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Promotion Status of Hydrogen Fuel Cell Vehicles and Typical Scenario Evaluation in China

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Abstract: *The study evaluates the progress of China's hydrogen energy industry from five dimensions: policy, technology, market, industrial chain, and hydrogen supply. It comprehensively reviews the current typical application scenarios of the industry and establishes an evaluation model to analyse advantageous scenarios for the large-scale deployment of hydrogen fuel cell vehicles. The research results show that China's fuel cell vehicle industry is currently in an adjustment phase during its promotion period, and fuel cell vehicles preliminarily formed the application demonstration effect in specific scenarios such as short-distance cargo, construction waste transportation and cold chain logistics, which demonstrate considerable market development potential.*

Keywords: *Hydrogen Energy, Fuel Cell Vehicle, Application Scenarios, Industrial Progress, Application Evaluation*

1. Introduction

Hydrogen fuel cell vehicle (FCV) is an important technical development direction of China's automobile industry, and an important technical support for achieving the carbon peak and carbon neutralization strategic objectives in the transportation field [1-6]. Driven by the policy of urban demonstration city cluster in China, the fuel cell automobile industry develops rapidly and the promotion scale is significantly improved [7-11]. Relevant vehicles are applied in diversified scenarios such as traction transportation, cold chain logistics, municipal sanitation, public transport and passenger transport, and e-hailing, thereby accumulating valuable experience in demonstration and promotion [12-16].

The purpose of this research is to fully summarize the progress of the hydrogen fuel cell automobile industry, strengthen the evaluation and selection of superior application scenarios, analyze the best practice cases and typical models, and accelerate the replication of practical experience to the whole industry. The research evaluates the progress of China's hydrogen energy industry from the five dimensions of policy, technology, market, industry chain and hydrogen energy supply, comprehensively clarifies the typical application scenarios of the current industry, establishes a set of evaluation models, and carries out the evaluation and analysis on the advantage scenarios of large-scale application of hydrogen fuel cell vehicles.

2. Overview of Industrial Development

Over 90 organizations and more than 130 industry experts from the upstream and downstream of the industrial chain have conducted comprehensive evaluation and scoring from five dimensions such as policy, technology and market. The results show that the overall fuel cell automobile industry is in the adjustment phase of promotion period (see Figure 1).

The details are as follows: 1) The top-level planning clearly leads the development direction, and some management policies still need to be improved; 2)Complete vehicle products are basically ready, while core materials and components still require intensified research and development; 3) The industrial chain is essentially complete, and the market structure and supply level are in the initial stage; 4) Significant progress has been made in hydrogen refueling station construction, yet supply stability and economic viability urgently require enhancement; 5) Market development is in the initial stage, and business mode exploration and application measures shall be strengthened.

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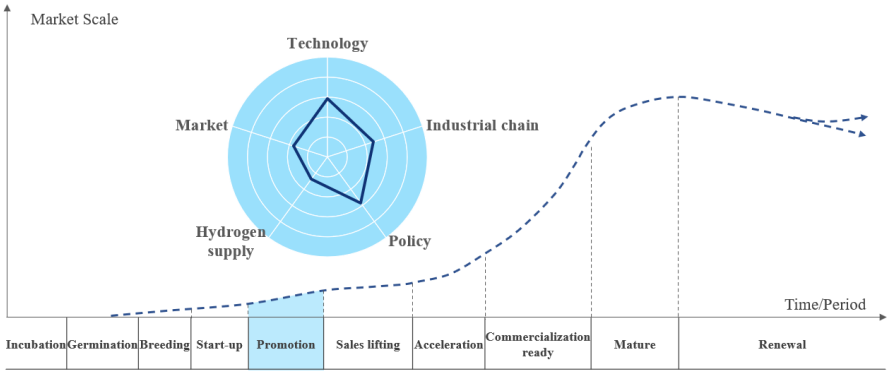

Figure 1: Overall readiness for commercialization of the hydrogen fuel cell vehicle industry.

3. Typical Scenario Analysis

Focusing on major demonstration regions and cities including Beijing-Tianjin-Hebei, Shanghai, Guangdong, Hebei, Henan, Shandong, and Chongqing, the study categorizes 10 typical application scenarios of hydrogen fuel cell vehicles based on different usage contexts. These are organized according to operational area, transportation type, operational route, delivery/operation content, and main vehicle models, which are municipal sanitation, construction waste transportation, concrete mixing, general logistics, cold chain logistics, long-haul trunk logistics, short-distance cargo, bus transportation, highway passenger transport, and ride-hailing services. Detailed information is presented in Table 1.

