Practice and Development of the Hydrogen Energy Industry in Shanghai*

EXPERT COMMITTEE OF SHANGHAI ENERGY CONSERVATION COMMISSION

ABSTRACT

With the deepening of China's energy revolution, the goal of "carbon peak and carbon neutrality" is pushed forward, and the new energy and industrial system with the core values of building green, low-carbon, clean, environmental protection, safety and efficiency are advancing steadily. In combination with national policy guidance and support for developing the hydrogen energy industry, relying on its science and technology, good manufacturing technology, and resources, Shanghai has intervened in the hydrogen energy industry. Fuel cell development in the hydrogen energy industry is at the leading level in Shanghai. This paper introduces the basis, technology, development practice characteristics, and experience of the Shanghai hydrogen energy industry and puts forward suggestions and specific measures for its continued development.

Keywords: Eco-civilization, green development, hydrogen energy, industry, revolution

Introduction

With the deepening of China's energy revolution, the goal of "carbon peak and carbon neutrality" is pushed forward, and the new energy system and industrial system with the core values of building green, low-carbon, clean, environmental protection, safety and efficiency are advancing steadily. Hydrogen energy, as a secondary energy source with rich reserves, is of great significance in reducing the proportion of traditional fossil sources, improving the application level of clean energy, optimizing the industrial energy structure, and constructing a safe and reliable energy supply. The development of the hydrogen energy industry aims to promote the strategic transformation of China's energy development and energy utilization models. It is not only the change and transformation of energy in the traditional sense but also the reconstruction of the whole energy structure, energy consumption structure, and industrial structure, alongside socio-economic development and the development of a green, low-carbon society.

Combined with national support and guidance for developing the hydrogen energy industry, Shanghai has intervened in the field of the hydrogen energy industry and fuel cell development. This has creatively promoted the coordinated development of the whole hydrogen energy industry chain, especially in fuel cell development and vehicle

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applications. According to the "Competitiveness ranking of China's hydrogen energy cities" recently released by relevant authorities, Shanghai ranks first in the competitiveness ranking of China's hydrogen energy cities with high competition and development potential. From the perspective of overall development, Shanghai's hydrogen energy industry has the advantages of hydrogen energy resources, first-mover advantage, manufacturing technology, and a combination of university and research activities.

Hydrogen energy, a clean and efficient secondary energy with a wide range of reserves and rich application scenarios, can lead an energy reform and cope with climate change.

Significance of the development of the hydrogen energy industry in Shanghai

The practice and development of the hydrogen energy industry is an important measure to practice ecological civilization

As a clean energy source, hydrogen energy can effectively reduce environmental pollution caused by fossil fuels. The development of the hydrogen energy industry is an important step toward energy conservation, emission reduction, and cross-border ecological civilization. Through the practice and development of the hydrogen energy industry, we can build a diversified energy supply system dominated by clean energy in Shanghai and guide the transportation industry. Deep decarbonization of industry, buildings, and other energy consumption terminals and achieving the goal of "Carbon peak and Carbon neutrality" are important measures to practice President Xi's goal of ecological civilization.

The practice and development of the hydrogen energy industry is an important way to realize energy revolution

Hydrogen energy, a clean, flexible, and efficient secondary energy with a wide range of reserves and rich application scenarios, can lead an energy reform, cope with climate change, and promote the large-scale development of renewable energy in Shanghai. It is the best choice to realize large-scale deep decarbonization in other areas such as transportation and the construction industry. It is also an important way to realize the next energy revolution.

The practice and development of the hydrogen energy industry is an important means to enhance future competitiveness

As the main production base of China's automobile manufacturing, Shanghai is also the pioneer of China's fuel cell vehicle technology research and development industry. The importance of the hydrogen energy industry is comparable to that of today's large aircraft, high-speed rail, and artificial intelligence industries. We should plan for its usage combined with the requirements of Shanghai's transformation and development and take advantage of the opportunity of hydrogen energy development to continuously improve Shanghai's core competitiveness.

