

China: Recent developments in the Chinese hydrogen market: policy and market trends

In brief

On 23 March 2022, China's National Development and Reform Committee (NDRC) and National Energy Administration released a plan on the development of hydrogen energy for 2021-2035¹ ("**Plan**"). As the first national-level industry plan for hydrogen development, the Plan recognizes hydrogen as a major component of China's future national energy system, an important carrier for realizing green- and low-carbon transition to the net-zero economy, and a key direction of China's strategic emerging industries.

China currently is the largest producer of hydrogen in the world but the industry is still in its early stage of development, facing problems in various areas such as innovation capabilities, technical equipment and policy support and regulatory framework. The aim of the Plan is to promote and guide an integrated, green and high-quality development of the hydrogen industry in China. To that end, the Plan sets out the main objective for the development of China's hydrogen industry, namely, building up a complete hydrogen value chain by 2035 with a significant proportion of hydrogen produced from renewable energy to support China's green energy transition.

This article provides a summary of recent market developments in China's hydrogen sector, covering its value chain from production, storage, transport to end use application, government policy support to the industry, issues that are particularly challenging to the industry, as well as potential investment opportunities for foreign investors who are interested in participating in this booming market.

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In more detail

Current regulatory framework

Prior to the release of the national Plan, we have seen increasing policy support for the hydrogen industry in China at both the national and local levels, although regional governments have been leading the efforts in setting development guidelines for hydrogen. Over the past five years, numerous policy documents mentioning hydrogen were issued at regional levels and expressed support for fuel cell vehicle standards, hydrogen production, storage and transportation, refueling services, etc.. However, there was a lack of a national level development plan. With the release of the national Plan, the country is now looking to promote high-quality, market-driven and rational development of a complete hydrogen value chain through coordinated market and infrastructure development. One of the key targets of the Plan is to develop a complete and dedicated regulatory framework by 2025 to support the establishment of the hydrogen value chain.

¹ 《氢能产业发展中长期规划（2021-2035年）》 · available at www.nea.gov.cn.



Clean hydrogen² production

Hydrogen has a long stretching value chain from upstream production, midstream transport and storage infrastructure, and charging network, to the downstream fuel cell vehicles and other end use applications.

Current production market

Currently, China is the largest hydrogen producer in the world with an annual production output of about 33 million tonnes, but most of the production remains gray hydrogen from coal gasification and as byproducts of the chemical process. The government is now promoting to build the hydrogen supply upon renewable and other clean energy sources, with strong support for hydrogen production from renewables. The Plan sets a target of annual hydrogen production from renewable energy reaching between 100,000 to 200,000 tonnes by 2025, and a wide use of hydrogen produced from renewable energy in the economy to support China's green energy transition for the period up to 2035. While the Plan calls for the significant expansion of hydrogen production from renewables over the next 15 years, the government supports multiple hydrogen production routes rather than relying on a single technology pathway.

P2G projects

There is already a surge of solar and wind power-to-gas (P2G) projects in China. The core of the P2G projects is to utilize renewable electricity to produce hydrogen via electrolysis of water. According to a market source,³ by February 2022, China had over 120 renewable hydrogen projects under development. Most of these projects are small-scale pilot projects but there are a number of large commercial scale projects emerging in the market. China's electrolysis market also experienced explosive growth in 2021, with a growing number of newly built renewable P2G projects in China using polymer electrolyte membrane (PEM) electrolyzer technology.

Policy incentives for hydrogen production

The explosive development of renewable P2G projects in China is largely due to China's renewable energy policies. The sector has benefitted from a set of policy measures that are aimed at boosting renewable energy development and consumption in China. In particular, to combat renewable energy curtailment or waste, those policy measures promote local renewable consumption, with hydrogen production listed as one of the crucial solutions. The policies on storage provide another policy momentum for renewable hydrogen production. The energy regulator requires new renewable energy project developments to develop matching storage solutions, of which P2G is one of the favored options. The emphasis on renewable energy-plus-storage has so far become the key driving factor for the growth of hydrogen production.

Market players

Power utilities are leading the investment in the current round of renewable hydrogen production in China, although previously private renewable developers led most projects. Many Chinese state-owned energy enterprises have all unleashed their hydrogen business plans. Many of them have been focusing on utilizing excess renewable electricity to produce hydrogen to reduce renewable energy waste or address curtailment in the power sector they are facing. The participation of these state-owned players is crucial to kick-start the nascent Chinese hydrogen market. Backed by state funding and the banking system, these state players could provide low-cost capital and are capable of investing for the long term.

