DOI 10.15302/J-SSCAE-2019.01.014

Development Situation of Ferrous Metal Resources in China

Task Group for *the Strategic Research on Great Power of Ferrous Metal Mineral Resources*

Abstract: As a forerunner of China's supply-side structure reform, the iron and steel industry actively resolved its overcapacity. Between 2016 and 2017, more than 1.2×10^8 t of excessive steel production capacity was resolved, and 1.4×10^8 t of illegal production capacity (i.e., substandard steel) was eliminated. Because the global iron and steel industry is currently in an excess production capacity cycle, China's steel consumption has grown from sustainment status to a peak-value platform phase. Meanwhile, both the crude steel consumption intensity per unit GDP and the per unit investment have decreased. The consumption demand and output of crude steel in China are expected to reach 6×10^8 to 6.5×10^8 t and 6.5×10^8 to 7.0×10^8 t by 2025, respectively, and 5.3×10^8 to 6.0×10^8 t and 5.9×10^8 to 6.5×10^8 t by 2030. The supply of steel scrap resources in China is expected to increase rapidly, and their sufficiency is anticipated to become a strong supporter for China's iron and steel industry. The structure of iron resources will therefore be greatly changed, and the demand for international iron ore resources will gradually decrease. All these changes are important for promoting ecological social growth through construction and green development.
Keywords: iron and steel; steel scrap; iron ore; peak-value platform area

1 Development status of ferrous metal resources

The iron and steel industry is a mainstay industry of the Chinese national economy, playing an irreplaceable role in guaranteeing societal growth. Because steel materials comprise the core structural and functional material of construction and daily existence, the position of the resource is not expected to change in the foreseeable future. As the primary raw materials for iron and steel production, ferrous metal mineral resources and steel scrap resources are the cornerstones of healthy and sustainable development.

Ferrous metal mineral resources comprise iron, manganese, chromium, vanadium, and titanium ores, where the output and value of iron accounts for more than 90%. Moreover, iron ores are the most important resources affecting the development of the iron and steel industry. Steel scrap is an important raw material that can be used in place of iron ore. The supply intensity of steel scrap resources directly influences the demand of iron and steel. Therefore, this paper focuses on iron ore and steel scrap resources.

1.1 Rich reserves of iron ore resources

From the aspect of confirmed iron ore reserves [1], those in China amount to 8.489×10^{10} t, distributed in 4790 iron ore areas with an average iron grade of 31.5%, as of the end of 2017 (Fig. 1). From 2005 to 2017, newly discovered large- and medium-sized ore deposits ($>5 \times 10^7$ t) were extracted in more than 80 locations. The amount of resources increased by 42.9%, but the reserves decreased by 58.7%.

Received date: January 10, 2019; **Revised date:** January 25, 2019

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Funding program: CAE Advisory Project "Research on Construction of a Great Power of Mineral Resources" (2015-XZ-35)

Chinese version: Strategic Study of CAE 2019, 21 (1): 097–103

Cited item: Task Group for *the Strategic Research on Great Power of Ferrous Metal Mineral Resources*. Development Situation of Ferrous Metal Resources in China. *Strategic Study of CAE*, https://doi.org/10.15302/J-SSCAE-2019.01.014

