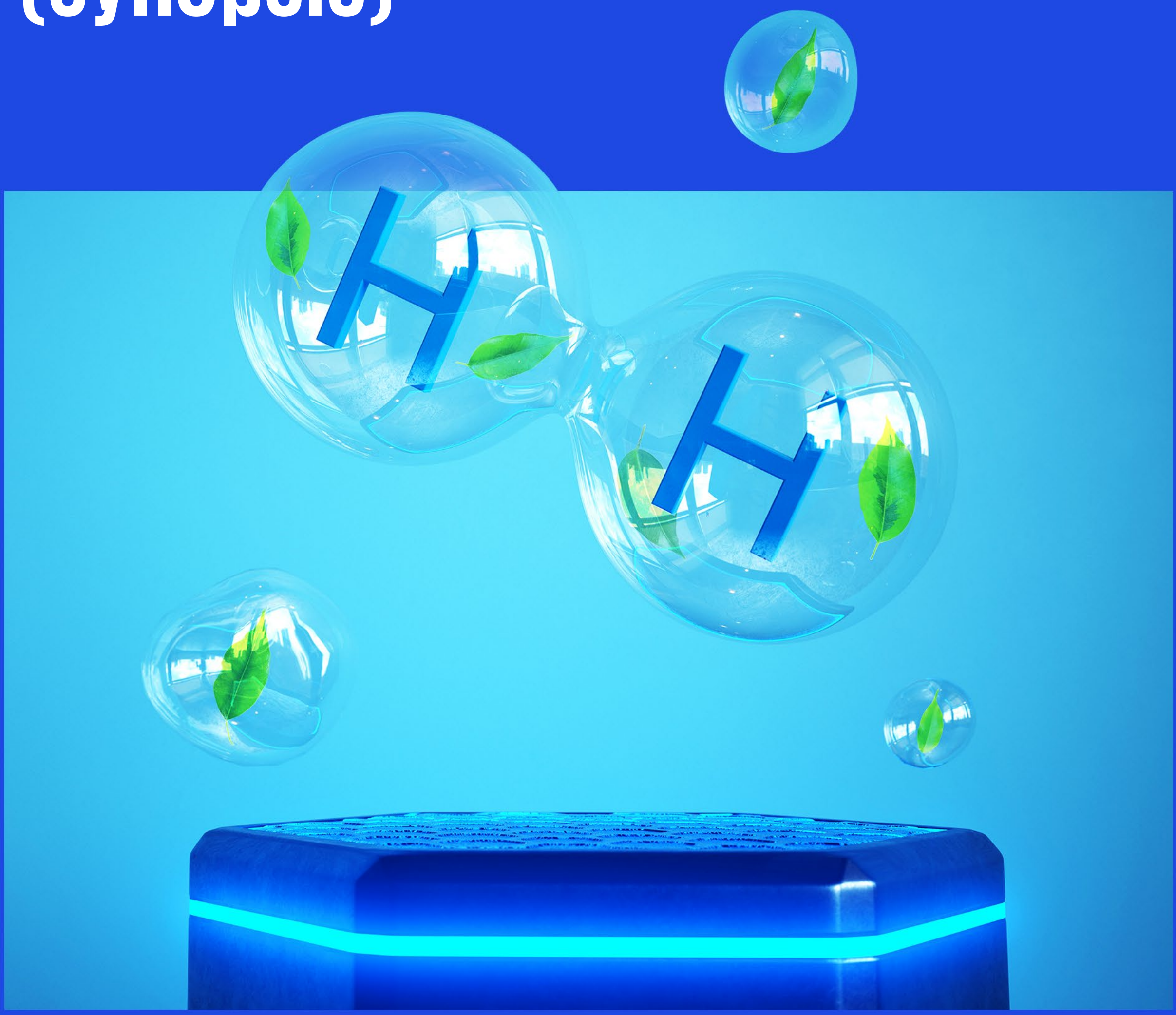
KPMG

The fast-growing hydrogen energy industry

(synopsis)



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Foreword

Energy is central to economic growth. With its increasing industrialisation and urbanisation, China has become a major energy consumer globally. At the same time, the country faces issues such as high dependence on overseas energy, the need to optimize its energy structure, and large carbon emissions, making sustainable development, energy transformation and energy security key development areas going forward. As a secondary energy that is green and low carbon, with abundant sources and wide-ranging application scenarios, hydrogen is gradually becoming a crucial carrier in the global energy transition.

In March 2022, China's National Development and Reform Commission (NDRC) and the National Energy Administration jointly issued the *Medium and Long-term Development Plan for the Hydrogen Industry (2021-2035)*, which puts forward the general direction for the country's pursuit of the "dual carbon" goals and makes it clear that hydrogen energy is a key component of the future national energy system and a major carrier for the green and low-carbon transformation of final energy consumption.[1] It also outlines the key development directions for strategic emerging industries. As an efficient and low-carbon energy carrier and a green and clean industrial feedstock, hydrogen energy can be widely applied in many sectors, such as transport, industry, power generation and construction; and for this reason, the sector is expected to develop rapidly in the future.

This report introduces the characteristics and types of hydrogen energy; gives a detailed overview of the industrial chain, the development strategies of various countries, China's industry policies, and industry investment and financing; and describes the future outlook for the development of the hydrogen energy sector.

Note: this is an abridged version of the original Chinese report. The full report can be downloaded at: https://home.kpmg/cn/zh/home/insights/2022/09/understand-the-hydrogen-energy-industry-in-one-article.html

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[1] Medium and Long-term Development Plan for the Hydrogen Industry (2021-2035), National Energy Administration's website, http://zfxxgk.nea.gov.cn/2022-03/23/c_1310525630.htm


H2
HYDROGEN

A low carbon society accelerates exploration of hydrogen energy

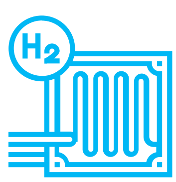
Hydrogen energy is the chemical energy of hydrogen, that is, the energy released by the element hydrogen during physical and chemical changes. Hydrogen and oxygen can be burned to produce heat or converted into electricity using fuel cells. Hydrogen energy is currently categorized by color into grey, blue and green hydrogen(see descriptions below), depending on how it is produced and its carbon footprint.

Grey hydrogen

Grey hydrogen is produced through the conversion reaction of fossil fuels (natural gas, coal, etc.). It is also the most common form of hydrogen production today due to its low production costs and mature technology. It is called grey hydrogen because it releases a certain amount of carbon dioxide during the hydrogen production process and is therefore not completely carbon-free and green.

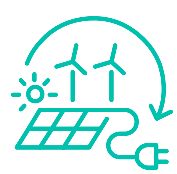
Blue hydrogen

Technologies such as carbon capture and storage are applied to grey hydrogen to retain carbon rather than emitting it into the atmosphere. Blue hydrogen production, as a transitional technical method, will accelerate the development of a green hydrogen society.



