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China's Demand for Energy and Mineral Resources by 2035

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Abstract: Since 2000, China's consumption of energy and mineral resources has grown rapidly, and its consumption of some important mineral resources has even exceeded half of the global consumption. Medium- and long-term resource demand forecast is an important basis for national policy formulation and strategic planning. Based on historical statistics such as China's population, GDP, and mineral resources consumption, this paper adopts the S-shape rule of per capita consumption, the demand analogy and proportional relationship measurement algorithm, and the departmental consumption method, to systematically predict the demand for 43 types of major mineral resources before 2035. Results show that China's demand for mineral resources has changed from high-speed growth to differential growth; its demand for most of the bulk minerals will peak by 2025; the structure of primary energy sources will change dramatically when their demand peak by 2030, with the demand for Coal falling from 60.4% in 2017 to 46.3%, that for natural gas increasing from 6.6% to 13.2%, and that for non-fossil energy increasing from 13.6% to 23.4%; and demand for most strategic emerging minerals will continue to grow before 2035, and the global structure and pattern of supply and demand for energy and mineral resources will change greatly.

Keywords: energy and mineral resources; consumption; demand forecast; 2035

1 Introduction

In 2017, China remained the global leader in energy and mineral resources consumption. Among the 43 minerals studied in this paper, China ranks first in the world in the consumption of 32 of the minerals. It accounts for more than 40% of the global consumption of 24 minerals, such as iron, vanadium, chromium, lead, zinc, tin, molybdenum, lithium, cobalt, and nickel, and more than 50% of 13 other minerals, such as coal, cement (limestone), graphite, phosphorus, manganese, aluminum, copper, antimony, tungsten, and rare earth. The huge demand for energy and mineral resources has given rise to concerns about China's resource and economic security.

The experience of developed countries shows that in the later stages of industrialization, the demand growth rate of most bulk minerals slows down. This implies that when economic and social development reaches different levels, the consistent change in the trend of mineral resources consumption is a universal law. The macro data shows that the characteristics of China's entry into the later stage of industrialization are very obvious. Correspondingly, the growth rate of China's future demand for mineral resources has begun to slow down significantly. The demand for bulk mineral resources will gradually peak and the demand structure will undergo

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major changes. However, even after entering the post-industrial stage (after around 2030–2035), China will still need to maintain a high level of per capita energy and mineral resources consumption. Thus, to achieve its “two hundred-year” goals, China will need a large amount of energy and mineral resources. The demand forecast for mineral resources is important for national strategic planning and investment decision-making by enterprises. It is also the focus of strategic game of various interest groups under the conditions of globalization. Therefore, it is highly valued by the international community. Moreover, many research institutions are also committed to it [1]. Although many studies have been conducted on China’s need for major mineral resources, including energy [2], iron [3], copper [4−6], aluminum [6], lead [7], zinc [8], nickel [9], tungsten [10], tin [11], antimony [12], magnesium [13], gallium [14], rhenium [15], cobalt [16], chromium [17], uranium [18], gold [19], platinum group [20], graphite [21], and other mineral resources, none of them use a variety of methods to systematically analyze the demand trends of major mineral resources. Therefore, this study will attempt to comprehensively analyze the future trends of China’s energy and mineral resources demand in the medium and long run and provide decision-making recommendations for national managers.

2 Demand forecasting methods and data sources

The data in this article are all from authoritative data. They include the mineral resources consumption data from the time of the founding of the People’s Republic of China by organizations like the National Bureau of Statistics, China Iron and Steel Industry Association, and China Nonferrous Metals Industry Association; global and major national consumption data by BP, EIA, IEA, USGS, BGS, WBMS, CRU, ROSKILL, and other institutions; GDP data by GGDC, and population data by the United Nations Statistics Agency.

The GDP data is in terms of PPP (GK in 1990). The projected GDP growth rates for different periods in the future include 6.5% in 2018–2019, 5% in 2020–2024, 4% in 2025–2029, and 3.5% in 2030–2035.

