Research on the Transformation and Development of Driving Forces for China's Electricity Demand Growth in the Next Decade

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Abstract. Accurately grasping the development trend of the industry is the foundation of electricity demand forecasting. Since the 13th Five Year Plan, traditional high energy consuming industries have steadily expanded, providing strong support for the rapid development and construction of China's economy and society. Since the 14th Five Year Plan, driven by technological innovation and the "dual carbon" goals, the development of new quality productivity has accelerated, industrial development has shown new characteristics, and the transformation of old and new driving forces has continued to advance. In the next decade, China will continue to lead industrial innovation with technological innovation, actively cultivate and develop new quality productive forces, accelerate the transformation and upgrading of traditional industries, cultivate and strengthen emerging industries, accumulate new momentum for high-quality economic development, and drive sustained growth in electricity demand. It is necessary to quantitatively analyze the transformation and development of the driving force behind China's electricity demand growth, in order to accurately predict future electricity demand.

Keywords: Driving forces of electricity demand, traditional high energy consuming industries, new high electricity consuming industries.

1 Introduction

Since entering the development of heavy industrialization, the four high energy consuming industries have contributed nearly 20% of China's electricity demand growth, but have shown a significant downward trend since 2024[1,2]. With the development of new quality productivity, in recent years, the scale of computing infrastructure has been continuously increasing[3], electrolysis of water for hydrogen production has flourished[4-6], and the number of new energy vehicles has been continuously expanding[7], contributing to the growth of electricity consumption. During the 15th Five Year Plan and the medium to long term, driven by factors such as energy transformation, advances in new generation information technology, and accelerated cultivation of new quality

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productivity[8-10], the contribution point of electricity demand growth has gradually shifted from "traditional high energy consuming" industries to "new high energy consuming" industries. Accurately analyzing and judging the development trend of high energy consuming industries is crucial for China's medium to long term electricity demand forecasting and electricity planning.

2 Analysis of Current Electricity Consumption Situation

2.1 Electricity Consumption in the Four Traditional High Energy Consuming Industries

In the first three years of the 13th and 14th Five Year Plans, the contribution rates of electricity consumption in the four high energy consuming industries to the growth of national electricity consumption were 17.7% and 18.7%, respectively. However, in 2024, the electricity consumption of the four high energy carrying industries increased by 2.2% year-on-year, a decrease of 3.1 percentage points from the previous year, and their contribution rate to the growth of national electricity consumption was only 8.7%. It can be seen that the contribution rate of the traditional four high energy consuming industries to electricity consumption growth has significantly decreased, mainly due to the slowdown in overall product output growth of high energy consuming industries as the real estate market gradually enters saturation. Taking the steel industry as an example, the focus of steel demand structure is gradually shifting from the construction industry to the manufacturing industry. The proportion of steel used in the manufacturing industry has increased from 42% in 2020 to 50% in 2024, and structural adjustment is still ongoing.

2.2 Electricity Consumption in new High Electricity Consuming Industries

With the development of new quality productivity, the electricity consumption of electric driven new formats has grown rapidly, mainly including computing power infrastructure, new energy vehicle charging, and electrolysis of water for hydrogen production.

Computing Infrastructure. The supply capacity is accelerating and the demand for electricity is maintaining a high growth rate. The number of 5G base stations in China has increased from 718000 in 2020 to 3.377 million in 2023, with an average annual growth rate of 67.5%; The number of standard racks in data centers has increased from 4.01 million in 2020 to 8.1 million in 2023, with an average annual growth rate of 26.4%. The construction of computing infrastructure has basically met the current demand for intelligent computing power, with a rapid increase in electricity consumption. By the end of 2023, the electricity consumption of 5G base stations and data centers in

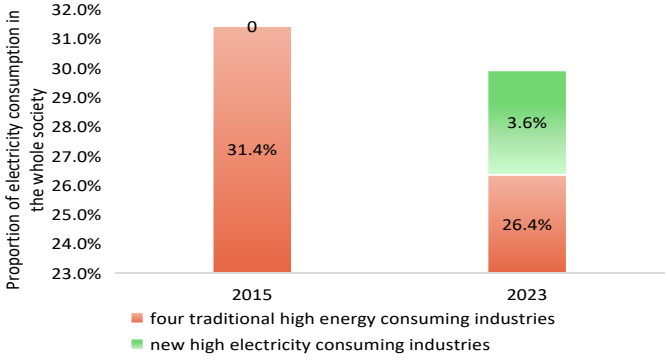
China will reach 120 billion and 110 billion kilowatt hours respectively, and the electricity consumption of computing infrastructure will be about 230 billion kilowatt hours.

