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Research Article

Mathematical Analysis of the Impact of French Standardization Strategy and Electric Vehicle Development on the Breakthrough Development of EVs in China

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The problems of operating range and costs are the two most critical bottlenecks restricting the extensive application of electric vehicles (EVs) in China and some other countries. There are also some prominent problems in China's EVs, which lead to poor competitiveness of EVs compared with traditional internal combustion engine vehicles. This paper analyzes the key mathematical factors restricting the development and popularization of EVs in China from the aspects of strategic policy, sales situation, and self-problems. For the best-selling family cars in China, select the representative models with the same body structure, and make statistics on various parameters most concerned by consumers, establish a database through data statistics and analysis software. Through summarizing France's standardization development strategy and relevant issues reflected by the development data of its EVs, this paper puts forward the hypothesis leading the development of EVs through standardization to enhance their competitiveness, gives the specific suggestions, and briefly analyzes the feasibility from the aspects of product situation. The research content of this paper provides a certain basis and ideas for the future research work.

1. Introduction

Bai [1] pointed out that the world would face a situation of oil depletion in the year 2038. Sorrell et al. [2] also believed that conventional oil would be physically depleted by 2030. The energy crisis has led countries around the world to consider using pure electric vehicles (EVs) instead of traditional internal combustion engines (ICEs) to reduce carbon emissions [3]. China has become one of the fastest-growing countries in the global EV market [4]. However, the problems of vehicle operating range and costs are the two most critical bottlenecks restricting the extensive adoption of EVs. Over the years, a lot of research has been done in China and other countries, and a lot of research results have been achieved in this field. However, there is still no breakthrough in the actual research and application to improve the operating range of EVs, and there is still a big gap between the operating range of most domestic EVs and the actual demands, which is a big problem that has plagued domestic and foreign researchers for many years. Compared with traditional ICE vehicles, the competitiveness of EVs has no advantage. The slow development of EVs, rather than replacing traditional ICE vehicles, may aggravate urban traffic congestion, thus increasing energy consumption and air pollution. How to improve the market competitiveness of EVs, rather than relying on policy survival and development, is a problem worth pondering. It is reported that in October 2022, the EU reached an agreement to sell only zero-emission new cars from 2035 [5]. French President Marc Long said in the interview that France will adhere to the goal of 100%

EVs by 2035 [6]. The release of the French standardization strategy (2019 edition) [7], as well as the exploration and valuable lessons learned by France in the field of EVs, can provide a very good roadmap for China to overcome the bottleneck problems during EV development. A preprint has previously been published [8].

What needs to be explained in advance is that the EV in this paper refers to pure electric, family-use, two-axle, four-wheel vehicles. In addition, the permeability mentioned in this paper can also be called the electrification rate, which refers to the proportion of the use of EVs in daily passenger vehicles. It can objectively reflect the proportion of EVs used in daily use from the perspective of the proportion of the sales of EVs to the proportion of passenger vehicles.

2. Materials and Methods

2.1. Data Sources. Relevant research data are from authoritative research institutions, data statistics institutions, media, and websites in China. Relevant data are compared and comprehensively analyzed, and the data with higher reliability are screened out for further comparison and analysis. Select the 2019 version of the French standardization strategy, analyze its main contents, study its guiding role in the rapid development of EVs in France, and conduct a reference analysis. A brief comparative analysis is made for several countries with high penetration rates of EVs in Europe. In addition, the relevant policies and requirements of France are briefly analyzed.

2.2. Data Processing. For the best-selling family cars in China, select the representative models with the same body structure, make statistics on various parameters most concerned by consumers, establish a database through data statistics and analysis software, input relevant information such as car performance, price, use cost, and conduct overall comparison and analysis. In the process of data storage, it is necessary to eliminate the parameters that have little impact on consumers' purchase intention and use experience.

3. Results and Analysis

3.1. Analysis of French Standardization Strategy and Development

3.1.1. Introduction to Relevant Contents. In 2019, the French Association for Standardization released the latest version of its standardization strategy (2019 edition), which proposed that French standardization would focus on seven major cross-functional and sectional (sustainable and smart cities and communities, trust and excellence for services, ecological transition, autonomous and remotely controlled mobility and logic, etc.) and five specific topics (artificial intelligence, energy storage-batteries, security, etc.). It has mentioned the important role of standardization in identifying and sustaining support for technological and social trends. It captures market demand in terms of openness, supporting the competitiveness of French companies and creating a framework for the harmonious development of activities and new jobs. Standardization can also support legislation and regulations to help limit the spread of laws and regulations. In the current international, this development trend is becoming faster and faster.