According to the characteristics of different minerals and actual conditions, different demand forecasting methods or their combinations were selected.

(1) Energy and bulk metals, like petroleum, iron, copper, aluminum, potassium, and phosphorus, have been selected for the “S” shape of per capita consumption.

(2) Minerals closely related to the steel industry, such as chromium, vanadium, molybdenum, and niobium, have been selected for analogy demand forecasting and proportional relationship measurement algorithms.

(3) Rare-earth, rare, and rare-scattered (“three rare”) minerals and nonmetallic minerals, such as lithium, cobalt, graphite, and barite, are subject to sectoral consumption laws.

(4) Some minerals have been selected for methods like per capita consumption trajectory analogy, regression analysis, and system dynamics to forecast demand.

3 Demand forecasting and trend analysis

3.1 Results of mineral resource demand analysis

For comparability and consistency between the minerals, the analysis process is expressed by the demand index, which is set to 1 for 2015, with the other annual values proportional to it. For the period 2015–2035, 38 out of 43 mineral resources indicated growing demand. The demand for 15 mineral resources such as petroleum, natural gas, tungsten, cobalt, gold, silver, platinum group, rare earth, lithium, niobium, tantalum, gallium, indium, graphite, and barite continues to grow, while that of the remaining 23 increased first and then decreased. The demand for five mineral resources, such as iron ore, magnesite, strontium, diamond, and cement limestone, is decreasing (Fig.1).

There are differences in the areas of application and functions of seven categories of mineral resources, indicating that there are huge differences in their future demand trends.

There are four kinds of energy minerals: primary energy, oil, natural gas, coal. In general, China’s energy demand will continue to grow, but its structure will undergo changes. Oil and natural gas demand will continue to grow, while coal demand will peak in 2020 and then gradually decline.

There are five kinds of ferrous minerals: iron ore, manganese, chromium, vanadium, and titanium. The areas of application of ferrous metal minerals are closely related to the steel industry. That is, given the level of infrastructure construction and social wealth accumulation, the future demand for ferrous metal minerals will slow down or decrease. The demand for crude steel has crossed its peak and the other mineral will also reach peak demand by 2025.

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There are 10 kinds of nonferrous metal minerals: copper, aluminum, lead, zinc, nickel, cobalt, molybdenum, tin, tungsten, and antimony. Nonferrous metal minerals can be divided into two categories according to their areas of application. The first category comprises of minerals like copper, lead, zinc, nickel, and molybdenum and they are mostly used in traditional industries. Thus, their future demand growth will slow down and demand will peak by 2025. The second category comprises of minerals like aluminum, cobalt, tin, tungsten, and antimony and they are widely used in emerging industries and for the manufacture of new materials. Thus, their demand will continue to grow substantially in the future and would only peak after 2025.

There are 13 kinds of precious metals, and "three rare" metals minerals: gold, silver, platinum group, rare earth, lithium, strontium, beryllium, zirconium, niobium, tantalum, gallium, germanium, and indium. Rare metals are mostly strategic emerging industry minerals, playing a vital role in the application of new energy and new materials. Their demand will maintain a rapid growth trend and peak after 2035, in the case of most minerals. Among them, strontium and zirconium are special. These two minerals are widely used as coatings and raw materials in glass manufacturing in traditional industries. With continuous application in new fields, their proportion of consumption in traditional industries will gradually decrease, resulting in a fall in demand or slowdown in demand growth. However, their demand in emerging industries will continue to grow.

There are 11 kinds of chemical minerals and nonmetallic minerals: graphite, diamond, sulfur, phosphorus, potassium salt, kaolin, barite, magnesite, fluorite, boron, and cement limestone. Nonmetallic minerals are used in a wide range of applications and there are large differences in their demand trends as well. Graphite, boron, kaolin, and barite have been applied in the field of new energy and new materials. Their future demand will increase considerably. Sulfur, phosphorus, and potassium salt are mainly used in agricultural fertilizers and their demand is nearly peaking. Hence, their growth is limited too. Fluorite and diamond minerals are used in new fields, but the fluorite industry is already witnessing a surplus. Diamond has been replaced by synthetic diamonds and thus, has little room for growth. Magnesite and cement limestone, which are widely used in the traditional industry, have already crossed peak demand and will fall in the future.