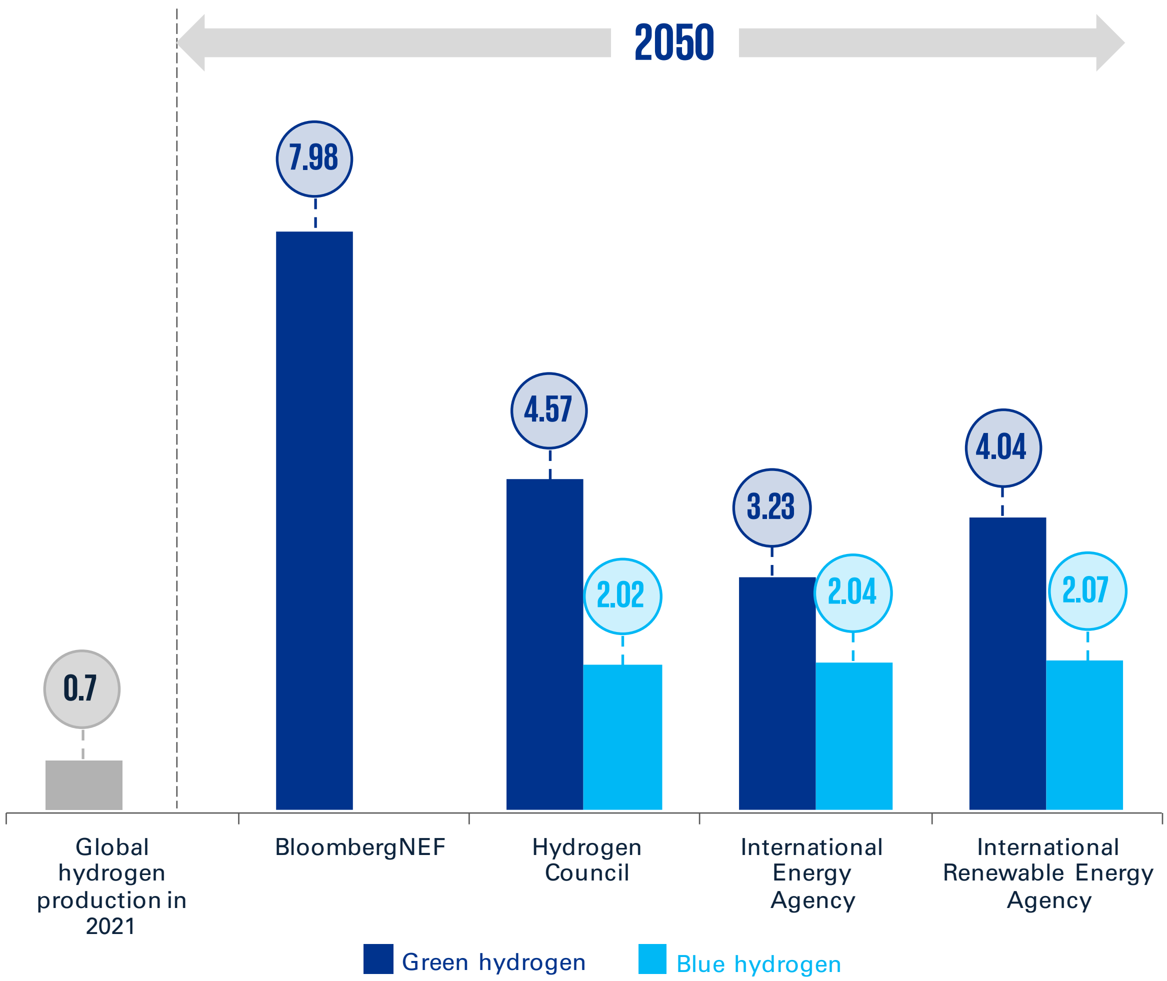
Green hydrogen

Green hydrogen is produced by using renewable energy sources such as solar and wind power to electrolyze water in a manner that results in essentially no greenhouse gas emissions, which is why it is called "zero carbon hydrogen." Green hydrogen is the ideal form of hydrogen energy, but at present the technical threshold and high costs mean that it will take time to achieve large-scale application.



Globally, approximately 70 million tons of hydrogen energy is produced annually, primarily from fossil fuels. As the global low-carbon transition accelerates, hydrogen energy, especially clean hydrogen energy, will develop rapidly. According to forecasts by the major international energy agencies, hydrogen energy production will reach 500-800 million tons annually by 2050 (see Figure 1). By this point, hydrogen energy that is produced will mostly consist of clean hydrogen energy, represented by blue and green hydrogen. In terms of market share, hydrogen energy is expected to rise from a mere 0.1% of global energy at present to more than 12% by 2050s.[2]

Fig 1 Forecasts of global hydrogen production by 2050 by major international energy agencies (in 100 million tons)

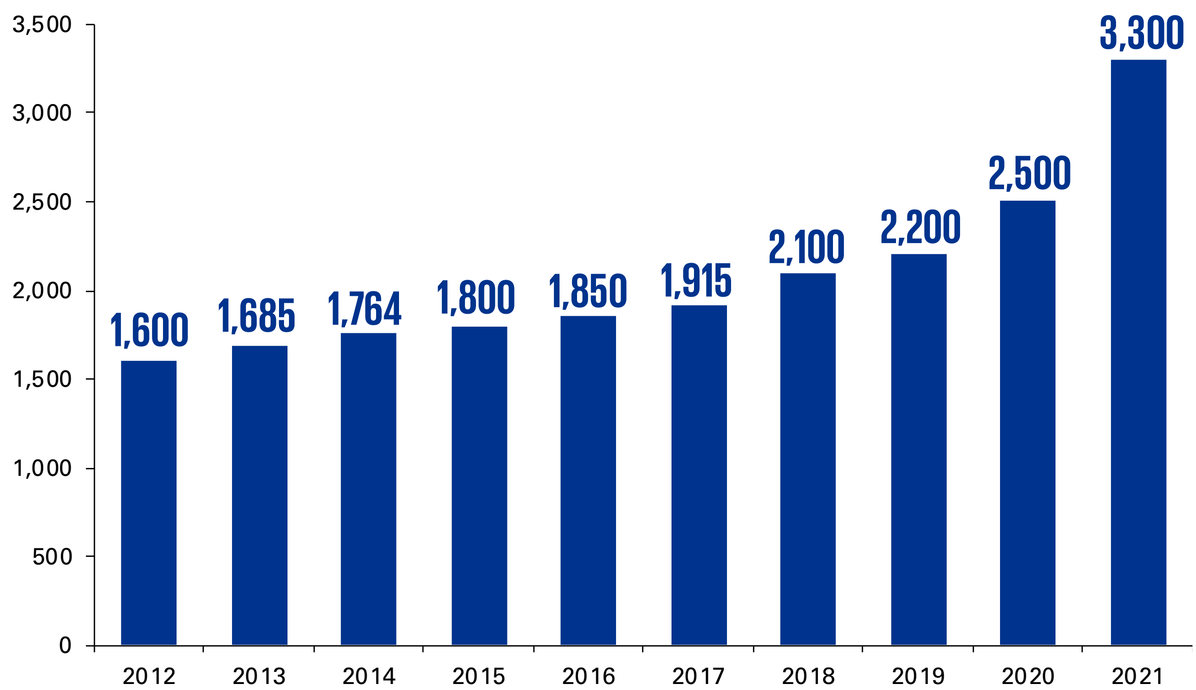


Sources: Statista; KPMG analysis

[2] https://www.irena.org/

Since the "dual carbon" goals were put forward in 2020, the hydrogen energy industry has gained popularity in China, and its development has entered the fast lane. In 2021, China produced around 33 million tons of hydrogen[3], an increase of 32% year-on-year, making China the world's largest producer of hydrogen (see Figure 2). The China Hydrogen Alliance expects that by 2030, during the carbon peak, the national annual demand for hydrogen energy will reach about 40 million tons, accounting for about 5% of final energy consumption; and the renewable hydrogen energy supply is expected to meet about 7.7 million tons of this demand.[4] In a carbon neutral scenario by 2060, the annual demand for hydrogen energy is expected to increase to around 130 million tons, accounting for about 20% of final energy consumption; and 70% will be produced from renewable sources.[5]

Fig 2 Annual hydrogen energy production in China (in 10,000 tons)



Sources: China National Coal Association; KPMG analysis

[3] Sina Finance, "China outperformed the world in hydrogen output in 2021," 11 April 2022, https://finance.sina.com.cn/jjxw/2022-04-11/doc-imcwipii3567766.shtml

[4] Rocky Mountain Institute and China Hydrogen Alliance, The Key to a New Era of Green Hydrogen Energy: China's 2030 Renewable Hydrogen 100 Development Roadmap, June 2022

[5] China Hydrogen Alliance, White Paper on China's Hydrogen Energy and Fuel Cell Industry 2020, April 2021

The value chain of the hydrogen energy industry is taking shape, with wide downstream applications

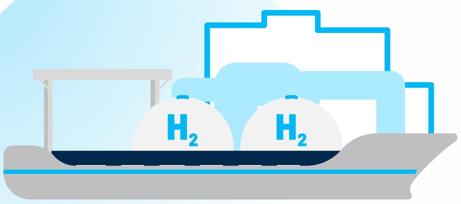
The hydrogen energy industrial chain includes upstream production; midstream storage, transportation and refueling stations; and diversified downstream application scenarios (see Figure 3).

Fig 3 Hydrogen energy industry chain

Upstream

Hydrogen production

- Hydrogen production by water electrolysis
- Fossil fuel hydrogen production
- Industrial by-product hydrogen production
- Emerging hydrogen production technologies



Midstream

Storage, transportation and distribution

Hydrogen storage and transportation

- High pressure
- Solid
- Liquid
- Organic liquid

Hydrogen refuelling

Hydrogen refuelling stations

Downstream

Application scenarios

Transport

- Highways
- Railways
- Aviation
- Shipping

Industry

- Steel
- Chemical

Power generation

- Hydrogen power generation
- Fuel cells
- Hydrogen energy storage

Construction

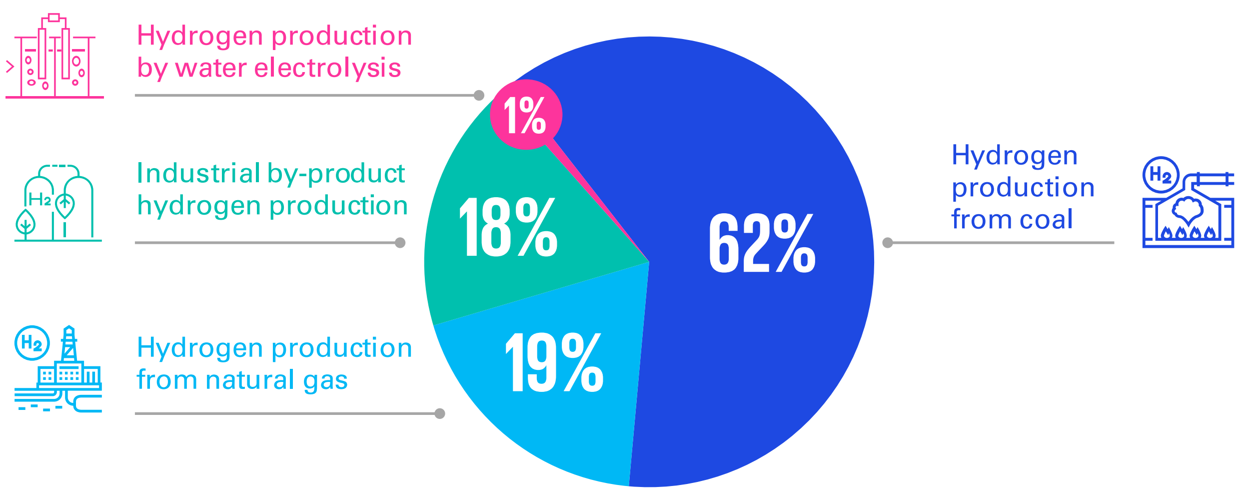
- Heating
- Hot water supply

Source: KPMG analysis

Hydrogen production

At present, three major methods are used to produce hydrogen: fossil fuel hydrogen production, industrial by-product hydrogen production and hydrogen production via water electrolysis. Hydrogen produced from fossil fuels is still the main production method at home and abroad. As it depends on fossil fuels and emits greenhouse gases such as carbon dioxide, the hydrogen produced from this method does not constitute clean hydrogen energy. In terms of the production structure, China's total hydrogen production reached 25 million tons in 2020, and this amount was mainly produced from fossil fuels (coal and natural gas). In terms of the breakdown, hydrogen produced from coal and natural gas accounted for 62% and 19% of China's total hydrogen production, respectively. Meanwhile, due to technological constraints and high costs, hydrogen produced via water electrolysis accounted for merely 1% of the total (see Figure 4). In 2020, hydrogen was also predominantly produced from fossil fuels at the global level, with natural gas accounting for 59% and coal accounting for 19% (see Figure 5).