The French standardization strategy points out that standardization will help China to cope with three major challenges: fight against climate change, controlled digitization, and create a more inclusive society. It is mentioned in "Fight against climate change" that the mobilization of carbon neutrality in Europe by 2050 can continue at the local, national, and international levels. Voluntary standardization helps to promote this progress in all sectors, namely the effective deployment of climate change on the basis of streamlined and effective management of resources, materials, and energy and their use.

In the "a more inclusive society" section, it is mentioned that the consideration of multiple individuals and education and income levels through common rules is a major social issue. Standardization is one of the tools used to integrate differences from the design stage. Standardization, which benefits diversity, is not as contradictory as it seems. Standardization leverages the know-how to provide solutions.

3.1.2. Brief Analysis of Related Enlightenment.
(1) Technical Standardization Support Policy Implementation. France is creating technical standards as technical tools that can support legislation and regulations, and standardization, as a means of consolidating technological achievements, promotes applications of best practices in the technical field. In the field of EV development, China has issued many related policies and measures to encourage sales and use, and the scientific aspects of the policies are also constantly improving.

However, in terms of the specific implementation of the policy, there may be some deviation in the understanding of the policy by all parties in the technical field; there is still a certain gap in the follow-up of the implementation of the new policy at the technical level. The most effective tool to combine technology and policy is standardization. In the field of standardization, the development and implementation of mandatory standards are the most closely combined with best practices.

(2) Technology Standardization Promotes Energy Conservation and Emission Reduction. On the one hand, EVs are planned to play an important role in addressing climate change as an alternative to traditional ICE vehicles. However, the most important problem to be solved is to improve its operating range capacity on the premise of ensuring safety, so as to enhance its competitiveness relative to ICE vehicles, thus to achieve additional market share. On the other hand, in the effective management of batteries, it is important to consider the recycling and depletion of batteries, so as to reduce the environmental pollution impacts and achieve the overall treatment and efficient recycling of EV battery materials.

(3) Technical Standardization Helping Cost Control. At present, the adoption of EVs still has a key problem to be solved, which is too high. The price remains high, causing many consumers not to buy it. The French standardization

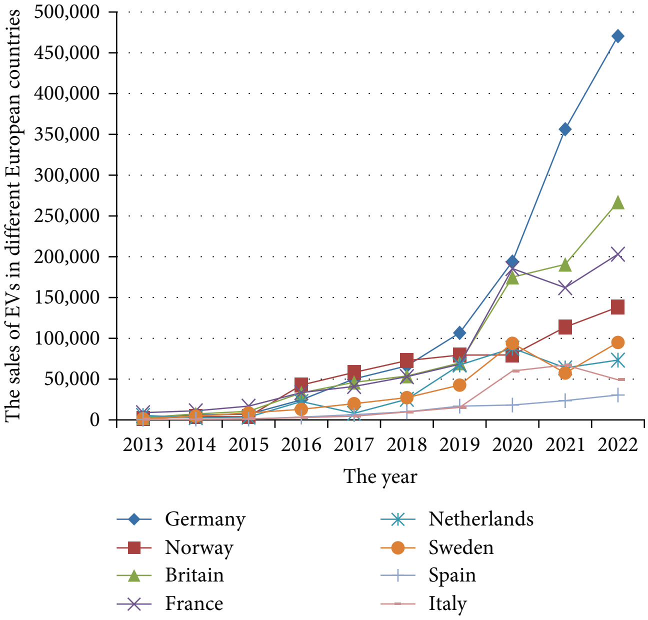

Figure 1: Comparison of sales statistics of EVs in different European countries in recent years.

strategy mentions that the common rules of standards are used to comprehensively take into account multiple individual needs. Standardization in the field of EVs requires comprehensive consideration of the interests of multiple parties. From the development policy of EVs to the design of related products, various differences shall be considered at all stages, so as to achieve standardization and mass production while taking into account the interests of all parties, so as to achieve the optimal allocation of resources and ultimately reduce the overall cost and price of EVs.

