

Research and Analysis on the Development of New Energy Vehicles in the Context of Low-Carbon Environmental Protection

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ABSTRACT

Driven by the global wave of low-carbon and environmental consciousness, the new energy vehicle industry is poised for unprecedented development opportunities. As environmental challenges become increasingly severe, governments worldwide have implemented a series of policies to encourage the research and promotion of new energy vehicles. These vehicles not only play a crucial role in alleviating environmental pressures but also foster technological innovation and the transformation of economic structures. This paper, from the perspective of low-carbon and environmental protection, examines the current development status and technological pathways of new energy vehicles, explores the impact of policy support and industry chain construction on their advancement, and provides a forecast of the market outlook. Through a thorough analysis, a better understanding of the role and significance of new energy vehicles in low-carbon environmental protection can be gained, offering scientific foundations for future policy-making and industrial development.

KEYWORDS

Low-Carbon Environmental Protection; New Energy Vehicles; Development.

1. INTRODUCTION

The global issues of climate change and environmental pollution are increasingly pressing, making low-carbon sustainability a topic of universal concern. Against this backdrop, electric vehicles emerge as green transportation solutions, crucial for reducing carbon emissions and mitigating air pollution. In recent years, propelled by technological advancements and policy initiatives, the electric vehicle market has rapidly expanded, becoming a pivotal direction for the transformation and upgrading of the automotive industry. Continuous refinement of low-carbon policies has not only fostered technological breakthroughs in electric vehicles but also garnered widespread recognition and support in the marketplace. The development of electric vehicles not only signifies technological progress but also represents an inevitable choice for economic restructuring and industrial upgrading. This paper aims to systematically analyze the role of electric vehicles in low-carbon sustainability, examining aspects such as technology, policy support, and market prospects. Additionally, it will explore the impacts of factors like charging infrastructure development and battery recycling on the electric vehicle supply chain, and their influence on widespread adoption. Through this study, it becomes evident that despite numerous challenges, electric vehicles have promising future prospects driven by multiple factors including policies, technology advancements, and market dynamics.

2. ANALYSIS AND COMPARISON OF NEW ENERGY VEHICLE TECHNOLOGIES

2.1. Pure Electric Vehicle

Pure electric vehicles, integral to the new energy vehicle landscape, derive their essence from electric propulsion, thereby achieving zero emissions, aligning with contemporary ideals of low-carbon sustainability. Relying primarily on battery storage, electric vehicles harness the advantages of high energy conversion efficiency and serene operation through electric motor propulsion. Particularly within urban environments, the widespread adoption of electric vehicles effectively mitigates tailpipe emissions, enhancing air quality and yielding pronounced environmental benefits. Technologically, the pivotal facet of pure electric vehicles lies in battery technology. Presently, lithium-ion batteries, renowned for their heightened energy density and extended lifespan, reign as the preferred choice. Nevertheless, challenges persist, including high costs, prolonged charging times, and limited driving ranges [1]. Addressing these challenges necessitates continuous exploration by researchers into novel battery materials and technologies, such as solid-state and graphene batteries, aiming for enhanced energy density and accelerated charging rates. Policy support and infrastructure development play indispensable roles in advancing pure electric vehicles. The refinement of complementary facilities like charging stations significantly influences user experience and purchasing intent. Hence, expediting the construction of charging infrastructure to deliver more convenient charging services stands as a pivotal stride toward widespread adoption of pure electric vehicles.

2.2. Hybrid Electric Vehicle

A Hybrid Electric Vehicle (HEV) integrates dual power systems of an internal combustion engine and an electric motor, aiming to enhance fuel efficiency and reduce emissions. The synergistic operation of these power sources enables HEVs to maintain high energy utilization efficiency across diverse driving conditions. This technology preserves the extended range advantage of traditional fuel-powered vehicles while mitigating carbon emissions through its electric propulsion system, thus becoming a pivotal pathway in the automotive industry's shift towards low-carbon transformation. In urban scenarios, HEVs capitalize on the advantages of electric motors, minimizing fuel consumption and exhaust emissions through electric propulsion and regenerative braking systems. Conversely, during highway driving, the internal combustion engine assumes primary operation to ensure vehicle power and range. Particularly, Plug-in Hybrid Electric Vehicles (PHEVs), which can recharge via external power sources, enhance electric-mode range and further reduce fuel consumption. Despite achieving notable technological and market successes, HEVs face several challenges. For instance, the complexity of dual-power systems increases manufacturing and maintenance costs, while consumer awareness and acceptance require further enhancement. Thus, strengthening technological innovation, optimizing powertrain configurations, and enhancing overall vehicle performance emerge as critical directions for future development.