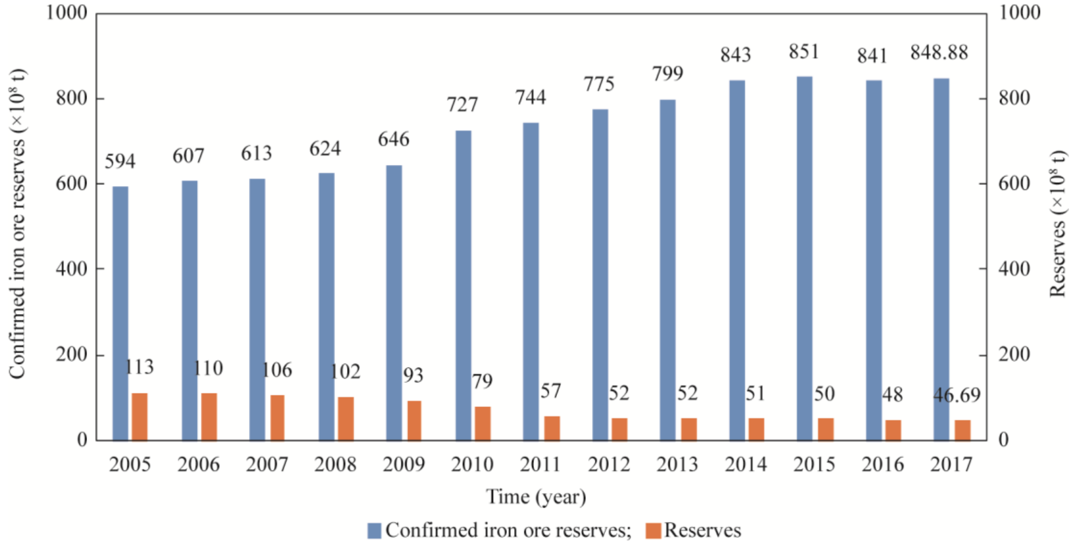

Fig. 1. Confirmed iron ore reserves and reserve changes of iron ores in China.

1.2 Substantial increase in iron ore output

From the perspective of crude iron ore production in China, the maximum output reached 1.514×10^9 t in 2014 and decreased by 7.7% in 2015. In 2016, it decreased 3.01% from 2015. Finally, the domestic crude iron ore output was only 1.229×10^9 t in 2017 (Fig. 2). Thus, from 2005 to 2017, the cumulative amount of crude iron ore output was 1.379×10^{10} t, equivalent to 3.83×10^9 t of finished ores (ratio of concentration=3.6).

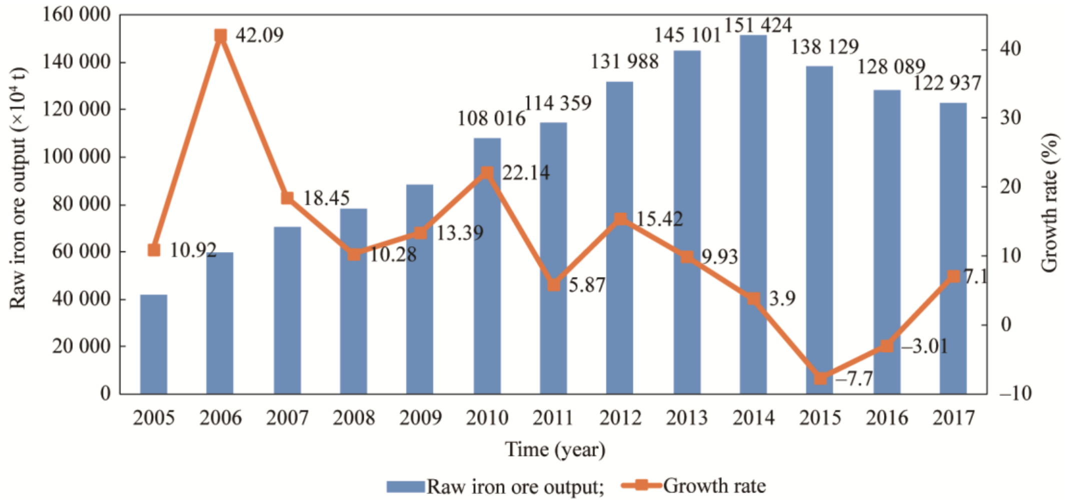

Fig. 2. Changes in raw iron ore output in China.

1.3 Structure optimization of iron ore industries

By the end of 2017, there were 1523 metallurgical and mining enterprises above the designated size in China, and 355 enterprises were out-of-market for the whole year. Additionally, 1739 enterprises exited the market in the past three years, reducing the total by 52.51%. Because iron ore output was only reduced by about 1.5×10^8 t, it shows that the industrial concentration improved and that the industrial structure was optimized (Fig. 3).

According to the statistical data of the 2017 Annual Report of Development and Utilization for National Abandoned Oil, Gas, and Mining Resources [2], by the end of 2017, the number of mining rights for iron ores was 3736 in China, and the raw ore output was 5.672×10^8 t (the statistical data of the National Bureau of Statistics were 1.229×10^9 t), which comprised 180 large mines, accounting for 4.65% of the total number, whose raw ore output was 4.261×10^8 t, accounting for 81.48%. There were 421 medium-sized mines, accounting for 10.31% of the total number, whose raw ore output was 1.02×10^8 t, accounting for 11.42%. Lastly, there were 3135 small and mini mines, accounting for 85.04% of the total number, whose raw ore output was only 3.913×10^7 t, accounting for only 7.10% (Fig. 4).

