



Views & Comments

The Development Trend of and Suggestions for China's Hydrogen Energy Industry



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1. Introduction

Driven by the current round of technological revolution and industrial transformation, and based on a consensus among countries around the world, the world's energy landscape is undergoing profound adjustments to promote a transition to clean, low-carbon energy in order to cope with global climate change. As a clean and carbon-free secondary energy source, hydrogen energy is an important component of the energy strategy in various countries. Fuel cell technology is also of great importance in directing the current global energy technology revolution. China has clarified its sustainable energy goals: to peak its carbon dioxide emissions [1] and achieve carbon neutrality [2]. With thorough development of technology and the industry, hydrogen energy will play a significant role in achieving these goals.

2. The development trend of China's hydrogen energy industry

In recent years, China's hydrogen energy industry has developed rapidly. By the end of 2020, China had more than 7000 fuel cell vehicles and over 100 hydrogen refueling stations, making it the world's largest producer of fuel cell commercial vehicles. The industrial layout of various regions has also accelerated. Thus far, more than 20 provinces (including municipalities) and 40 cities have issued hydrogen energy plans and guidance. In addition, more than 30 hydrogen energy industrial parks have been planned, many of which have already been built. Of these, the Yangtze River Delta, Pearl River Delta, and Bohai Rim regions have begun to take shape, with a number of hydrogen energy companies and research and development (R&D) institutions gathering and showing a clustered development trend.

The Chinese Government also attaches great importance to the development of the hydrogen energy industry. During the National People's Congress of the People's Republic of China and the Chinese People's Political Consultative Conference in 2019, based on various opinions, the statement "to promote the construction of hydrogen refueling facilities" was finally added to the government work report of 2019 [3]. In the Energy Law of the People's Republic of China (draft for comment) [4], it was proposed for the first time to incorporate hydrogen energy into the management of the

energy system in order to coordinate the development of the hydrogen energy industry. To favor the development of hydrogen energy technology, the *Energy Technology Revolution and Innovation Action Plan (2016–2030)* [5], the *13th Five-Year Plan for Energy Technology Innovation* [6], and other initiatives clearly support hydrogen energy and fuel cell R&D and the demonstration and application of key technology equipment. The development goals and supporting policies for fuel cell vehicles are relatively clear. The *New Energy Vehicle Industry Development Plan (2021–2035)*, which was officially released in 2020 [7], emphasizes the importance of hydrogen fuel cell vehicle application and proposes to start by improving the economy of hydrogen fuel production, storage, and transportation; promoting the construction of hydrogen refueling infrastructure; and, finally, promoting commercial applications. In 2020, the Ministry of Finance, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, the National Development and Reform Commission, and the National Energy Administration of the People's Republic of China released the *Notice on Carrying Out Fuel Cell Vehicle Demonstration Applications* [8], which takes fuel cell vehicles as its starting point and adopts a method that focuses on reward instead of compensation to promote the healthy and orderly development of the hydrogen energy industry.

3. Problems confronting China's hydrogen energy industry

3.1. Coal-to-hydrogen dominance restricts the high-quality development of hydrogen energy

China is a major producer of hydrogen. According to industry statistics, the output of industrial hydrogen production is about 30 million tonnes per year, most of which is used as an industrial raw material. Furthermore, China produces about six million tonnes per year of industrial byproduct hydrogen, which can be used to meet the new hydrogen demand. At present, hydrogen production primarily relies on fossil energy, with the coal-to-hydrogen process yielding the greatest proportion of hydrogen (Table 1) [9] and being equipped with the most mature technology. However, according to the research reported by relevant institutions, the proportion of non-fossil energy consumption in China's primary

Table 1
Current conditions of China's hydrogen production structure.

