Hindawi
Mathematical Problems in Engineering
Volume 2022, Article ID 4746320, 13 pages
https://doi.org/10.1155/2022/4746320

Research Article

An Investigation into the Social Benefits of China's Standardization of Electric Vehicles in Response to the Demand for High Energy and Low Emissions

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Received 26 January 2022; Revised 22 February 2022; Accepted 10 May 2022; Published 29 June 2022

Academic Editor: Ciro Núñez-Gutiérrez

This study investigates the use of standardized methods to promote the endurance of electric vehicles in the context of China's high-quality development, to reduce environmental pollution, thereby enhancing the standardization and social benefits of electric vehicles in China. It analyzes the current development status and existing problems of electric vehicles in China from three aspects: incentive policy, sales situation, and its own problems. From the perspective of standardization, the key factors restricting its development and popularization are analyzed. The pattern of exploration leading the development of electric vehicles through standardization is proposed, the specific development path and implementation plan are given, and the mechanism of its effect on the promotion of standardization and social benefits is analyzed. The content of this article provides a certain basis and ideas for the development of future research work. It also has a certain reference values for other areas to solve the bottleneck problem of electric vehicle development through standardized methods.

1. Introduction

As Sorrell et al. [1] have mentioned the problem of energy crisis and China has entered into the stage of high-quality development, people are paying increasing attention to health and their tolerance for environmental pollution becomes lower and lower. Therefore, pure electric vehicles (hereinafter referred to as electric vehicles) are getting more attention. Electric vehicles are considered the only long-term solution for future transportation [2]. Therefore, high energy and low emission are direct requirements for electric vehicles. However, endurance, safety, and environmental protection are the three key issues currently restricting the large-scale promotion and application of electric vehicles. The endurance of electric vehicles is seriously affected by temperature, which reduces the environmental adaptability of the vehicles. For the convenience of use, users pursue fixed parking spaces too much, which will inevitably reduce resource utilization. The high price of electric vehicles, high cost, and difficulty of battery replacement will inevitably affect the involvement of new customers of electric vehicles and the promotion of products in the entire industry. The battery technology of electric vehicles is regard as the main difficulty [3]. Over the years, a large number of domestic and foreign researchers have made a lot of research achievements in this field. However, there is still no breakthrough in the biggest limiting factor of practical research and application to promote the endurance of electric vehicles, and there is still a big gap in actual demand, which is a major problem for domestic and foreign researchers for many years. The slow development of electric vehicles instead of replacing traditional fuel vehicles may aggravate urban traffic congestion and reduce the social benefits of their application. How to improve the market competitiveness of electric vehicles, rather than survival and development just relying on policy is a thought-provoking question. In addition, with the increasing

Table 1: Summary of relevant incentive policy for electric vehicle batteries in China.

Number	Published time	Name of the relevant policy document	Policy issuing agency	Role of relevant policy documents
1	June 2012	Industry development plan on energy saving and new energy vehicles (2012–2020)	State council	It pointed out and determined the important position of pure electric vehicles
2	October, 2015	Development guide for charging infrastructure development of electric vehicles (2015–2020)	National development and reform commission; National energy administration; Ministry of industry and information technology; Ministry of housing and urban rural development	It promoted the development of supporting facilities, such as charging piles
3	December, 2017	Catalogue of new energy vehicle models exempted from vehicle purchase tax	Ministry of finance of the People's republic of China; state administration of taxation; ministry of industry and information technology of the People's republic of China; ministry of science and technology of the People's republic of China	It played a great role in promoting the sales and use of electric vehicles
4	October, 2020	The new energy vehicle industry development plan (2021–2035年) mainly including key technology research, infrastructure construction of charging and swapping, international cooperation, and policy support. The formulation of relevant strategic planning fully demonstrates the determination of China to develop electric vehicles, and the continuous introduction of relevant policies to support development reflects China's active exploration in promoting its rapid development.	The state council	It promoted the high-quality development of electric vehicles, and pointed out the direction for the future development of electric vehicles

development of electric vehicles, the battery pollution problem cannot be underestimated, which shall be planned in advance and carefully considered. Standards play an irreplaceable role in standardizing the development of new products, reducing development costs, improving research efficiency, and ultimately promoting their social benefits [4].

2. Analysis of Domestic Situation

The electric vehicle studied in this article refers to a pure electric vehicle with two axles and four wheels for household use. The standardization social benefits mentioned in this article refer to the relevant definitions in GB/T 3533.2–2017, that is, to adopt standardized methods in the field of electric vehicles to promote social development, energy conservation, and environmental protection, to promote its social benefits. With the energy crisis and the pursuit of energy conservation and environmental protection, many foreign countries have issued plans to replace traditional fuel vehicles with electric vehicles and announced the implementation time of the policy. China is also actively promoting the development of electric vehicles and has formulated national and local policies.

2.1. Analysis of Incentive Policy. China has issued many relevant strategic policies and plans for the development and recycling of electric vehicles, and some strategic policies are shown in Table 1. For example, the "Industry Development Plan on Energy saving and new energy vehicles (2012–2020)" was published in June 2012 in the form of State Council Announcement, guiding the direction of China's new energy vehicle development and automobile industry transformation from a strategic height, and pointing out and determining the important position of pure electric vehicles. Subsequently, a series of policies such as promotion and application, subsidy and tax-free, charging facilities, construction, and unrestricted traffic introduced, which played a great role in promoting the sales and use of electric vehicles. To encourage the development of electric vehicles, China has put forward various policies to promote the development of supporting facilities, for example, "Development Guide for Charging infrastructure development of electric vehicles (2015–2020)", which promotes the development of supporting facilities including charging piles. On October 9, 2020, the State Council reviewed and approved the new energy Vehicle Industry development plan to promote the high-quality development of new energy, automobile industry, and