The practice and development of the hydrogen energy industry is an important driving force for strengthening green industry

Developing hydrogen energy and fuel cells can expand Shanghai's green and low-carbon industry. Hydrogen has a wide range of applications. It can be used in daily energy consumption, transportation, construction, and many other fields. It can be directly used in production, such as refining and metallurgy, to reduce carbon emissions. Fuel cell technology can also be applied to automobiles, rail, and ships to reduce the dependence of long-

distance and high load transportation on oil and natural gas. It can also be applied to distributed power generation to supply energy for settlements and commercial properties.

As an emerging industry, from production, storage, and transportation to the downstream application of the energy industry chain, hydrogen spans many fields such as energy, materials, and equipment manufacturing, and high-end manufacturing industries involving important materials and key parts. It can effectively drive the transformation and upgrading of traditional industries to create a new green, low-carbon industrial chain.

The practice and development of the hydrogen energy industry is an important direction of international energy cooperation

It has become a trend for the international community to strengthen cooperation and promote the development of the hydrogen energy industry. Shanghai has rich hydrogen energy resources and the first-mover advantage in the hydrogen energy industry. Facing the rapid development momentum of the global hydrogen energy industry and the huge opportunities contained in international cooperation, Shanghai committees should actively participate in the cooperation and management mechanisms of the global hydrogen energy industry. By taking advantage of the favorable opportunity to develop the hydrogen energy industry, Shanghai can establish and strengthen international cooperation mechanisms and grasp the new direction of international energy industry cooperation.

Foundation of the Shanghai hydrogen energy industry

The practice and development of the hydrogen energy industry in Shanghai has a good foundation and conditions, mainly reflected in the following three aspects.

Exterior view of The New SHPT (Shanghai Hydrogen Propulsion Technology) Park. (Zhang Yang / Shanghai)

Hydrogen energy resources are abundant, and the foundation is available

Shanghai is a major refining and chemical production base in China, with rich industrial by-product hydrogen and rich resources for hydrogen production. According to recent statistics, the H_2 capacity of 5 gas companies in Shanghai and 2 by-product enterprises can reach 130 thousand tons per year. Considering that 2kg of hydrogen energy is enough to cover the average daily usage of vehicles (100km), current production can theoretically support 180 thousand fuel cell vehicles for their daily operations.

The first-mover advantage and leading technology

As early as the Tenth Five Year Plan period, Shanghai began to participate in the research and development of national fuel cell vehicles and key equipment and was listed in the "863" project of the Ministry of Science and Technology. With the support of the project, Anting Hydrogenation Station, China's first hydrogen energy station, was built in 2006. At the same time, the independent research and development capacity was enlarged. Breakthroughs were made in such fields as membrane electrode assembly (MEA) technology,

integration of hydrogen energy vehicles, fuel cell technology, high-pressure hydrogen dispensers, hydrogen power units, and the localization rate of hydrogen refueling stations.

Excellent manufacturing capability and rich experience

Shanghai is an innovator in developing and utilizing new energy and a leader in the new energy automobile industry. As a pioneer, the sales volume of fuel cell vehicles in 2020 has reached 1050, ranking first in China. From the "Surpass No. 1" fuel cell vehicle started in 2003 to the large-scale mass production of SAIC Maxus FCV80, Shanghai's fuel cell vehicle technology has always been the leader and highest level of fuel cell vehicle technology in China.

Shanghai has formed a relatively complete hydrogen energy industry chain through the practice of the hydrogen energy industry for many years.

Shanghai also has rich experience in demonstration operations. Since 2003, with the support of GEF/UNDP (Global Environment Facility, The United Nations Development Program), Shanghai has successively participated in phase II and III demonstration projects of "Promoting the commercial development of fuel cell vehicles in China". Additionally, the cumulative demonstration mileage of various fuel cell vehicles has exceeded 20 million km.

The practice of the hydrogen energy industry in Shanghai

At present, Shanghai has formed a relatively complete hydrogen energy industry chain through the promotion and practice of the hydrogen energy industry for many years. The conditions for promotion and application are mature and have gradually radiated to the Yangtze River Delta, driving the regional development of the hydrogen energy industry.

Industrial policy lead development

Guidance of Planning

Shanghai has been paying attention to the development and utilization of the hydrogen energy industry for a long time. As early as the Tenth Five Year Plan period, Shanghai participated in the national "863" plan and focused on the scientific and technological development of hydrogen energy fuel cells.