Fig 4 China's hydrogen production structure in 2020



Sources: China National Coal Association; KPMG analysis

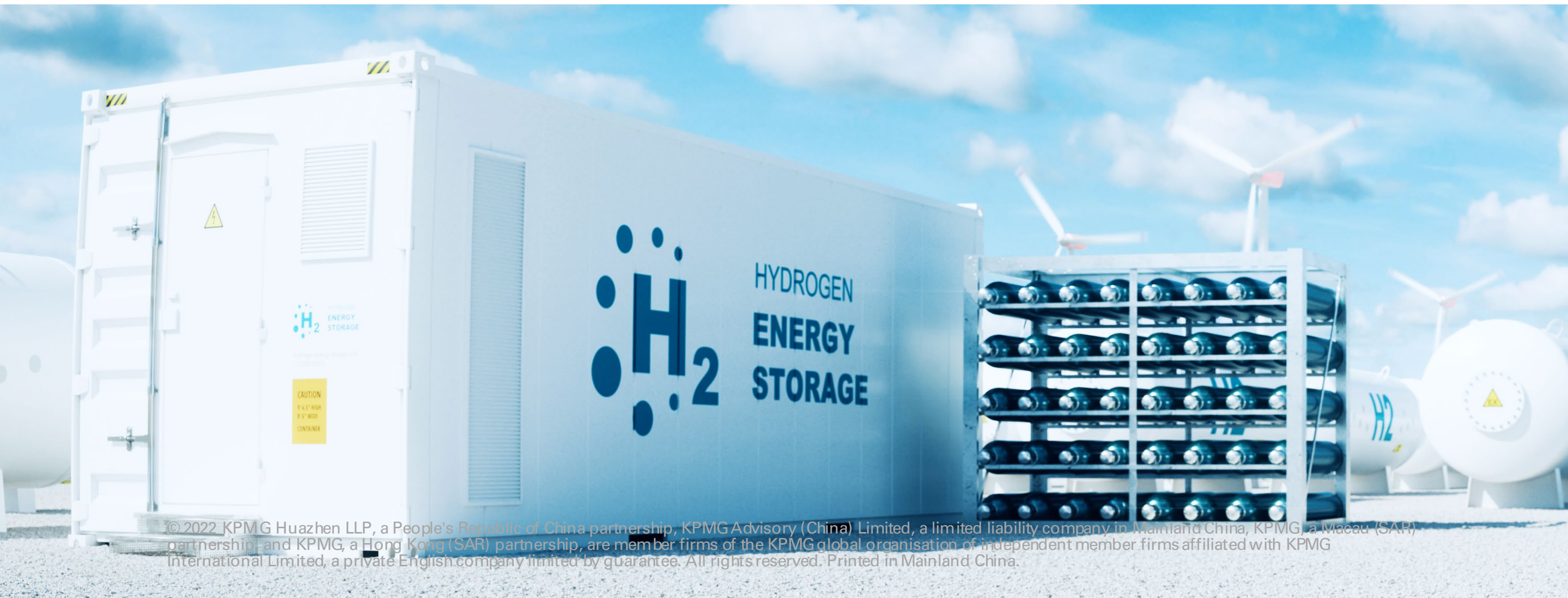
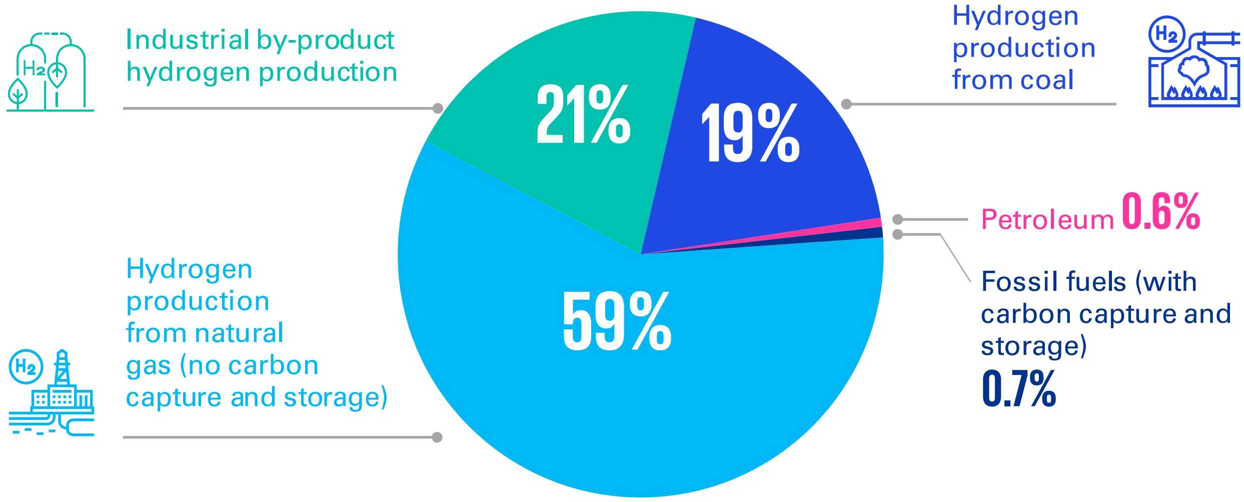


Fig 5 Global hydrogen production structure in 2020



Sources: International Energy Agency; KPMG analysis

Industrial by-product hydrogen production refers to using hydrogen-rich industrial exhaust gas as a raw material to recover and purify hydrogen, mainly using the pressure swing adsorption method. Meanwhile, hydrogen is produced via water electrolysis by splitting water molecules into hydrogen and oxygen under direct current conditions, which are precipitated at the cathode and anode respectively, resulting in highly purified hydrogen (>99%). This is currently the most promising method for producing green hydrogen, especially since electrolysis of hydrogen from renewable energy sources results in the lowest emissions among the various options and aligns most closely with the global trend towards low-carbon energy development.

Energy storage and transportation

High-pressure gaseous hydrogen storage and low-temperature liquid hydrogen storage are already used commercially, while the technologies for organic liquid hydrogen storage and solid-state hydrogen storage are still under development. Gaseous hydrogen storage is relatively mature and widely used[6], but pain points exist in relation to storage density and the safety of energy (see Table 1).[7] Gaseous transportation using long tube trailers is more mature at present (see Table 2).[8]

Table 1: Comparison of hydrogen storage technologies

Methods of storage	Core technology	Advantages	Disadvantages	Technological maturity
Gaseous storage	High pressure compression	▪ Lower cost ▪ Operational at normal temperatures ▪ Low energy consumption for storage ▪ Fast charging and discharging	▪ Low hydrogen storage density ▪ Large storage vessel volume ▪ Risk of hydrogen leakage and vessel ruptures	Mature technology, most widely used at present
Low temperature liquid storage	Low temperature insulation	▪ High energy density ▪ High bulk density ▪ Short refueling time	▪ Higher cost ▪ High energy consumption for refrigeration ▪ High thermal insulation requirements	Mature technology, mainly used in sectors such as aviation
Organic liquid storage	Organic hydrogen storage media	▪ High hydrogen storage density ▪ Highly stable ▪ Very safe ▪ Easy to transport ▪ Hydrogen storage medium can be recycled multiple times	▪ Higher cost ▪ High dehydrogenation temperature ▪ High energy consumption ▪ Low purity of hydrogen and risk of gaseous impurities	No major technical obstacles
Solid-state storage	Physical or chemisorption hydrogen storage	▪ Very safe ▪ High hydrogen storage density ▪ High purity of hydrogen; hydrogen can be purified ▪ Easy to transport ▪ Fast charging and discharging	▪ High cost ▪ Constraints on hydrogen storage and discharge, difficulty in exchanging heat, high temperatures are needed to discharge hydrogen	Technology still needs to be upgraded; used in distributed power generation, wind power hydrogen production and large-scale hydrogen storage

Sources: Institute of Nuclear and New Energy Technology; Tsinghua University[6]; Blue Book of World Energy[7]; KPMG analysis