Charging of new Energy Vehicles. The number of new energy vehicles is growing rapidly, and the demand for charging is significantly increasing. The number of new energy vehicles in China has increased from 4.92 million in 2020 to 20.41 million in 2023, with an average annual growth rate of 60.7%; The charging infrastructure has grown from 1.681 million units in 2020 to 8.596 million units in 2023, with an average annual growth rate of 72.3%, driving the rapid growth of demand for new energy vehicle charging. By the end of 2023, the total charging capacity of new energy vehicles in China will be approximately 82.17 billion kilowatt hours.

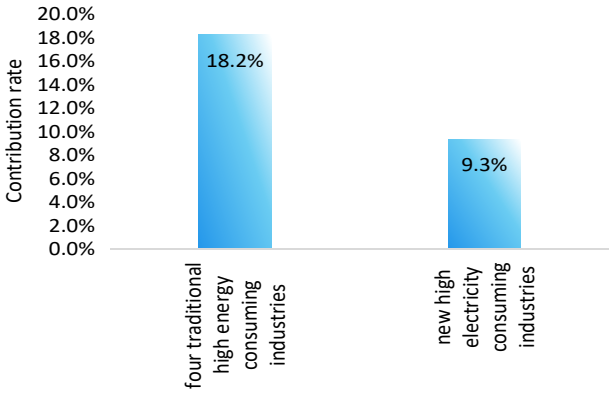
Electrolysis of water to Produce Hydrogen. The development scale of hydrogen production through electrolysis of water is steadily expanding, continuously cultivating the demand for green hydrogen consumption. China takes multiple measures and vigorously encourages and supports the development of the hydrogen energy industry. By the end of 2023, the national hydrogen production capacity will exceed 49 million tons per year, a year-on-year increase of 2.3 percentage points; The production capacity of hydrogen through electrolysis of water is about 450000 tons per year, a year-on-year increase of about 10.5%. In 2023, the production of hydrogen through electrolysis of water will be approximately 300000 tons, a year-on-year increase of 5.1%, driving an increase of approximately 16.5 billion kilowatt hours in electricity demand.

2.3 Growth Since the 13th Five Year Plan

Since the 13th Five Year Plan, the contribution rate of electricity consumption in the four major high energy consuming industries to the growth of electricity consumption in the whole society has decreased from 31.4% to 26.4%; The contribution rate of emerging industries driven by electricity is 9.3%, with a proportion ranging from 0 to 3.6% as shown in Figure 1, achieving a breakthrough from scratch.



(a)



(b)

Fig. 1. Since the 13th Five Year Plan, the contribution rate and proportion of the two to the total electricity consumption of the society have changed.

3 Future Electricity Demand Forecast

3.1 Electricity Consumption in the Four Traditional High Energy Consuming Industries

(1) Black metal smelting and rolling processing industry. The new energy industry and high-end equipment manufacturing industries such as automobiles and home appliances support the demand for related steel, but the steel market for housing construction is gradually saturated, and overall product output continues to decline. Under the dual effects of decreased production and increased proportion of electric furnace steel, it is expected that the electricity consumption of the black metal industry will stabilize after a slight decrease. The specific calculation method is shown in Figure 2.

(2) Nonferrous metal smelting and rolling processing industry. Traditional demand such as real estate is gradually declining, while green demand such as photovoltaics, new energy vehicles, and energy storage continues to grow. Electrolytic aluminum production capacity has reached its "ceiling", and the increase in supply will mainly come from resuming production and utilizing recycled metals. Overall, product output is gradually entering a plateau period, electrification level continues to improve, and electricity consumption will increase slightly.

(3) Non metallic mineral products industry. With the continuous optimization of product structure, the limited development of real estate has led to a downward trend in electricity demand for traditional building materials such as cement production. Green building materials and new materials have become key drivers of electricity growth.