Hydrogen production		Percentage
Methods	Raw materials	
Hydrogen production from fossil energy	Coal-to-hydrogen	62%
	Natural gas reforming to hydrogen	19%
	Hydrogen production from petroleum, coke oven gas, chlor-alkali tail gas, etc.	18%
Hydrogen production by the electrolysis of water	—	1%
Other methods	Biomass, photocatalysis, etc.	Microscale

energy consumption should reach 70% by 2050 in order to achieve the goal of carbon neutrality. As this proportion was only 16.4% by the end of 2020, the consumption of non-fossil energy must be greatly increased in the future. At present, due to the immaturity and high cost of carbon capture and storage technology, the production of hydrogen from fossil energy is unsustainable. Thus, the development of the hydrogen energy industry should move in a “green” and environmentally friendly direction, and the industry should focus on hydrogen production from renewable energy based on local conditions.

3.2. Weak independent innovation capabilities push up the cost of the entire industry chain

There is a large gap between China and the advanced international level in terms of the key core technologies of each link in the hydrogen energy industry chain, including hydrogen energy industrial systems, storage/transportation, refueling, fuel cell manufacturing, and so on. For example, the volumetric power density of the fuel cell stacks manufactured in China, the amount of platinum catalyst per kilowatt, and the compressed hydrogen pressure of a long tube trailer are 1.8 kW·L⁻¹, 0.4 g·kW⁻¹, and 20 MPa, respectively, while those at an advanced international level are 3.1 kW·L⁻¹, 0.2 g·kW⁻¹, and 45 MPa, respectively. Import dependence leads to high industrial chain costs. For example, the manufacturing cost of a 3.5 t fuel cell logistics vehicle is 800 000 CNY, and the total end-use hydrogen cost is 50 CNY·kg⁻¹ (Table 2). The government will not provide long-term subsidies to any specific industry, so the hydrogen industry should examine the requirements of the 2019 National Energy Commission meeting [10] to explore the commercialization path of hydrogen energy as an important direction for industrial development.

3.3. As localities lay out an entire hydrogen industrial chain, signs of overheating are emerging

At present, local governments are cultivating the hydrogen energy industry as an important new driving force and have carried out the whole industrial chain layout. However, there is a lack of objective analysis of the comparative advantages of the local hydrogen energy industry. In addition, there is a serious phe-

Table 2
End-use hydrogen cost.

Production		Storage and transportation	Refueling	Total
Method	Unit price (CNY·kg ⁻¹)			
Coal-to-hydrogen	10	20 CNY·kg ⁻¹ (150 km transportation radius)	10 CNY·kg ⁻¹	40–50 CNY·kg ⁻¹
Electric hydrogen (0.3 CNY·(kW·h) ⁻¹)	20			

The calorific value of 1 kg of hydrogen is equivalent to 3 kg (4 L) of 92# gasoline. Taking the Beijing 92# gasoline price of 6.1 CNY·L⁻¹ (as of 24 January 2021) as an example, when the price of hydrogen is about 24 CNY·kg⁻¹, it will be similar to the gasoline price.

nomenon of homogeneous development and disorderly competition. According to the *White Paper on Hydrogen Energy Application Development in 2020* [11], the number of hydrogen energy industry-chain-related enterprises in China has reached 2196, and the number of newly registered hydrogen energy-related enterprises has increased by 457% in the past five years, with 137 listed companies being involved in hydrogen energy. According to incomplete statistics, the hydrogen fuel cell vehicle output proposed in relevant local plans is expected to reach over 100 000 by 2025. However, from 2016 to 2020, the average annual production and sales of fuel cell vehicles in China only comprised about 1500 units (Fig. 1) [12]. Due to the pandemic, the production and sales of fuel cell vehicles in 2020 dropped by more than half in comparison with the previous year. The entire industry is relatively fragile. It will take time to move toward large-scale commercial use, and the risk of hidden overcapacity must be considered.

4. Suggestions for promoting the high-quality development of China's hydrogen energy industry

The development of China's hydrogen energy industry is beginning to take off in this new era it is necessary to coordinate and advance this development in an orderly manner based on thorough research and analysis in order to promote high-quality industrial development.