[6] Institute of Nuclear and New Energy Technology of Tsinghua University, Development Status and Prospects of Hydrogen Storage and Transportation Technology, November 2021

[7] Huang Xiaoyong, Blue Book of World Energy: World Energy Development Report (2021), Social Sciences Academic Press, September 2021

[8] Cai Lian Press and New Energy Daily, "Insight report on the technological development of China's hydrogen energy industry in 2022," March 2022

Table 2 | Hydrogen storage and transportation methods and application scenarios

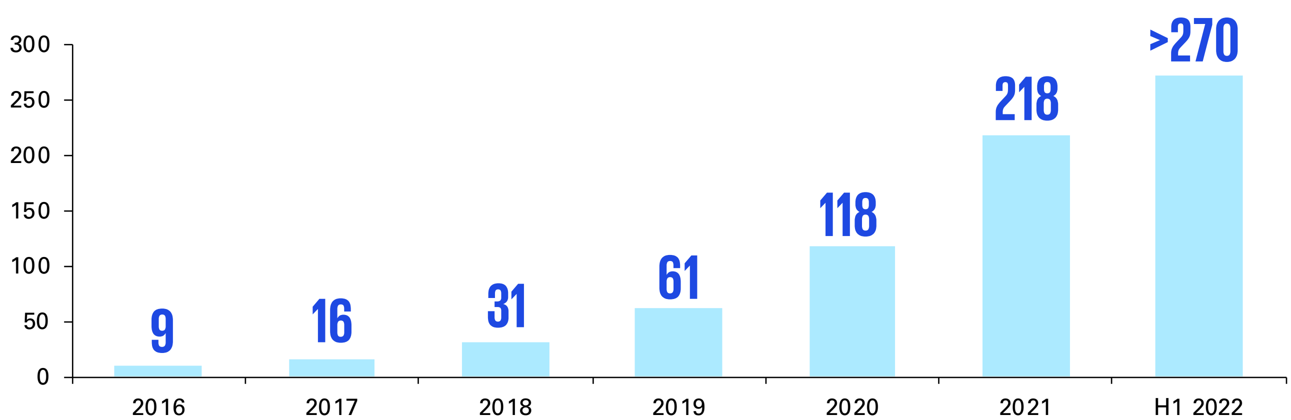
Storage and transportation method	Means of transportation	Economic distance (km)	Application scenarios
Gaseous storage and transportation	Long tube trailers	≤200	Intra-city distribution
	Pipelines	≥500	International, inter-city and intra-city distribution
Liquid storage and transportation	Liquid hydrogen tankers	≥200	International, large scale and long distance
	Liquid hydrogen carriers	≥200	International, large scale and long distance
Solid-state storage and transportation	Trucks	≤150	Experimental research phase

Sources: *Insight Report on the Technological Development of China's Hydrogen Energy Industry 2022*[7]; publicly available data; KPMG analysis

Hydrogen refuelling stations

In terms of scale, China built 100 new hydrogen stations in 2021, bringing the total number of stations to 218[9], which ranks first in the world. In the first half of 2022, China continued to coordinate the construction of hydrogen refuelling networks, increasing the total number of stations to 270 (see Figure 6). [10] In terms of regional distribution, hydrogen stations cover all provinces except Tibet, Qinghai and Gansu. The refuelling stations are to a certain degree regionally concentrated, with the top four provinces being Guangdong, Shandong, Jiangsu and Zhejiang, in that order.

Fig 6 Number of hydrogen refueling stations in China



Sources: KPMG analysis of publicly available data

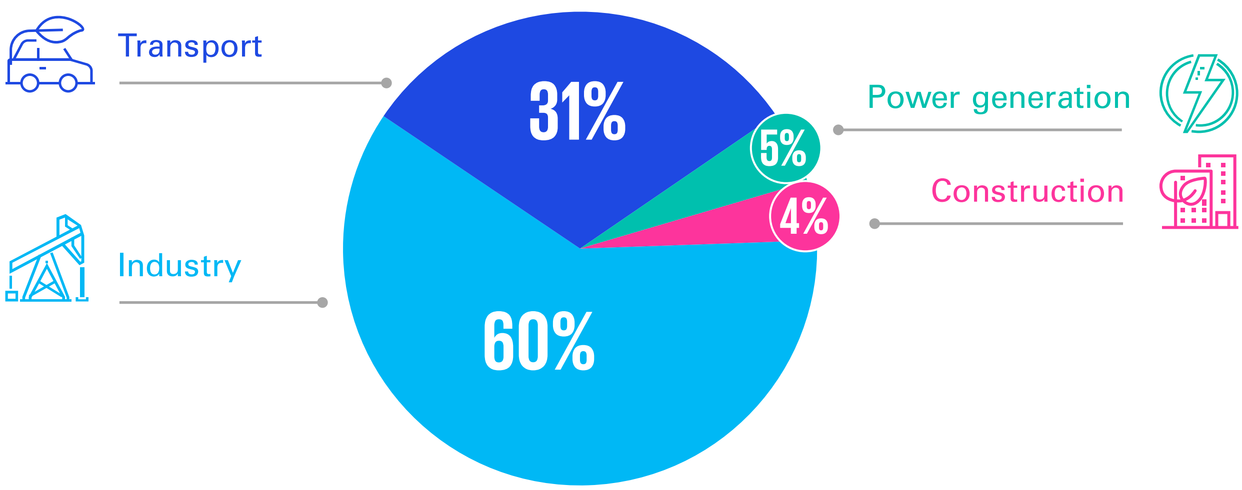
[9] EV100plus and EV100 Hydrogen Energy Center (百人会氢能中心), "2022 China Hydrogen Energy Industry Development Report," June 2022
[10] People News, "Over 270 hydrogen stations built in China," 14 August 2022, http://finance.people.com.cn/n1/2022/0814/c1004-32501926.html

Overall, the technologies required for China's hydrogen stations are not yet mature, and imports are still relied on for key equipment. High-pressure hydrogen stations are composed of hydrogen compression, storage and refuelling systems. Due to the lack of mature mass production of equipment in China, current equipment costs account for a relatively high proportion of total expenses. A standard high-pressure refuelling station currently costs approximately RMB 15 million. Experts estimate that there is still room to reduce costs by 30% to 40%.[11] Hydrogen energy is not yet widely applied domestically, but as the demand increases and hydrogen stations are promoted, the need for key hydrogen refuelling equipment to be produced domestically will only grow more urgent. China may introduce supporting policies to accelerate the process of independent research and development of core equipment for hydrogen stations, so as to enable such equipment to be manufactured domestically and maximize the success of hydrogen energy commercialization.

Main application scenarios

At present, hydrogen energy is primarily used in the industrial and transport sectors, while applications in the construction, power generation and heating sectors are still being explored. By 2060, hydrogen use is expected to account for 60% and 31% of total energy used in the industrial and transport sectors, respectively, while hydrogen use in the power generation and construction sectors is expected to account for 5% and 4%, respectively. [11]

Fig 7 Hydrogen energy demand forecast by use applications for China by 2060 (%)



Sources: China Hydrogen Alliance; KPMG analysis

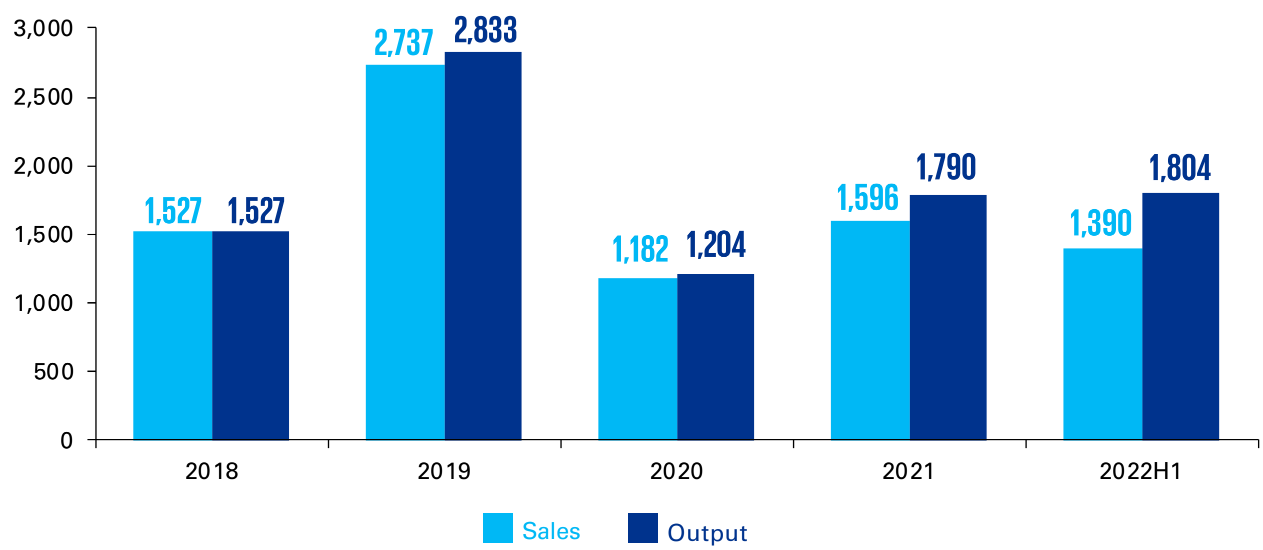
[11] The Paper, "What is pushing up the costs of hydrogen stations?" 29 October 2020, https://www.thepaper.cn/newsDetail_forward_9768848