1) In September 2017, Shanghai took the lead in releasing “Shanghai's fuel cell vehicle development plan” (hereafter referred to as "the plan"). The plan specifies that Shanghai will take the development of fuel cell vehicles as the core in the development and utilization of hydrogen energy to drive the development of the hydrogen energy industry.

The plan puts forward the overall goal of "Establishing a domestic leading and international first-class fuel cell vehicle industrial chain, and building a fuel cell vehicle technology innovation center and industrial base".

The plan also defines the six tasks of building an application-driven development model, planning the construction of hydrogen refueling stations, creating industrial parks, building public service platforms, and implementing major special projects to establish industrial funds for the development of the Shanghai hydrogen energy industry.

2) In May 2019, the “Yangtze River Delta hydrogen corridor construction and development plan” (hereafter referred to as the "development plan") was released. The development plan is based on the development conditions of the hydrogen energy industry in the Yangtze River Delta. The plan will build the Yangtze River Delta hydrogen corridor into a hydrogen infrastructure network internationally to realize the coordinated and balanced development of hydrogen

infrastructure and fuel cell vehicles.

3) In November 2020, the Sixth Committee of the Shanghai Economic and Information Technology Commission jointly issued the implementation plan for the Shanghai fuel cell vehicle industry (the implementation period is 2020-2023). By 2023, the aim is to develop Shanghai's fuel cell vehicle industry to reach "100 stations and 100 billion vehicles". More than 30 hydrogenation stations have been completed and are operating.

In Shanghai, the hydrogenation network is the largest in the country, with an output scale of about 100 billion yuan. There are more than 10000 fuel cell vehicles in Shanghai, and the application scale of hydrogen energy is the greatest in the country. The overall development level of the fuel cell vehicle industry has reached an international level. Key technologies have been mastered independently, innovative products have been introduced to the global market, the hydrogen energy infrastructure has been improved, and the promotion and application scale has expanded significantly.

4) July 2021, the General Office of Shanghai Municipal People's Government has announced the 14th five-year plan for developing the advanced manufacturing industry in Shanghai. The plan aimed:

To focus on the application of hydrogen energy and fuel cells

To realize batch production of key parts such as power electronic stacks, membrane electrodes, and bipolar plates

To achieve an international leading industrial chain

To promote the efficient storage and transportation of hydrogen

To promote the technology research and development of rapid hydrogen filling and multiple safety protection

To accelerate planning of the layout of hydrogen infrastructure.

Improving management and service

Hydrogen energy is an emerging industry that has been developed in recent years, involving many management departments. In recent years, Shanghai has actively explored the construction and improvement of the hydrogen energy industry management system.

Fifteen buses equipped with hydrogen fuel cell systems developed by the Jiading district-based Shanghai Hydrogen Propulsion Technology Co (SHPT) are delivered to three Shanghai bus companies.
(Shanghai Jiading WeChat account, 2022)

The formulation of the layout plan of the Shanghai vehicle hydrogenation station has been made. The construction and operation management measures of fuel cell vehicle hydrogenation stations have been taken. Before the relevant management measures are released, the Shanghai Municipal Commission of Housing and Urban Development and relevant management departments will approve the project to manage hydrogen infrastructure construction on a case by case basis.

To further promote the development of the hydrogen energy industry in Shanghai, relevant administrative departments will further accelerate the construction and layout of hydrogen refueling stations in Shanghai, expand the demonstration operations of fuel cell vehicles, and study a series of supporting policies for the development of fuel cell vehicle industry.

Shanghai Energy Conservation Association cooperated with Shanghai Petrochemical Shenneng group, Xinao Gas, Pujiang Gas, and other 32 enterprises in the Yangtze River Delta. It also initiated the

establishment of the Yangtze River Delta Hydrogen Energy Infrastructure Industry Alliance. The alliance is committed to bringing comprehensive solutions to hydrogen energy infrastructure in the Yangtze River Delta and actively promoting the development of the hydrogen energy industry in the Yangtze River Delta. The alliance's motivation is to establish mutually beneficial resource-sharing relationships in the hydrogen energy industry chain.

In the Tenth Five Year Plan period, a scientific research-driven model was formed, and several national projects were undertaken.