Challenges to the industry

The nascent Chinese hydrogen sector is still in its early stage of development, facing multiple challenges. The cost of renewable-based hydrogen is currently high and cannot compete in cost with the cheap gray or blue hydrogen sources (from coal synthesis or petrochemical process). Investors are facing high technological and commercial risks for investing in first-of-a-kind projects (although for state-owned players, their investment is more likely to be driven by governmental policies rather than the market in China). Hydrogen demand is uncertain due to its limited use in the economy and there is a lack of sufficient hydrogen distribution networks and infrastructure. China has yet to develop a clear market structure and business model, and an appropriate regulatory framework to support this industry.

² Please note that "clean hydrogen" or "low-carbon hydrogen" are not defined in the Plan. Both terms are used in a generic manner.

³ See Yuki Yu, 'China's National Hydrogen Development Plan' (Blog post, 6 April 2022) <<https://energyiceberg.com/national-hydrogen-development-plan/>>



The Plan calls for putting in place a supporting regulatory framework for the hydrogen sector, but it remains unclear at this stage what such framework would look like. The Plan identifies a few areas for further policy research, such as pricing support for hydrogen production from renewable sources, setup of pricing mechanisms for storage facilities and participation of hydrogen storage in electricity trading markets. Currently, there is no subsidy or revenue support mechanisms at the central level offered to renewable-based hydrogen producers to enable them to overcome the cost gap between low carbon hydrogen and high carbon fuels. Policy and regulatory uncertainty remain high risks for potential investors. Despite this, with the release of the Plan, we would expect significant investment to be made in renewable hydrogen projects in the near term. Renewable-based hydrogen will play a major role in the growth of hydrogen production in China.

Storage and transport infrastructure

Developing network infrastructure to allow hydrogen to be transported to end users is central to the expansion of the hydrogen economy. Storage, on the other hand, can support security of supply as production and use increase and become more spread out over time and distance. For a future energy system with a lot of intermittent renewable power generation, hydrogen can serve as an important storage medium, converting excess renewable energy into a fuel for use across the economy. Currently, China falls behind in both hydrogen storage and transport technology.

Storage

There are a number of ways in which hydrogen can be stored. Specialist tanks or storage vessels, either stationary or mobile, such as tube trailers, which are built using materials able to hold hydrogen at pressure, are likely to be the most common storage option in the near term. Currently, gaseous storage and tube trailer is the common technology used in China. Tube trailer is well developed but the technical specifications are far from ideal. Compared with Gen IV steel containers of 70 megapascals pressure deployed in Europe, North America, Japan and Korea, steel containers used in China for hydrogen storage are still of Gen III type with pressure at 35 megapascals. China also lacks experience and technology in liquid hydrogen storage. Technology for storing hydrogen in liquid form does exist but is only used in the aerospace and defense sectors. Hydrogen carriers (such as ammonia, liquid organic hydrogen carriers, etc.) provide a route to store hydrogen at increased energy density but these storage methods are still in a very nascent stage. Salt caverns storage, a large-scale underground storage option being considered for strategic hydrogen storage in the US and Europe, is not currently available in China. Notwithstanding, significant investment has been made in China to develop salt caverns for natural gas storage and energy storage.

Transport

Hydrogen can be transported in either compressed gaseous or liquid form. Networks for transporting hydrogen include a range of pipeline and non-pipeline channels (e.g., road and rail vehicles, marine vessels). In China, there is limited distribution through hydrogen pipelines. China already has two hydrogen pipelines in operation, but the overall length of the pipelines is still well under 500 kilometers. In contrast, the global pipeline for hydrogen distribution is around 4,500 kilometers, of which 56% is located in the US and a large part of the rest in Europe. China's renewable hydrogen supply centers are mainly located in the west, where there is abundant solar and wind capacity that could be taken advantage of. Those areas, however, are far from the hydrogen demand areas in the east and south of the country. To close this supply and demand gap, one possible solution would be a distribution pipeline connecting hydrogen supply from renewables rich regions to high demand areas on the coast.

China is also considering blending hydrogen and natural gas through the existing gas infrastructure. China has one hydrogen and natural gas blending pilot project in place. The decision on blending hydrogen into the gas grid will have a significant impact on the ultimate development of hydrogen networks.

As part of the hydrogen infrastructure, China has built more than 250 hydrogen refueling stations, accounting for about 40% of the global total. China now ranks first in the world for the number of hydrogen refueling stations.

Areas for investment

Recognizing technology constraints in hydrogen storage and transport, which could hamper the development of the hydrogen midstream value chain, the Plan has now focused on supporting innovation and R&D and exploring multiple storage and transport options for hydrogen, with a particular focus on improving the technology of high-pressure gaseous storage and transport and advancing liquid hydrogen storage and transport technology. The Plan also supports construction of new hydrogen pipelines and a range of demonstration projects on blending hydrogen in gas pipelines although it remains to be seen how building and operating hydrogen network will be regulated in China. China will continue to scale up the deployment of hydrogen refueling stations across the country.