[12] China Hydrogen Alliance, White Paper on China's Hydrogen Energy and Fuel Cell Industry, June 2019

Transport sector

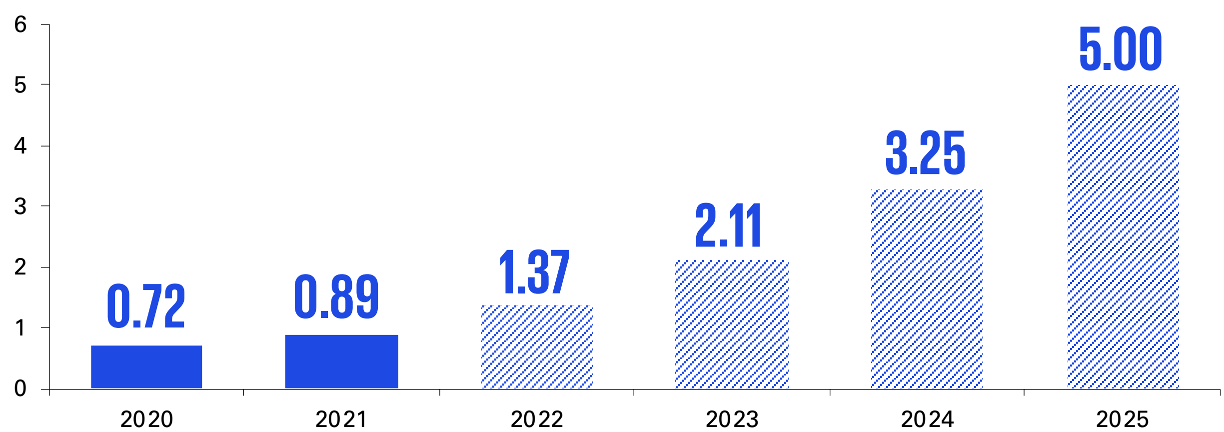
Hydrogen energy is largely used in fuel cell electric vehicles (FCEVs), and the use of hydrogen in transportation is expected to grow rapidly in the future. 2020 saw a decline in the production and sale of FCEVs in China due to factors such as COVID-19; but in 2021, the production and sale of FCEVs surged by 49% and 35% year-on-year, respectively. This growth continued in 2022, with 1,804 FCEVs produced in the first half of the year, exceeding the total output in 2021 (see Figure 8). According to the Medium and Long-term Development Plan for the Hydrogen Industry (2021-2035), China aims to have 50,000 hydrogen FCEVs operating domestically by 2025. According to the plan, the average annual growth rate of FCEV penetration will exceed 50% in the next few years (see Figure 9).

Fig 8 Production and sale of fuel cell electric vehicles in China (2018 to H1 2022)



Sources: Wind; KPMG analysis

Fig 9 Fuel cell electric vehicle penetration in China (10,000 units)

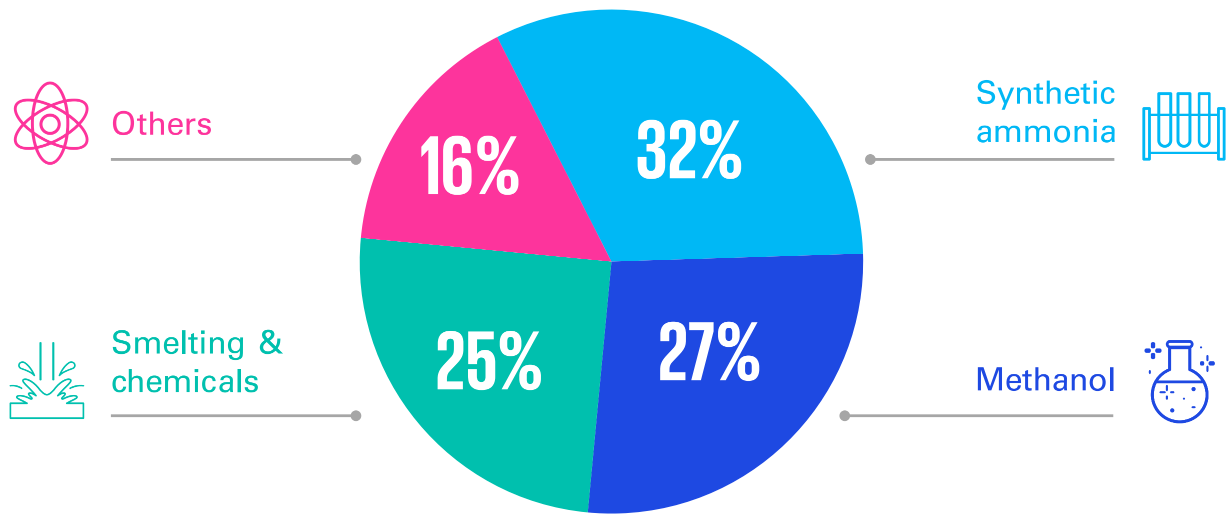


Sources: Xiangchenghui Institute (香橙会研究院); Medium and Long-term Development Plan for the Hydrogen Industry (2021-2035); KPMG analysis
*Figures for 2022-2025 are forecasts

Industrial sector

Hydrogen is not only used as an industrial fuel, but also as an industrial raw material to help reduce emissions. In China, the steel industry's total carbon emissions reached approximately 1.8 billion tons in 2020, accounting for about 15% of total emissions nationally. In order to meet the steel industry's goal of reducing carbon emissions by 30% by 2030, a reduction of 540 million tons is required, which presents a huge challenge.[13] Hydrogen metallurgy represents a major pathway for the steel industry to achieve the "dual carbon" goals. Meanwhile, green hydrogen is expected to gradually become a regular feedstock for chemical production. In the chemical industry, hydrogen is a major feedstock for ammonia synthesis, methanol synthesis, petroleum refining and coal chemical sectors (see Figure 10). Currently, industrial hydrogen production relies chiefly on fossil fuel sources. However, as the price of renewable energy generation continues to fall, green hydrogen is expected to become affordable in some regions by 2030, and it will gradually become more widely used in the industrial sector and become a conventional feedstock for chemical production.[14]

Fig10 Industrial distribution of hydrogen energy consumption in China's chemical industry in 2019 (%)



Sources: China Hydrogen Alliance; KPMG analysis

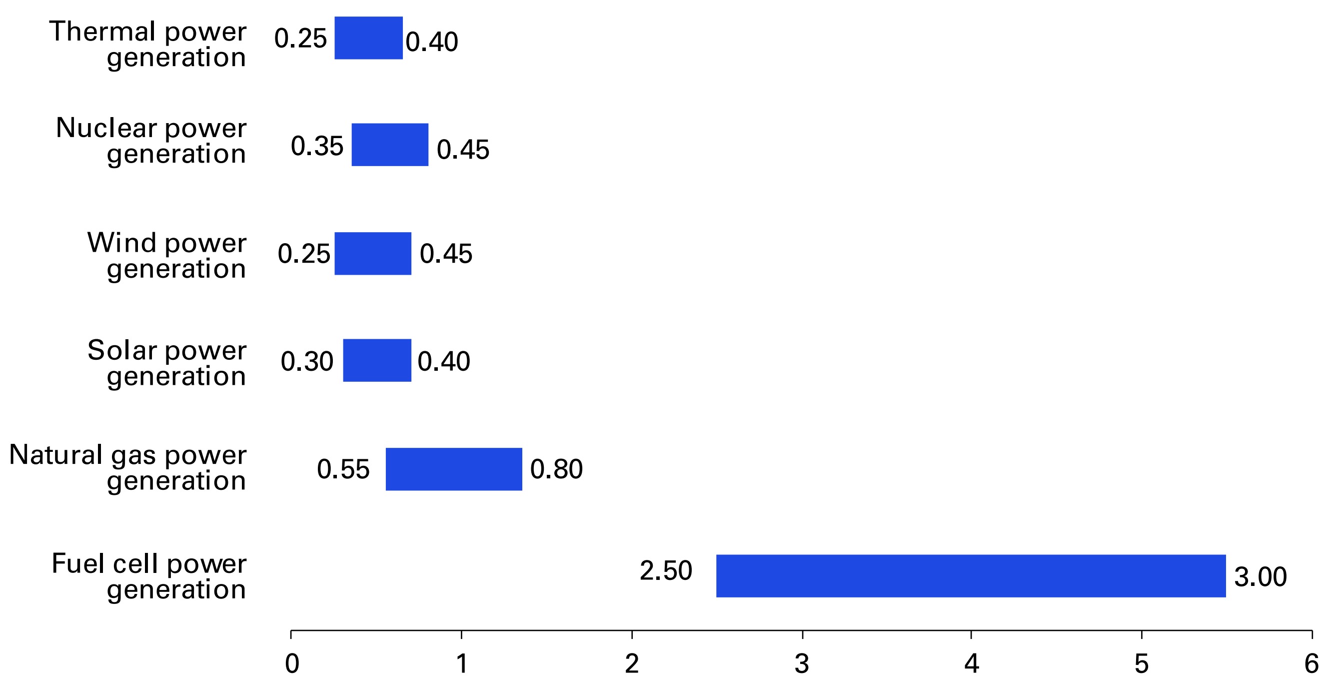
[13] Zhang Zhen and Du Xianjun, Study on the Economics of Metallurgy Using Hydrogen for Carbon Reduction under the Carbon Neutrality Goal, Price Theory and Practice, 2022

[14] International Association for Hydrogen Energy and China Hydrogen Alliance, The Road to Hydrogen Parity, July 2020

Power generation sector

There are two major ways to generate electricity from hydrogen. One is to use hydrogen energy in gas turbines to drive electric motors to produce current output, i.e. "hydrogen generators." The other method is known as "fuel cell technology," which reverses the reaction in water electrolysis by causing hydrogen to react electrochemically with oxygen (or air) to produce water and release electricity. At present, both methods are costly. Fuel cells cost around RMB 2.5-3/kWh while other power generation methods basically cost less than RMB 1/kWh (see Figure 11). [15] Cost reduction is the key to the development of hydrogen energy in power generation.