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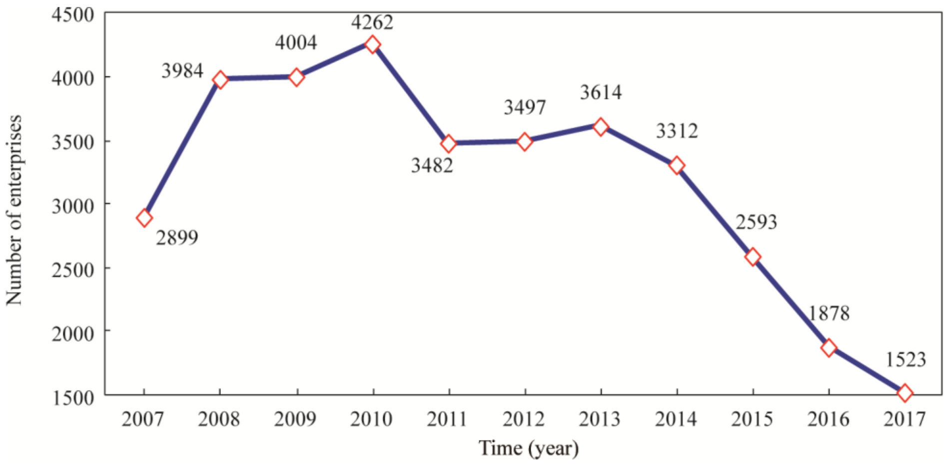

Fig. 3. Recent changes in iron ore enterprise number.

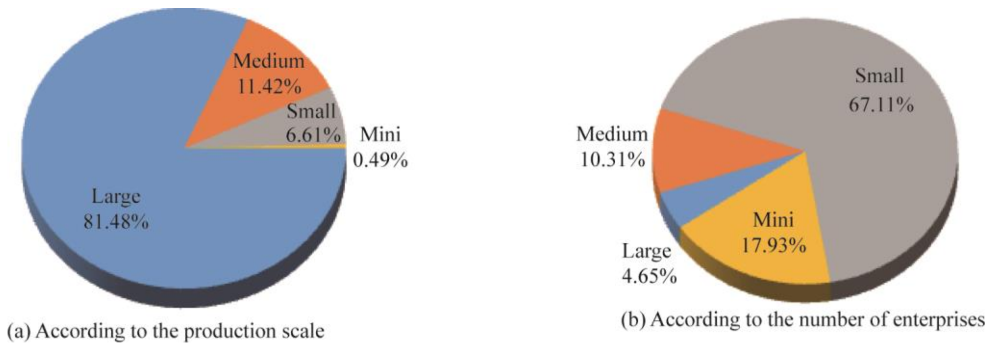

Fig. 4. Distribution of iron ore enterprise types in 2017.

1.4 Iron ore import amount soars, and the degree of foreign trade dependence approaches 90%

In 2003, China imported 1.48×10^8 t of iron ores, becoming the largest importer in the world. Afterwards, the annual growth rate continued to increase at a double-digit rate, where the amount of imported iron ores exceeded 1×10^9 t for the first time and reached 1.024×10^9 t in 2016. Finally, it reached 1.075×10^9 t in 2017.

In 2005, the degree of foreign trade dependence of iron ores reached 39%. With the rapid economic development and construction in China, steel production capacity continued to grow rapidly, resulting in an increased demand of ore resources with a growing external dependence, year by year. The external dependence reached 69% in 2009 and 89.29% in 2017. Currently, China's external iron ore dependence is nearly 90%, which could seriously affect the economic security of the industry.

The international price of iron ore remained relatively stable for a long time at approximately USD 20/t from the 1980s to the beginning of the 21st century. However, the average annual price of imported ores was USD 32.79/t in 2003, which was 31.16% higher than the previous year. Then, the international iron ore price continued to rise, and the average annual price imported iron ores increased to USD 136.20/t by 2008, which was 4.2 times of the price in 2003. With the outbreak of the global financial crisis, there was a sharp correction to the international iron ore prices in 2009, and the average annual price of Chinese imported iron ores fell to USD 79.87/t, 41.36% lower than 2008.

