

# Exploration of the Development Path of the Hydrogen Fuel Cell Vehicle Industry Chain and Research on Industrial Chain Security Early Warning Mechanism under the Background of Hainan Free Trade Port Construction

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## Abstract

As the largest free trade port in China, Hainan Province shoulders the strategic positioning of "three zones and one center" and has been playing an important role as a pioneer and practitioner in the development of new energy vehicles, being the first region in China to propose goals for clean energy in all sub-sectors of the automotive industry. The "Development Plan for Clean Energy Vehicles in Hainan Province," implemented in March 2019, identifies fuel cell vehicles as one of the important directions for the development of new energy vehicles, clearly stating the tasks and measures to advance the development of fuel cell vehicles, accelerate research on the fuel cell vehicle industry, actively apply for national fuel cell vehicle pilot demonstrations, and provide leading experience in overcoming constraints on hydrogen energy and fuel cell vehicle development in the country. This study focuses on the fuel cell vehicle industry chain and supply chain security, revolving around pilot applications and industrial layout, scientifically proposing the key path for the development of the fuel cell vehicle industry in Hainan Province, and providing feasible policy recommendations from both financial and non-financial aspects.

## Keywords

Fuel Cell; Stack; Bipolar Plate; Membrane Electrode.

## 1. Introduction

"The Guiding Opinions of the Central Committee of the Communist Party of China and the State Council on Supporting Hainan in Deepening Reform and Opening Up" (April 13, 2018) proposes promoting the transformation of existing manufacturing industries towards intelligence, greenness, and service-orientedness, and accelerating the construction of a green industrial system. It aims to reduce the consumption of coal and other fossil fuels and expedite the establishment of a safe, green, efficient, and intensive clean energy supply system. "The Recommendations of the Communist Party of China Hainan Provincial Committee on Formulating the Fourteenth Five-Year Plan for National Economic and Social Development and the Vision for 2035" puts forward the goal of building a clean energy island, vigorously advancing the green and low-carbon transformation of industries, energy, and transportation structures, and significantly increasing the proportion of renewable energy.

Hydrogen energy is an important carrier for green energy transformation and a priority choice for achieving deep decarbonization in transportation, industry, and construction sectors. Hydrogen fuel cell vehicles serve as a crucial application downstream of hydrogen energy. Through demonstration and application in Hainan Free Trade Port, on the one hand, it will contribute to achieving the goal of a comprehensive ban on the sale of fuel vehicles by 2030 in Hainan. On the other hand, by promoting widespread adoption, it will drive industrial

development and contribute to the high-quality growth of Hainan Free Trade Port. This article combines the current status and existing issues of the hydrogen fuel cell vehicle industry in Hainan to further explore the development path of hydrogen fuel cell vehicles.

## **2. Current Development Status of National Fuel Cell Vehicle Demonstration City Clusters**

### **2.1. Top-level Design is Launched with Clear Direction and Objectives**

In March 2022, the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) jointly released the "Medium- and Long-Term Development Plan for the Hydrogen Energy Industry (2021-2035)". It is China's first medium- and long-term plan for the hydrogen energy industry and the first to explicitly define the significant role of hydrogen energy in the national energy system. The plan sets a specific target for the promotion of hydrogen fuel cell vehicles, aiming to have approximately 50,000 vehicles in operation by 2025. As of the end of 2022, China had a total of 13,249 hydrogen fuel cell vehicles, making it the world's largest hydrogen production country and the leading market for fuel cell commercial vehicles.

### **2.2. Incentive policies are Implemented, and Demonstration and Promotion have Begun**

In September 2020, five ministries and commissions jointly issued the "Notice on Carrying out Demonstration Applications of Fuel Cell Vehicles", approving five major demonstration city clusters including Beijing-Tianjin-Hebei, Shanghai, Guangdong, Henan, and Hebei in two batches. The notice introduced a point-based reward system to replace vehicle purchase subsidies, significantly increasing financial support. According to relevant statistics from China Automotive Technology and Research Center (CATARC), during the first demonstration year (August 2021 to August 2022), the cumulative number of registered hydrogen fuel cell vehicles in the demonstration city clusters reached 2,590, achieving an overall completion rate of approximately 7.9%. This has driven the implementation of a batch of projects, including "Eight Core Components" such as fuel cell stacks, membrane electrodes, bipolar plates, proton exchange membranes, catalysts, carbon papers, air compressors, and hydrogen circulation systems.

### **2.3. Ensuring and Supplying Hydrogen Energy has Become a Common Issue Faced by the Demonstration Application City Clusters**

By the end of 2022, a total of 274 hydrogen refueling stations have been built and put into operation in China. However, based on the current layout of the refueling station network, the conditions necessary to support large-scale demonstration operations of fuel cell vehicles are still not in place. Developing a comprehensive plan for refueling station construction and effectively addressing issues such as site selection, safety inspections, key equipment supply, and acceptance are crucial tasks and key challenges faced by the five major demonstration city clusters.