Fig11 Range of estimated costs for different types of power generation in China (RMB/kWh)



Sources: Publicly available data, KPMG analysis

Construction sector

Currently, the application of hydrogen energy is relatively limited in heating. Compared to natural gas, hydrogen still needs to be improved in terms of its heating efficiency, cost, safety and infrastructure development. In the early stage, hydrogen energy in buildings will predominantly be used in a hybrid form, with the pure use of hydrogen expected to overtake hybrid use in the late 2030s. [16]

[15] CNNPN, "The Future Competitiveness of EPR in terms of the Cost of Electricity Generation from Various Energy Sources," January 2021, https://www.cnnpn.cn/article/23072.html

[16] DNV，Hydrogen Forecast to：Energy Transition Outlook 2022，June 2022

China has actively released policies to promote the development of hydrogen energy

Ever since the term "hydrogen energy" was first included in the 2019 Government Work Report, Chinese authorities have released various policies to support the development of hydrogen energy. Those policies cover the production, storage, transport, and use of hydrogen, technical know-how across the hydrogen supply chain, demonstration applications for hydrogen, and infrastructure development, among other areas (see Table 3). According to a plan released in March 2022 on the development of hydrogen energy for the 2021-2035 period, by 2035, China will basically master the core technologies and manufacturing processes involving hydrogen energy and have approximately 50,000 FCEVs. In addition, during this period, China will plan and build a number of hydrogen stations, and annual hydrogen production from renewable energy should reach 100,000 to 200,000 tons, which should reduce carbon dioxide emissions by 1,000,000 to 2,000,000 tons per year.

Table 3: National-level policies in support of the hydrogen energy industry (2019-2022)

Release date	Releasing authorities	Document name	Our analysis
June 2022	Jointly issued by the National Development and Reform Commission, the National Energy Administration and seven other central government departments	The Renewable Energy Development Plan for the 14th Five-Year Plan (2021-25) Period	Highlights: The plan aims to promote the role of photovoltaic power in controlling desertification, promote hydrogen production from renewable energy, and ensure a diverse and balanced energy mix, while also enabling hydrogen production from renewable energy on an industrial scale. Significance: It highlights the importance of promoting hydrogen production from renewable energy on an industrial scale, and establishes a high-level direction for China's hydrogen development during the 14th Five-Year Plan period.
March 2022	The National Development and Reform Commission and the National Energy Administration	The 2021-2035 Plan for the Development of Hydrogen Energy	Highlights: It analyzes the current status of hydrogen development in China, and identifies the role of hydrogen in the country's strategy for transforming towards a green and low-carbon future as well as the country's overall requirements and goals for hydrogen development. In addition, the plan proposes innovation systems, infrastructure, applications, supporting policies, organizations and implementation pathways for hydrogen energy. Significance: It incorporates hydrogen into China's energy strategy.

Release date	Releasing authorities	Document name	KPMG analysis
November 2021	The National Energy Administration and the Ministry of Science and Technology	The 14th Five-Year Plan (2021-25) for Scientific and Technological Innovation in the Energy Sector	Highlights: The plan calls for mastering more efficient technologies for producing, storing, transporting, and refuelling hydrogen, including fuel cell technologies, and promotes the integration of hydrogen with renewable energy. Significance: It provides guidance on key innovative technologies across the supply chain, including those related to hydrogen production, storage, transport and use, as well as on leading practices for hydrogen applications and safe deployment.
October 2021	The State Council	Action Plan to Peak Carbon Dioxide Emissions Before 2030	Highlights: The plan calls for actively expanding the application of new and clean energies, such as electricity, hydrogen power, and natural gas, in transportation. Significance: It highlights the significant role that hydrogen will play in the country’s journey toward carbon peaking and carbon neutrality.
March 2021	The 13th National People's Congress	The 14th Five-Year Plan (2021-25) for National Economic and Social Development and the Long-Range Objectives through the Year 2035	Highlights: The plan calls for establishing incubators and accelerators to promote the development of industries that are fit for the future, particularly those related to cutting-edge technologies such as hydrogen and storage technologies as well as those that drive industrial transformation. Significance: China’s 14th Five-Year Plan introduces hydrogen energy as one of the six key industries going forward.
December 2020	The National Development and Reform Commission and the Ministry of Commerce	The Catalogue of Encouraged Industries for Foreign Investment (2020 Edition)	Highlights: The entire supply chain for hydrogen/fuel cells has been included in the investment scope for foreign investors. Significance: The industry has been further opened up for foreign investment.
April 2020	The National Energy Administration	The Energy Law of the People’s Republic of China (Exposure Draft)	Highlights: “Energy” refers to the resources that generate energy, such as thermal energy, mechanical energy, electric energy, nuclear energy and chemical energy, which mainly includes coal, petroleum, natural gas, nuclear energy, hydrogen energy, etc. Significance: For the first time, a legal document has acknowledged the status of hydrogen as energy by including it in the definition of energy.
March 2019	The State Council	2019 Government Work Report	Highlights: The report says that to maintain stable consumption in the automotive sector, China will continue to implement preferential policies on the purchase of new-energy vehicles and facilitate the construction of charging and hydrogenation facilities. Significance: Hydrogen energy has been included in China’s Government Work Report for the first time.

Sources: Data compiled by KPMG; KPMG analysis

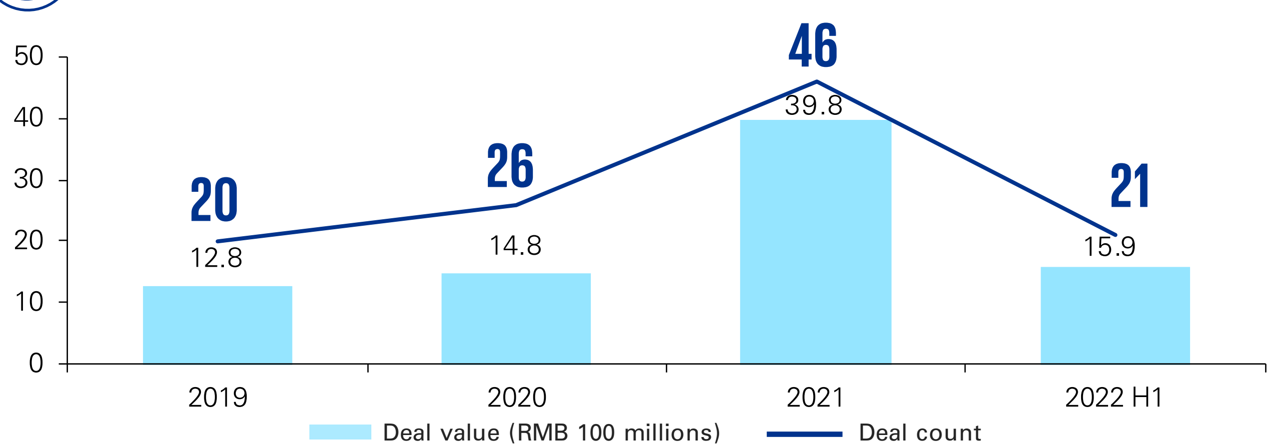
In addition, since 2019, at least 12 provinces (including autonomous regions and municipalities) have set quantitative hydrogen targets for the period through 2025. In excess of national targets, Inner Mongolia aims to achieve hydrogen production from renewable energy of over 100,000 to 200,000 tons per year; and Beijing, Hebei, Shandong, and Shanghai each aims to reach 40,000 FCEVs. However, as China’s hydrogen energy industry is still in its infancy, the country will need time to overcome certain key technological challenges in the supply chain. Each provincial region should reasonably evaluate their current foundation, gauge their market and growth potential, and establish sound policies and plans. Meanwhile, provinces should not acquire land or compete with each other for hydrogen projects, as these practices have been forbidden by the NDRC. [17]

[17] “NDRC: Strictly prohibit blindly following the trend and wasting resources in developing hydrogen energy projects,” People.com, 23 March 2022, http://finance.people.com.cn/n1/2022/0323/c1004-32382433.html

With investors focusing on the entire value chain, investment in hydrogen energy is growing rapidly

In H1 2022, the hydrogen energy sector saw robust equity financing activity, continuing the trend seen in the previous year. In China, hydrogen energy companies raised RMB 1.59 billion in 21 deals, which represented an increase in deal value and deal count of 137% and 50% year-on-year, respectively (see Figure 12). [17]