Table 1: Summary of typical application scenarios for hydrogen fuel cell vehicles.

S/N	Scenario	Area	Type	Route	Cargo/Operation Content	Vehicle Type
1	Municipal sanitation	Urban	Freight	Fixed area/route	Garbage collection and transportation.	Van-type garbage truck, dump garbage truck, compactor garbage truck, sealed barrel garbage truck, etc.
					Sweeping, high-pressure cleaning, dust suppression, etc.	Sweeping vehicle, cleaning vehicle, road maintenance vehicle, sprinkler vehicle, etc.
2	Construction waste transportation	Urban	Freight	Fixed route	Transport of raw materials required for urban infrastructure,	Dump truck
3	Concrete mixing	Urban	Freight	Fixed route	Loading, transporting, and unloading of concrete slurry	Tank mixer truck
4	General logistics	Urban/intercity	Freight	Fixed/non-fixed	Transport of express parcels, daily necessities, furniture, hardware and building materials, moving services, alcoholic beverages, and soft drinks	Van transport vehicles, box trucks, etc.
5	Cold chain logistics	Urban/intercity	Freight	Fixed/non-fixed	Fruits, vegetables, meat, dairy, aquatic products, prepared dishes, etc.	Insulated vehicles, refrigerated vehicles
6	Long-haul trunk logistics	Intercity	Freight	Fixed/non-fixed	Express delivery and express freight, large-item transportation, green channel transportation, industrial raw material transportation, etc.	Heavy-duty tractor
7	Short-distance cargo	Port/park	Freight	Fixed area/route	Transport of finished and semi-finished vehicles, coal, steel, essential daily goods, construction materials, and other bulk cargo	Tractor
8	Bus transportation	Urban	Passenger	Fixed area/route	Public passenger transportation	Low-floor/low-entry city buses
9	Highway passenger transport	Urban/intercity	Passenger	Fixed/non-fixed	Primarily urban central districts, urban suburbs, and short-distance intercity routes	Bus
10	Ride-hailing services	Urban	Passenger	Non-fixed	Passenger transportation	Passenger car

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4. Evaluation Index System

A two-level evaluation index system is established based on five comprehensive dimensions affecting the application scenarios of fuel cell vehicles: technical stability, convenience of use, economic efficiency, promotion feasibility, and environmental friendliness. For details, see Table 2.

Table 2: Evaluation Index System for Typical Application Scenarios of Hydrogen Fuel Cell Vehicles.

Primary Indicators	Secondary Indicators	Indicator Definition
Technical Stability	Driving Range	Comparison of actual driving range of FCVs with that of conventional vehicles of the same model
	Failure Rate	Proportion of vehicle downtime due to failures relative to total operating time
Convenience of Use	Number of Hydrogen Refueling Stations	Matching between the amount of constructed hydrogen refueling stations and hydrogen demand from promoted vehicles
	Hydrogen Station Matching Degree	Matching of hydrogen station service radius, facility technical conditions, and hydrogen capacity with FCVs demand
Economic usability	Hydrogen consumption cost	Comparison of hydrogen consumption cost with fuel cost of equivalent conventional vehicles
	Vehicle cost	Average purchase cost (excluding subsidies) compared with conventional fuel vehicles of the same model
	Total ownership cost	Total ownership cost of fuel cell vehicles compared with conventional fuel vehicles of the same model
Promotion feasibility	Market development potential	Supply and demand status and development potential of target markets under different scenarios
	Business model	Clarity of elements such as customer groups, cooperation channels, resource costs, operating income, model cases, and replicability of business model
Environmental friendliness	Low-carbon emission	Whether the operation scenario has clear environmental protection requirements, and whether the use of FCVs can bring obvious emission reduction and achieve relevant benefits

5. Analysis of Evaluation Results

Based on the evaluation indicator system for typical application scenarios of fuel cell vehicles, industry-focused discussions and systematic evaluations were conducted to identify three categories of common advantageous scenarios: short-haul transportation (heavy-duty short-distance traction transportation), construction waste transportation (heavy-duty urban construction waste transportation), and cold chain logistics (light-duty urban logistics). The evaluation results are shown in Table 3.

