Forecast and Suggestions on The Demand of Lithium, Cobalt, Nickel and Manganese Resources in China's New Energy Automobile Industry

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Abstract. As the key resources of power battery production, lithium, cobalt, nickel and manganese have become important factors to ensure the healthy development of new energy automobile industry. In this paper, the distribution and application status of lithium, nickel, manganese and cobalt resources are introduced and briefly analyzed. Combined with the development trend of new energy automobile industry, the demand of lithium, cobalt, nickel and manganese resources in China's new energy industry is reasonably predicted. It is estimated that during 2021-2025, 76,000 tons of lithium, 88,200 tons of cobalt, 219,600 tons and 128,000 tons of manganese will be consumed. Because there is a big gap between supply and demand of resources, it is suggested to enhance the development of local resources, optimize the overseas resource supply system and build a closed loop of resource recycling.

Keywords: New energy vehicles, Lithium resources, Cobalt resources, demand forecasting.

1. Introduction
In recent years, new energy vehicles have become the main direction of the transformation and development of the global automobile industry. With the introduction of a series of supporting policies such as subsidies and tax exemption for new energy vehicles, China's new energy vehicle industry has shown a vigorous development trend. By the end of 2020, the cumulative production of new energy vehicles in China exceeded 5.45 million. The development of new energy vehicles has entered the fast lane, which has driven the strong demand for power batteries, and the power battery industry continues to maintain rapid growth. According to the statistics of China Automobile Center, by the end of 2020, the cumulative installed capacity of power batteries in China exceeded 266GWh (about 2.31 million tons).

Lithium, cobalt, nickel and manganese, as irreplaceable key resources of various power battery technology routes, have become important factors to ensure the healthy development of new energy automobile industry. With the popularization of new energy vehicles and the application of large-scale energy storage technology in power system in the future, China's demand for these resources will keep rising. In this paper, the current supply situation of lithium, cobalt, nickel and manganese resources in the world is introduced and briefly analyzed. On the basis of previous studies [1-2], combined with the development trend of new energy automobile industry, the demand of lithium, cobalt, nickel and
manganese resources in China's new energy industry is reasonably predicted, which will provide reference and basis for the formulation of relevant resource supply security policies.

2. Resource distribution and application status

2.1. Distribution and application of lithium resources reserves
In 2019, the global reserves of lithium resources are about 17 million tons (equivalent to metal equivalent, the same below), and the resources are highly concentrated, mainly distributed in Chile, Australia, Argentina and China. The reserves of the four countries account for 50.6%, 16.5%, 10.0% and 5.9% of the total reserves respectively, accounting for 83% of the total reserves [3].

China is the largest consumer and importer of lithium resources. In 2019, China's lithium consumption reached 35,000 tons, accounting for 60% of the global total consumption [4]. The gap between supply and demand of lithium resources was 27,000 tons, and the dependence on foreign countries was as high as 78.5%. Although China is rich in lithium resources, they are mainly distributed in areas with high altitude, poor environment and poor industrial foundation. The lithium resources in salt lakes have some problems, such as high ratio of magnesium to lithium, difficult separation and poor universality of lithium extraction technology, resulting in slow growth of self-produced output [5]. Lithium resources are mainly consumed by batteries, glass ceramics and grease. In 2019, the global consumption of the three fields accounted for 65%, 18% and 5% of the total respectively. The consumption structure of lithium resources in China is not much different from that in the world, and batteries are still the main consumption field of lithium, among which power batteries account for more than 60% of the total lithium consumption in the battery field.

2.2. Distribution and application of cobalt resources reserves
In 2019, the global reserves of cobalt resources are about 7 million tons, and cobalt resources are highly concentrated, mainly distributed in Congo and Australia, accounting for 51.4% and 17.1% of the total reserves respectively. The reserves of cobalt resources in China are about 80,000 tons, accounting for only 1.2% of the global total reserves, and cobalt resources are extremely short [3].

China is the world's largest producer of refined cobalt and a consumer of cobalt resources. In 2019, China's cobalt consumption reached 70,000 tons, accounting for 52.6% of the global total consumption. Due to the shortage of cobalt resources in China, raw materials are heavily dependent on imports, with a gap between supply and demand of 68,000 tons and an external dependence of 97.1%. Cobalt resources in China are mainly used in battery consumption. As the core raw material of batteries, cobalt consumption in the battery industry accounted for about 54% of the total consumption in 2019. Among them, power batteries account for about 15%, digital batteries account for about 39%, and other cobalt consumption fields include superalloys, cemented carbides, magnetic materials and catalysts, which account for about 14%, 7%, 6% and 4% of the total cobalt consumption respectively [6].

2.3. Distribution and application of nickel reserves
There are abundant nickel resources in the world. In 2019, the reserves of nickel resources in the world are about 89 million tons, and the concentration of nickel resources is lower than that of lithium and cobalt, mainly distributed in Indonesia, Australia, Brazil and Russia. The reserves of the four countries account for 23.6%, 22.5%, 12.4% and 7.8% of the total reserves respectively. China's nickel ore reserves are 2.8 million tons, accounting for only 3.1% of the world's total [3].