Fig 12 Equity financing in the hydrogen energy sector from 2019 to H1 2022

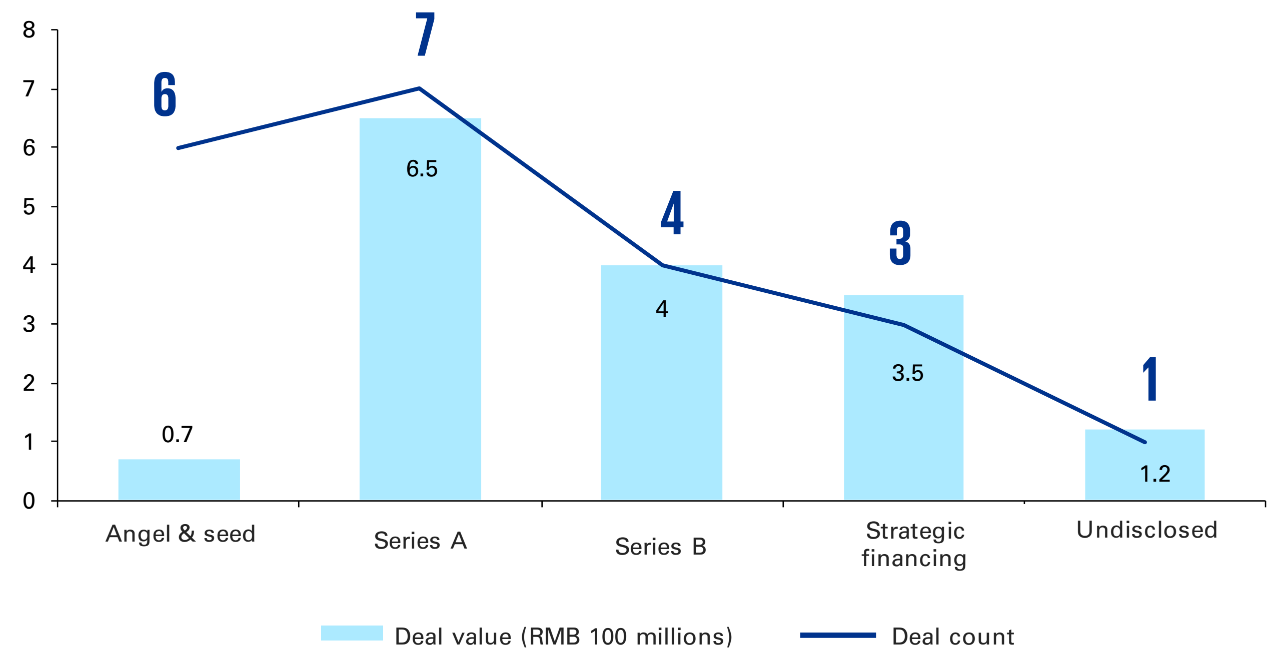


Sources: Data provided by CV Source; publicly available data; KPMG analysis

[17] In this article, financing refers to equity financing in the primary market participated by PE/VC firms.

In terms of deal share by financing series, given that China's hydrogen energy industry is still in its infancy, financing mainly occurred at early rounds. In H1 2022, series A deals ranked first in both deal value and count. During this period, hydrogen energy companies raised RMB 650 million in 7 series A deals, RMB 400 million in 4 series B deals, RMB 350 million in 3 strategic financing deals, and RMB 70 million in 6 angel & seed deals (see Figure 13).

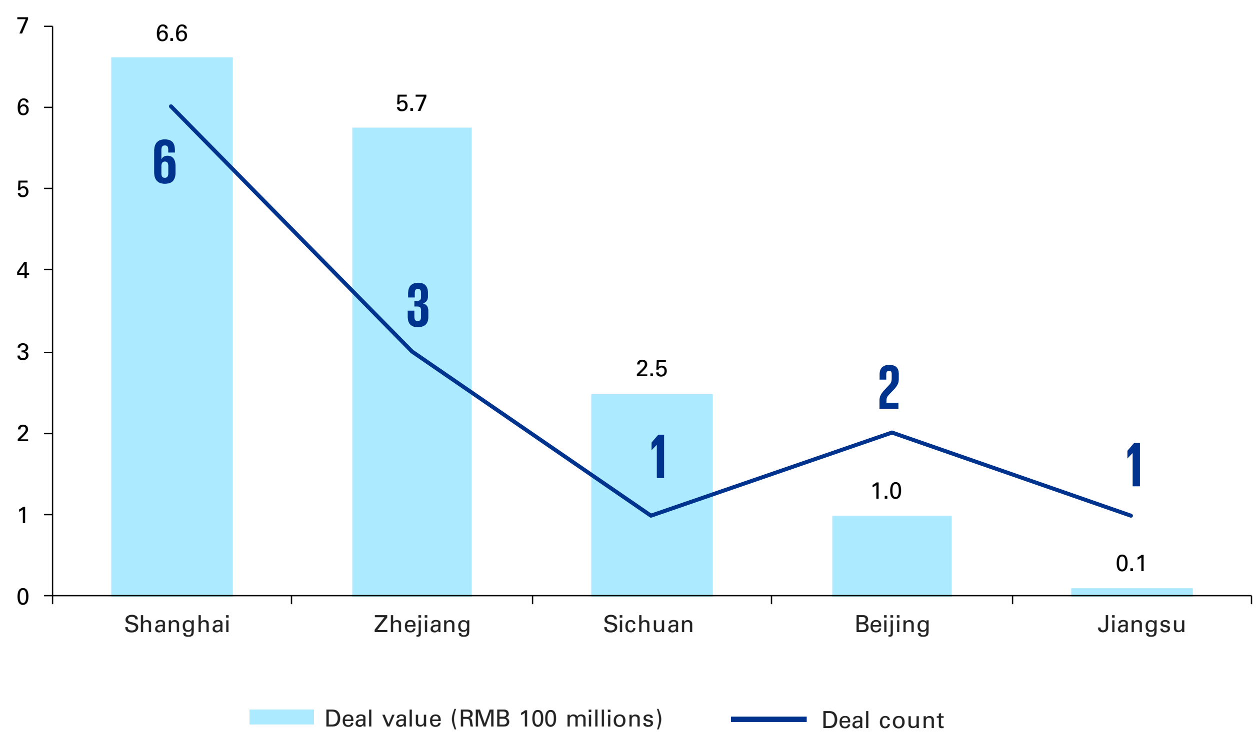
Fig 13 Equity financing in the hydrogen energy sector by series in H1 2022



Sources: Data provided by CV Source; publicly available data; KPMG analysis

In terms of deal share by location, Shanghai, Zhejiang, Sichuan, and Beijing outperformed other areas. In recent years, these regions have taken advantage of their own resources to introduce local hydrogen plans, and they have carried out pilot programs to promote the industrialization of hydrogen and fuel cell technology. In particular, Shanghai and Jiangsu have been among the first in China to research, develop and demonstrate FCEVs. In addition, Sichuan is one of the major domestic bases for producing hydrogen from renewable energy and researching and developing stacks for core fuel cell components. Furthermore, Beijing was among the first cities or regions to research and develop fuel cell stacks and their key components. Industrial clusters in these regions have grown over the years and begun to deliver a real impact. In H1 2022, hydrogen energy companies raised RMB 660 million in Shanghai, RMB 570 million in Zhejiang, RMB 250 million in Sichuan, and RMB 100 million in Beijing, altogether accounting for 99% of the total deal value for the period. In terms of deal count, Shanghai led with 6 deals, followed by Zhejiang and Beijing with 3 and 2, respectively, in H1 2022 (see Figure 14).