### **2.4. Due to Technological and Cost Constraints, Hydrogen Fuel Cell Vehicles are Currently Difficult to Achieve Commercial Operation**

From the perspective of hydrogen production and supply, a low-carbon, low-cost hydrogen production structure has yet to be established. The transportation of hydrogen primarily relies on high-pressure gas transportation through long tubes and trailers. Transportation costs are highly sensitive to distance, and when combined with the amortization of refueling station construction costs, this leads to high hydrogen refueling prices. In terms of the operating costs of hydrogen fuel cell vehicles, the cost of fuel cell stacks accounts for over 50% of the total

vehicle cost. According to statistics from the China Automotive Engineering Research Institute, the average cost of fuel cell systems and fuel cell stacks in China in 2021 was approximately 4.4 thousand RMB/kW and 2.6 thousand RMB/kW, respectively. This represents a decrease of 10.6 thousand RMB/kW and 7.5 thousand RMB/kW, respectively, compared to 2017. In contrast, the average cost in countries such as the United States and the European Union is approximately 1.3 thousand RMB/kW and 0.9 thousand RMB/kW, respectively. Additionally, significant breakthroughs in key technical parameters have yet to be achieved. As a result, the era of large-scale deployment and widespread application of hydrogen fuel cell vehicles has not yet arrived.

### **3. The Conditions for Promoting Hydrogen Fuel Cell Vehicles and Developing Related Industries in Hainan Province, as Well as the Challenges Faced**

#### **3.1. Basic Conditions**

##### **3.1.1. The Top-level Planning and Design for the Development of the Hydrogen Energy Industry have been Initiated**

In May 2021, the Provincial Development and Reform Commission, in collaboration with industry research institutions, initiated the compilation of the "Hainan Province Hydrogen Energy Industry Development Plan." Regarding hydrogen fuel cell vehicles, preliminary plans have been made to promote long-term, large-scale application through pilot demonstrations in specific scenarios, and to further advance the development path of the industry chain through market-driven growth and sequential layout.

##### **3.1.2. The Hydrogen Supply Capacity for Hydrogen Fuel Cell Vehicles has Initially been Established**

Hydrogen production enterprises in Hainan are mainly located in Yangpu and Dongfang, focusing on industrial by-product hydrogen (gray hydrogen). The filling facility project constructed by Kaimeite Gas was completed in April 2021, with a high-purity hydrogen production capacity of 4 tons per day, which can meet the hydrogen demand of 8 hydrogen refueling stations. With the increase in the installation capacity of new energy sources such as offshore wind power and photovoltaics in Hainan Province in the future, the use of "green hydrogen" will become a highlight of the pilot demonstration of hydrogen fuel cell vehicles in Hainan Province. For example, during the 14th Five-Year Plan period, Hainan plans to construct 12.3 million kilowatts of offshore wind power projects. In May 2022, the Provincial Department of Industry and Information Technology organized the first "Special Work Day for Wind Power Equipment Industry" and issued the implementation plan for the "Hainan Province Wind Power Equipment Industry Development Plan (2022-2025)," aiming to strive for the formation of a wind power equipment industry cluster in Hainan by 2025, with a total output value of 55 billion yuan throughout the entire industry chain, and aiming to form a billion-yuan industry cluster during the 15th Five-Year Plan.

##### **3.1.3. Demonstration Applications of Fuel Cell Commercial Vehicles have been Conducted Within the Province**

During the Boao Forum for Asia in April 2021, State Power Investment Corporation Limited provided 10 hydrogen fuel cell buses manufactured by Zhejiang Electric Vehicle Company for guest transportation. These buses served as effective demonstration applications and helped to establish the initial approval process for hydrogen refueling station construction in Hainan Province. Valuable experience was gained in terms of commercial operation.

### **3.1.4. Haima Automobile is Accelerating the Research and Development of Fuel Cell Products, While Sinopec is Expediting the Layout of Hydrogen Refueling Stations**

Haima Automobile and Toyota have established a deep collaboration, with the completion of prototype vehicle development. They will introduce hydrogen fuel cell vehicles equipped with Toyota's second-generation MIRAI production vehicle fuel cell stack. Additionally, they have constructed a combined photovoltaic hydrogen production and high-pressure hydrogen refueling station. It is expected that gradual commercial operation will commence in 2024. Sinopec Hainan Branch has built four hydrogen refueling stations in Haikou, Sanya, Danzhou, and Qionghai, laying the foundation for fuel cell vehicle operation around the island.

### **3.1.5. Empowered by the Policies of the Free Trade Port, it Enjoys Advantages**

The Free Trade Port provides a superior business environment for industrial development, benefiting from policies such as duty-free processing and value-added, zero tariffs on production equipment, and preferential personal income tax. In addition, "Investment and operation of direct power supply, energy storage, hydrogen energy, and LNG transfer stations" is included in the newly added encouraged category in the Hainan Free Trade Port, eligible for a 15% preferential enterprise income tax, which is currently not available in other regions of China. "Carrier catalysts with precious metals and their compounds as active substances" are included in the second batch of duty-free raw materials list in the Hainan Free Trade Port, allowing imported platinum catalysts for fuel cells to be exempt from import duties and value-added tax when used in products sold within the island.