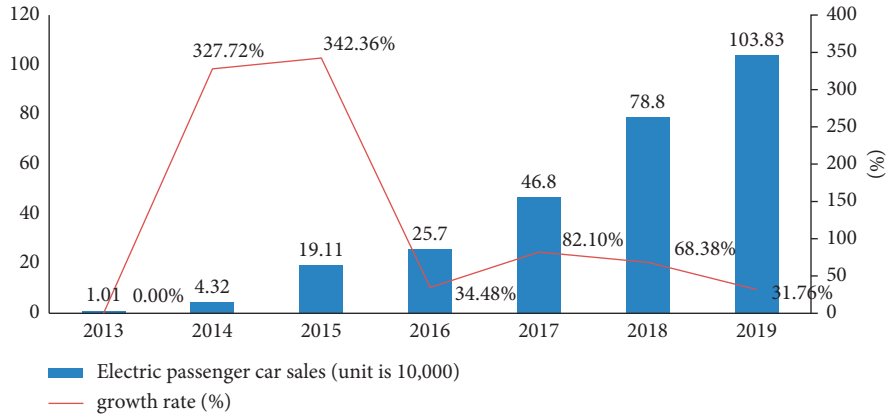

Figure 1: Sales volume and growth rate of electric passenger vehicles in China (2013–2019).

the construction of automobile power. The plan points out the direction for the future development of electric vehicles, mainly including key technology research, infrastructure construction of charging and swapping, international cooperation, and policy support. The formulation of relevant strategic planning fully demonstrates the determination of China to develop electric vehicles, and the continuous introduction of relevant policies to support development reflects China's active exploration in promoting its rapid development. However, the proposal of policies only plays a role in promoting, and further practical and feasible supporting work in the field of technology is needed to improve the social benefits of China's electric vehicle standardization.

2.2. Sales Analysis. In terms of sales volume, according to the statistics of China Automobile Industry Association and China Passenger Car Association, in 2019, a total of 21.444 million passenger cars were sold, and a total of 1.0383 million pure electric passenger cars were sold. In 2018, a total of 23.7098 million passenger cars were sold, and 788000 pure electric passenger cars were sold. In 2017, a total of 24.7183 million passenger cars and 468000 pure electric passenger vehicles were sold. In 2016, a total of 24.3769 million passenger cars were sold, and 257000 pure electric passenger cars were sold. The sales volume and growth rate of electric vehicles in recent years are shown in Figure 1. From the sales volume of electric vehicles year by year, it shows the development situation of rapid growth. From the annual growth rate, it shows the trend of first rising and then overall declining.

In terms of relative quantity, in 2016, 2017, 2018, and 2019, the proportions of China's electric vehicle sales in passenger car sales were 0.048%, 0.219%, 1.066%, and 0.639%, respectively. The comparative development trend is shown in Figure 2. From the domestic statistical data in recent years, although the sales of electric passenger cars have been increasing, and the proportion has also showed an overall upward trend, but the sales volume of electric vehicles is still in sharp contrast with the number of automobile sales. The proportion of electric vehicles is still low. Compared with previous years, there is no significant

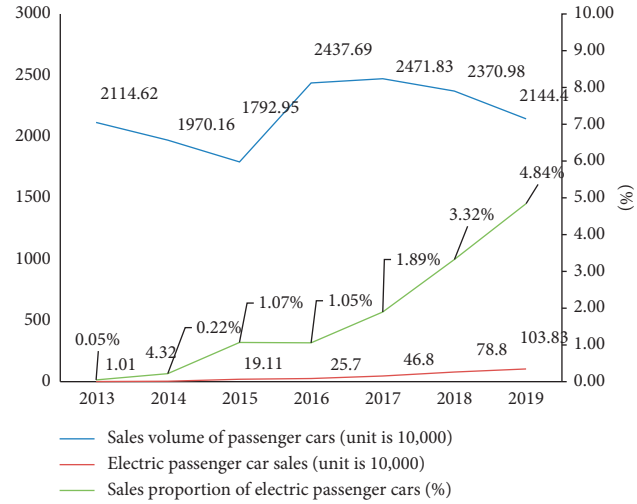

Figure 2: Sales comparison between pure electric passenger cars and passenger cars in China in recent years.

increase, and these data appear under the condition of policy intervention of the state on restricting the registration of fuel vehicles in some cities. According to the statistics of mandatory liability insurance for traffic accidents of passenger cars, in the first half year of 2020, there were 298000 new energy passenger vehicles insured in China, of which the top six cities were Beijing, Shanghai, Shenzhen, Guangzhou, Hangzhou, and Tianjin. The number of vehicles with insurance was 35, 34, 19, 16, 12, and 12 thousand. All of the above are cities where car license plates are restricted. [5] It can be seen that the effectiveness of a series of measures in the field of electric vehicles, such as policies, related technological progress, and infrastructure construction, is not obvious. The incentive of relevant policies has not promoted the explosive growth of electric vehicle sales. It can be seen that people's recognition of electric vehicles has not fundamentally changed.

2.3. Analysis of Problems. However, in the process of practical development, the development of electric vehicles mostly faces with the technical problems that are difficult to

overcome in a short period, because under the existing technology development path and mode, it is limited by the inherent properties of many products and materials in electric vehicles.

2.3.1. Analysis of Endurance Problems. As one of the key factors affecting the sales of electric vehicles, the driving distance of electric vehicles is relatively short compared with the actual demand. In addition, the electric vehicle's cruising distance in cold weather areas or general areas in winter will further reduce, which makes this problem more obvious. In view of this situation, from the perspective of consumers, it is often desirable to have a private parking space to ensure the convenience and speed of charging. Otherwise, they need to face the trouble of finding other ways to return home after charging by a public charging pile. However, in cities with priority development of electric vehicles, the natural resources are normally short that it is almost impossible to provide each electric vehicle with a private parking space. As a result, the survey data of consumers' satisfaction with electric vehicles has not been high. In general, the endurance of electric vehicles is affected by many factors.

(1) Low Capacity. The energy density of the battery system is low. At home and abroad, the research on improving battery capacity mainly focuses on two aspects, one is to improve the energy density and number of batteries, the other is to reduce the size and weight of batteries. Increasing the number of batteries will increase the quality and space occupation of electric vehicles, thus affecting the vehicle's maneuverability and space layout design. Researchers at home and abroad have carried out a lot of research and exploration on the lightweight design of battery packs [6–11]. However, separate research on batteries in different structure, size, and performance leads to the dispersion of power, which is not conducive to rapid technological breakthrough.

(2) Difficult to Control. The battery system is difficult to control. Battery pack of a pure electric vehicle is generally composed of many single cells in series and parallel. In addition, to control the temperature, it is often necessary to package the battery. Take Tesla as an example, its 70 kw·h battery pack is composed of nearly 10000 cells in series and parallel. The performance of the battery pack depends on the performance of the cell on the shortest board [12]. Therefore, it is particularly important to manage and control the quality and health status of each cell in the battery pack. The packaged battery system is difficult for ordinary users to achieve regular monitoring. It is not enough to rely solely on the short warranty period of 4S shops of various brands of electric vehicles, so it is necessary to carry out unified management and overall specification through standardized means. At present, the size and performance of battery cells and battery packs produced by different manufacturers in China are quite different, lacking relevant mandatory standards to regulate and guide, which have an important impact on the development of new energy vehicle industry.