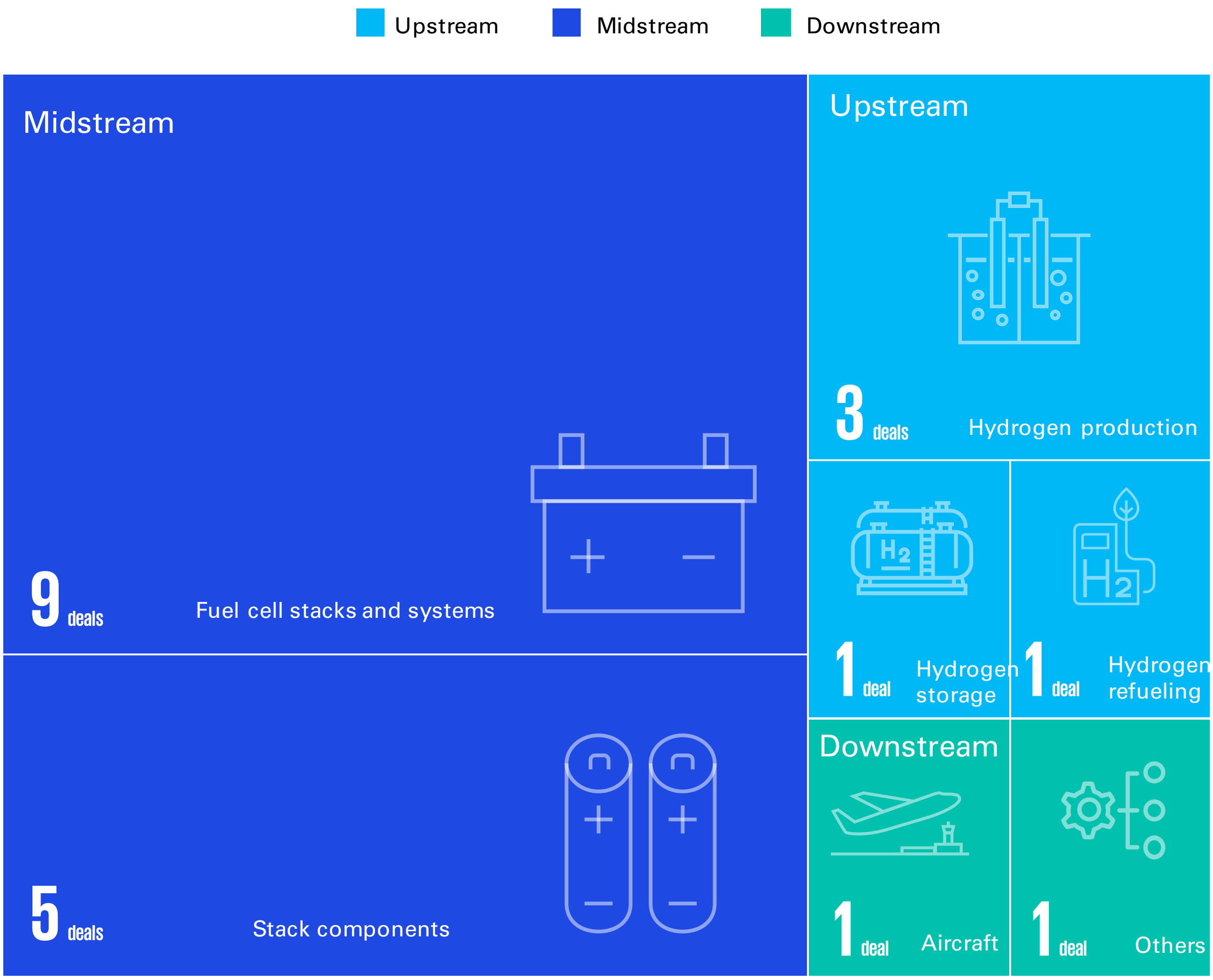
Fig 14 Equity financing in the hydrogen energy sector by location in H1 2022



Sources: Data provided by CV Source; publicly available data; KPMG analysis

In terms of their position in the supply chain, in H1 2022, most hydrogen energy companies that received financing were midstream enterprises. Research and development of fuel cells was a particularly hot area of investment, with companies that focus on high-precision technologies attracting a total of 14 deals. In the midstream segment, companies specializing in fuel cell stacks and systems drew significant attention from investors (see Figure 15). Meanwhile, upstream companies, including those focusing on hydrogen production, storage, and refueling, recorded five deals, representing a year-on-year increase of four and indicating that more financing is moving upstream from the fuel cell segment as investors focus on covering the entirety of the hydrogen supply chain.

Fig 15 Supply chain position of hydrogen energy companies receiving financing in H1 2022



Sources: Data provided by CV Source; publicly available data; KPMG analysis

International development and cooperation in hydrogen energy

Given the profound changes in the world's energy structure, hydrogen has become a key element of many countries' energy strategies for the future. In recent years, major economies around the world have released their own hydrogen strategies and plans (see Table 4).

For example, Japan has put in place a hydrogen strategy that aims to maintain the country's national energy security and promote the development of a global hydrogen community. Japan is now seeking to develop a global Japan-led hydrogen supply chain.

As a key part of its diverse energy strategy, the United States is currently developing a pool of hydrogen and related technologies along its supply chain to help realize the emission reduction commitments made by the Biden administration in response to climate change.

Meanwhile, the EU has enacted a hydrogen strategy that intends to decarbonize the economy and deploy green hydrogen quickly and on a large scale. Especially since the onset of the Russia-Ukraine conflict, the EU has been working diligently to reduce energy dependence on Russia and accelerate its own deployment of green hydrogen.

China has incorporated hydrogen into its national energy strategy, and a supporting system based on policies released at the central and local government levels has taken shape domestically. The country expects high-quality growth for the industry and aims to build a relatively complete hydrogen supply chain and industrial system by the end of its "14th Five-Year Plan" period.

Leveraging the country's rich domestic resources, Australia aims to become a major exporter of hydrogen to Asian markets amid efforts to develop new sources of growth. To this end, the country is stepping up the development of hydrogen hubs in an effort to achieve economies of scale as quickly as possible.

In Chile, green hydrogen has been driving the shift in growth drivers from non-renewable resources such as copper mines to renewable energy such as wind and solar power, as the country works to become a global leader in green hydrogen exports.

Table 4: Hydrogen strategies adopted by foreign countries

Country	Key document	Release date	Goals	Highlights
Japan	The Sixth Basic Energy Plan	October 2021	Reduce the production cost of hydrogen to JPY 30/Nm3, and raise the hydrogen supply to 3 million tons/year by 2030 Reduce the production cost of hydrogen to JPY 20/Nm3, and raise the hydrogen supply to 20 million tons/year by 2050	Japan's Sixth Basic Energy Plan called for raising the proportion of hydrogen/ammonia power generation from 0% to 1% (hydrogen/ammonia power generation was not deployed for use in 2019) in order to achieve a diverse clean energy mix by 2030.
United States	The Department of Energy's (DOE) Hydrogen Program Plan	November 2020	The DOE's plan aims to reduce electrolyser costs to USD 300/kW, with a prolonged duration of 80,000 hours and an electrical conversion efficiency of 65%. The plan also aims to reduce the cost of hydrogen to less than USD 1/kg for industrial and bulk power use and to less than USD 2/kg for transportation end use by 2030.	The mission of the DOE Hydrogen Program is to research, develop, and validate transformational hydrogen and related technologies including fuel cells and turbines, address institutional and market barriers, and ultimately enable adoption for multiple uses and sectors. By developing hydrogen energy from diverse domestic resources, the United States aims to ensure access to an abundant supply of reliable and affordable clean energy.
EU	The EU Hydrogen Strategy	July 2020	The EU will install electrolytic facilities with a capacity of 6 million kW in order to generate 1 million tons of green hydrogen by 2024. By 2030, the EU aims to install electrolytic facilities with a capacity of 40 million kW in order to generate 10 million tons of green hydrogen. The EU has called on hard-to-abate sectors to replace natural gas with green hydrogen by 2050.	The strategy provides a clear direction for the development of clean energy, especially hydrogen energy, over the next 3 decades in the EU, and outlines a comprehensive plan for investing across the supply chain, including hydrogen production, storage, and transport, as well as in existing natural gas infrastructure, carbon capture, and sealing techniques. Over EUR 450 billion is expected to be invested in these projects.
Australia	The 2019 National Hydrogen Strategy	November 2019	Australia's National Hydrogen Strategy sets a vision for a clean, innovative, safe and competitive hydrogen industry that benefits all Australians and is a major global player by 2030.	The strategy, which identifies 57 joint actions and 15 goals, aims to make Australia a top-three exporter of hydrogen in the Asian market, as well as a global pioneer in promoting hydrogen safety, the hydrogen economy, and hydrogen certification.
Chile	The National Green Hydrogen Strategy	November 2020	The strategy calls for hydrogen production capacity from renewable energy to reach 5 million kW by 2025. Chile aims to become a leader in the production of low-cost green hydrogen by 2030. Chile aims to become a hydrogen exporter by 2040.	The strategy takes a comprehensive look at the growth opportunities for green hydrogen in Chile, sets a strategic goal of becoming a global leader in green hydrogen exports, and outlines the key goals in each stage of the country's three-stage development plan for green hydrogen.

Sources: Data compiled by KPMG; KPMG analysis

Future trends of hydrogen energy

As supporting policies, active participation by enterprises, and investor interest combine, the hydrogen energy sector is expected to thrive rapidly. Trends to watch for in China include:

Hydrogen will be commercialized first for transportation end use.

The increase in demand for hydrogen energy in China during the "14th Five-Year Plan" period is expected to come mainly from transportation end use, with the scale-up of hydrogen FCEVs as a key driver. In the long run, hydrogen is expected to find the widest application in the industrial sector, and demand will continue to increase given the release of supporting policies and technological progress.

Competition will occur in sub-sectors including green hydrogen production, key materials for hydrogen fuel cells, and localization of hydrogenation equipment.

As downstream use cases increase, more than one-third of central SOEs are currently planning to engage in business across the hydrogen supply chain, including hydrogen production, storage, refuelling, and use.[18] With those leading companies entering the market, interest from investors is expected to continue to grow; and they will probably focus on green hydrogen production, key materials for hydrogen fuel cells, localization of hydrogenation equipment and other subsectors, which should promote the continuous innovation of hydrogen technologies.

Rapid regional layout of hydrogen energy.

How hydrogen is laid out in a region is highly dependent on the resource reserves there. In the short term, many enterprises will still face cost pressure due to the need to transport/store hydrogen over a long distance/on a large scale. In the early stages, priority will be given to building local hydrogen ecosystems. As the industry matures and hydrogen pipelines and other transportation infrastructure improve, a nationwide network will be developed.

[18] "The State Council Information Office held a briefing on the economic performance of central enterprises in the first half of 2021," Gov.cn, July 18, 2021, http://www.gov.cn/xinwen/2021-07/18/content_5625983.htm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