Due to the lack of nickel resources in China, it is necessary to import a large amount of nickel ore and concentrate every year. In 2019, China's nickel consumption reached 1.3 million tons, accounting for 51.6% of the global total consumption. The gap between supply and demand of nickel resources was 1.19 million tons, and the dependence on foreign countries was as high as 91.5%. Nickel consumption is mainly concentrated in stainless steel, nickel alloy, electroplating, batteries and other...
fields. In 2019, stainless steel consumption accounted for 80%, and batteries, electroplating and alloys accounted for 9%, 5% and 4% respectively.

2.4. Distribution and application status of manganese resources reserves

There are abundant manganese resources in the world. In 2019, the reserves of manganese resources in the world are about 810 million tons, among which the reserves of manganese resources in South Africa, Ukraine, Brazil and Australia account for 32%, 17.2%, 17.2% and 12.3% of the global reserves respectively, and the total reserves of the four countries account for 78.7% of the global total reserves. The reserves of manganese resources in China are 54 million tons, accounting for 6.7% of the global total reserves [3].

In 2019, although China's manganese ore reserves ranked sixth in the world, in the same year, China's manganese consumption reached 14.3 million tons, accounting for more than 50% of the global total consumption, making it the world's largest consumer of manganese resources. Manganese resources still mainly depend on imports, with a gap between supply and demand of 13 million tons and an external dependence of 91%. Manganese resource consumption is mainly concentrated in iron and steel industry, accounting for about 90% of total consumption, and the remaining 10% is used in non-ferrous metallurgy, electronics, chemical industry, batteries, agriculture and other fields.

| Resources        | Resource reserves in 2019 (10,000 tons) | China's situation in 2019 (10,000 tons) | Market price at the end of 2020 (ten thousand yuan/ton) |
|------------------|----------------------------------------|----------------------------------------|--------------------------------------------------|
|                  | Whole world | China | Proportion | Ore yield | Consumption | Supply and demand gap | External dependency |
| Lithium (Li)     | 1700        | 100   | 5.9%       | 0.75      | 3.5         | 2.75                  | 78.5%               | 4.88 Battery grade lithium carbonate |
| cobalt           | 700         | 8     | 1.1%       | 0.2       | 7           | 6.8                   | 97.1%               | 26.4 Cobalt |
| Nickel           | 8900        | 280   | 3.2%       | 11        | 130         | 119                   | 91.5%               | 3.35 Battery grade nickel sulfate |
| Manganese        | 81000       | 5400  | 7.1%       | 130       | 1430        | 1300                  | 91%                 | 0.64 Battery grade manganese sulfate |

Note: The data in the table are converted according to metal content, and the recycling of raw materials is not considered.
Generally speaking, the distribution of lithium, cobalt, nickel and manganese resources in the world is highly concentrated and characterized by oligopoly. Although China is rich in lithium and manganese resources, the output is far from meeting the demand, while nickel and cobalt resources are scarce. Lithium, cobalt, nickel and manganese resources are heavily dependent on imports and highly dependent on foreign countries. In the application field, lithium batteries have become the dominant areas of lithium and cobalt consumption, but the proportion of nickel and manganese resources consumption is low. From the market price point of view (Figure 1), the supply of lithium and cobalt resources in the industry exceeded demand, and its price continued to fall. The price of battery-grade lithium carbonate fell to 49,000 yuan/ton, down 71% from the end of 2017; The price of electrolytic cobalt dropped to 264,000 yuan/ton, down 50% from the end of 2017. In the world, nickel resources are in short supply. In addition, the power battery is developing towards high nickel, and the price of nickel continues to increase. The price of battery-grade nickel sulfate has risen to 33,500 yuan/ton, an increase of 26.4% compared with the end of 2017. The supply of battery-grade manganese sulfate is sufficient, and the overall price has no obvious change. At present, the price is maintained at 6,400 yuan/ton.

3. Resource demand forecast of new energy automobile industry
With the rapid development of new energy vehicles, the scale of the power battery industry has expanded rapidly, and the industry has a strong demand for lithium, cobalt, nickel, manganese and other resources. In this paper, the consumption of metal resources in the new energy automobile industry over the years is measured, as shown in Figure 3, based on the data of the output of new energy vehicles and the installed capacity of power batteries in China over the years (Figure 2) and previous research results [1-2].