(4) Chemical raw material and chemical product manufacturing industry. This industry is accelerating its structural transformation, continuously eliminating excess production capacity of basic chemicals and developing high-end chemicals. Driven by economic growth, the demand for industry products is steadily increasing, driving steady

growth in electricity consumption. It is expected that by 2035, the total electricity consumption of the four high energy consuming industries will be 2.7 trillion kilowatt hours, with a growth rate of less than 1% over the past decade, entering a saturation stage, and the growth rate will significantly decrease compared to the growth level in the first three years of the 14th Five Year Plan.

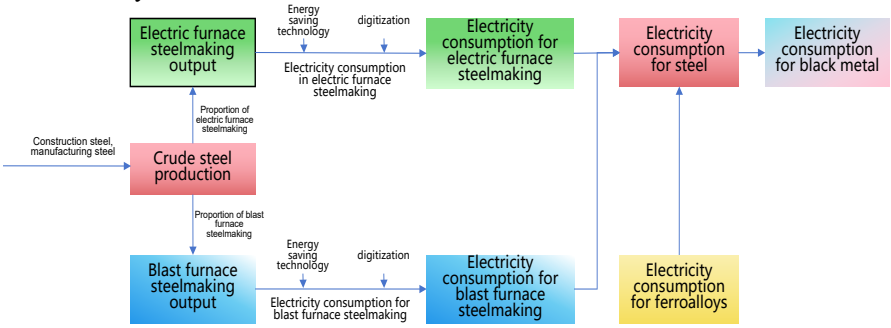


Fig. 2. Diagram for Predicting Electricity Consumption in Black Metal Smelting and Rolling Processing Industry.

3.2 Electricity Consumption in new High Electricity Consuming Industries

Computing Infrastructure. With the deepening development of artificial intelligence technology and the continuous stimulation of innovation vitality in the digital economy, computing infrastructure has gradually grown into a new engine to promote high-quality economic and social development.

5G base stations: Digital infrastructure represented by 5G base stations is becoming a new engine to stimulate innovation vitality in the digital economy. As of the end of October 2024, China has 4.141 million 5G base stations, with 29 5G base stations per 10000 people, achieving the development goal of 26 5G base stations per 10000 people in the 14th Five Year Plan ahead of schedule. The Ministry of Industry and Information Technology, the National Development and Reform Commission, the Ministry of Finance and other seven departments jointly issued the "Action Plan for Green and Low Carbon Development of the Information and Communication Industry (2022-2025)", which requires further saving on supporting needs such as base station rooms, power supply, air conditioning, etc., and improving the energy efficiency of 5G base stations by more than 20% by 2025. It is expected that by 2035, the electricity consumption of 5G base stations will exceed 300 billion kilowatt hours, with an average annual growth rate of nearly 10% during the 15th Five Year Plan period.

Data Center: With the deepening and widespread application of artificial intelligence, the electricity consumption of data centers has significantly increased.

Electricity consumption=computing power scale * load rate * daily electricity consumption * PUE * 365 (1)

Among them, computing power scale: the amount of information data that the server can process per second; Load rate: the ratio of actual operating computing power to total computing power scale; Daily electricity consumption: 1 FLOPS of electricity consumption per day; PUE (Electricity Utilization Efficiency): The ratio of total energy consumption to IT equipment energy consumption. By calculation, it is expected that the electricity consumption of data centers will reach around 1.3 trillion kilowatt hours by 2035, with an average annual growth rate of over 20% in the next decade.

New Energy Vehicles. In 2023, the number of new energy vehicles in China will be 20.4 million, with a charging capacity of 82 billion kilowatt hours. There are significant differences in the annual charging capacity of different types of new energy vehicles as shown in Figure 3, and the average annual charging capacity of hybrid vehicles is about 60% of that of pure electric vehicles of the same type. It is expected that by 2035, the number of new energy vehicles in China will reach 200 million, and the charging capacity of new energy vehicles will exceed 700 billion kilowatt hours, with an average annual growth rate of 15% in the next decade.