2.3. Fuel Cell Vehicles

Fuel Cell Electric Vehicles (FCEVs) harness hydrogen and oxygen in a fuel cell to undergo electrochemical reactions, generating electricity to drive the electric motor, while emitting only water vapor, achieving true zero emissions. At the forefront of new energy vehicle technologies, FCEVs exhibit significant advantages in environmental friendliness and energy efficiency. The cornerstone of FCEVs lies in their fuel cell systems, where efficiency and reliability directly impact vehicle performance. Currently, Proton Exchange Membrane Fuel Cells (PEMFCs) have emerged as the mainstream technology owing to their efficient energy conversion and rapid startup capabilities. However, challenges persist in the production, storage, and transportation of hydrogen. Despite the higher production costs of green hydrogen, advancements in technology and economies of scale are

expected to substantially reduce costs and enhance economic viability in the future. Infrastructure development, particularly the proliferation of hydrogen refueling stations, is critical for the advancement of FCEVs. Compared to charging infrastructure, hydrogen refueling stations incur higher construction and maintenance costs, alongside more complex spatial planning, necessitating concerted efforts from governments and businesses. Nevertheless, FCEVs demonstrate clear advantages in terms of range and refueling time, making them particularly suitable for long-distance transport and commercial vehicle applications.

3. POLICY SUPPORT AND INDUSTRY CHAIN ANALYSIS OF NEW ENERGY VEHICLE DEVELOPMENT

3.1. Manufacturing of new energy vehicles

The new energy vehicle manufacturing industry stands as a crucial pillar in achieving sustainable development within the context of a low-carbon, environmentally friendly era. This sector encompasses the entire process from battery production, motor development, to vehicle assembly, characterized by high technical complexity and strong demands for industrial chain synergy. With robust national policy support—manifested through fiscal subsidies, tax incentives, and research and development funding—this industry has been propelled forward with remarkable speed and effectiveness. In the realm of technological innovation, the new energy vehicle manufacturing sector exhibits trends of electrification, intelligence, and lightweight design. The advancement of efficient battery technologies, such as breakthroughs in solid-state batteries and hydrogen fuel cells, offers more potent power sources and extended driving ranges for these vehicles. The integration of intelligent driving technologies has elevated new energy vehicles not only in terms of environmental performance but also in safety and user experience. Improvements in manufacturing processes and supply chain optimization are also pivotal to the development of new energy vehicles. State-of-the-art manufacturing techniques, such as 3D printing and robotic automation production lines, have significantly enhanced production efficiency and product quality. Meanwhile, a well-structured supply chain ensures the stable provision of critical components, reducing production costs. Government policies aimed at advancing the new energy vehicle sector have accelerated the transformation of traditional automotive manufacturers while fostering a wave of new enterprises, infusing the industry with fresh vitality and innovative spirit. Through close cooperation among industry, academia, and research institutions, breakthroughs in new energy vehicle manufacturing technologies continue to emerge, refining the industrial chain and propelling the future of the automotive industry. With the dual drivers of policy support and technological innovation, the new energy vehicle manufacturing industry is set to continue its robust growth, making significant contributions to global green transportation and sustainable development [2].