(3) Security Issues

(a) Collision safety: according to the statistical data of "China Statistical Yearbook", in recent years, the number of traffic accidents in China every year is about 200000, and the death reaches 60000. However, for electric vehicles, a large number of batteries are collided severely, which is undoubtedly very dangerous. Some studies [13] suggest that when electric vehicles collide, the electrical leakage, fire, or even explosion of batteries inside the battery pack will occur due to strong impact and extrusion. According to the overall statistical analysis of electric vehicle accidents from 2014 to the first half year of 2019 in the literature [14], it is found that the top three causes of electric vehicle fires are battery self-ignition, battery charging, and vehicle collision accidents. Among them, 38% and 20% of the electric vehicle fires are caused by battery spontaneous combustion and charging, respectively, accounting for 58% of the total. It is pointed out that the basic reason of battery spontaneous combustion is the internal short circuit caused by metal impurities or electrode burr, electric abuse, and uneven electrolyte infiltration. Under the current operation mode, it is very difficult for consumers who are not engaged in professional research in this field to find, replace, or repair these batteries, which are not qualified or damaged in the process of use. Therefore, a professional battery management team is particularly needed for maintenance and management.

(b) Thermal safety issues: as a means of traffic, it is very difficult to avoid the convenience of electric vehicle as a vehicle. Because its normal charging is slow, most electric vehicles have designed a battery-fast charging interface. In the process of fast charging, the battery temperature rises rapidly in a short time due to high battery rate charging. High temperature has a great negative impact on the safety and life of battery charging [15]. A study [16] found that when the temperature of a lithium-ion battery exceeds 50 °C, it affects its own service life, charging, and discharging performance. On the other hand, charging in a low temperature environment is likely to form lithium deposits on the surface of the negative electrode of the battery and cause battery short circuit [17]. When the battery temperature is low, the average charging voltage, internal resistance, heat generation, and energy consumption of the battery will increase, and the low temperature will cause irreversible damage to the interior of the lithium-ion battery [18, 19]. Both high temperature and low temperature will have a serious impact on battery performance and safety [20]. In the case that fast charging may damage the battery life, most users prefer to charge at night. The high failure rate (improper manual operation, defects and damage of parts themselves, night weather, and surrounding environmental impacts) of charging equipment and supporting facilities is easy to cause safety accidents such as overcharge under charge and explosion. Thus, the daily use of electric vehicle, battery, and charging environment management are essential.

In summary, the design of electric vehicle battery boxes shall consider not only temperature control requirements, but also moisture-proof, anti-collision, and explosion-proof. Currently, there is no widely recognized comprehensive

application of battery boxes with various performance structures. Therefore, it is necessary to adopt a standardized method with a relatively optimal solution to standardize under the conditions of the existing technological development level and focus on solving technical problems.

2.3.2. Environmental Impact Analysis. The environmental impact involved in this study mainly includes the impact on ecological environment, resource environment, and power grid environment. The following is a specific analysis from these three aspects, namely, under the existing development mode, three serious problems in the present and future will be preliminary analyzed.

(1) Ecological Environment Crisis. Improper treatment of electric vehicle batteries will have adverse effects on the ecological environment and destroy the ecological environment. Although our country has considered the power battery for a long time, formulated and issued, such as "Automobile power battery industry specification conditions", "Electric vehicle power battery recycling technology policy (2015)", "New energy vehicle waste power battery comprehensive utilization industry standard conditions", "Interim measures on new energy vehicle waste power battery comprehensive utilization industry standard announcement management", "Pilot implementation plan on new energy vehicle power battery recycling" and other documents. At the end of 2019, the Ministry of Industry and Information Technology issued the "New energy vehicle waste power battery comprehensive utilization industry standard conditions (2019)" and "Interim measures on new energy vehicle waste power battery comprehensive utilization industry standard announcement management (2019)". The Ministry of Ecological Environment also issued two new regulations of "Technical specification on waste lead battery treatment pollution control" and "Guide for examination and license of hazardous waste management units of waste lead-acid batteries (Trial)" in May 2020 to put forward new requirements for waste battery recycling. Relevant policy documents put forward the corresponding requirements for power battery production, use, and recycling from a macro perspective. However, the free development of electric vehicle enterprises in the early stage has caused a lot of chaos in the battery market. The problems of low efficiency, low life, and high risk are becoming increasingly prominent, which are incompatible with the overall development trend and the level of China's economy and society. According to one research [21], the output of power batteries in China from January to November 2019 has reached 79.2GWh, with a year-to-year increase of 29.3%. The output of the ternary lithium batteries is 50.3GWh, accounting for 63.5% of the total output of the power batteries, with a year-to-year increase of 46.2%. According to the study, the scrapped quantity of power batteries in China will reach 1.5 million sets and 1.31 million tons by 2025, which will increase exponentially year by year. In the future, China will face the problem of disposing a large number of waste batteries. The high treatment cost and the risk of ecological environment damage will be the serious problems that we have to face. However, there are only 5 enterprises in the list of qualified and recyclable enterprises in the industry standard conditions for comprehensive utilization of waste power batteries of new energy vehicles issued by the Ministry of Industry and Information Technology, which is seriously inconsistent with the market demand.

(2) Low Resource Utilization. According to the statistics of the International New Energy Network, by the end of 2019, there were 1,219,000 charging piles in China, with a year-on-year increase of 56.95%, including 516,400 public charging piles and 702,600 private charging piles. The ratio of national electric vehicle to pile is about 3.13 : 1, but the construction of charging facilities lags far behind the promotion scale of new energy vehicle products, which still cannot meet the actual demand. The lag of charging facilities construction has become an important factor restricting the large-scale promotion of electric vehicles in China. However, the construction of charging facilities needs comprehensive consideration and coordination of various factors. There are also many problems in the expansion and rapid development of charging piles. In addition, the utilization rate of existing public charging piles is not high due to the lack of timely, scientific, and effective management and maintenance. In addition, many electric vehicle users pursue the construction of a personal charging pile for charging convenience. According to the statistics of China Charging Alliance, in recent years, the proportion of private piles has increased from 12.2% in 2015 to 57.8% in the first half year of 2020. Therefore, in part of accelerating the construction of charging and swapping infrastructure in the "New energy vehicle industry development plan" newly approved in 2020, it is the first time to strengthen the research and development of new charging technologies such as intelligent orderly charging, high-power charging, wireless charging, and plug-and-play charging, to improve the charging convenience and product utilization efficiency.

