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Influence of Water Resources on the Development of Green Hydrogen Industry in China

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Abstract

As China has accumulated a lot of experience in the field of fuel cell vehicle demonstration, the development of China's hydrogen energy industry has started to expand to the field of renewable energy hydrogen production, but China's renewable energy hydrogen production faces the constraints of water resources, and the water consumption of green hydrogen will have a greater impact on the layout of China's hydrogen energy industry, and the layout of China's green hydrogen industry will pay more attention to local conditions and orderly development in the future, and it is expected to rapidly expand to the field of seawater hydrogen production. In the future, the layout of China's green hydrogen industry will focus more on localization and orderly development, and it is expected to be rapidly developed in the field of seawater hydrogen production.

Keywords: Green Hydrogen; Water Resources; Renewable Energy Hydrogen Production

Introduction

Driven by hydrogen fuel cell vehicles, some Chinese experts and scholars also actively support the development of hydrogen as an energy source in China from the perspectives of no carbon emission during hydrogen application, high energy density per mass of hydrogen, and high efficiency of hydrogen fuel cell power generation. Meanwhile, under the background of global warming, the United States, Germany, Japan, South Korea and the European Union have put forward the goal of developing clean energy such as hydrogen energy and carbon neutrality, and China has also put forward the goal of "carbon peaking and carbon neutrality" in 2020, so the development of hydrogen energy has entered the explosion stage. As the hydrogen energy industry chain becomes more and more perfect, the industrial layout from the application side of fuel cell vehicles to the hydrogen production side has started to shift, and only the low-carbon source can ensure the low-carbon property of hydrogen for downstream application has become the consensus of the hydrogen energy industry. Hydrogen production by electrolysis of water from renewable energy sources is commonly referred to as green hydrogen in China. Green hydrogen is produced by purifying water resources and passing them through an electrolyzer, where they are decomposed and formed into hydrogen and oxygen by the action of a catalyst and electric current; the hydrogen is then further purified to form high purity green hydrogen.

Since hydrogen as a raw material is maturely applied in industry, the replacement of hydrogen made from traditional fossil energy with low carbon and clean hydrogen can realize the corresponding low carbon of the whole life cycle of the industry. Especially since the second half of 2021, hydrogen energy is no longer limited to automotive applications, and related research has started to shift to industrial energy and feedstock substitution, which has increased the importance of renewable energy electrolysis in society and industry.

However, when the main source of hydrogen is made from renewable energy sources, the demand and supply markets for both industrial and automotive hydrogen in China are separated, and the areas rich in renewable energy are concentrated in the "Three Norths" (Northeast, North and Northwest China) and Southwest China, where the economic conditions are relatively poor and the geographical location is relatively remote. The demand for hydrogen is concentrated in the eastern and southern coastal areas, which increases the transportation cost of green hydrogen and thus the cost of using green hydrogen [1].

The proposal of hydrogen production from renewable energy is an adjustment of energy structure based on the characteristics of hydrogen storage, which alleviates the instability of renewable energy generation at the present stage through hydrogen production, and realizes the full consumption and high quality output of electricity by storing the excess electricity from renewable energy or storing the low quality electricity in the form of hydrogen. In terms of power consumption, the installed scale of renewable energy in China has increased rapidly in recent years, and it is difficult for the existing grid channels and grid systems to achieve a high proportion of green power transmission and consumption, and the speed of new power grids lags significantly, and the contradiction between the speed of installation and the speed of consumption is becoming more and more prominent, although the average level of renewable energy consumption is high, the level of consumption in local areas is still low, and with the rapid expansion of the installed scale, the proportion of consumption With the rapid expansion of installed capacity, the proportion of power abandonment is also further expanded.

Problems of Green Hydrogen Industry

While the rapid development of renewable energy hydrogen production in China, some problems brought by climate change have also affected the production life in China, especially in the summer of 2022, when high temperature caused 66 rivers to break and 25 reservoirs to dry up in Chongqing, China [2], Severe weather has changed the perception of abundant water resources in southwest China. Water scarcity or changes in water distribution under extreme weather remind humans that they should be cautious with water and speed up the solution of climate problems.

China has a strict water use policy

On March 1, 2022, Ministry of Water Resources of the People's Republic of China and National Development and Reform Commission jointly released the "14th Five-Year Plan" Water Consumption and Intensity Control Targets, and the total water consumption in the "Three Norths" region is more stringent, especially in the Inner Mongolia Autonomous Region, which has recently announced more renewable energy hydrogen production projects. In particular, most cities in Inner Mongolia Autonomous Region, which has recently announced more renewable energy hydrogen projects, are in a water overload situation [3].

Administrative District	Total water consumption (billion cubic meters)	Decrease in water consumption of 10,000 Yuan GDP compared to 2020 (%)	Water consumption of 10,000 yuan of industrial added value decreased compared to 2020 (%)
Beijing	42.5	10	10
Tianjin	35	10	10
Hebei	206	15	13
Shanxi	85	12	10
Inner Mongolia	196.3	12	13
Liaoning	140	14	12
Jilin	137.3	16	13
Heilongjiang	363.3	12	13
Shaanxi	107	12	10
Gansu	120.9	13	10
Qinghai	29.6	10	10
Ningxia	72.8	15	10
Xinjiang	563	20	12

Table 1: "Fourteenth Five-Year Plan" Double Control Targets for Total and Intensity of Water Consumption by Provinces, Autonomous Regions and Municipalities directly under the Central Government in the "Three Norths" Region of China.

