Research on Cost-Effectiveness Optimization of Hydrogen-Powered Buses from the Perspective of Green Supply Chain

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DOI: 10.32629/memf.v5i3.2347

Abstract: This study examines optimizing the cost-effectiveness of hydrogen-powered buses within the green supply chain framework. Given the urgency of climate change, green supply chains and new energy transportation are crucial for sustainable development. Hydrogen-powered buses, as eco-friendly and efficient transport, have vast potential in public transportation but are hindered by high costs. Studying their cost-effectiveness optimization is thus theoretically and practically significant. The article explores the relationship between green supply chain and cost-effectiveness optimization of these buses, suggests optimization strategies, and discusses challenges and countermeasures to foster their market development and green transformation of public transportation.

***Keywords*:** hydrogen-powered buses; fuel cell; cost-effectiveness optimization; green supply chain; carbon reduction

1. Introduction

With the increasing severity of global climate change, green supply chains and new energy transportation have emerged as two critical areas for promoting sustainable development. Hydrogen-powered buses, as an environmentally friendly and efficient new energy transportation tool, have vast application prospects in the public transportation sector. However, their high costs have always been a significant obstacle to their widespread adoption. Therefore, studying the cost-effectiveness optimization of hydrogen-powered buses from the perspective of green supply chains holds significant theoretical and practical significance.

2. The Relationship between Green Supply Chain and Cost-effectiveness Optimization of Hydrogen-powered Buses

2.1 The green supply chain emphasizes supplier selection and collaboration

Choosing environmentally aware suppliers for hydrogen-powered bus production ensures raw material and component quality, cutting losses from substandard materials. Long-term, stable supplier relationships enhance supply chain coordination, reducing procurement costs and boosting efficiency.

2.2 The green supply chain focuses on green design and production

In the design stage of hydrogen-powered buses, environmental factors should be fully considered to optimize vehicle structures, reduce energy consumption, and emissions. During production, the use of environmentally friendly processes and equipment can reduce waste and pollutants, lowering production costs. Additionally, the green supply chain emphasizes the recycling and treatment of waste generated during production, enabling resource recycling and reducing environmental pollution.[1]

2.3 The green supply chain involves green logistics and recycling

Optimizing logistics routes and modes in the transportation and distribution of hydrogen-powered buses can reduce energy consumption and emissions during transportation, thereby reducing logistics costs. Implementing green recycling and reuse strategies for scrapped vehicles can reduce resource waste and environmental pollution, enhancing the environmental benefits of hydrogen-powered buses.[2]

By optimizing the green supply chain, the cost-effectiveness of hydrogen-powered buses will be greatly enhanced. The use of eco-friendly materials and processes can cut production costs while boosting product quality and performance. Efficient and sustainable supply chain operations can further lower operational costs and improve market competitiveness. With increasing societal awareness of environmental protection and sustainable development, demand for hydrogen-powered buses will rise, further optimizing their cost-effectiveness. In essence, the green supply chain and cost-effectiveness optimization of hydrogen-powered buses are mutually beneficial, leading to their wider adoption and sustainable growth in public transportation.

3. Green Supply Chain Strategy for Cost-Benefit Optimization of Hydrogen-Powered Buses

3.1 Supplier Selection and Collaboration Optimization

In terms of supplier selection and optimization of collaboration, we prioritize suppliers' environmental protection qualifications and cost-effectiveness assessments. Through thorough investigation and evaluation of suppliers' environmental practices, product quality, and cost control capabilities, we screen out high-quality suppliers with environmental certifications and sustainable development ideologies. Simultaneously, we establish long-term and stable collaborative relationships with these suppliers, realizing coordinated optimization of the supply chain and effective cost control through signing long-term contracts, sharing information and resources.[3]

3.2 Green Design and Production Innovations

green design and innovation in production processes are crucial for enhancing the cost-effectiveness of hydrogen-powered buses. In the product design stage, we focus on lightweight design and material selection, adopting high-strength, lightweight materials to replace traditional ones, reducing vehicle weight, and improving energy efficiency. Additionally, we introduce advanced energy-saving technologies and intelligent management systems to optimize vehicle structures and operation modes, reducing energy consumption and emissions. In terms of production processes, we promote the application of environmentally friendly processes and equipment, minimizing waste and pollutant emissions during production and enhancing resource utilization efficiency.