In addition, due to China's unique economic and natural conditions, China's electric vehicle promotion adopts the development mode of pilot cities. In 2013, the four ministries and commissions jointly identified 28 cities or regions as the first batch of new energy vehicle promotion and application cities in China, and then further announced the second batch of pilot provinces and cities. To encourage development, a series of policies supporting the development of electric vehicles have been launched in pilot cities. Taking Beijing as an example, Beijing has implemented a series of measures for many years, such as subsidies for purchasing electric vehicles, unlimited travel, tax exemption, increasing lottery winning rates, and promoting infrastructure construction, which have played a certain role in promoting, but the promotion effect is not obvious. Relevant policy incentives have not promoted the explosive growth of electric vehicle sales [22]. If only from the perspective of environmental protection, as the first batch of developing cities with extremely strong demand for electric vehicles, Beijing has been the city with the most charging infrastructure for many years, and the construction of charging piles in China also costs a lot of capital and human resources. However, according to the data of China Alliance for Electric Vehicle

Charging Infrastructure Promotion, as of December 2019, Beijing and Shanghai are no longer the provinces with the largest number of charging piles. The top four cities in China are Guangdong, Jiangsu, Beijing, and Shanghai, with the number of 62,834, 60,509, 59,060, and 55,113 in turn. The specific number and development trend are shown in Figure 3. Among them, Guangdong Province and Jiangsu Province show a strong development trend. In addition, although the number of charging piles in Zhejiang Province and Anhui Province is small in the early stage, the speed of increasing the number of charging piles in recent years is accelerating, which also shows great development potential, likely to surpass Beijing and Shanghai in the future. The reason is more likely that the other provinces and cities have more development space than Beijing and Shanghai in terms of natural environment conditions. The early development of first tier cities benefited from policy support. However, they are also facing problems such as shortage of land resources and limited land planning, which have higher requirements for resource utilization efficiency.

(3) Load increase on Power Grid. The number and proportion of electric vehicles are continuously increasing, and the charging of electric vehicles will bring greater pressure on the power grid [23]. At the same time, a large number of electric vehicles charging loads connected to the grid may also cause new voltage stability problems. When the transmission limit of power grid cannot meet the demand of load growth, the load balance of the system will be broken and the stability of voltage will be threatened. As a new type of fast-growing load, the charging of electric vehicles will pose more challenges to the voltage stability of the power grid. [24, 25] In addition, electric vehicle charging has the features of mobility, randomness, and dispersion, and it is closely related to people's lives. If users are allowed to charge according to their own habits without control and effective guidance, the peak load of the power grid will be increased, and the operation of the distribution network will be added to a new burden [26, 27]. Therefore, in the case of a large number of developments of electric vehicles, we shall do a good job in planning, to strengthen the effective regulation of electric vehicle charging.

2.3.3. Development Mode Problems. At present, there is a situation of fragmented research in the field of electric vehicles. There is more competition between automobile enterprises and less cooperation between them, which leads to technical progress, especially in the battery bottleneck area, which restricts the development of electric vehicles. One study [28] pointed out that the development of China's new energy vehicle industry is still in a state of confusion over the direction and path selection of industrial development due to the limitation of technology completion degree. The development of electric vehicles is an effective way to solve the energy crisis at present and in the future. It has basic conditions for promotion and development. However, due to the existence of technical bottlenecks that

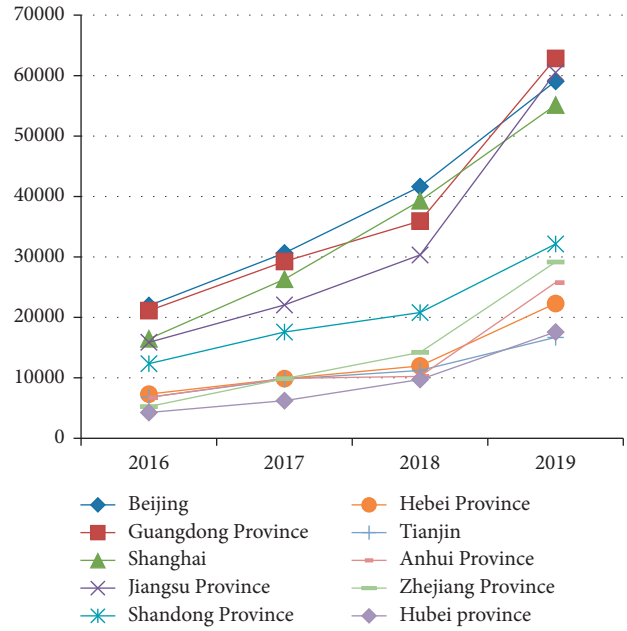

Figure 3: Number and development trend of charging piles in the top provinces and cities in China.

are difficult to overcome in the short term, it is imperative to explore a positive and effective promotion and application modes. According to statistics [29], in recent years, many enterprises have fallen down one after another and many existing enterprises are also in a poor state of operation. Through the investigation of the car rental industry at home and abroad, it is found that it is inconvenient to take and return the car. The high cost and poor experience of using the car are also some problems restricting the use of consumers. At present, the general shared car operation mode cannot meet the conventional demand, let alone meet the personalized needs of consumers. The important reason for the high cost of using car is the operating cost of power battery is too high.

2.4. Development Mode Analysis. The current development mode of electric vehicles in China is mainly based on the charging mode, which is a necessary stage of development. Current research focuses on the improvement and upgrading of battery systems, including improving battery energy density, battery safety, and battery environmental adaptability. However, due to the limitations of batteries, the cruising range of electric vehicles is slow to increase. Electric vehicle batteries are slow to charge, have a short lifespan, and the batteries are significant affected by various external environments, which cannot meet the actual needs of consumers for household electric vehicles. Therefore, it is necessary to innovate and consider a new development mode. Although there is already a power exchange mode in China, it cannot be widely promoted due to the limitation of standards. Therefore, it is necessary to discuss relevant standardization plans to gradually promote and popularize this mode.

Table 2: Summary of relevant standards for electric vehicle batteries in China.