In March 2021, the Shanghai hydrogen energy industry development professional committee, which aims to combine resources from all sectors of society to promote technological progress, commercialization, and large-scale development of the hydrogen energy industry, was officially established. The committee focuses on the goal of "100 stations, 100 billion yuan (in production scale), 10000 vehicles" to develop the fuel cell vehicle industry in Shanghai and promotes a scientific and rational approach. The committee actively participates in the formulation of standards, promotes the commercialization of various technical products, and actively guides the development strategy of the hydrogen energy industry. The committee covers the fields and enterprises related to the hydrogen energy industry's production, storage, and transportation, fuel cell vehicles, and system supporting applications. The first initiative had 66 enterprises as member units.

Development of the Industry

After nearly 20 years of effort, a relatively complete hydrogen energy industry chain has been formed, and the agglomeration effect of the hydrogen energy industry in Shanghai has appeared. The development characteristics of the Shanghai hydrogen energy industry mainly include the following five aspects.

The development of hydrogen energy is qualified, and the technology is advanced

As early as the Tenth Five Year Plan period, a scientific research-driven model was formed, and several national projects were undertaken. The model has shown the advantages of technology accumulation and R & D foundations. During the Eleventh Five Year Plan period, Shanghai formed a demonstrative application model, built infrastructure such as hydrogen refueling stations, and accumulated rich experience in the demonstration operation of hydrogen fuel cell vehicles. During the 13th five year plan, Shanghai's hydrogen energy development route was clearer, and the fuel cell vehicle industry was focused.

Within the efficient production process, the "Surpass No. 1" hydrogen fuel cell vehicle and "SAIC Roewe 950" hydrogen fuel cell passenger vehicle were manufactured in 2003 and 2015, respectively. SAIC started the mass production of the FCV80 in 2017, which is the first fuel cell light passenger vehicle in the world, representing the cutting-edge technology of China's automobile industry, with a total sales volume of 400 vehicles. In 2018, six fuel cell buses manufactured by SAIC Shenwo had been in operation for 100000 km and initially achieved commercialization. The Roewe 950FCV fuel cell car is the first fuel cell passenger car with sales and licensing in China.

Initially forming three industrial clusters and completing the industrial chain

After years of operation, the development of hydrogen fuel cell vehicles in Shanghai formed three industrial clusters: the R & D of hydrogen fuel cell vehicles with Jiading at the center, the manufacturing of hydrogen fuel cell vehicles with Lingang at the center, and the hydrogen energy supply with Jinshan Chemical Zone at the center. These clusters form a relatively complete enterprise covering the whole industrial chain

of hydrogen fuel cell vehicles. At present: 9 hydrogen refueling stations have been built in Shanghai; 23 hydrogen fuel cell industry chains have been formed; 21 hydrogen production industrial centers have been built; 18 hydrogen refueling station industrial centers have been made; 11 hydrogen fuel cell system industrial centers have been established.

Effects of the exemplary initiative

With the support of the international organization GFF/UNDP, the Ministry of Finance, and the Ministry of Science and Technology, Beijing and Shanghai jointly implemented the project "Promoting the commercial development of hydrogen fuel cell vehicles in China". As one of the main exemplary cities, Shanghai used the international demonstration platforms of electric vehicles to carry out the demonstration operations of 86 fuel cell buses, fuel cell passenger vehicles, and fuel cell commuter vehicles, including 6 fuel cell city buses purchased with GEF funds. So far, many sales in Shanghai have occurred. A total of 1500 hydrogen fuel cell vehicles have been demonstrated and operated, including 1445 fuel cell vehicles connected to the Shanghai New Energy Vehicle Data Acquisition, Monitoring and Research Center platform. Fuel cell buses and passenger vehicles have started to operate in succession. The demonstration operation of postal vehicles and van logistics vehicles has nearly 20 million km of total operating mileage.