3.2. Charging Infrastructure Construction

The infrastructure for recharging plays a pivotal role in the advancement of electric vehicles, directly influencing user experience and market acceptance. The extent of charging network development determines the practical convenience and pace of adoption for electric vehicles. Currently, national and local governments are actively implementing policies to promote the construction and distribution of charging stations, aiming to alleviate the bottleneck of charging difficulties. In terms of charging technology, advancements in fast and ultra-fast charging technologies have significantly enhanced charging efficiency. The deployment of high-power charging stations enables electric vehicles to complete charging in a short period, akin to the speed of refueling traditional fuel vehicles, greatly enhancing user convenience. Furthermore, the development of smart charging systems enhances charging efficiency and intelligence, optimizing charging resource allocation through data analysis and optimization. The establishment of charging infrastructure requires not only

technological breakthroughs but also refined commercial models and policy support. Governments play a crucial role in promoting the construction of public charging stations by providing financial subsidies and land support to attract private capital. Simultaneously, the proliferation of private charging stations, particularly in residential areas and workplaces, continues to accelerate, further meeting the daily charging needs of electric vehicle users. Interconnectivity within the charging network is another pertinent issue. Currently, the lack of unified standards among different brands and operators of charging systems often leads to inconvenience for users during charging. Therefore, establishing unified technical standards and highly compatible charging platforms is essential for future development. Governments, enterprises, and industry associations should strengthen cooperation to standardize and smarten the development of charging infrastructure, creating an efficient and convenient charging ecosystem. Overall, the construction of charging infrastructure holds a crucial position in the promotion of electric vehicles. With ongoing technological advancements, policy support, and innovations in business models, charging infrastructure will continue to improve, propelling electric vehicles into a new phase of widespread adoption. Throughout this process, close collaboration between governments and enterprises, along with active participation from society as a whole, will collectively contribute to achieving low-carbon environmental goals and fostering sustainable development.

3.3. Battery Production and Recycling

One of the core components of electric vehicles is the power battery, which holds a pivotal position in the entire industry chain due to its production and recycling. The advancement of battery technology directly determines the performance and market competitiveness of electric vehicles. Lithium-ion batteries, renowned for their high energy density and long lifespan, stand as the primary power source for current electric vehicles. Nevertheless, the battery production process involves substantial resource consumption and environmental pollution, underscoring the critical importance of applying green manufacturing technologies. In the realm of battery production, process optimization and material innovation are pivotal in enhancing battery performance. The gradual adoption of high-nickel, low-cobalt ternary lithium batteries and cobalt-free battery technologies aims to reduce reliance on rare metals while boosting energy density and cycle life. Moreover, the development of solid-state batteries offers new prospects for the future, offering superior safety and energy density over traditional lithium batteries. Battery recycling plays a crucial role in achieving sustainable development. Discarded batteries contain significant amounts of precious metals and hazardous substances; mishandling them can lead to severe environmental pollution. Efficient recycling technologies enable the extraction of valuable materials, thereby reducing resource wastage and environmental pressures. The progress in battery recycling technologies has steadily increased recovery rates and economic benefits, making it an integral part of the circular economy. Policy support plays a pivotal role in battery recycling; governments enact stringent environmental regulations and provide financial subsidies to encourage enterprises to establish comprehensive recycling systems. The establishment of a full lifecycle management model from production to recycling effectively reduces environmental pollution and enhances resource utilization efficiency. Simultaneously, heightened environmental awareness among consumers continuously drives the growth of the battery recycling industry. The virtuous cycle of battery production and recycling forms the foundation for the healthy development of the electric vehicle industry. Under the combined impetus of policy guidance, technological innovation, and market demand, the battery industry chain will become more refined and environmentally friendly [3].