Number of standard	Names of standard	Type of standard	Standardization field
GB 8897.4-2008	Primary batteries-part 4: Safety of lithium batteries	MS	Performance of battery pack
GB 18384-2020	Electric vehicle safety requirements	MS	Performance of battery pack
GB 38031-2020	Electric vehicle traction battery safety requirements	MS	Performance of battery pack
GB/T 8897.1-2013	Primary battery	RS	Performance of battery
GB/*Z* 18333.1-2001	Lithium-ion batteries for electric road vehicles	GD	Performance of single cell battery
GB/T 20234-2015	Connection set for conductive charging of electric vehicles	RS	Battery charging device
GB/T 29316-2012	Power quality requirements for electric vehicle charging/battery swap infrastructure	RS	Charging and changing facilities
GB/T 29317-2012	Terminology of electric vehicle charging/battery swap infrastructure	RS	Charging and changing facilities
GB/T 29772–2013	General requirements of electric vehicle battery swap station	RS	Battery replacement station
GB/T 31467-2015	Lithium-ion traction battery pack and system for electric vehicles	RS	Performance of battery system
GB/T 31484-2015	Cycle life requirements and test methods for traction battery of electric vehicle	RS	Performance of battery
GB/T 31486-2015	Electric performance requirements and test methods for traction battery of electric vehicle	RS	Performance of battery cell and module
GB/T 31525-2015	Graphical signs—Electric vehicle charging and battery swapping infrastructure signs	RS	Charging and changing facilities
GB/T 33059-2016	Methods for disposal and recycling of lithium-ion battery material wastes	RS	Battery recycling
GB/T 33060-2016	Treatment and disposal methods for the waste liquid from the treatment of waste batteries	RS	Battery recycling
GB/T 33143-2016	Aluminum and aluminum alloy foil for lithium-ion batteries	RS	Battery recycling
GB/T 33341-2016	General requirements for swapping battery pack rack of electric vehicle	RS	Battery replacement
GB/T 33598-2017	Recycling of traction battery used in electric vehicle—Dismantling specification	RS	Recycling of battery pack and module
GB/T 33598.2-2020	Recycling of traction battery used in electric vehicle——recycling——part 2: Material recycling requirements	RS	Recycling of battery pack and module
GB/T 33824-2017	Aluminum and aluminum alloys plates, sheets and strips for cans, and caps of new energy power batteries	RS	Battery packaging
GB/T 34013-2017	Dimensions of traction battery for electric vehicles	RS	Specification and size of battery unit and module
GB/T 34014-2017	Coding regulation for automotive traction battery	RS	Management of battery pack
GB/*T* 34015-2017	Recycling of traction battery used in electric vehicle—Test of residual capacity	RS	Recycling of battery pack
GB/T 34015.2–2020	Recycling of traction battery used in electric vehicle—echelon use—part 2：Removing requirement	RS	Recycling of battery pack
GB/T 38661-2020	Recycling of traction battery used in electric vehicle—Management specification	RS	Battery management system
GB/T 38698.1-2020	Recycling of traction battery used in electric vehicle—management specification—part 1：Packing and transporting	RS	Battery recycling

3. Standardized Solutions

3.1. Analysis of Limiting Factors of Standardization. In view of the current low battery capacity, difficult to control, and safety problems of electric vehicles in China, especially the environment (ecological environment, resource environment, and power grid load increase), it is particularly necessary to standardize and lead with standardized means. Next, we will sort out and briefly analyze the current relevant national standards for electric vehicle batteries in China.

The collection and summary of relevant national standards for power batteries of electric vehicles in China are shown in Table 2. Through combing, it is found that most of them are recommended national standards (referred to as RS in Table 2). In terms of mandatory national standards (referred to as MS in Table 2), there are only a few safety-

related standards for electric vehicles. In addition, there is a guiding technical document (referred to as GD in Table 2) related to the performance of lithium-ion power batteries. The recommended national standards generally focus on battery performance, battery management, charging facilities, and battery recycling. In addition, there are relevant standards for battery size and replacement. For example, GB/T 34013–2017 "Dimension of traction battery for electric vehicles" effectively solves the problem that power batteries are difficult to match the structure of energy storage power stations and household energy storage equipment due to different sizes. However, the standards about battery size and battery recycling are the only recommended standards, and there is no compulsory unified nationwide standard. The reason may be related to the current development mode of electric vehicles in China. In terms of updating and revising, the national standards related to electric vehicle batteries in China have been formulated and revised timely, which has played an important role in standardizing and guiding the development of the industry. There are also some standards that cannot meet the requirements of the rapid development of electric vehicle batteries due to the early development of individual standards. In actual use, some industry and enterprise standards replace the use of these standards.

In recent years, the newly developed standards are more about electric vehicle safety and battery recycling standards. On the one hand, it reflects the current focus on safety improvement, on the other hand, it also reflects the current situation that some batteries are facing replacement or elimination with serious degradation of battery performance of the first batch of electric vehicles in China, and car owners are faced with the problem of not finding the original vehicle batteries and high batteries replacement costs, not universal batteries, and high price of new electric vehicles.

3.2. Standardization Solution Proposal

3.2.1. Introduction of Standardization Solution. One study [30] pointed out that the business mode of electric vehicles has a scale effect, the investment demand of infrastructure and other fixed assets is large, and the payback period is long. Adam Smith believes that the greatest improvement in labor productivity is the result of division of labor. He believes that division of labor is conducive to the improvement of skills. [31] All of these have a good reference value for improving the core competitiveness of electric vehicles in China. Currently, the relatively low performance and high comprehensive cost of electric vehicles will be the most critical limiting factors at present and in the future for a long period of time, regardless of the two modes of consumers purchasing their own cars and sharing rental electric vehicles. We shall study how to lead technical improvement from standardization and actively explore the breakthrough of the new development modes.

(1) Develop Mandatory Standards for Battery-Related Fields of Electric Vehicles. Speed up the formulation of national standards for the structure, size, and charging method of electric vehicle, batteries, cabinets, and battery packs. Among them, some standards can consider the formulation of mandatory standards. It is not talking about a simple compulsory unification, but a series of specifications according to the actual situation and needs, to achieve the serialization design of the corresponding facilities such as the charging and swapping power station. In addition, considering the rapid development characteristics of electric vehicle battery technology, the formulation and implementation of relevant standards shall not only maintain stability but also fully consider the openness.