Speeding up the construction of hydrogen refueling stations

Shanghai Anting hydrogen refueling station began operation in July 2009. It is the first hydrogen refueling station in Shanghai. Shanghai has built 9 hydrogenation stations, 5 in Jiading District, 3 in Fengxian District, and 1 in Baoshan District. In 2020, stations served fuel cell vehicles 55000 times, with 300,000 kg of hydrogen. By 2025, 78 hydrogen refueling stations are planned. In addition to the completed stations, 69 more will be built.

aoshan Iron & Steel Co, a core enterprise of Shanghai-based China Baowu Steel Group Corp, has made great efforts to turn its Baoshan base into a model of low-carbon development. (Liu Ming / China Daily)

Promoting the construction of a "hydrogen high-speed network" in the Yangtze River Delta

In 2017, Shanghai established an investment, construction, and operation platform for hydrogen energy infrastructure to build a "Hydrogenation station corridor around Shanghai" within three to five years. This platform was established by the investments of Shanghai Shunhua New Energy System Co. Ltd., Linde Gas (Hong Kong) Co. Ltd., Shanghai Yidong Automobile Service Co. Ltd., and Shanghai Jianwan Investment Co. Ltd. In April 2018, the "Yangtze River Delta hydrogen corridor construction and development plan" was officially launched in Jiading, Shanghai, and the construction of a "hydrogen high-speed network" with Shanghai, Suzhou, Nantong, Rugao and Yancheng as the centers was put on the agenda.

The practice of the industry

Using the industrial advantages

Thanks to the existing initiative advantages of the Shanghai hydrogen fuel cell industry in enterprise projects and R & D, the commercial promotions of the industry are improving. Shanghai has preliminarily possessed relatively complete industrial elements

such as hydrogen energy, hydrogen fuel cell, fuel cell vehicles, and infrastructure.

1) Enterprise advantages

Many powerful enterprises related to the hydrogen energy fuel cell industry chain have emerged in Shanghai, providing important resources and good conditions for developing the hydrogen energy and fuel cell industry.

Shanghai also pays great attention to exploring other application fields of hydrogen energy.

2) Project advantages

On February 12, 2018, Shanghai's first hydrogen energy and fuel cell industrial park was unveiled in the "Huantongji Chuangzhi City" located in Anting, Jiading. According to the plan, the output value of the industrial park will strive to exceed 10 billion yuan by 2025. Shanghai Hydrogen Fuel Cell Vehicle Powertrain Co., Ltd. and other energy research institutions and related enterprises have signed contracts to settle in the park. 12 enterprises have signed strategic cooperation agreements as well.

3) R&D advantages

We're taking advantage of the scientific research technology and professional talents of Shanghai universities to carry out the combination of production, learning, and research to form a joint force to promote the development of the hydrogen energy industry and accelerate technological progress. The new energy vehicle engineering center of Tongji University (hereafter referred to as the center), which is the national fuel cell and power system engineering technology research center of the Ministry of Science and Technology, undertakes the work of the Liaison Office on the international hydrogen energy economy and fuel cell partnership programs. The fuel cell research institute of Shanghai Jiaotong University is the first professional fuel cell research institution established by colleges and universities in China. It has successfully carried out research with enterprises in molten carbonate fuel cells, proton-exchange membrane fuel cells, and solid oxide fuel cell systems.

Improving the supporting policies

The recent focus is on introduction projects, enterprise cultivation, and scientific and technological innovation of the hydrogen energy industry. It is planned to further improve various supporting policies in terms of financial support and industrial support and introduce relevant support measures, including the whole link from enterprise registration to project implementation and later development to cover the whole industrial chain of fuel cell vehicles.

1) Enlarging the agglomeration of the industry

New large-scale domestic and foreign-funded projects will be rewarded.

2) Optimal financial support

The optimal financial support policies are very important to developing the hydrogen energy industry and guiding the development foundation for hydrogen fuel cell vehicles.

3) Expanding the scope of the support

In developing the hydrogen energy industry, we should further expand the scope of support. For example, subsidies can be obtained to construct hydrogen refueling stations to speed up the construction of hydrogen energy infrastructure.

4) Covering the industrial fields

The first batch of advanced oil and hydrogen joint construction station plans and other projects in the Yangtze River Delta have been signed, covering six fields, including the vehicle and parts industry, an industry-university research platform, demonstration operations, and data acquisition.

Expansion of application field

In addition to focusing on hydrogen fuel cell vehicles, Shanghai also pays great attention to exploring other application fields of hydrogen energy.