3.3 Green Logistics and Recycling Initiatives

The establishment of a green logistics and recycling system is also an important measure for optimizing the cost-effectiveness of hydrogen-powered buses. In logistics, we optimize transportation routes and modes, adopting energy-efficient transportation tools and green packaging materials to reduce energy consumption and emissions during transportation. Simultaneously, we strengthen the construction of logistics information systems, achieving supply chain transparency and real-time monitoring, thereby enhancing logistics efficiency and response speed. In recycling, we establish a comprehensive waste vehicle recycling and resource reuse system, dismantling and sorting scrapped vehicles to reuse valuable components and materials, reducing resource waste and environmental pollution.[4]

3.4 Green Sales and Service Strategies

Green sales and service strategies are also essential for enhancing the cost-effectiveness of hydrogen-powered buses. We actively promote environmental protection ideologies, raising public awareness and acceptance of hydrogen-powered buses through advertising, science education, and other means. Simultaneously, we provide excellent after-sales services, including regular maintenance, troubleshooting, and technical support, ensuring the normal operation and extended lifespan of the vehicles. Additionally, we strengthen customer relationship management, establishing customer profiles and feedback mechanisms to promptly understand customer needs and opinions, improving customer satisfaction and loyalty.

In summary, the cost-benefit optimization strategy for hydrogen-powered buses based on a green supply chain is a comprehensive approach encompassing all stages from supplier selection to production, logistics, sales, and service. By implementing this strategy, we can effectively reduce the cost of hydrogen-powered buses, enhance their environmental and economic benefits, and promote their widespread application and sustainable development in the public transportation sector. Simultaneously, this also contributes to the green transformation and sustainable development of the entire supply chain, achieving a win-win situation for both economic and social benefits.

4. Challenges and Countermeasures for Cost-Benefit Optimization of Hydrogen Energy Buses

4.1 Technological challenges and countermeasures

Currently, the core technology of hydrogen-powered buses, such as the hydrogen fuel cell system, has not yet achieved large-scale commercial application, and the technical maturity needs to be improved. At the same time, the cost of on-board hydrogen systems is relatively high and needs to be further reduced.

Increase investment in scientific research, promote breakthroughs and innovations in hydrogen fuel cell technology, and improve energy conversion efficiency and system reliability. At the same time, through optimized design and material selection, reduce the cost of on-board hydrogen systems. In addition, strengthen cooperation and exchanges with international

advanced enterprises, introduce advanced technology and management experience, and improve the technical level of domestic hydrogen energy buses.[5]

4.2 Market challenges and countermeasures

The purchase and operating costs of hydrogen-powered buses are relatively high, lacking competitiveness compared to traditional fuel buses. High production and storage costs of hydrogen further inflate operating expenses. To address this, policy support and financial subsidies can reduce purchase costs, while innovation in hydrogen production and storage can lower hydrogen costs. Enhanced market promotion and public awareness can also expand market demand. Currently, the hydrogen bus market lacks scale and faces fierce competition from traditional fuel buses and electric vehicles. Therefore, market research and analysis are crucial to understand demand and competition. Targeted market promotion strategies, government procurement, and demonstration operations can help expand market share. Coordinated development with other transportation modes will promote diversification and greening of public transportation.

4.3 Infrastructure challenges and countermeasures

The development of hydrogen-powered buses necessitates robust infrastructure, particularly hydrogen refueling stations. However, the current progress of their construction is sluggish, and their distribution inadequate, hindering the operational needs of these buses. To address this, we must expedite the building of hydrogen refueling stations, optimize their layout and distribution, and enhance their coverage and convenience. Additionally, technological advancements and standardized construction are crucial to boost refueling efficiency and safety. Furthermore, fostering international collaboration and learning from advanced experiences and technologies will accelerate the development of hydrogen-powered bus infrastructure.[6-7]

In summary, the cost-benefit optimization of hydrogen-powered buses faces multiple challenges, but through the comprehensive application of technological innovation, policy support, market promotion, and infrastructure construction, these challenges can be gradually overcome to promote the widespread application and sustainable development of hydrogen-powered buses in the field of public transportation.

5. Conclusion

After a thorough analysis, we conclude that while optimizing the cost-effectiveness of hydrogen-powered buses faces challenges in technology, economy, market, and infrastructure, these can be effectively addressed through various strategies such as technological innovation, policy support, market expansion, and infrastructure development. Despite these challenges, the environmental benefits and long-term potential of hydrogen-powered buses remain promising for green transportation.

Acknowledgments

Funding Project: Guangdong Provincial Special Funds for Science and Technology Innovation Strategy Project "Research on Carbon Emission Reduction Benefits of Hydrogen-powered Buses Based on the Green Supply Chain Perspective under the Dual Carbon Goals" (pdjh2022b0762).

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