4. MARKET PROSPECT ANALYSIS OF NEW ENERGY VEHICLES UNDER LOW CARBON AND ENVIRONMENTAL PROTECTION

4.1. Forecast of new energy vehicle market size

Against the backdrop of global emphasis on low-carbon sustainability, the prospects for the electric vehicle market are exceedingly promising. Policies, technological advancements, and heightened environmental awareness among consumers have led to an explosive growth trajectory in the scale of this market. According to authoritative forecasts, over the next decade, electric vehicles are expected to progressively capture a significant share of the automotive market, with a projected compound annual growth rate exceeding 20%. As governments worldwide announce timelines for phasing out combustion engine vehicles, the traditional fossil fuel vehicle market is expected to diminish gradually, thereby creating greater opportunities for the development of electric vehicles. Particularly noteworthy is the substantial growth in markets such as China, Europe, and the United States, where electric vehicles have gained significant traction. China's "dual carbon" goals clearly outline that by 2035, electric vehicles will become mainstream, with an anticipated market penetration rate exceeding 50%. In Europe, increasingly stringent carbon emission regulations have further propelled the adoption of electric vehicles, with expectations that by 2030, electric vehicles will account for approximately 40% of the market share. Technological advancements, particularly in battery technology like solid-state and hydrogen fuel cells, have significantly enhanced the range and safety performance of electric vehicles, further driving market expansion. Additionally, advancements in smart and connected technologies have enhanced the user experience of electric vehicles, attracting increased consumer attention and adoption. The development of comprehensive charging infrastructure serves as a critical assurance for further market expansion. As charging networks continue to expand and charging speeds improve, consumer concerns about charging convenience are gradually alleviated, thereby greatly enhancing the usability of electric vehicles. These factors collectively lay a solid foundation for the continued expansion of the market. Upstream in the industry supply chain, improvements in the supply capacity and cost reductions of key components have also promoted the widespread adoption of electric vehicles. The declining costs of batteries are narrowing the purchasing cost gap between electric vehicles and traditional combustion engine vehicles, thereby highlighting their economic advantages and further stimulating market demand. The expansion of the electric vehicle market not only addresses environmental demands but also signifies a crucial aspect of the automotive industry's technological revolution. Driven by concurrent forces of policy, technology, and market demand, the electric vehicle market is poised for sustained growth, making a significant contribution towards achieving global goals of low-carbon sustainability [4].

4.2. Consumer awareness and preference analysis

Against the backdrop of low-carbon environmental awareness, consumer perceptions and preferences towards new energy vehicles are undergoing significant transformations. Heightened environmental consciousness, guided policies, and technological advancements are prompting an increasing number of consumers to pay attention to and embrace new energy vehicles. Primarily, the awakening of environmental awareness stands as a pivotal factor driving consumers towards new energy vehicles. With the global climate crisis escalating, public emphasis on environmental protection has notably intensified. More consumers are realizing the adverse environmental impacts of traditional fuel-powered cars, thereby cultivating greater interest in zero-emission new energy vehicles. This elevation in environmental consciousness manifests not only in purchasing decisions but also in everyday driving behaviors, such as prioritizing energy-efficient driving and regular maintenance. Technological advancements have greatly enhanced consumer acceptance of new energy vehicles. Previously, challenges such as limited range, inconvenience in charging, and safety concerns hindered consumer adoption of these vehicles. Today, breakthroughs in battery technology and the

improvement of charging infrastructure have significantly increased the driving range of new energy vehicles, accelerated charging speeds, and greatly enhanced convenience of use. The development of smart and connected features has also endowed new energy vehicles with greater advantages in driving experience and safety, thus attracting more consumers' favor.[5] Transformations in brand recognition and marketing strategies are also crucial factors influencing consumer preferences. Traditional automotive manufacturers and emerging electric vehicle companies are intensifying their investments in the new energy vehicle sector, winning consumer trust through innovative designs and high-quality service. The success of brands like Tesla lies not only in their technological leadership but also in their robust brand influence and effective market promotion. Consumer affinity towards brands significantly impacts their purchasing decisions. Economic considerations among consumers are gradually favoring new energy vehicles as well. With expanded production scales and maturing technologies, the purchase costs of new energy vehicles are gradually declining. Simultaneously, government subsidies, tax incentives, and other policies further lower the purchasing thresholds for consumers. The cost advantages in terms of usage are also becoming evident, with electricity costs significantly lower than fuel costs and relatively lower maintenance costs, making new energy vehicles more attractive in total ownership costs. Market research indicates that there are certain differences in consumer perceptions and preferences towards new energy vehicles across different age groups and regions. The younger generation places greater emphasis on environmental sustainability and technology, resulting in higher acceptance of new energy vehicles. In urban areas where charging infrastructure is relatively well-developed, there is a stronger willingness among consumers to purchase new energy vehicles.[6]