With strong demand during the development of the steel industry in China, the amount of iron ore imports increased steadily. Global suppliers manipulated market prices using their resource advantages and monopoly positions, resulting in a sustainable increase in the price of ores. In 2010, the top three major iron ore suppliers in the world (i.e., Brazil's Vale, Australia's BHP Billiton, and Rio Tinto) offered to increase their iron ore prices by 80% to 90% over the 2009 prices. In 2011, the average annual price of imported iron ore reached USD 163.84/t, which is unprecedented. This accelerated the release of the new global production capacity and emerged as a tendency, where supply gradually increased the demand, resulting in falling prices for several years.

1.5 Rapid increase in supply of steel scrap resources

Steel scrap is an indispensable raw material for the modern iron and steel industries. It is also the only green raw material that can replace iron ores. It is a renewable resource that can be used to save and carry energy. For 1 t steel, 1.65 t iron ore will be saved when using steel scraps. Moreover, energy consumption can be reduced by about 350 kg of standard coal with reduced emissions of 1.4 t CO_2 and 3 t solid waste.

Steel scraps include home scraps, new scraps, and old scraps. In China, there are no specific statistical data for new and old scraps, which are collectively referred to as “social scraps.” The recovery amount of home and social scraps has increased yearly, whereas the amount of imported scraps has fluctuated greatly because of the influence of international trade and scrap prices. Additionally, the price of imported scraps has decreased since reaching a peak in 2009 (1.369×10^7 t). The amount of imported scraps in China was only 2.32×10^6 t by 2017.

The total steel scrap consumption [3] for steel-making in China was 1.479×10^8 t in 2017. The year-on-year increase was 5.781×10^7 t, up 64.1%. The unit consumption of scrap was 177.8 kg/t, with a year-on-year increase of 66.4 kg/t. The scrap ratio was 17.78%, an increase of 6.6% year-on-year. The unit consumption of converter scrap was 128.2 kg/t, with a year-on-year increase of 56.1 kg/t. The unit consumption of steel scrap using electric furnaces was 660.6 kg /t, with a year-on-year increase of 441 kg/t. The electric furnace steel ratio was 9.3%, which is an increase of 2.1% year-on-year.

Following are the main causes for the substantial increases in steel scrap consumption of China in 2017. First, the material flows of scrap resources changed significantly because of the ban on “substandard steels,” which led to scrap price drops. Afterwards, it was advantageous to replace iron ore with steel scraps for the cost advantage. Therefore, iron and steel enterprises enjoyed an increase in the use of scrap steels. Second, the utilization proportion of the electric arc furnace steelmaking method continued to increase under the environmental protection pressures as an eco-friendly production process, which further enhanced the demand for steel scraps. Third, the enterprises in “the 2+26” areas (e.g., Beijing City, Tianjin City, and Hebei Province) consumed considerable steel scraps to increase output.

During the first three quarters of 2018, the total consumption of steel scraps in China was 1.41×10^8 t, which amounted to 3.939×10^7 t over the previous year, showing an increase of 38.9%. The total consumption of steel scraps in 2018 was 1.87×10^8 t. The unit consumption of steel scraps was 201 kg/t, adding 42.6 kg/t from the previous year, leading to an increase of 26.9%. Additionally, the steel scrap ratio was 20.1%, which is an increase of 4.3% from the previous year. The statistical data show that the generation of domestic steel scrap resources increased greatly, and the utilization of steel scrap resources reached a new level. The steel scrap ratio exceeded 20%, which accomplished the goal of the “13th Five-year Plan of Steel Scrap Industries” ahead of schedule, demonstrating that the development of the steel scrap industry had entered an important transformation period and that the iron and steel industry had entered a new era of massive application of steel scrap resources.

Usually, the amount of steel scrap resources is predicted using the social steel stock conversion method and the steel product life cycle method. The predicted total amounts of steel scrap resources in China are shown in Table 1.

Table 1. Predicted total amount of steel scrap resources in China for 2019−2030 **(**$\times 10^8$ t).