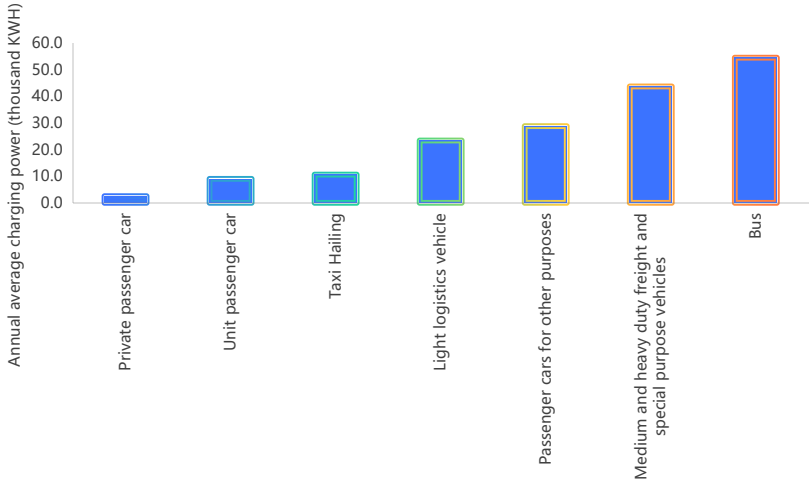


Fig. 3. Annual average charging capacity of various types of new energy vehicles.

Electrolysis of Water to Produce Hydrogen. According to the "China Hydrogen Energy Development Report (2023)" by the Science and Technology Department of the National Energy Administration, as of the end of 2023, the national hydrogen production will exceed 35 million tons. Coal based hydrogen production, natural gas based hydrogen production, and industrial by-product hydrogen are still the main sources of hydrogen supply in China. The production capacity of electrolytic water based hydrogen production is 450000 tons per year, with a production of about 300000 tons, accounting for 0.9% of the total production as shown in Figure 4. The current cost of hydrogen production through electrolysis of water is 20-25 yuan/kg; The cost of grey hydrogen is about 10-12 yuan per kilogram; The cost of blue hydrogen is about 17-18

yuan per kilogram. With the decrease in hydrogen production costs, electrolytic water hydrogen production will usher in large-scale development, driving a significant increase in hydrogen production capacity. It is expected that by 2035, the national electrolytic water hydrogen production will reach about 14 million tons, and the hydrogen production capacity will exceed 700 billion kilowatt hours, with an average annual growth rate of 40% in the next decade. The hydrogen energy consumption path during the 15th Five Year Plan period is shown in Figure 5.

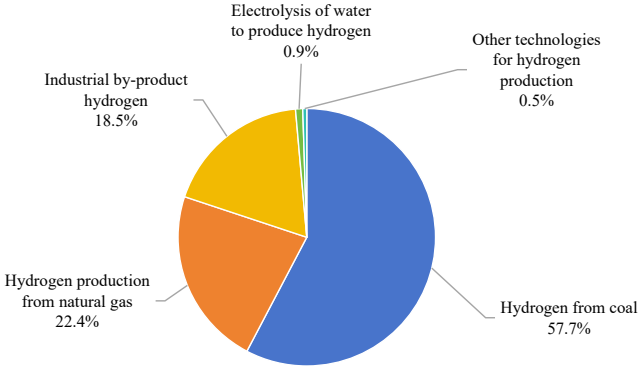


Fig. 4. Composition of hydrogen production sources in China in 2023.

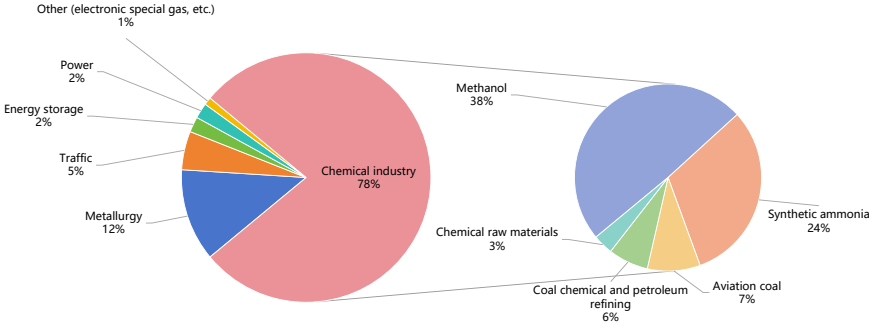


Fig. 5. The hydrogen energy consumption path in China during the 15th Five Year Plan period.