1) Popularization of standby power supply with hydrogen fuel cell

According to statistics, among about 12000 base stations in Shanghai, more than 100 base stations have adopted hydrogen fuel cells as backup power supply.

2) Hydrogen fuel cell distributed generation

Besides their studies and exploration, relevant enterprises and institutions have also carried out demonstration projects. For example, Shanghai Shunhua New Energy System Co., Ltd. and Tongji University have built a hydrogen fuel cell to provide part of the power and heat (cooling) capacity for the building of the Automotive Faculty of Tongji University.

Relevant enterprises and scientific research institutes in Shanghai are actively doing research. There are studies about applying portable fuel cells in ocean freight shipping, urban rail transportation, mobile phones, and laptops. As for the development of hydrogen energy storage methods, relevant scientific research institutes are carrying out feasibility exploration considering the characteristics of Shanghai's energy supply development.

Practical characteristics of the hydrogen energy industry in Shanghai

Market development enters the industrial period

After more than ten years of effort, Shanghai has mastered fuel cell stack technology and its key components, core technologies (such as power generating systems), and vehicle integration. Various demonstration projects of hydrogen energy development and utilization have also gained preliminary experience and have formed a relatively complete market industrial system, including evaluation and certification institutions, demonstration operators, and hydrogen energy infrastructure construction enterprises. The whole market development of hydrogen energy development and utilization has entered the industrial period.

A hydrogen racing car displayed at the 4th China International Import Expo (CIIE) in Shanghai. (Meng Tao / Xinhua, 2021)

Application of technology enters a new period

Shanghai attaches great importance to the leading role of scientific, technological innovation in developing the hydrogen energy industry. Shanghai actively promotes the construction of new R & D institutions, strengthens public relations in key areas, introduces high-level innovative talents and teams in hydrogen energy, and cooperates with universities and enterprises. These efforts have injected vitality into the industrialization of hydrogen energy development and utilization.

At present, the fuel cell lifetime of passenger cars has exceeded 5000 hours, and the lifetime of commercial vehicles has exceeded 10000 hours, which meets standard vehicle operating conditions. The engine power density of hydrogen fuel cell vehicles has reached the level of the traditional internal combustion engine, the power of electric stacks has reached 3.0 kW/l (kilowatt per litre), and the power covers 30 ~ 150 kW. Many performance indexes are close to the international advanced level. Based on 70 MPa hydrogen storage and hydrogenation technology, the driving range of hydrogen fuel cell vehicles has reached 750 km. The starting temperature of hydrogen fuel cells has reached - 30 C. The overall application range of vehicles has reached the level of traditional vehicles, and the key technology has entered the upgrading period.

Diversity period in investments methods

Energy enterprises, automobile enterprises, and scientific research institutions have entered the field of hydrogen energy development and utilization to create competitiveness in the hydrogen energy industry. They each rely on their capabilities such as traditional business investment, design, innovation, and construction capabilities to carry out business extensions and innovation. They cooperate with strategic partners and projects through diversified investment, obtain the strategic resources required for development, accelerate the transformation and development of enterprises, and realize the integration and optimization of funds, resources and business required to develop the hydrogen energy industry.

By 2025, Shanghai will build several comprehensive hydrogen energy industrial parks to carry out hydrogen energy operations.

The active participation of private enterprises and social funds, especially the state-owned comprehensive energy group companies, has stabilized the development expectation of the hydrogen energy industry, enhanced the confidence in its development, and strengthened consensus.

The business models have entered a period of innovation

During the market introduction period of hydrogen energy development, Shanghai has vigorously guided the construction of hydrogen energy infrastructure and hydrogen energy vehicles to create a good environment for the market-oriented and commercial development of the whole industrial chain of hydrogen energy. Hydrogen energy commercial operations have entered a period of innovation.

The methods include; using the "UNDP" project to promote the commercial development of hydrogen fuel cell vehicles; using "Leasing + TCO + TC" to enlarge the service scale and reduce costs; providing complete services for users, promoting commercial operations; exploring diversified application methods.

Qingpu Industrial Park will demonstrate the operation of hydrogen energy vehicles. By expanding into diversified application fields, we are exploring new business models, providing a large-scale market for the hydrogen energy industry.