(2) Technical Improvement Corresponding to the New Mode. In view of the new separation mode of battery and vehicles, the overall design of electric vehicle and technical improvement of related products shall be carried out. For example, in view of the current development trend of electric vehicles and the continuous expansion of information application in the automotive field, it is necessary to ensure the power supply of on-board electronic equipment in the process of power exchange. Therefore, it is necessary to increase the separate power supply of on-board information equipment to ensure the stable power supply and functional stability of the vehicle information equipment in the process of battery replacement.

(3) Actively Develop New Modes. The expansion of the new mode often cannot achieve overnight, but needs further experimental research and continuous improvement. Therefore, it is suggested that the above measures shall be carried out in specific cities to gradually accumulate experience and lessons, thus to gradually promote them nationwide. In addition, in terms of city selection, the comprehensive factors such as climate and environment, geographical conditions, resources, economic development characteristics (such as the development of tourism industry), and policies shall be fully considered.

In general, the current power battery model, size, and specification are standardized through standardization means, the separation of electric vehicle and battery system is achieved through the modular and standardized design of the battery, and the unified management of battery rental mode is adopted. Only in this way, the competitiveness of China's electric vehicles relative to traditional fuel vehicles can improve, and its standardized social benefits can improve, which is a more feasible way at present and in the future. The standardization means is not to limit the technology update and development, but on the contrary, to lead the development of technology. Because the rapid development of electric vehicle technology requires collective wisdom to tackle key problems and reduce resource waste. In addition, we suggest that the initial mandatory standards tend to be formulated in terms of the size and safety of electric vehicle battery packs, and continue to encourage enterprises to make research and breakthroughs in the energy density of electric vehicle batteries. Just like in the field of mobile phone charging port, we only impose mandatory restrictions on the size, but we still encourage competition in terms of the charging speed of charging line.

And relevant standards need to be revised according to the actual needs, because the rapid development of electric vehicle technology needs collective wisdom to tackle key problems and reduce the waste of resources. In the process of

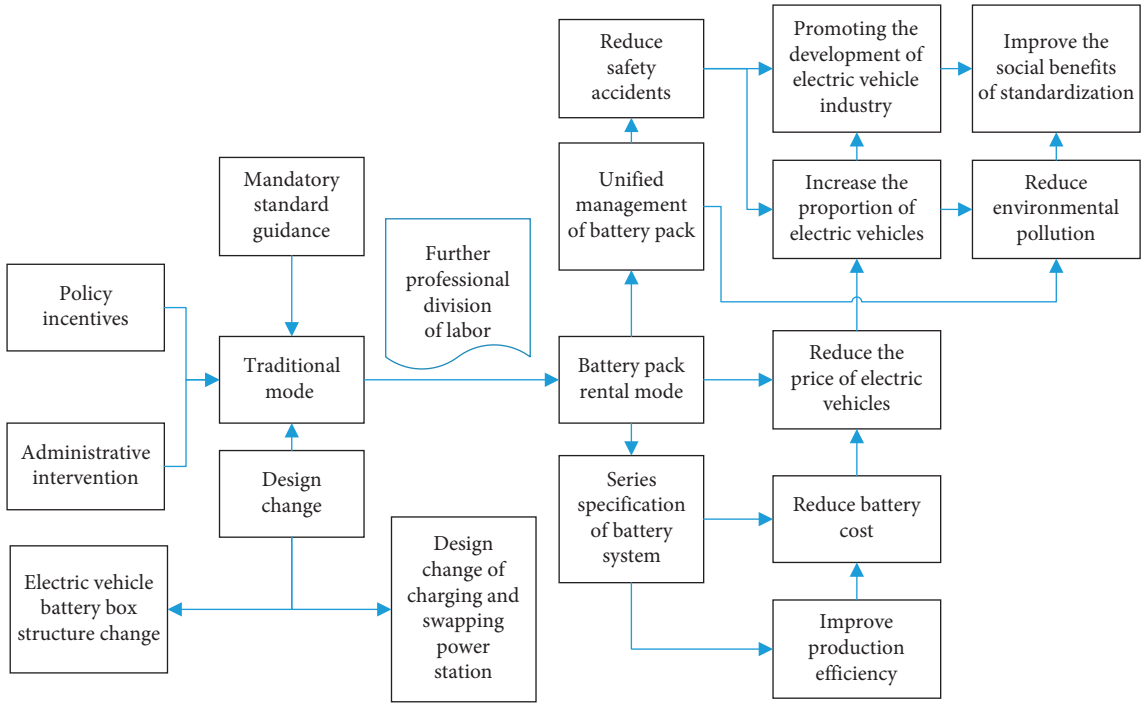

Figure 4: Comprehensive action mechanism diagram.

standard formulation, we should do a good job in the early stage of coordination, consider the foresight, and minimize the number of unnecessary revisions of the standard. In addition, standardization has more important significance for China than other countries with small demand for electric vehicles in other regions. It can quickly solve the problem of low efficiency of multi-polarization development and progress in China.

3.2.2. Scheme Implementation Path. The specific implementation and action mechanism of the standardized solution can refer to the comprehensive action mechanism diagram as shown in Figure 4. Through the development of mandatory standards in the battery system specifications and related fields of electric vehicles, it plays a leading role, thus breaking the technical feasibility limit of the solution. At the same time, it also needs the support of relevant supporting policies to break through the management restrictions of relevant aspects. The implementation of the solution also needs to solve many problems, for example, the unified recycling cost borne by the automobile enterprises and the government; to improve the enthusiasm and user experience of consumers in the delivery of waste batteries by increasing subsidies; to pay attention to avoiding policy loopholes to prevent speculation; to reorganize the relevant management regulations of electric vehicles; to guide research and development institutions to provide relevant structures and supporting services for electric vehicles, for example, the original design of related devices of electric vehicle to power station shall be modified. On the whole, the two aspects are to guide and promote the development of the new administrative mode. To achieve the evolution from the traditional development mode to the new mode, on the basis of further strengthening the professional division of labor, accelerate the relevant technical progress, and finally enhance the competitiveness of electric vehicles, to enhance the standardization and social benefits. For example, just take the data of sales comparison between pure electric passenger cars and passenger cars in China in 2018, the proportions of China's electric vehicle sales in passenger car sales was 1.066%. About 100 persons in 10000 buy pure electric passenger cars. After applying the new mode, there are maybe 3 thousand persons in 10000 who buy pure electric passenger cars. The comparison of emissions in these two cases is shown in Table 3.