Year	Social steel stock conversion method	Steel product life cycle method	Average value of two methods
2019	2.037	1.983	2.010
2020	2.142	2.096	2.119
2021	2.258	2.154	2.206
2022	2.379	2.241	2.310
2023	2.488	2.402	2.445
2024	2.605	2.643	2.624
2025	2.722	3.042	2.882
2026	2.823	3.115	2.969
2027	2.931	3.217	3.074
2028	3.034	3.282	3.158
2029	3.124	3.348	3.236
2030	3.224	3.460	3.342

Table 1 shows that, in China, by 2020, the social steel stock will reach 1×10^{10} t, and the total amount of steel

DOI 10.15302/J-SSCAE-2019.01.014

scrap resources will reach 2.1 × 10^8 t. By 2025, the social steel stock will reach 1.2 × 10^{10} t, and the total amount of steel scrap resources will reach 2.7 × 10^8 t to 3.0 × 10^8 t. By 2030, the social steel stock is expected to reach 1.3 × 10^{10} t, and the total amount of steel scrap resources will exceed 3.3 × 10^8 t.

2 Study and estimation of development of iron and steel industries

2.1 Estimation of development of global iron and steel industries

There have been three stages to the development of global iron and steel industries since World War II. The first stage began with the period from the end of World War II to the oil shock in early 1970s. Western countries played leading roles then, and the steel industry enjoyed a long period of rapid growth. Steel output increased 3.7 times in 24 years with an average annual growth rate of 5.6%.

The second stage lasted from the early 1970s to the end of the 20th century: The development of global steel industries remained stable, where development fluctuated but showed a low-speed growth tendency because of the influencing factors of two oil shocks, an economic restructuring of western countries, and the collapse of the USSR, especially with the support of steel production growth in China. The world crude steel output increased by only 10.4% at an average annual growth rate of 0.4% over the past 24 years.

The current third stage began in 2000, when the rapid development of steel production and consumption in China brought the global steel industry to a new level of development. During this period, the global crude steel output has increased from 8.5 × 10^8 t in 2000 to 1.665 × 10^9 t in 2014, and the steel production output has increased more than 2 times at an average annual growth rate of 5.3%.

The global crude steel output was 1.62 × 10^9 t in 2015, exhibiting a decrease of 2.8% from the previous year, and 1.629 × 10^9 t in 2016, showing an increase of 0.6% from the previous year. Additionally, global crude steel production was 1.675 × 10^9 t, which showed an increase of 5.5% from the previous year. Many people in the industry consider that the global steel industry has entered a new period (a fourth stage), such that there begins a new round of plateau duration where the major steel-producing countries in the world will experience a very long adjusting process, except for India.

The main characteristics of the fourth stage are as follows. First, there will be green growth. A scaled-up study on low-carbon and cyclic development applying advanced low-carbon and cyclic technologies will be the new trend for development. Second, there will be transformation and upgrade that will lead to significant improvement in competitiveness, especially given the background of the overcapacity of the global steel industry and worsening trade frictions. Third, there will be international production capacity collaborations. The construction of the Belt & Road Initiative is a great cause that demands great practice. International production capacity cooperation in the steel industry will convey important benefits to the world. Fourth, international trade frictions of steel products will worsen, and the number of countries and regions implementing trade protections will increase.

2.2 Consumption and production in China

The consumption of steel in China has fluctuated, increasing from 1980 to 2000. The domestic steel consumption data reveals a straight line from 2001 to 2014. It reached its historical peak value of 7.02 × 10^8 t in 2014. However, Chinese domestic steel consumption dropped to 6.64 × 10^8 t in 2015, a decrease of 5.4% from the previous year, which was the first decline since 1996. In 2016, actual steel consumption reached 6.73 × 10^8 t, driven by automobile, infrastructure, and real estate fields, indicating a 1.3% increase over the previous year. Additionally, steel consumption reached 7.28 × 10^8 t in 2017, which was an increase of 8.2% from the previous year.

According to the data of National Bureau of Statistics, the crude steel output in China reached 8.23 × 10^8 t in 2014, which was an increase of 5.6% over the previous year. The crude steel output in 2015 showed negative growth, decreasing 2.29% from the previous year. Furthermore, it decreased in 2016 by 2.08% over the previous year, making 2014 the first peaking year of domestic crude steel production. In 2017, the output of crude steel reached 8.32 × 10^8 t, an increase of 5.67% from the previous year. These statistical data do not include the output of substandard steel.