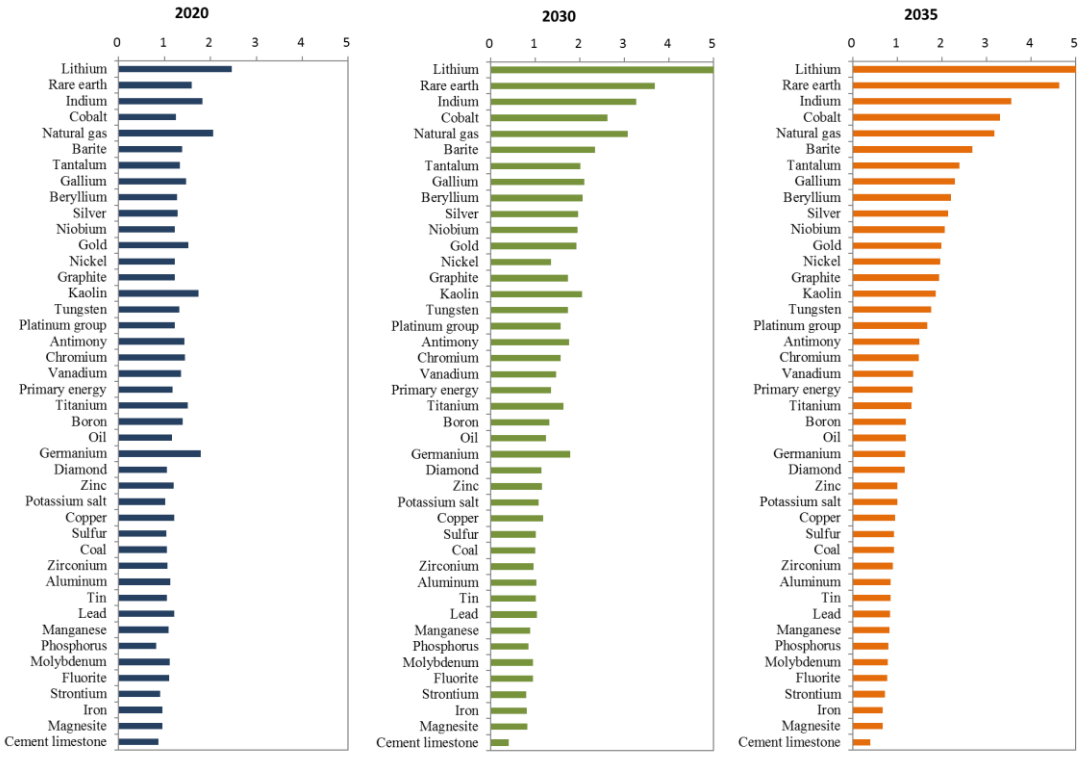

Fig. 1. Overall trends of China's demand for various mineral resources.

Note: The demand index of 2015 is 1.

3.2 Future cumulative demand analysis

The cumulative demand for major mineral resources for the next 18 years (2018–2035) will indicate a different magnitude of increase as compared to that for the past 17 years (2001–2017) (Table 1).

Table 1. Comparison of cumulative demand relationship of major mineral resources between 2018–2035 and 2001–2017.