![Figure 1: Market prices of lithium, nickel, manganese and cobalt resources](image1)

**Figure 1** Market prices of lithium, nickel, manganese and cobalt resources

![Figure 2: Output of new energy vehicles and installed capacity of power batteries in China over the years](image2)

**Figure 2** Output of new energy vehicles and installed capacity of power batteries in China over the years
In 2020, the production of power batteries will consume about 7,000 tons of lithium, 8,000 tons of cobalt, 19,000 tons of nickel and 11,000 tons of manganese; The accumulated consumption is about 27,000 tons of lithium, 28,000 tons of cobalt, 70,000 tons of nickel and 48,000 tons of manganese. Although some early-produced new energy vehicles have entered the scrap recycling process, and the retired batteries have been recycled as resources, the number of batteries retired in the short term is still small, and the recovered metal resources cannot meet the needs of new battery production. According to the calculation of China Automobile Center, in 2020, major recycling enterprises will recover about 1,100 tons of metal lithium, 2,200 tons of metal cobalt, 3,400 tons of metal nickel and 3,400 tons of metal manganese from waste batteries and battery waste [7]. Although the import demand of these resources was reduced to a certain extent, it was far from meeting the consumption of new batteries in that year. Therefore, the demand for metal resources such as lithium, cobalt, nickel and manganese will still depend on imports in the short term.

![Figure 3](image-url) Consumption of metal resources in China's new energy automobile industry over the years

Recently, the state issued the New Energy Vehicle Industry Development Plan (2021-2035), which further clarified that new energy vehicles will gradually become the mainstream of newly sold vehicles in the next 15 years. With the acceleration of the process of automobile electrification, the power battery industry will maintain rapid growth, the demand for metal resources such as lithium and cobalt will continue to expand, and the supply of domestic raw material resources will be insufficient, which will further increase the dependence of China's resources on foreign countries. According to "Energy Saving and New Energy Vehicle Technology Roadmap 2.0", the sales volume of new energy vehicles will reach about 20% of the total sales volume of new vehicles by 2025. This paper takes this as the basis for predicting the annual output of automobiles, but the roadmap does not involve the installed capacity of batteries and the proportion of battery types, which needs to be further predicted in combination with the current situation of industrial development. In 2020, the installed capacity of power batteries reached 63.6GWh, of which the installed capacity of ternary power batteries was 38.9GWh, accounting for 61.1% of the total installed capacity; The installed capacity of lithium iron phosphate power battery is 24.4GWh, accounting for 38.4% of the total installed capacity, and the installed capacity of other batteries is 0.33GWh, accounting for 0.5% of the total installed capacity. In view of the increasing market attention to the safety of power batteries in recent years and the rising market share of lithium iron phosphate batteries in 2020, this paper predicts that the annual installed capacity of power batteries will reach 76GWh, 103GWh, 133GWh, 175GWh and 233GWh respectively from 2021 to 2025, and the installed capacity of various types of power batteries will remain basically unchanged.
Combined with the annual output of power batteries, the predicted values of various battery assembly ratios, and the demand for metal resources per unit capacity of various batteries, the demand for lithium, cobalt, nickel and manganese of power batteries before 2025 is finally predicted (as shown in Figure 5). By 2025, the annual demand for lithium, cobalt, nickel and manganese in China's new energy automobile industry will reach 24,600 tons, 28,500 tons, 71,000 tons and 41,400 tons respectively. During 2021-2025, 76,000 tons of lithium, 88,200 tons of cobalt, 219,600 tons and 128,000 tons of manganese will be consumed cumulatively.

Figure 5 Forecast of metal resource demand of China's new energy automobile industry in the next five years

4. Suggestion
Facing the huge demand for metal resources in China's new energy automobile industry, how to ensure the stability of the supply chain will become the key to the sustainable development of the whole industry. This paper puts forward the following three suggestions for consideration.

(1) Improve the development technology of local resources, improve the local supply capacity and reduce the dependence on foreign countries. China's reserves of lithium and manganese resources have always been at the forefront in the world, but due to many factors restricting local development, the output is far from meeting the demand. Therefore, the exploration and exploitation of lithium and manganese resources should be further strengthened, and cooperative exploitation should be encouraged through corresponding policies to improve the exploitation efficiency.
(2) Strengthen the layout and development of overseas resources and build a reasonable overseas resource supply system. In recent years, Chinese enterprises have successively acquired overseas resources, and Chinese enterprises have gained nearly 30% control in the global cobalt market, providing certain raw material guarantee for the development of new energy industry. On this basis, the state should establish an overseas mineral resources development investment guidance catalogue, actively guide the layout and development of enterprises in high-quality resource areas, reduce the market risks that may be caused by excessive concentration of overseas resources investment, and build a reasonable overseas lithium resource supply system.

(3) Accelerate the establishment of a sound recycling system and build a closed loop of resource recycling. China has successively issued a number of power battery recycling management policies [8-9], and the recycling industry has developed rapidly. It is necessary to further guide and improve the construction of recycling system, and promote the recycling of recycled metal resources in power batteries, thus reducing the exploitation of mineral resources and reducing the supply pressure. According to the forecast of China Automobile Center, by 2025, the accumulated decommissioned power batteries will reach 145.8GWh, and 14,400 tons of lithium, 11,400 tons of cobalt, 28,300 tons of nickel and 24,600 tons of manganese can be recovered. It is estimated that by 2030, the accumulated decommissioning amount will reach 558.9GWh, and 59,600 tons of lithium, 71,900 tons of cobalt, 179,000 tons of nickel and 112,000 tons of manganese can be recovered.

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