After 2013, China entered the “peak-value platform zone” for the production and consumption of crude steel [4]. The GDP of the Chinese tertiary industry began to exceed that of the secondary industry in 2013, which is an important reference value for peak value in many countries. It showed a peak value of 7.63 × 10^8 t in apparent consumption of crude steel in 2013. The per capita consumption of crude steel in China reached 562 kg in 2013, exceeding the average value of 545 kg in 15 developed countries at their peak value. This differs from other developed countries, where free fall demand declines are unlikely, as determined by the uneven development of regional economies in China. However, there will be a peak-value platform zone of high consumption fluctuation, which will continue downward after running in the peak-value platform zone for some years until it reaches a new platform zone in a post-industrial stage. Following the peak value of crude steel output in 2014, the decline of output in 2015 and 2016, and the increase in 2017, the basic characteristics of the peak-value platform zone have been clearly identified.

2.3 Remarkable effect of overcapacity reduction of the steel industry in China

With continued advancements of supply-side structural reforms in China, the iron and steel industry, a pioneer of supply-side structural reform, has proactively reduced overcapacity and has completely banned the production of “substandard steel” in accordance with the Central Committee of the Communist Party in China and the State Council. This significantly improves the environment of the steel market, allows full high-quality production capacity, and fulfills a dramatic upturn of enterprise benefits.

The reduction of overcapacity reached more than 1.2×10^8 t in 2016−2017, where steel production capacity was reduced over 6.5×10^7 t in 2016 and over 5.5×10^7 t in 2017. Meanwhile, the curtailment of illegal production (e.g., substandard steel) eliminated 1.4×10^8 t. The overcapacity reduction in the steel industry yielded the following significant effects. The problem of severe overcapacity in steel production was effectively alleviated, the high-quality production capacity was given full play, and the availability rate of production capacity was recovered to a reasonable level. The market order was properly regulated, which restrained vicious competition and restored reasonable prices. Industrial operation performance revealed a trend of growth, and most enterprises achieved profits.

2.4 New development stage of the steel industry in China

During the “13th Five-year Plan” period, the fundamental tendency of the Chinese economy toward growth remained unchanged for the long run. The consumption upgrade and infrastructure construction are expected to expand the space of steel demand, and the economic development will require several new steel products. Although we still should realize that the economic growth may not achieve a V- or U-shaped rebound through any short-term stimulus as before, it will go through an L-shaped development stage, and the domestic steel demand and export volume will gradually enter a coexisting pattern of fluctuating decline and overcapacity. This will continue for a long period. It will be no longer possible to absorb overcapacity through sustained and high-speed economic growth. The total growth potential of steel consumption demand is limited, and the development of the steel industry in China has entered this new stage given a comprehensive consideration of factors, such as the demand of economic development, structural changes in the industry, characteristics of the aforementioned peak plateau of steel consumption, and the per capita steel consumption trend. This follows steel output reaching 8.23×10^8 t in 2014 (the actual output was $>9.2 \times 10^8$ t considering the additional output of “substandard steel”), and the apparent consumption of domestic steel products reached 7.6×10^8 t in 2013.

It is estimated that the average consumption demand of crude steel in China will reach 6.5×10^8 t to 7.5×10^8 t by 2020, which follows an overall downward tendency. Average crude steel output may reach 7.3×10^8 to 8.3×10^8 t. With the continued implementation of measures for steel overcapacity reduction, the absolute overcapacity in steel production has been alleviated. However, the overcapacity conflicts of this stage will exist for a long time. Domestic crude steel production and consumption demand may decline steadily in 2025, and the average expected consumption demand may reach 6×10^8 to 6.5×10^8 t and remain at 6.5×10^8 to 7.0×10^8 t production capacity. It will enter a second peak plateau range, and the domestic crude steel production and consumption demand could reach 5.3×10^8 to 6.0×10^8 t by 2030, if the output is maintained at 5.9×10^8 to 6.5×10^8 t.

3 Study and estimation of the demand of steel raw materials

3.1 Demand of future steel raw materials

The steel consumption in China has passed a turning point, entering a peak platform zone. It has entered a new era of capacity reduction and structure regulation. In the long run, the output and consumption of social steel scraps will increase rapidly, and the demand for imported iron ore will decrease slowly.

According to the low value of the peak plateau of crude steel output in China, it is estimated that, by 2020, the

DOI 10.15302/J-SSCAE-2019.01.014

crude steel output will reach 7.3×10^8 t, the pig iron output will reach 6.7×10^8 t, the demand for iron ores will reach 1.05×10^9 t, and the steel scrap consumption will reach 1.3×10^8 t. By 2025, the crude steel output will reach 6.5×10^8 t, the pig iron output will reach 5×10^8 t, the demand for iron ores will reach 8×10^8 t, and the steel scrap consumption will reach 2.1×10^8 t. By 2030, the crude steel output will reach 5.9×10^8 t in 2030, the pig iron output will reach 4×10^8 t, the demand for iron ores will reach 6.5×10^8 t, and the steel scrap consumption will reach 2.4×10^8 t.