Table 3: Evaluation of typical application scenarios for hydrogen fuel cell vehicles.

S/N	Typical scenario	Technical stability	Convenience of use	Economic usability	Promotion feasibility	Environmental friendliness
1	Municipal sanitation	-	++	-	-	++
2	Construction waste transportation	++	++	+++	++	+++
3	Concrete mixing	-	+	-	-	+++
4	General logistics	+	--	--	--	++
5	Cold chain logistics	+++	+++	+++	+++	+++
6	Long-haul trunk logistics	+	+	+	+	+++
7	Short-distance cargo	+++	+++	++	++	++
8	Bus transportation	++	+++	+	+	++
9	Highway passenger transport	+++	+	+	+	+++
10	Ride-hailing services	+	+	+	+	++

5.1 Short-distance cargo

This scenario is characterized by short transportation distances, heavy loads, high utilization intensity, stringent requirements for driving range and power performance, and strong emission reduction demands. The operational tasks primarily involve transporting finished and semi-finished commercial vehicles, coal, steel, daily necessities, construction materials, and other bulk goods. The operating areas mainly include ports, industrial parks, and logistics distribution hubs, typically following fixed routes. The representative vehicle model is a 49-ton tractor.

The application scenario requires moderate speed (the actual average speed is 30-50 km/h), and the power performance of the existing fuel cell vehicle and system can meet the demand. The hydrogen consumption per 100km is about 10.5kg (about 367.5 yuan), and the hydrogen consumption cost is

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slightly higher than that of diesel vehicles of the same level (about 316 yuan). The transportation is mainly based on the fixed line, which is convenient to arrange the internal hydrogenation station.

5.2 Construction waste transportation

This scenario involves heavy loads, high operational intensity, stringent requirements for transport efficiency and profitability, restrictions on traffic time windows and routes, as well as high vehicle environmental protection requirements and noise pollution control requirements. It mainly transports raw materials and waste generated from urban infrastructure, real estate trenching, river construction, and road construction. The operational area varies with project progress, while routes remain relatively fixed. The representative vehicle model is a 31-ton dump truck.

The driving range of the fuel cell muck truck can meet the scenario requirements, which has advantages over the pure electric models. The hydrogen consumption per 100km is about 10kg (350 yuan), and the hydrogen consumption cost is close to that of diesel vehicles of the same level (about 435 yuan). The route is relatively fixed, which is convenient for energy supplement planning. However, there are traffic time and route restrictions, particularly issues related to road access during heavy pollution weather that require further resolution.

5.3 Cold chain logistics

This scenario encompasses a wide operational range (including intercity transport), with stringent temperature control requirements throughout the journey (continuous operation of refrigeration), high delivery timeliness demands, and road right-of-way operation requirements. The primary transported goods include fruits, vegetables, meat, dairy, aquatic products, and prefabricated dishes, etc. The operation area and route demand change greatly, and the representative model is 4.5-ton refrigerated truck.

The fuel cell models demonstrates superior overall performance in terms of range and energy consumption, fully meeting the scenario requirements (within 200 kilometers). It offers advantages over diesel and pure electric vehicles in energy consumption and refrigeration noise. The hydrogen cost per 100 kilometers is approximately 105 yuan, close to that of diesel vehicles of the same class (about 119 yuan). Due to wide operation area, it is difficult to guarantee energy supplement demand and delivery timeliness. The enforcement of road access rights for most 4.5-ton fuel cell refrigerated vehicles in urban areas has become a decisive factor influencing the effectiveness of this scenario's promotion.

6. Conclusion

This paper evaluates the progress of China’s hydrogen energy industry from five dimensions: policy, technology, market, industrial chain, and hydrogen supply. It provides a comprehensive review of current typical application scenarios within the industry and establishes a set of evaluation models to analyze advantageous scenarios for the large-scale deployment of hydrogen fuel cell vehicles.

The research results show that the overall fuel cell automobile industry in China is in the adjustment phase of promotion period. Initial demonstration effects have been established in specific scenarios such as short-distance cargo, construction waste transportation and cold chain logistics. In the future, it is essential to advance the industry towards scaling and commercialization by reinforcing policy guidance, overcoming technological bottlenecks, enhancing infrastructure construction and innovating business models, thereby facilitating the realization of low-carbon transformation objectives in the transportation sector.

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