Mineral species	Minerals	Cumulative demand (2018–2035)/ Cumulative demand (2001–2017)
Energy	Primary energy	1.8
	Oil	1.7
	Natural gas	4.9
	Coal	1.3
	Uranium	7.6
Ferrous metals	Iron ore	1.2
	Manganese	1.5
	Chromium	1.8
	Vanadium	2.7
	Titanium	3.4
Nonferrous metals	Copper	2.1
	Aluminum	2.2
	Lead	1.7
	Zinc	1.7
	Nickel	3.0
	Cobalt	4.5
	Molybdenum	1.5
	Tungsten	2.6
	Tin	1.4
	Antimony	2.3
Precious metals	Gold	3.1
	Silver	2.8
	Platinum	1.8
Rare-earth, rare, and rare-scattered metals	Rare earth	3.9
	Lithium	17.9
	Strontium	0.7
	Beryllium	4.8
	Zirconium	1.3
	Niobium	2.5
	Tantalum	3.0
	Gallium	5.0
	Germanium	2.9
	Indium	5.9
Chemical metals	Phosphorus	1.4
	Sulfur	1.6
	Sylvite	1.7
	Barite	2.8
	Fluorite	1.6
	Boron	1.9
Nonmetals	Graphite	1.6
	Diamond	1.3
	Kaolin	2.9
	Magnesite	1.3
	Cement	1.3

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3.3 Analysis of peak demand

The areas of application of different mineral resources are different. Hence, the time when they will reach peak demand will also be different. This is due to the inherent law of the consumption of mineral resources. Among the demand forecasts for 43 minerals, the demand for iron ore, magnesite, strontium, diamond, and cement limestone peaked before 2015 (including 2015). The demand for coal, manganese, zinc, and fluorite peaked between 2015–2020 (including 2020). The demand for chromium, vanadium, titanium, copper, aluminum, nickel, molybdenum, tin, and 16 other minerals like antimony, germanium, beryllium, zirconium, sulfur, phosphorus, boron, and kaolin will peak in 2020–2025 (including 2025). The demand for primary energy, petroleum, bauxite, and potassium salts will peak in 2025–2030 (including 2030). The demand for natural gas, tungsten, cobalt, gold, silver, platinum group, rare earth, lithium, niobium, tantalum, germanium, indium, gallium, and graphite will not peak before 2030. (Fig. 2).