Suggestions for the development of the hydrogen energy industry in Shanghai

Development requirements

Considering the overall requirements of Shanghai's development and the objective of "carbon peak and carbon neutrality", we will adhere to an innovative, green, open, and shared development concept, establish a scientific outlook on energy development, and progress towards the goal of building a green, low-carbon energy supply system. We should make full use of the existing hydrogen energy resources and the industrial foundation in Shanghai. We will arrange the development of different links in the hydrogen energy industry scientifically, strive to build a whole industrial chain cluster, build a high-quality hydrogen energy industry ecosystem in the Yangtze River Delta, and make Shanghai a capital of the hydrogen energy industry with global influence.

Development principles

1) Adhering to market orientation and government guidance

Considering the decisive role of the market, we will clarify the positioning and development direction, issue corresponding support policies, and gradually cultivate the hydrogen energy development and utilization market. In this process, we will give roles to the enterprises in all links of the hydrogen energy industry and form a hydrogen energy market dominated by market

development and guided by government policies.

2) Adhering to overall planning and orderly development

We should coordinate the resources of the hydrogen energy industry, clarify the main areas of hydrogen energy industry development, optimize the planning and layout of industrial clusters, and manage the development holistically.

3) Adhering to innovation-driven cooperation and opening-up

While establishing and improving the innovation system of the hydrogen energy industry, we will promote collaborative research platforms, strengthen cooperation and exchange, and stimulate the innovation vitality of different fields within the industry.

4) Adhering to the law and adjusting measures to local conditions

We should attach importance to the objective law of the development of the hydrogen energy industry, formulate development goals at different stages, consider both the development phase and the basic conditions of development, and guide the continuous healthy industrial development.

Development goals

The development of the hydrogen energy industry in Shanghai implements the "two-step" strategy. The first step is to complete the layout of the hydrogen energy industry chain by 2025. This step includes forming a regional industrial cluster covering the hydrogen energy industry chain, making breakthroughs in key core technologies, reaching an international standard, building a reliable hydrogen energy industry infrastructure and application network in key development areas, and forming an output value of 100 billion yuan. The second step is to develop the hydrogen energy industry into a major energy industry in Shanghai by 2030. The industrial chain cluster will influence all industrial chain links and the key core technologies. We plan to establish a complete infrastructure network for the hydrogen energy industry in the whole city, expand the scope of application, and radiate the Yangtze River Delta hydrogen energy development model.

A technician works at the fuel cell test area at the hydrogen energy technology center of Great Wall Motor (GWM).

1) Breakthrough in hydrogen energy industry technology

By 2025, many national innovative R & D platforms for the hydrogen energy industry will be formed. The technical level of all links in the hydrogen energy industry, especially fuel cell vehicles, will reach international standards. By 2030, some gaps in cutting-edge technologies in the hydrogen energy industry are planned to be filled. The hydrogen energy technology application, power generation, energy storage, and energy supply distribution in aerospace and other fields will be expanded.

2) Forming the development foundation of the hydrogen energy industry

By 2025, several hydrogen energy industrial policies, industrial norms, and standards will be formulated. The industrial policy system will be formed and improved, and the industrial supervision methods will be established. The standard system for all links of the hydrogen energy industry will be constitutively enhanced and covered. By 2030, Shanghai will improve the hydrogen energy industry policies, industry standards, and regulatory system and complete the development system of the hydrogen energy industry.

3) Remarkable achievements have been made in the cultivation of hydrogen energy enterprises

By 2025, Shanghai will build several comprehensive hydrogen energy industrial parks to carry out hydrogen energy operations, introduce and establish enterprises, and provide sources for storage, transportation, and

manufacturing of key equipment such as fuel cells and other industrial chain applications. By 2030, many influential hydrogen energy industry enterprises in China and abroad will be cultivated in all hydrogen energy industry chain links.

By 2025, a complete network of hydrogen refueling stations and supporting facilities will be established in Shanghai.