4.3. Future Development Trend of New Energy Vehicles

The future development trends of new energy vehicles, under the backdrop of low carbon and environmental protection, unveil a promising horizon, with technological innovation, market demand, and policy impetus serving as the core driving forces. In the coming years, new energy vehicles will witness significant breakthroughs and transformations in areas such as intelligence, sharing, and sustainability. Intelligence will be a pivotal direction for the development of new energy vehicles. The rapid advancement of autonomous driving technology is making intelligent driving a reality. In the future, the commercialization of Level 4 and above autonomous driving will gradually be realized, enhancing vehicle safety and user experience. Simultaneously, the development of vehicle-to-everything (V2X) technology will foster closer interactions between vehicles, infrastructure, and users, facilitating a comprehensive upgrade of intelligent transportation systems. This intelligence not only elevates driving convenience and safety but also introduces an array of value-added services and innovative business models for new energy vehicles. The trend towards sharing is becoming increasingly pronounced in the realm of new energy vehicles. With the rise of the sharing economy, car-sharing and ride-hailing services are becoming ubiquitous. Thanks to their low operational costs and environmental benefits, new energy vehicles emerge as the ideal choice for shared mobility. As 5G technology and artificial intelligence become more prevalent, the scheduling and management of shared new energy vehicles will evolve to be more intelligent and efficient, catering to diverse user travel needs. This not only effectively alleviates urban traffic congestion but also further reduces carbon emissions, promoting sustainable development. Sustainability remains the fundamental objective of new energy vehicle development. In response to climate change and environmental pollution, the global demand for low carbon emissions is escalating. Innovative technologies such as hydrogen fuel cell vehicles and solar-powered cars are maturing, offering more environmentally friendly travel solutions. Hydrogen fuel cell vehicles, with their efficient and clean attributes, are poised for widespread application in long-distance transport and heavy-duty vehicles. Solar-powered cars harness renewable energy, injecting new vitality into the evolution of new energy vehicles. The continuous innovation in battery technology is also a key factor driving the development of new energy vehicles [7]. The research and development of new battery technologies, such as solid-state and graphene batteries, will further enhance energy density and safety, extend driving range, and

reduce charging times. These technological breakthroughs will significantly bolster the market competitiveness of new energy vehicles, meeting user demands for high performance and safety. In the future, the new energy vehicle industry chain will become more comprehensive and globalized. International technological cooperation and market openness among countries will facilitate the collective advancement of the global new energy vehicle industry. Collaborations between multinational enterprises in technology research and market expansion will accelerate the application and promotion of new technologies, driving rapid growth in the global new energy vehicle market. With the combined forces of policy, technology, and market demand, new energy vehicles are poised to embrace a broader development landscape in the future. The trends of intelligence, sharing, and sustainability will not only propel technological progress and innovation in business models within the new energy vehicle industry but also make significant contributions to achieving global low carbon and environmental goals.[8]

5. CONCLUSION

Electric vehicles, pivotal carriers of environmental stewardship, bear substantial implications not only for ecological preservation but also for sustainable economic and societal advancement. This discourse, through a systematic analysis of electric vehicle technology trajectories, policy frameworks, and market prospects, unveils their pivotal role amid the contemporary landscape of low-carbon environmentalism. Despite encountering challenges such as technological bottlenecks and inadequate infrastructure, concerted efforts have propelled robust growth within the electric vehicle sector. Looking forward, with ongoing technological breakthroughs and sustained policy backing, electric vehicles are poised to further proliferate globally. Concurrently, the establishment of comprehensive industrial chains and efficient systems for resource reclamation will provide robust assurance for the sustainable evolution of electric vehicles. Throughout this trajectory, nations must enhance collaboration to collectively address environmental challenges and foster the robust development of global green economies. The proliferation of electric vehicles not only represents an effective measure against climate change but also constitutes a pivotal pathway toward achieving low-carbon environmental objectives, deserving widespread societal attention and endorsement.

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