4.1. Implement the new concept of green development

Based on the goals of peaking carbon dioxide emissions, carbon neutrality, and China's mid- and long-term energy development plan, the development of China's hydrogen energy industry must proceed from the national conditions and from the actual needs of energy development, while moving in the direction of green and low-carbon technologies. In accordance with the planned goal, there should be zero growth in coal consumption, and coal consumption should gradually decline during the period of the 14th Five-Year Plan. The proportion of non-fossil energy consumption should reach about 25% by 2030 and should increase to 30% or so by 2035. In the future, China's new installed hydropower capacity will enter a period of slow growth. Wind and solar renewable energy should be used as the basis for the long-term sustainable development of hydrogen energy, and the role of hydrogen energy in the construction of a clean, low-carbon, safe, and efficient energy system should be fully utilized. It will be necessary to adapt measures to local conditions, adhere to hydrogen production from renewable energy, and encourage regions with advantages in hydrogen production from clean energy (e.g., regions with wind and water) and regions with economic advantages to prioritize the development of a hydrogen production industry.

4.2. Promote new momentum for technological development

It is necessary to give full play to the role of China's new national scientific research system; to comprehensively improve basic research, cutting-edge technology, and the original

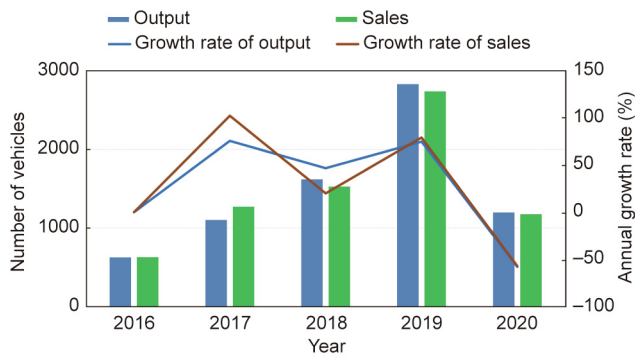


Fig. 1. China's production and sales of hydrogen fuel cell vehicles in 2016–2020.

capabilities of innovation; to organize leading companies in the industry chain to conduct joint research through industrial alliances, innovation platforms, and so forth; and, finally, to avoid wasting valuable scientific research resources due to decentralized R&D and duplicate construction. By focusing on the entire industrial chain of hydrogen energy production, storage, transportation, refueling, and diversified applications, the nation should make rapid breakthroughs in key materials, core technology, and equipment bottlenecks; gradually reduce hydrogen costs; improve relevant technical standards; and establish testing, certification and regulatory systems. At the same time, China should seize the new opportunities inherent in the world's energy transformation, further strengthen international exchanges and cooperation, and actively utilize both the international and domestic market and their resources.

4.3. Build up a new pattern of industrial development

Top-level design of hydrogen energy should be introduced in a timely manner in order to promote coordinated development; under the guidance, local governments will rationally carry out regional demonstrations, concentrate the superior resources to promote the iterative development of technology and products through demonstration applications, and verify commercial application paths; these steps will make it possible to avoid chaotic competition. The hydrogen energy industry requires investment in many aspects, such as building factories. Furthermore, in accordance with the common Chinese phrase “seven accesses and one leveling,” municipal roads, water supply, electricity, heating, drainage, sewerage, telecommunications or broadband, and upland formation will be required. It will also be necessary to buy equipment and instruments, develop technological research and development, and build hydrogen refueling stations. Therefore, the Chinese Government should analyze the benefits

of the entire industry and the entire hydrogen life-cycle from a scientific and comprehensive perspective, and should consider the advantages of both input and output, rather than simply focusing on how many billion CNY of new output value is formed in a certain year. In addition, while developing the fuel cell vehicle industry, China should promote the demonstration and application of diversified technologies, such as distributed power generation, hydrogen storage, emergency power supplies, and hydrogen-powered ships, in order to more fully tap the value and potential of hydrogen energy.

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