3.1.3. Brief Analysis of EV Development in France.

(1) Development Profile. The development of EVs in France can be described as groundbreaking. A tricycle powered by a lead-acid battery invented by French engineer Gustav Truff was launched in 1881, which was the first EV in the world. From the current point of view, in order to promote the development of EVs, France has adopted measures similar to those of the United States, Germany, and China, including technical support, incentives for consumers, and promotion of infrastructure construction. The French government's goal is to reach 7 million charging poles in France by 2030. They have also achieved better results in their domestic product sales. In addition, they have also conducted research on the grid load problems caused by the popularization of EVs and charging poles and the business model of used batteries in 2018. By comparing the sales statistics of EVs in different European countries in recent years [9–12], Figure 1 shows that before 2016, France had long been the country with the highest sales of EVs in Europe. The rapid popularization of EVs in Germany and Britain is due to the supportive policies, including its car purchase subsidies. The rapid popularity of EVs in Norway is due to various preferential policies such as ultra-high car purchase subsidies, ultra-low electricity prices, and free parking. Subsequently, due to factors such as industrial development and policy support in neighboring countries, France has faced more competition. It is getting more intense. Therefore, France has mentioned "Implementing circular economy" in the theme of "Ecological transformation" of the 2019 standardization strategy and has pointed out in its leadership goal that "by proposing the positions and initiatives of French actors on the circular economy at the international level, to strengthen France's leadership in addressing climate change." In recent years, the French government's incentives for EVs have gradually reduced. Lévay et al. [13] have sorted out the purpose of the incentive policies for new energy vehicles in various countries and pointed out that while reducing CO_2 emissions, France hopes to ensure the competitiveness of the French automobile industry. In the years after the release of the French standardization strategy, pure EVs in France have developed rapidly. In 2021, the registered volume of pure electric passenger vehicles in France was more than 162,000, up 46% year on year [14]. The cumulative sales volume of the French automobile market in September this year was 141,142, including 35,835 new energy vehicles, up 20% year on year. Among the top ten pure EV sales in France in September 2022, only the Tesla Model 3 and Model Y are overseas brands, and the other models belong to French local automobile brands [6]. It can be seen that French consumers recognize French automobile brands very much.

To sum up, the development of EVs in France not only has the historical origin of early development but also has the influence of its policies, standards, technology, economy, management, and environmental conditions. Among them, France has played an important role in maintaining its industry competitiveness by monitoring and regularly updating the standardization strategy. In addition, the French standardization strategy has played an important role in stimulating the enthusiasm of stakeholders.

(2) Brief Analysis of the French EV Rental Model. In 2011, France launched an electric car rental public service project (autolib) in Paris. The government tried to reduce the purchase of private cars in this way, so as to achieve the purpose of energy conservation and emission reduction and alleviate urban traffic congestion. After several years of exploration, it gradually turned losses into profits. In 2014, the net profit of the project reached 10.9 million euros. Although the operation, management, and other factors eventually failed to last, the Autolib project in Paris, France, is relatively mature and worthy of learning EV time-sharing leasing mode. Other countries have also made some explorations in the field of EV leasing, such as Zipcar, a representative company of time-sharing leasing in the United States, Maven of GM, and Drive Now of BMW. France and the United States, as well as others' early exploration, research, and attempts on the development mode and integration of EVs [15–17], have provided us with good experience and lessons. We shall add more research and analysis to explore the development mode applicable for China's actual situation.

Table 1: The amount of state subsidies and tax exemptions for the purchase of pure electric passenger cars in recent years.

Year	Amount of car purchase incentives (pure electric passenger vehicles)			The amount of tax required for purchasing an electric passenger vehicle
	Operating range <300 km	300 km ≤ Operating range ≤ 400 km	Operating range >400 km	
2020	0	16,020 yuan	22,500 yuan	0
2021	0	13,000 yuan	18,000 yuan	0
2022	0	9,100 yuan	12,600 yuan	0
2023	0	0	0	0
2024–2025	0	0	0	0 (the reduced tax amount shall not exceed 30,000 yuan)

EVs are different from other shared electrical equipment. First, from the user's point of view, EVs are different from sharing mobile power supply and sharing bicycles. The feeling of people using shared cars is affected by the comfort of the internal environment, the convenience of taking vehicles, and the cost of using shared cars. The current operation mode of EVs is difficult to meet the demand of daily convenience. At the same time, people's requirements for the comfort of an automobile environment are higher than those of shared bicycles. From the perspective of operators, EVs are different from common shared products. Due to the high product cost, land resources, and enterprise funds, it is difficult to launch EV-sharing services on a large scale to meet the actual needs of users. Based on the above reasons, this mode has not been well developed in China, and in recent years, many EV rental companies in China are in a state of bleak operation or even bankruptcy.