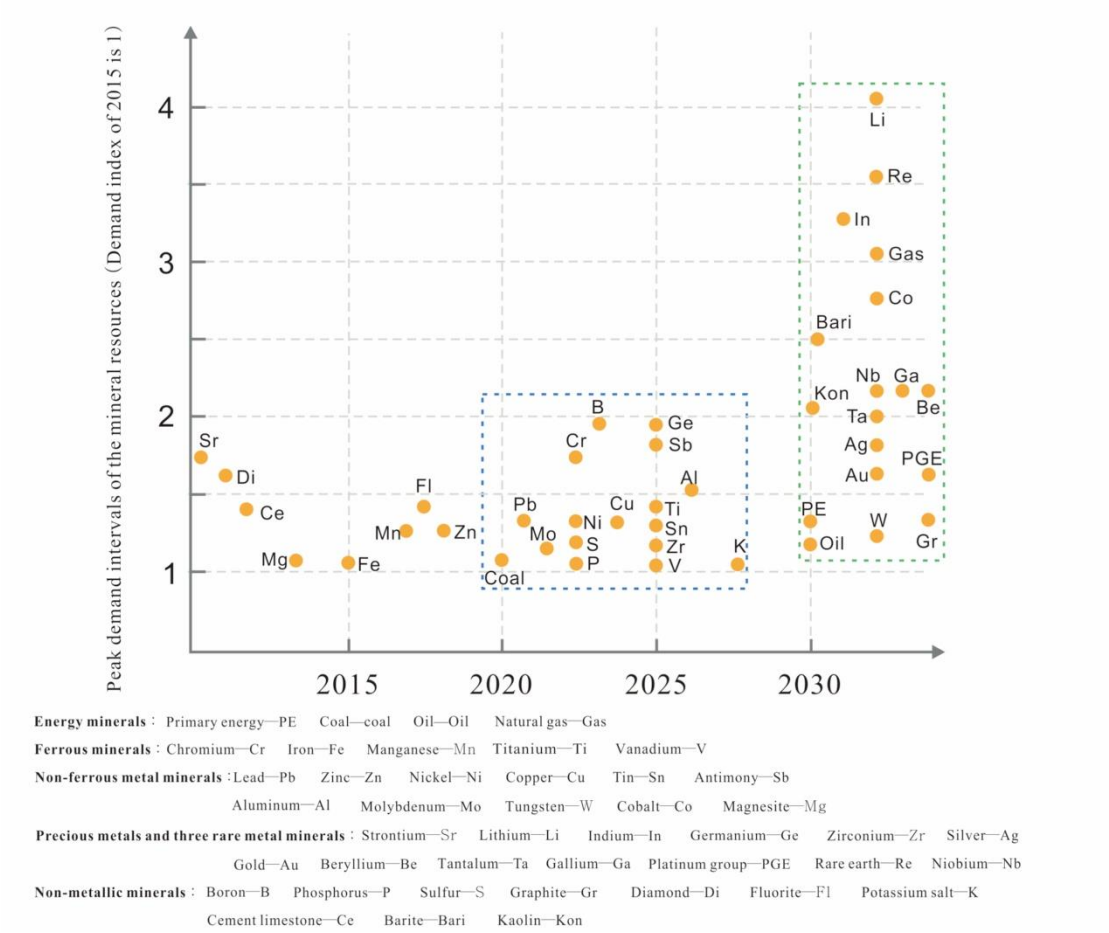

Fig. 2. Peak demand for mineral resources in China.

4 Conclusion and discussion

(1) China's demand for mineral resources has shifted from a comprehensive high-speed growth to a differentiated growth. The 10 years since the beginning of the new century has witnessed a period of rapid industrialization, with the consumption of mineral resources growing at an unprecedented rate. From 2000 to 2010, the average annual growth rates of primary energy consumption was 7.2%, crude steel was 16.2%, copper was 14.4%, aluminum was 16.3%, lead was 21%, zinc was 15%, and cement was 12%. From 2013 to 2014, crude steel and cement consumption has peaked, which is consistent with the law of consumption. In the past three years (2015–2017), the average annual growth rates of primary energy has dropped to 3%, copper to 1%, aluminum to 5%, lead to 3%, and zinc to 5%. As China enters the later stage of industrialization, the consumption of commodities and resources will gradually saturate and the demand trend of mineral resources will undergo major changes.

(2) Most major minerals will reach peak demand before 2025. As the industrialization process matures, per capita income will continue to increase, along with the increase in urbanization rate, infrastructure construction, and social wealth accumulation. The transformation and upgrading of the industrial structure will accelerate and demand growth rate for bulk mineral resources will slow. The forecasts show that after the demand for steel and cement peaks in China, most of the other major minerals, such as copper, aluminum, lead, and zinc, will also gradually peak by 2025. For example, demand for copper, which is project to peak in 2024, has only 30% growth space as compared to 2017

(3) The structure of primary energy demand will change significantly when it peaks in 2030. In 2030, China's primary energy demand is projected to reach 4.1 billion tonnes of oil equivalent, which is only 30% more than that in 2017. However, the structure of energy consumption will undergo major changes. The proportion of coal consumption will fall from 60.4% to 46.3%, while that of natural gas and non-fossil energy consumption will increase from 6.6% to 13.2% and 13.6% to 23.4%, respectively. Coal demand will peak around 2020 and natural gas demand will increase to 600 billion cubic meters in 2030, which is 2.5 times that in 2017.

(4) In 2035, most of the strategic emerging minerals will still maintain demand growth. Industrialization will enter into the later stage, and the transformation of the industrial structure will intensify. The transition from a big industrial country to an industrial power will continue to drive the growth of demand for strategic emerging minerals, which will continue until 2035. For example, the development of the new energy vehicle industry will have an important impact on the demand for the six most critical minerals: lithium, cobalt, nickel, graphite, rare earth, and platinum. The forecasts show that compared to 2017, the demand for lithium will increase by 10 times, cobalt by 2.3 times, nickel by 1.5, rare earth by 2.7 times, graphite by 80%, and platinum by 69% in 2035. Global supply and demand structures and patterns will all undergo major changes.

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