4. Analysis of Standardization Social Benefits

4.1. Brief Analysis of the Role of Social Development. Electric vehicles promote economic and social development. On the one hand is the development of its own electric vehicle industry, and on the other hand is the promotion of other industries and economic and social development. The key of both aspects is to improve its performance and economy. By improving the performance and economy of electric vehicles and reducing the cost of a single vehicle, it is bound to improve the sales volume and overall economic benefits of electric vehicles. By improving the performance and economy of electric vehicles, the utilization efficiency of supporting infrastructure (charging and swapping battery system facilities) is improved, and the waste of resources is reduced, to promote the optimal allocation of urban resources, and finally promote its technological progress and overall economic and social development.

Table 3: Emissions comparison between two development modes.

Development mode	Sales of passenger cars	Sales of pure electric passenger cars	Sales of pure electric passenger cars	Proportion of cars that emit polluted exhaust in cities (%)	Reduction rate of pollution tail gas emission (%)
Traditional development mode	10000	107	9893	98.9	19.1
The new development mode	10000	2000	8000	80	

4.1.1. Brief Analysis of the Role of Industrial Development

(1) Enhance Practicability. Under the condition of existing technology development, the development mode is mentioned in this article (mainly the power exchange mode, charging mode as a necessary supplement). On the one hand, it can improve the actual endurance of electric vehicles, to improve their performance, on the other hand, through the separation of electric vehicles and power, batteries, the mass production and management of batteries are conducive to reduce the use cost and purchase cost of electric vehicle batteries. On the whole, it improves its use, economy, and competitiveness.

(2) Improve Safety. At present, a number of studies at home and abroad have found and confirmed that due to the lack of professional knowledge of ordinary consumers and the nonstandard charging methods and environmental conditions, the unified standardized management of electric vehicle battery system will greatly reduce the probability of safety accidents caused by nonstandard charging operation and adverse environmental disturbance.

(3) Promote Technological Progress. Through the unified management of electric vehicle batteries, it can promote the industrial division of labor and promote the rapid progress of related technologies. For example, to ensure the service life of the battery, the operating temperature range of the battery is generally recommended to be 15°C~40°C [32]. However, in most areas of China, the temperature range is usually -30 °C ~ 45 °C. Since the normal use of the electric vehicle battery will only have a small temperature rise, so for the electric vehicle battery temperature control system running in our country, the insulation problem under low temperature shall generally be focused on. Therefore, through the modular and standardized design of the battery, we can concentrate the research strength on the centralized design of its supporting structures or systems (such as boxes, thermal management systems, electrical system, and monitoring systems) and break through one by one, to speed up the pace of technical progress in the design of automobile battery insulation structure and related aspects.

4.1.2. Brief Analysis on the Role for the Development of Other Industries

(1) Improve Resource Utilization Efficiency. Previous studies have pointed out that the precondition for the popularization and application of electric vehicles is the large-scale construction of charging facilities [33]. However, in the first tier cities, parking spaces shall be increasingly scarce, and the popularization of one tram and one parking space is more difficult. Unified and standardized management of the electric vehicle battery system can effectively improve the utilization efficiency of charging resource facilities, reduce the demand for private parking spaces, and promote the optimal allocation of resources.

(2) Reduce the Pressure on Power Grid. With the continuous development of electric vehicles, it is bound to cause a lot of pressure on the urban power grid. If this pressure cannot be effectively managed, it is likely to have adverse effects on the power supply in other fields. Through the unified management of electric vehicle battery, the orderly charging of the battery pack can be achieved, which has a certain positive effect on peak load shifting and valley filling of the power grid, and can improve the charging efficiency. It will reduce the adverse impact of disordered charging on the grid load.

(3) Important Strategic Energy Reserves. Electric vehicles have the characteristics of mobile distribution. With the development of electric vehicles, if they can achieve good interaction with the power grid, they can be used as power supply to the power grid when the power grid needs, otherwise, it may cause a burden on the power supply guarantee in China [34–39]. If unified management can be carried out, the power supply can not only guarantee the daily use of electric vehicles but also serve as an important strategic energy reserve in emergency situations such as natural disasters and man-made accidents, and provide stable power resources for medical treatment, rescue, living security, and other activities caused by emergency epidemics and disasters.

4.2. Brief Analysis of the Role for Energy Conservation and Environmental Protection

4.2.1. Brief Analysis of Carbon Emission Pollution. Whether electric vehicles are really environmental protection products in China and whether their promotion and use are really conducive to reducing environmental pollution have been questioned, because whether the access to electric energy is environmentally friendly, and whether the process of energy conversion will cause more waste has always been questioned. Jan Hromadko et al. [40] took the Czech Republic as the research object and found that compared with the traditional fuel vehicles, the CO_2 emission of vehicles using energy combination electric power is 56% lower, and even if the battery energy is all from coal power generation, the CO_2 emission can be reduced by 16%. A study in China [41] found that even if emissions from electric vehicles are

converted into standards for power plants, CO_2 emissions significantly reduce. That from the perspective of CO_2 emissions, the use of electric vehicles is more environmentally friendly. The following is a specific comparative analysis of China's power generation types and international ones.

According to the data of the Statistical Review of World Energy, 67th Edition (2018.6) and 69th Edition (2020), at present, thermal power generation is still the main power generation type in the world, and the power generation capacity of hydropower, nuclear power, and renewable energy shows an increasing trend year by year. Taking 2018 as an example, according to the statistics released by the National Grid of France (RTE), nuclear power accounted for 71.6%, hydropower accounted for 12.4%, wind power accounted for 5.1%, thermal power accounted for 7.1%, and solar power and biomass power accounted for 1.8%. The current international power generation energy types are divided into fuel energy, power generation mode (including oil, natural gas, and coal), and environment-friendly power generation mode (including nuclear energy, hydropower, renewable energy, and other modes) by us. In France in that year, the proportion of fuel energy power generation mode and environment-friendly power generation mode was 7.1% and 92.9%, while that of China in that year was 69.58% and 30.42%, and the proportion of fuel energy power generation mode and environment-friendly power generation mode in the world as a whole was 64.20% and 35.98%. One study [42] (Pegelsa et al. 2014) has found that the unit pollution emission of coal-fired power generation is 100 times that of wind power generation and 10–20 times that of solar power generation.