3.3 Display of Demand Forecasting Results

Overall, by 2035, the total electricity consumption of the four high energy consuming industries will be approximately 2.7 trillion kilowatt hours as shown in Table 1, with an average annual growth rate of less than 1% over the next decade. The total electricity consumption of emerging industries driven by electricity is about 3 trillion kilowatt hours as shown in Table 2, exceeding the electricity consumption of the four major high energy consuming industries, with an average annual growth rate of 20% in the next decade.

Table 1. Electricity consumption of the four major high energy consuming industries in 2035.

	Main product	Main product output(Million tons)	Electricity consumption (billion kilowatt hours)
Black metal smelting and rolling processing industry	Steel	850	610
Nonferrous metal smelting and rolling processing industry	Electrolytic aluminum	40	870
Non metallic mineral products industry	Caustic soda	50	740
	Calcium carbide	30	
	Chemical fertilizer	60	
Chemical raw material and chemical product manufacturing industry	Cement	1500	460

Table 2. Electricity consumption of emerging industries driven by electricity in 2035.

		Quantity	Electricity consumption level	Electricity consumption (billion kilowatt hours)
Computing power base facility	5G base station	1500 pieces	2.5 kW/h	329
	Data center	Universal computing power: 900EFLOPS	1.4 million kWh/EFLOPS	449
		Intelligent computing power: 6800EFLOPS	350000kWh/EFLOPS	847
New energy vehicles		200 million vehicles	As shown in Figure 3.	700
Water electrolysis		14.5 million tons	50000 kWh/ton	725

4 Policy Recommendations

To adapt to the rapid growth of new industries driven by electricity, it is necessary to continuously deepen electricity demand forecasting, conduct rolling optimization analysis, provide strong support for electricity planning, grid planning, and power supply guarantee, and effectively cope with the phased and even long-term impacts brought about by the increase of uncertainty and unforeseeable factors.

(1) Deepen the application of electricity demand forecasting analysis. Regularly hold national and provincial consultations on electricity demand forecasting, roll out medium - and long-term electricity demand forecasting, strengthen the sharing and promotion of load forecasting and electricity supply information, increase social attention and support for the situation of electricity safety supply, and gather joint efforts to ensure supply. Based on electricity demand forecasting, promote the improvement of the

electricity market mechanism, strengthen the coordination between supply and demand, and ensure the stable operation of the power system and the safe supply of electricity.

(2) Increase demand response and tap into potential. Demand response is an important means of regulating the balance of electricity supply and demand in the future. Suggest strengthening communication and reporting with government departments to promote the inclusion of demand response in the "15th Five Year Plan" for electricity planning; Promote the normalization and full participation of demand side resources in the electricity market, fully stimulate and release the flexible adjustment capability of the demand side.

(3) Optimize the statistical system for electricity consumption. The rapid growth of emerging electricity demands such as data centers, new materials, hydrogen production through electrolysis, electric vehicles and their charging and swapping is reshaping the power economy relationship, but relevant statistics have not yet been independently or comprehensively compiled. Suggest strengthening the refinement of electricity consumption statistics, optimizing the industry's electricity consumption statistics system, and adapting to the needs of electricity demand analysis under the new situation of economic digitization, intelligence, and greening.

5 Conclusion

Overall, as the real estate market gradually enters saturation, the electricity consumption of traditional high energy consuming industries will gradually slow down. Driven by energy transformation, advances in new generation information technology, and accelerated cultivation of new quality productivity, emerging industries driven by electricity may experience large-scale development in the next decade, and the contribution of electricity demand growth will shift towards new high energy consuming industries. It is expected that by 2035, the electricity consumption of electric driven new industries will exceed 3 trillion kilowatt hours, bringing a total increase of about 2.5 trillion kilowatt hours in electricity consumption over the next decade, driving a rapid growth in electricity consumption in the whole society. In this situation, in order to ensure the safe and stable supply of electricity, a series of measures need to be taken on the demand side, including further deepening the application of electricity demand analysis in strengthening supply and demand coordination, improving market mechanisms, and exploring the potential for demand response and promoting the normal participation of demand side resources in the market, as well as optimizing the electricity consumption statistical system to consolidate the foundation of electricity demand analysis and forecasting.

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