3.2. Analysis of the Relative Situation in China. At present, standardization, together with policies and regulations, has gradually become an effective modern management mode in China. However, in the specific technical field, standards have shown unique advantages that can not be replaced by policies and regulations and become one of the most effective methods of modern technology management.

3.2.1. Incentives Policy Decline. In the early stage, China has issued many policies to promote the development of EVs [18, 19]. While supporting national brands and promoting the development and popularization of pure EVs, it has achieved certain results but also has certain limitations. In recent years, with the development of Chinese brand pure EVs, the purchase Incentives policies of the country and all parts of the country have shown a trend of decreasing. According to the "Notice on the Financial Incentives Policy for the Promotion and Application of New Energy Vehicles in 2023," published on December 31, 2021, the incentives policy for the purchase of new energy vehicles will be terminated on December 31, 2022 [20]. Based on the documents of the Ministry of Finance, the State Administration of Taxation, and the Ministry of Industry and Information Technology, the amount of state incentives and tax exemptions for the purchase of pure electric passenger cars (refers to the EV studied in this paper) in recent years are shown in Table 1. In 2023, China's incentives policy for the purchase of pure EVs has stopped, and how the market sales of pure EVs will go remains to be further observed and analyzed. How to fundamentally improve the competitiveness of pure EVs also requires a comprehensive evaluation of its competitiveness from the performance, price, and other factors of pure EVs.

3.2.2. Analysis of Sales. According to the statistics of the China Automobile Industry Association and China Passenger Car Association, the sales volume of EVs has shown a rapid growth. However, the sales volume of EVs is still in sharp contrast with that of overall automobile sales. The market share of EVs in passenger cars is still very low, shown in Table 2. Although the market share of EVs in passenger vehicles has been greatly improved, there is still much room for improvement. Compared with previous years, there has been a significant increase, but the current data is still under the condition of national policy incentives, for example, limiting the registration of ICE vehicles in some cities. It can be seen that a series of measures in the field of EVs, such as policies, related technological progress, and infrastructure construction, have not fundamentally achieved the explosive growth of EV sales, and people's adoption of EVs has not fundamentally changed. Only by solving the bottleneck restricting its development can the competitiveness of EVs surpass that of traditional ICE vehicles.

From the perspective of Europe, the market share (electrification rate, which refers to the proportion of the use of EVs in daily passenger vehicles) for European vehicles in 2022 was 11%, among which the permeability of Norwegian vehicles was the highest, accounting for 79.32%. The second was Sweden (32.95%), while the sales volume of Denmark, Germany, and Britain are all about 20% [21]. Comparing these data with China's data, as shown in Figure 2 [22], compared with some European countries, China's permeability has a higher proportion, but there is still a big gap compared with the European countries with higher permeability. The reality is not in line with the original intention of developing EVs in China.

3.2.3. Analysis of Factors Affecting Sales Volume. The sales of EVs are affected by many factors. Xu et al. [23] found that the factors that affect whether consumers buying EVs are herd effect, vehicle performance, sales price, use feasibility, operating range, after-sales guarantee, and other factors. Zhang [24] found that consumers are more concerned about the performance indicators of EVs. Niu [25] found through

Table 2: Sales comparison of EVs and passenger cars in recent years.