The data comparison of environmental friendly power generation modes in China, Europe, and the world in recent years is shown in Figure 5. According to Figure 5, in recent four years, China's power generation mode has gradually changed from fuel energy power generation to environment-friendly power generation, which is consistent with the global development trend, but there is still a certain gap compared with Europe. Germany takes renewable green energy such as wind energy, solar energy, nuclear energy, and bioenergy as its core. Britain also promotes energy structure reform through legislative and economic measures [43]. Nuclear power generation in France occupies a dominant position. Reducing the excessive dependence on natural energy is the main motivation for the development of electric vehicles. In recent years, China's power generation mode is gradually reducing the consumption of natural resources. With the continuous optimization of China's relevant policies and power generation technology, the speed of this reduction will be faster and faster.

4.2.2. Brief Analysis of Environmental Pollution. In view of the large development of electric vehicles, another question comes from the disposal of waste batteries. Whether it can be effectively recycled and utilized, whether it will require a large amount of cost and high difficulty technology is another social concern. Waste lithium-ion batteries contain metals such as cobalt, nickel, lithium, manganese, and inorganic and organic

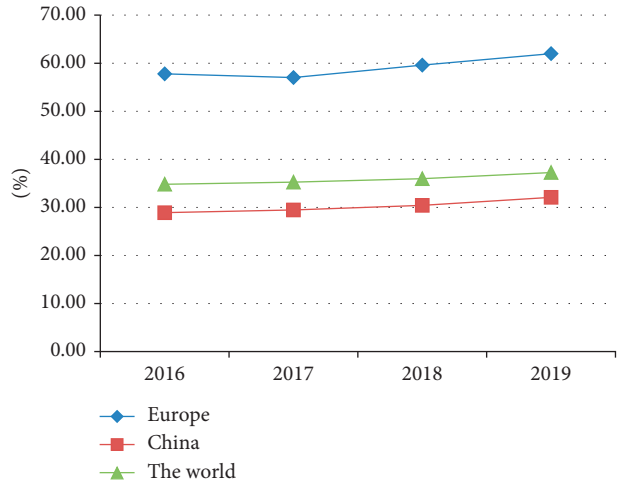

Figure 5: Data comparison of environmentally friendly power generation modes among China, Europe, and the world in recent years.

compounds, which will cause serious pollution to the atmosphere, water, and soil [44]. If heavy metals accumulate in the human body through various ways, they may cause acute or chronic poisoning and cause great harm to the human body. However, at present, the phenomenon of irregular treatment and random discarding of electric vehicle batteries occurs frequently. According to the statistics, in 2018, the total amount of power batteries retired and scrapped in China reached 74000 tons, while the recovery amount was only 5472 tons, accounting for 7.4% of the total amount of discarded power batteries [45]. According to the prediction data of the medium and long-term development plan of automobile industry issued by the Ministry of Industry and Information Technology, one research [46] calculated the weight of discarded batteries of electric vehicles in the next few years. According to the two kinds of batteries with the largest consumption at present, we have estimated the content and growth rate of various pollutants contained in waste batteries in the next few years. The development trend chart is shown in Figure 6, showing a rapid growth rate. It can be seen that scientific and effective recycling is undoubtedly the best treatment scheme. However, in the process of recycling, the recycling brought by batch management proposed by us is undoubtedly the most efficient. In addition, for cities with high requirements for resource utilization efficiency, the safety and environmental pressure on the recycling process are greater. Therefore, it is not only necessary to do a good job in recycling the power battery of electric vehicles but also to ensure the safety of all links. On the other hand, whether it is a physical method, chemical method, or biological method [47–50], it is necessary to have an appropriate cost for the recovery and utilization of waste batteries of electric vehicles. While considering the social benefits, the consideration of its economic benefits is also an important factor.

The development mode mentioned in this article, through the unified and scientific management of power battery, compared with the current development mode, on the one hand, can improve the efficiency of resource

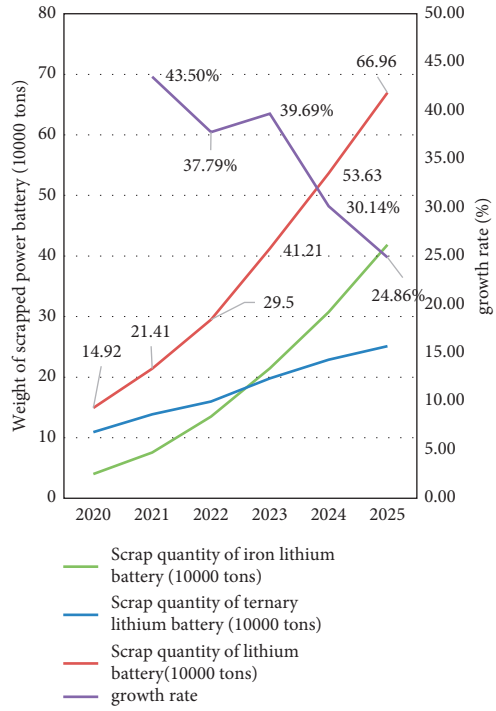

Figure 6: Development trend of pollutant content and growth rate in waste batteries.

utilization, and more importantly, can reduce the safety risk and heavy metal pollution. Batch planning of recycling treatment is also conducive to reducing the cost of recycling and controlling the overall economic benefits.

5. Conclusion

Electric vehicles for the energy crisis and environmental protection requirements develop slowly due to the inherent attributes, technical level and development mode, and other factors. Only by improving its core competitiveness can it replace the traditional fuel vehicles, to achieve real energy saving and emission reduction, and improve its standardized social benefits. This article points out the main problems restricting electric vehicles' rapid development, provides specific and operable standardized solutions to promote the rapid development and popularization of electric vehicles in China, and analyzes the ways of improving the standardization social benefits. This method can be applied in pilot cities or some pilot electric vehicle brands. Firstly, the application scope can be gradually expanded by formulating group standards and gradually upgrading them to national mandatory standards, so as to continuously broaden the application field. In the process of expansion, we should timely summarize the practical problems encountered in the development process, constantly optimize and improve, and finally complete a wider range of promotion and application. The content of this article provides a certain basis and ideas for future research work. In the future, it is necessary to further investigate and analyze the size, model, and battery box structure of the existing mainstream electric vehicle brands in China, and consider the determination of specific parameters and indicators during the formulation of specific mandatory standards.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

This work was supported by the State Administration for Market Regulation under Grant numbers 572021C-8479 and 572019C-7060.

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