## **3.2. Challenges**

### **3.2.1. The Normalization of Demonstration Operations is Still in a Blank State**

Although Hainan Province has already established hydrogen-related industries such as natural gas reforming for hydrogen production and Kemet hydrogen purification, the entire hydrogen supply chain, including production, storage, transportation, and utilization, has not been fully established. Additionally, the high cost of hydrogen and the lack of clear policy support have posed challenges. After the completion of the hydrogen vehicle pilot project during the Boao Forum for Asia in 2021, the vehicles and mobile hydrogen refueling stations were gradually withdrawn from Hainan. As a result, the pilot mode for promoting hydrogen fuel cell vehicles through regular demonstration operations is still in a blank state in Hainan Province.

### **3.2.2. Hainan Province has Limited Subsidy Efforts for Hydrogen Fuel Cell Vehicle Applications**

The application of hydrogen fuel cell vehicles is still in the stage of financial subsidy cultivation. Apart from the support from national special financial funds, various demonstration city clusters have successively introduced implementation plans. For example, cities like Shanghai and Guangdong have provided matching subsidies on a 1:1 basis. Hainan Province is not included in the demonstration city clusters, thus unable to receive central financial subsidies, and the provincial-level support policies remain unclear, which presents certain difficulties in promoting pilot demonstration projects.

### **3.2.3. The Division of Responsibilities for the Operation Approval of Hydrogen Refueling Stations is not Clear**

Based on the research conducted, there is a common issue of unclear division of responsibilities in the operational approval process for hydrogen refueling stations in Hainan Province, which has resulted in delays in their commercial operation. Additionally, hydrogen gas still retains its hazardous chemical property, and large-scale hydrogen production facilities are required to be located within chemical industrial parks. This limitation hinders the selection of integrated hydrogen production and refueling station sites.

## 4. Relevant Recommendations

### 4.1. Issue the "Hainan Province Hydrogen Energy Industry Development Plan" as Soon as Possible

It is recommended to expedite the formulation of a top-level plan and development roadmap for the hydrogen energy industry, establish a policy environment for hydrogen energy development, promote the coordinated construction and development of hydrogen energy demonstration zones and industrial bases, and systematically advance the infrastructure construction of hydrogen refueling stations.

### 4.2. Concentrate financial Resources on Introducing Several High-profile Projects in 1-2 Demonstration Areas to establish a Complete Hydrogen Value Chain Encompassing Production, Storage, Transportation, and Utilization

In the initial stage, it is recommended to focus primarily on two major areas: port logistics and public transportation. This includes projects such as hydrogen-powered forklifts, container tractors, warehouse forklifts, logistics vehicles, waste transfer vehicles, sprinkler trucks, and buses. In the long term, projects can be expanded to include areas such as ships and distributed power stations. It is advised to refer to relevant subsidy policies in mainland China and concentrate financial resources on implementing several high-profile projects, thus establishing a complete hydrogen value chain.

### 4.3. Coordinate and Organize the City's Application Scenario Resources and Effectively Leverage Them for Investment Attraction in Various Application Scenarios

Comprehensively coordinate the application scenario resources throughout the province, conduct holistic planning, and establish government-led procurement plans to attract investment by leveraging the market in exchange for industrial development.

### 4.4. Clearly Define the Focus of Investment Attraction, Emphasizing the Importance of Capturing Opportunities at Both Ends of the Spectrum to Drive Growth in the Middle

Based on the upstream, gradually promote the establishment of a clean, low-carbon, and low-cost diversified hydrogen production system. In the initial stage, focus on establishing a hydrogen supply system centered around the hydrogen resources of Yangpu Petrochemical Industry and the utilization of renewable energy for hydrogen production in the Zero Carbon Industry Park. Attract companies engaged in hydrogen purification and electrolysis for hydrogen production, and promote the integration of renewable energy-based hydrogen production, hydrogen storage, and hydrogen refueling stations within the Zero Carbon Industry Park. In the long term, capitalize on the operation of offshore wind power to attract companies for wind-powered hydrogen production demonstrations. Open up the downstream of the industrial chain by exchanging demonstration projects for the establishment of fuel cell vehicle assembly projects, including forklifts, buses, trucks, and municipal vehicles. Promote the middle section of the industrial chain to drive the development of fuel cell system testing, design, assembly, and research industries, effectively filling the gap in R&D and manufacturing of hydrogen fuel cell terminals in Hainan. Strengthen talent cultivation in this field. Utilize Hainan International Design Island as a platform to attract the construction of hydrogen and fuel cell laboratories, including durability and performance testing of fuel cell stacks. Import testing equipment can be exempted from tariffs. Utilize the tariff exemption policy for processing and value-added activities to attract domestic system manufacturers and hydrogen

refueling equipment companies that primarily rely on imported fuel cell stacks to establish assembly operations. For example, the tariff for "fuel cells" is 10% and for "fuel cell boosters" is 5%. Attract the establishment of membrane electrode production capabilities, with a tariff of 5% for "carbon electrode sheets for fuel cells," among others.

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