3.2 Source of iron ore supply

With the slow decline of iron and steel output and the continuous increase in steel scrap resource supply, the demand for iron ores will slowly reduce. The import amount will continue to decline, and the oversupply of iron ore in the world will persist. It is estimated that the amount of Chinese finished sintered ores will remain at 2.2×10^8 t to 2.5×10^8 t until 2030. It is predicted that the amount of imported iron ores will decrease from 1.075×10^9 t in 2017 to 1.068×10^9 t in 2022 with a compound annual growth rate of approximately −0.1%. The export compound annual growth rate of giant iron ore suppliers will remain at approximately 2% for the next five years. Furthermore, the output of iron ore from Vale Corp. may reach 4.35×10^8 t, 2.89×10^8 t from BHP Billiton Corp., 3.45×10^8 t from Rio Tinto Corp., and 1.68×10^8 t from the Fortescue Metals Group by 2022.

3.3 Cost changes of iron ores

Recently, with the completion of major mine expansion projects, the average cash cost of global iron ores has decreased yearly, and the global weighted average cost of iron ore (FOB) in 2016 was about USD 27.30/t.

With the end of high-quality resource extractions among all major worldwide miners, the declining trend of cash costs will cease, and the cash costs for the four giant mining companies may rebound slightly, except for Vale Corp., which may still have room for cost reduction because of their initiation of the S11D project. It is predicted that the global cash cost of iron ores will gradually return to the pre-2007 level, and the FOB price will reach around USD 36/t by 2020.

The global output of iron ores is divided into four cost levels: enterprises comprising the four major miners with cost at USD 20/t; enterprises with cost above USD 20/t but lower than the global average price; enterprises above the average price but lower than USD 40/t; and those with costs greater than USD 40/t.

According to the data of Table 2, the pool mark for 50 points of the global product cost is USD 20/t. For 60 points, it is USD 27/t (i.e., the global average cost level). For 75 points, it is USD 35/t, and for 85 points, it is USD 40/t.

Table 2. Cost classification of global iron ore.

Classification	Output ($\times 10^8$ t)	Percentage of output (%)
Cost lower than $20/t	10.16	52
Cost at $20−27.3/t	2.53	13
Cost at $27.3−35/t	2.68	14
Cost at $35−40/t	1.03	5
Cost higher than $40/t	3.13	16

3.4 Price changes of iron ores

Considering changes in supply and demand and the cost of global iron ores, oversupply conditions will endure (if the steel industry in India grows at a normal range). There is no basis for an abrupt rise in the price of iron ores, which will show a fluctuating tendency at low prices. The price may fluctuate in the range of USD 55/t to USD 75/t (Table 3).

4 Strategic judgment

With the increase in steel stock and scrap resources and the prominent price advantages of steel scraps, the total amount of steel scrap resources in China will remain sufficient for the next 20 years.

Future steel scrap resources will form a strong support to the development of the iron and steel industry in China while helping make China a strong ferrous metal resource provider. A significant change will occur in the composition of ferrous resources for the iron and steel industry in China, and the demand for international iron ore resources will gradually fall, which will play an important role in promoting the construction of ecological civilization and green development.

Table 3. Prediction of price change of iron ores.

Year	Annual average price (Platts at 62%) (USD/t)	Price fluctuating range (USD/t)
2013	135.11	110−160
2014	96.73	65−135
2015	55.50	40−70
2016	58.50	42−84
2017	71.32	54−95
2018e	65.00	55−80
2019e	63.00	55−75
2020e	60.00	55−75
2021e	61.00	55−75
2022e	62.00	55−75

The substantial increase in steel scrap resources will surely accelerate the transformation and upgrading of the steel industry and will have important impacts on the adjustment of the production process flow and structure. It will result in changes to the work patterns and layouts of steel mills, iron resource consumption, energy consumption, and carbon emissions. In summary, it will be a strategic choice to promote orderly and moderate development of the electric furnace process for steel enterprises via technological innovation.

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