The General Office of the Ministry of Water Resources issued the "2023 water conservation work points of the water conservancy system" pointed out that the continued implementation of the national water conservation action, to further strengthen the total amount of water intensity double control. Strengthen the water consumption of 10,000 yuan of gross regional product, 10,000 yuan of industrial value added water consumption, the effective utilization coefficient of irrigation water in farmland and other key water consumption indicators control, and promote the completion of annual control targets around. Continuously promote deep water conservation and water control in the Yellow River Basin. Explore the implementation of mandatory water quota management in the Yellow River Basin [4].

In 2021, Ministry of Industry and Information Technology of the People's Republic of China and six other departments jointly issued the Implementation Plan for the Recycling of Industrial Wastewater, proposing that by 2025, strive to achieve a repeat utilization rate of about 94% for industrial water above the scale, further improve the repeat utilization rate of industrial water above the scale in industries such as iron and steel, petrochemicals and chemicals, and non-ferrous, and further improve the repeat utilization rate of industrial water above the scale in industries such as textiles, paper and food compared to 2020 In 2020, the industrial municipal water reclamation rate will be increased by more than 5 percentage points, the water consumption of 10,000 yuan of industrial added value will be reduced by 16% compared with 2020, and a new pattern of efficient recycling of wastewater in major water-using industries will be basically formed. Al [5] though hydrogen energy as an emerging industry has not yet been included in the policy, the investment in pure water preparation equipment will be increased when reuse of water resources is adopted in the future.

Large-Scale Production of Green Hydrogen Consumes a Lot of Water Resources

Theoretically, 9 kg of water can make 1 kg of hydrogen, but the water used is deionized water, when using tap water, it needs to go through the conventional deionized water production process, the overall water production efficiency is about 50%-70%, the actual consumption of tap water for making 1 kg of hydrogen is about 20 kg, and in order to extend the life of water purification equipment In order to prolong the life of water purification equipment, most of the filtered wastewater is treated to the standard and then discharged. For a green hydrogen project with an annual production capacity of more than 10,000 tons, the water consumption of the hydrogen production process alone is more than 200,000 tons. For areas where water resources are scarce, water resources will be an important factor affecting the scale of hydrogen production and the operation of the hydrogen production project under the strict water use system in China. With the total amount of water used in the region remaining unchanged, the layout of green hydrogen projects will inevitably squeeze the water used by other industries, which will, to a certain extent, aggravate the water scarcity or raise the price of water resources.

Hemi Consulting has measured the cost of 100MW of electrolytic water to hydrogen in Europe in 2020, and the cost of hydrogen is 56% for electricity, 38% for capital cost, 5% for electrolyzer operation and 1% for water cost. The assumption of 20 kg of water consumption per kg of hydrogen was chosen, which is basically in line with some market research in China, where 20 kg of water consumption is a relatively conservative figure [6]. As the cost of electrolytic water system decreases and the price of renewable electricity decreases, the overall cost of green hydrogen will decrease, however, the proportion of water cost will increase, and with the increasing scarcity of resources, the proportion of water cost will be further expanded.

For the 31 consecutive [7] renewable energy hydrogen production projects announced in Inner Mongolia Autonomous Region of China since 2021, the cumulative hydrogen production capacity will reach 531.89 million tons/year after all of them are put into operation, which corresponds to the water demand without considering recycled water. The total hydrogen production capacity will reach 531.89 million tons/year after all the projects are put into operation, and the corresponding water demand will be 106.4 million cubic meters, which accounts for 0.54% of the total water consumption in Inner Mongolia. The large-scale hydrogen production projects will definitely have a squeezing effect on the existing industrial and agricultural water in Inner Mongolia Autonomous Region, and it will be difficult to maintain the existing balance of water resources supply in Inner Mongolia in order to maintain normal production and life.

Development Trend of Green Hydrogen in China

The development of green hydrogen will be accompanied by the orderly reduction of production of traditional chemical industry and the market launch. Under the condition of water resources, the new industry and the existing industry are in a zero-sum game, and they are in a state of extinction. Only after the traditional chemical industry gradually withdraws from the market under the pressure of carbon emission reduction and vacates the water resources quota, the green hydrogen industry will have the opportunity to realize large-scale. Therefore, the development of the hydrogen industry in the "three northern" regions of China will be a gradual

development accompanied by carbon emission reduction to the industry pushing back the development, and the large-scale development of the green hydrogen industry in a short period of time will certainly have the problem of uncoordinated development of the industry due to the policy and natural condition constraints and water supply restrictions.

Green hydrogen does not have the same production and use conditions in all regions of China. Although green hydrogen is expected to reduce carbon emissions globally and has many application scenarios, China has a relatively diverse topography with many ecological reserves, with the sea in the east, the desert in the west, and the Qinghai-Tibet Plateau in the southwest, and the whole China is rich in water resources in the south and scarce in the north in terms of the abundance of renewable energy. As a strict environmental protection country, China has strict environmental protection requirements, especially the Yellow River Basin, the main river in the north, is specially protected by special national policies and laws, and there are more strict restrictions on water use in these areas. In addition, the impact of extreme weather on the south of China has also warned about the exploitation of water resources, and the south is also subject to the crisis of less rain and drought or even the drying up of rivers. So when water resources are used, especially for industrial production activities like hydrogen production, which consumes more water, the water resources situation in each region needs to be fully coordinated.

Sea water will be an important resource for green hydrogen production. Offshore wind power and offshore photovoltaic industry are developing in China, and seawater is an inexhaustible water resource with huge space for development, and the combination of offshore wind power and offshore photovoltaic can make good use of the advantages of marine resources. Relying on offshore power generation platform to carry out hydrogen production after purification of seawater or in-situ hydrogen production from seawater will be the direction of hydrogen production with great resource advantages, and it is also important for developing deep-sea resources [8].

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