Thus, hydrogen storage and transport technology is likely to become the next investment hit in China as the country is looking for breakthroughs in these areas in the next five to 10 years. Liquid hydrogen is already gaining traction as both the industry and the government show great interest in advancing liquid hydrogen storage and transport technology. We expect that more hydrogen pipeline projects are likely to kick off in the coming years and significant investment would be made to scale up hydrogen networks. Investment in hydrogen infrastructure, like many other infrastructure investments in the country, faces challenges of complex regulatory procedures, large capital investment, cost of land use and a long payback period. The government is well aware of the importance of providing policy and financial support to encourage midstream investment but detailed supporting schemes have yet to be issued by the government to ensure network infrastructure development. At present, local subsidies are available to investors for investment in hydrogen fueling stations in some regions but not all.

End use application

With more than 120 hydrogen production projects under development and more on the way, whether all of the renewable hydrogen production capacity could find its end use market remains a question. The majority of China's renewable hydrogen production projects are for transport end use, although a growing number of projects are now for end use in other sectors, such as providing flexible power generation using hydrogen as a fuel.

According to the Plan, China's hydrogen application will continue focusing on the transport market in the near term, with the total quantity of hydrogen-fueled vehicles to be increased to about 50,000 by 2025. The government encourages use of hydrogen across a range of transport modes, including heavy goods vehicles, buses and rail, along with early stage uses in commercial shipping and aviation. The government also promotes a wide range of hydrogen use across multiple sectors, including power, industrial sectors and other fields and commits to support research, innovation and commercialization of hydrogen technologies across a wide range of end uses.

Policy support for fuel cell vehicles

It is worth noting that China implements a unique reward policy for hydrogen fuel cell vehicles. This reward policy is a city-based demonstration subsidy policy under which financial support is provided to cities or city alliances that successfully implement the hydrogen and fuel cell industry plan, rather than directly to the fuel cell industry or consumption companies. It is essentially a financial reward by the central government to city-level local governments to support the development of fuel cell vehicles and value chain. The total reward amount is RMB 1.7 billion for each city. Most of cities also provide local subsidies and have established a 1 to 1 subsidy ratio to match the central government's reward (which means the total reward amount can reach RMB 3.4 billion for each city). The reward aims mostly at providing funding to fuel cell technology R&D, innovation and development of effective business models.

End use in heavy industries

Hydrogen could play a vital role in decarbonizing heavy industries (steelmaking, petrochemical and chemical industries) but the industries face several barriers in fuel switching to hydrogen. These include the higher cost of hydrogen supply compared with fossil fuels, the capital cost of retrofitting or replacing equipment to be hydrogen-ready, the operational disruption of conversion and the subsequent costs associated with optimizing new industrial processes using hydrogen. Government support would be crucial in enabling the industries to switch to hydrogen as an industrial fuel and stimulating early investment in fuel switching processes and technologies. This will in turn build demand for hydrogen in industry and help to develop a commercial case for further expansion of hydrogen production. The policy design in these areas remains to be seen. The development and scaling up of each part of the hydrogen value chain will rest on appropriately designed policy frameworks dedicated to stimulating the expansion of the hydrogen market as a whole.

Opportunities for foreign investors?

We believe the recent boom of China's hydrogen market will lead to plenty of opportunities for international technology providers and investors. In China, the hydrogen sector is fully open to foreign investment without restrictions. In fact, the newly released Catalogue for Encouraged Industries for Foreign Investment (2022 Edition) (draft for consultation), administered by the NDRC and the Ministry of Commerce, contains the entire hydrogen value chain, including hydrogen production, storage, transportation, and liquefaction, as industries encouraged with respect to foreign investment.

The current hydrogen production market is primarily dominated by Chinese utilities and developers. Being able to identify Chinese partners to work with and understand their business interest and strategy will be critical to most foreign investors considering entering this market. We have already seen the success of some foreign investors.



The storage and transport market presents significant opportunities for foreign investors, especially technology providers. Liquid hydrogen in particular could be a market with huge potential for foreign investment. The government is also actively promoting international cooperation through joint R&D, standards setting, infrastructure construction, hydrogen trading, etc. China started developing the clean hydrogen economy after Europe, the US, Japan and Korea, but now, with the release of central planning for hydrogen, this process is accelerating very fast. China has set high ambitions to become a leader in hydrogen. The window for foreign investors to act will not last long.

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