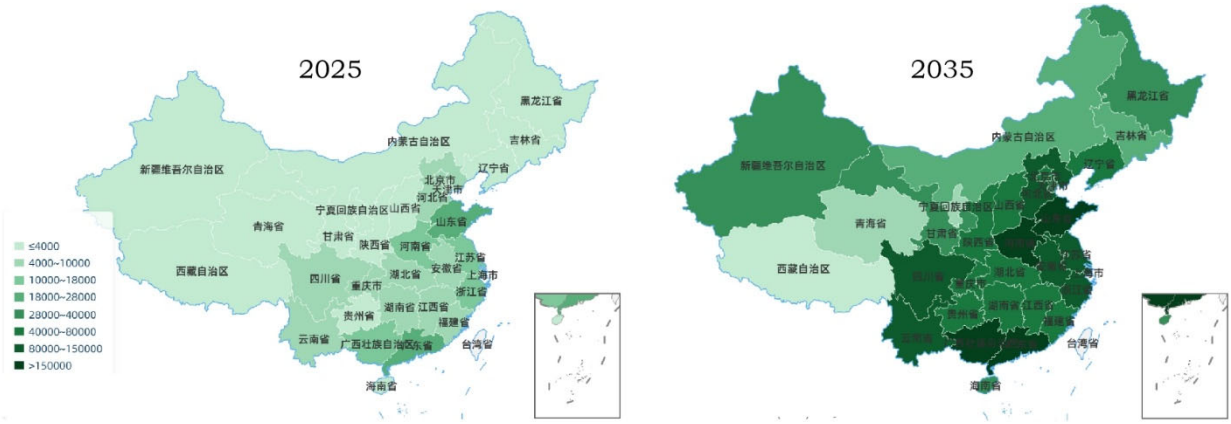

Figure 11. Prediction of Recyclable Nickel Resource Distribution from NEVs in China

By 2025, China's recyclable cobalt resources from NEVs are expected to reach 34,000 tons, mainly distributed in Guangdong, Guangxi, Zhejiang, Jiangsu, Shandong, and Henan provinces, with Guangdong and Shandong forming the first tier, with recyclable cobalt resources exceeding 2,000 tons. By 2035, recyclable cobalt resources will increase to 301,000 tons, with the distribution remaining consistent with 2025, and first-tier recyclable cobalt resources exceeding 16,000 tons.

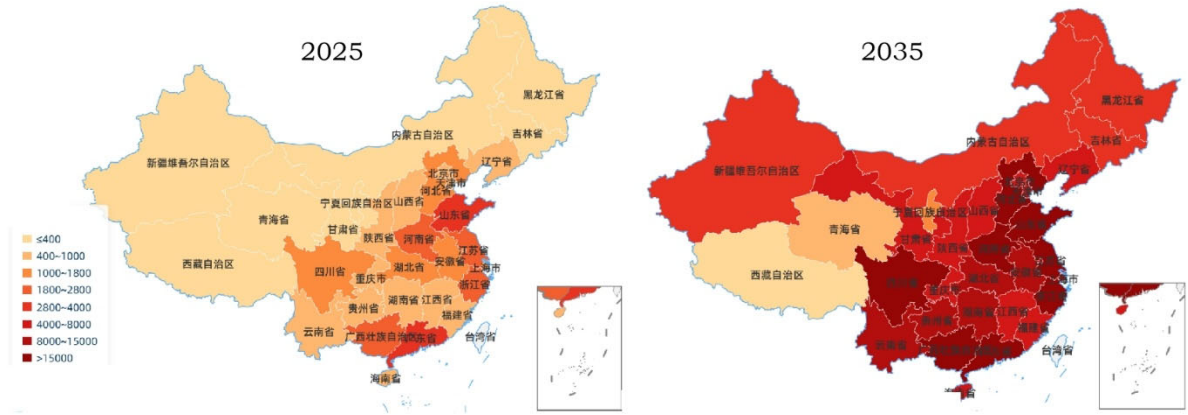

Figure 12. Prediction of Recyclable Cobalt Resource Distribution from NEVs in China

5. Conclusion

Based on the Gompertz curve model, scenario analysis, recycling, and elasticity models, this study predicts the distribution of recyclable metal resources from NEVs in China. The main conclusions are as follows:

(1) From 2023 to 2035, recyclable lithium resources from NEVs will significantly increase, from 65,000 tons to 695,000 tons, mainly distributed in Guangdong, Guangxi, Zhejiang, Shandong, and Henan provinces.

(2) From 2023 to 2035, recyclable nickel resources from NEVs will grow substantially, from 102,000 tons to 2.49 million tons, mainly distributed in Guangdong, Guangxi, Zhejiang, Shandong, and Henan provinces.

(3) From 2023 to 2035, recyclable cobalt resources from NEVs will show an increasing trend, from 16,000 tons to 301,000 tons, with the distribution trend consistent with lithium and nickel.

(4) Key metal resources have significant potential for secondary recycling. It is recommended that provinces plan their recycling industries based on resource distribution to avoid overcapacity or shortages. Enterprises can also plan production lines according to the distribution of key metal resources.

References

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