Sales volume	Year						
	2016	2017	2018	2019	2020	2021	2022
Total sales volume of domestic passenger cars (unit: 10,000)	2,437.69	2,471.83	2,370.98	2,144.4	1,928.8	2,148.2	2,356.3
Sales volume of EVs in China (unit: 10,000)	25.7	46.8	78.8	103.83	111.5	291.6	567.4
The proportion of sales volume of EVs in the sales volume of passenger cars (%)	1.054	1.893	3.324	4.842	5.781	13.574	24.080

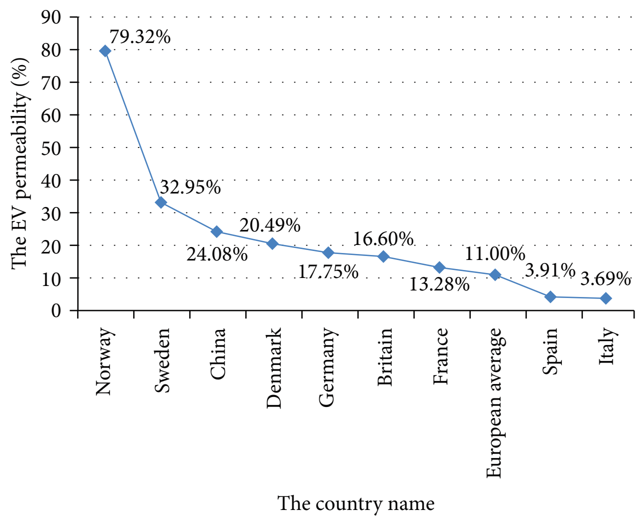

Figure 2: Comparison of European countries with higher EV permeability and China's EV permeability in 2022.

questionnaire surveys and analysis that environmental cognition has a significant impact on consumers' willingness to purchase and pointed out that government incentives have an important impact on consumers' willingness to purchase EVs. The research of Hao et al. [26] confirms that household income, household car ownership, and vehicle comfort also significantly affect consumers' willingness to purchase EVs. In addition, the city of residence and marital status have also been proved to be important determinants of consumers' purchase of EVs. Wang [27] evaluated the impact of various policies on the purchase of EVs by Chinese consumers and divided the policy measures into fiscal incentive policy measures, information provision policy measures, and convenience policy measures and found that the three types of policy measures are related to EV sales. Significant positive correlation, among which convenience policy measures are the most relevant. Sun et al. [28] found that price is an important variable that determines whether consumers choose EVs; government subsidies can promote consumers to purchase EVs, but the effect of government subsidies is relatively weak. In addition, the use cost, time cost, and whether there are charging piles and other vehicle attributes and government policy variables, as well as the educational background, the number of existing cars, the annual mileage, the number of monthly trips, the degree of understanding of preferential policies, environmental awareness, and technical trust, etc. also affect consumer choice. Based on the above research, it is found that the endurance and price of EVs are the two most important factors that affect consumers' purchases. Solving problems from these two perspectives is also the most effective way to increase sales of EVs. In addition, the first batch of electric car buyers in my country are currently experiencing serious battery damage and are facing the problem of replacement. Poor customer experience is bound to affect the entry of a new batch of consumers.

3.2.4. Brief Analysis of the Bottlenecks of EVs in China. Due to the development mode and the inherent properties of battery products and materials, the competitiveness of EVs is difficult to surpass that of ICE vehicles in a short time. Next, let's make a detailed analysis step by step.

(1) Comparative Analysis of the Overall Situation. In the early stage, a lot of research has been carried out on the performance improvement of EVs in China and other countries, and certain results have been achieved [29–32]. In 2022, the top 15 domestic car sales in China are shown in Table 3 [33, 34]. It can be seen from Table 3 that four of the top 15 are electric car models. In 2021, only 2 of the top 15 are EV models, and there are no EV models in the top 25 household car sales list in 2020. However, it is worth noting that the Hongguang MINI model of SAIC-GM-Wuling is at the top of the list of EVs. This model is a very low-price minicar, and the lowest manufacturer's guide price is only 32,800 yuan. This is very attractive for some cities that advocate the development of EVs and cannot buy ICE vehicles at will. These are factors that promote their sales. Therefore, the sales data of this model has no extensive reference value for the analysis of the overall sales data of EVs. Among 11 ICE models in the top 15, sales of seven models declined from last year, accounting for 63.6%. On the other hand, among the top 15 EV models, sales of all models increased from last year, accounting for 100%, with an average growth rate of 212.25%. On the whole, the competitiveness of EVs in China has been greatly improved compared with that of ICE vehicles and shows a rapid development momentum. Next, we select the model with the highest sales volume of the same body structure for a detailed comparison of various parameters.

On the whole, the competitiveness of EVs in China has been greatly improved compared with that of ICE vehicles and shows a rapid development momentum. From the average price of the two types of power cars, the average price of electric cars is 184,700 yuan (excluding the Hongguang

Table 3: Information table of the top 15 domestic sedan models in 2022.