4) The market of the hydrogen energy industry continues to expand

By 2025, a complete network of hydrogen refueling stations and supporting facilities will be established in Shanghai. There will be mass launches of regional public transport vehicles, official vehicles, commercial logistics, and other fields, contributing to the exploration, industrialization, and commercialization of hydrogen energy, hydrogen standby power supply systems, and hydrogen power generation. By 2030, Shanghai will become a fuel cell vehicle application city with international influence. Its overall technology will be synchronized with international standards, and some technologies will be ahead of the international standards. The field of hydrogen energy will be expanded to the civil consumption market, and the hydrogenation distributed energy system will be popularized and applied. It is planned to diversify the application of the national hydrogen energy industry, radiate the Yangtze River Delta model to the whole country, and guide the transformation of energy in the future.

Specific measures for the development of the hydrogen energy industry

Institutions

At present, industrial by-product hydrogen is the main resource for developing the hydrogen energy industry in Shanghai. However, with the development of the hydrogen energy industry, hydrogen demand has increased greatly. Therefore, it is necessary to promote construction of hydrogen production market systems and hydrogen energy systems. In the near future, hydrogen, the main industrial by-product, will be used as the main resource of hydrogen energy production. Carbon-free production will be realized in later development by relying on clean and renewable energies. We can first pilot the manufacturing of green hydrogen from renewable resources such as waste heat (cooling) and wind in the demonstration projects and pilot the comprehensive utilization of Yangshan LNG cold energy in Lingang to expand the manufacturing capacity of green hydrogen in Shanghai. This can form green and clean development in the whole life cycle, from "ash and hydrogen" to "blue hydrogen", and finally to "green hydrogen".

Storage and transportation

It is necessary to increase the research on liquid hydrogen materials and improve the localization level of gas storage and cylinders, liquid hydrogen cones, and other equipment. We should continuously improve the efficiency and safety of hydrogen storage and transportation and promote a formation of a complete hydrogen storage and transportation standard. We should encourage research on solid hydrogen storage and hydrogen gas pipeline transportation. In the near future, the container and long tube trailer will still be the main method of storage and transportation. In later development, a transportation network based on liquid stations, solid-state storage/transportation, and pipeline hydrogen transportation will be gradually formed to reduce costs, expand applications, and improve efficiency.

Hydrogenation stations

We will clarify the competent departments of hydrogen refueling stations and related infrastructure,

The commissioning ceremony of the New Hydrogen Technology Park (SHPT). (Information Office of Jiading District, 2021)

and strengthen planning management. We will take demand as a guide, integrate resources, allocate reasonably, pay attention to the market-oriented expansion of the hydrogen infrastructure network, and improve the strength and accuracy of financial support. We should accelerate the construction and popularization of hydrogen refueling stations and reduce their construction and operation costs. In the forthcoming period, we should accelerate the construction of hydrogenation infrastructure, take the formation of a hydrogenation network in the Yangtze River Delta as a goal, and apply it to the needs of the development of the hydrogen energy industry in Shanghai.

Hydrogen fuel cell

The power density of domestic key components, such as membranes and fuel cells, is continuously improving. In later development, we will integrate the production and R & D forces of fuel cells, cultivate enterprises that integrate production, and accelerate technological progress. We will consolidate the foundation of Shanghai's independent core technology of fuel cells, support development, and maintain Shanghai's leading position in the fuel cell industry.

Hydrogen fuel cell vehicles

We will focus on developing hydrogen passenger cars, logistic trucks, official vehicles, urban sanitation vehicles, and other specific vehicles. Later, we will focus on the development of ordinary passenger vehicles and the utilization of hydrogen fuel cells in rail transits, shipping vehicles, aerospace, and other fields. We will support the fuel cell vehicles in terms of policies such as right of way and reduced license costs to popularize the usage of fuel cell vehicles.

Expanding the field of hydrogen energy development and utilization

The emerging industrial changes that can respond to Shanghai's development are as follows: scientific development of the energy industry, efficient energy utilization, the transformation of energy structure, adjustments in industrial structure, energy conservation and emission reduction, and improvement of modern energy supply systems. In later development, Shanghai will make full use of the advantages and characteristics of hydrogen energy and continuously expand the application fields of hydrogen energy. We will enhance the peak shaving capacity of urban energy supplies, improve the quality and safety of urban energy supplies, and integrate them into the energy supply system of the whole city.