Sales ranking	Brand	Vehicle model	Sales volume in 2022	Annual growth rate of sales (%)	Power type	Body structure	Manufacturer's guide price (unit: 10,000 yuan)
1.	Dongfeng Nissan	Sylphy	420,665	−18.0	ICE	4-door 5-seat hatchback	9.98–17.49
2.	SAIC-GM-Wuling	Hongguang MINI	404,823	2.4	EV	3-door 4-seat mini two-compartment vehicle	3.28–9.99
3.	SAIC Volkswagen	New Langyi	351,130	−18.7	ICE	4-door 5-seat hatchback	10.09–15.09
4.	BYD	Qin	341,943	81.0	EV	4-door 5-seat hatchback	12.99–17.48
5.	BYD	Han	272,418	132.2	EV	4-door 5-seat hatchback	21.78–33.18
6.	FAW Toyota	Carola	252,790	−23.5	ICE	4-door 5-seat hatchback	10.98–15.98
7.	GAC Toyota	Camry	242,225	11.3	ICE	4-door 5-seat hatchback	17.98–26.98
8.	FAW-Volkswagen	Sagitar	227,556	−2.8	ICE	4-door 5-seat hatchback	12.79–17.29
9.	GAC Honda	Accord	220,771	11.6	ICE	4-door 5-seat hatchback	16.98–25.98
10.	FAW-Volkswagen	New Bora	212,732	−15.2	ICE	4-door 5-seat hatchback	9.88–15.70
11.	BYD	Dolphin	204,226	633.4	EV	4-door 5-seat two-compartment vehicle	11.68–13.68
12.	GAC Toyota	Levin	192,517	−16.2	ICE	4-door 5-seat hatchback	11.18–15.28
13.	SAIC Volkswagen	Passat	176,621	20.8	ICE	4-door 5-seat hatchback	18.19–25.29
14.	BMW Brilliance	BMW 5 Series	171,142	−0.4	ICE	4-door 5-seat hatchback	43.39–55.19
15.	Chang'an	Yidong	168,478	34	ICE	4-door 5-seat hatchback	7.29–10.39

Table 4: Comparison of relevant parameters of China's most popular family cars in 2022.

Vehicle model		Sylphy	Qin
Power type		ICE	EV
Performance parameter	Endurance mileage (km)	962	450
	Maximum power (kw)	90	100
	Maximum torque (N*m)	155	180
	Vehicle curb weight (kg)	1,230	1,625
	Maximum load (kg)	420	375
	Maximum speed (km/hr)	182	130
	Time required for energy replenishment (min)	About 3	About 420
Price parameter	Manufacturer's guide price of mid-range configuration (10,000 yuan)	14.08	16.58
	Seller's preferential price (10,000 yuan)	1	0
	Government incentives for car purchase in 2022 (10,000 yuan)	0	1.26
	Vehicle purchase tax (10,000 yuan)	1.37	0
	60,000 km energy consumption expense (10,000 yuan)	0.6	2.88
	6 years insurance expense (10,000 yuan)	2.64	2.88
	60,000 km maintenance expense (10,000 yuan)	0.80	0.24
	Comprehensive use cost (10,000 yuan)	18.49	21.32

MINI model), and the average price of ICE cars is 186,100 yuan. It can be seen that the average price guided by manufacturers is around 180,000 yuan, which is generally acceptable. However, due to the large number of parameters related to the vehicle model, the overall comparison cannot be carried out accurately and specifically. Next, we select the model with the highest sales volume of the same body structure for detailed comparison of various parameters. They are Sylphy (Dongfeng Nissan) and Qin (BYD), which are both 4-door 5-seat hatchbacks. We compare and analyze these two models from their performance parameters and some factors that can most affect the sales volume.

(2) Analysis of Performance Problems. At present, the performance of EVs in China still has the following two problems.

(a) High Price. Based on the conclusion of the above relevant research, the performance, endurance, price, and convenience of the vehicle are the key factors that affect the competitiveness (sales volume) of EVs compared with traditional ICE vehicles. We compare these relevant parameters of the two most popular domestic cars in China, as shown in Table 4 [34, 35].

The following is a brief comparison and analysis of the data of the two representative models in Table 4. First, in terms of

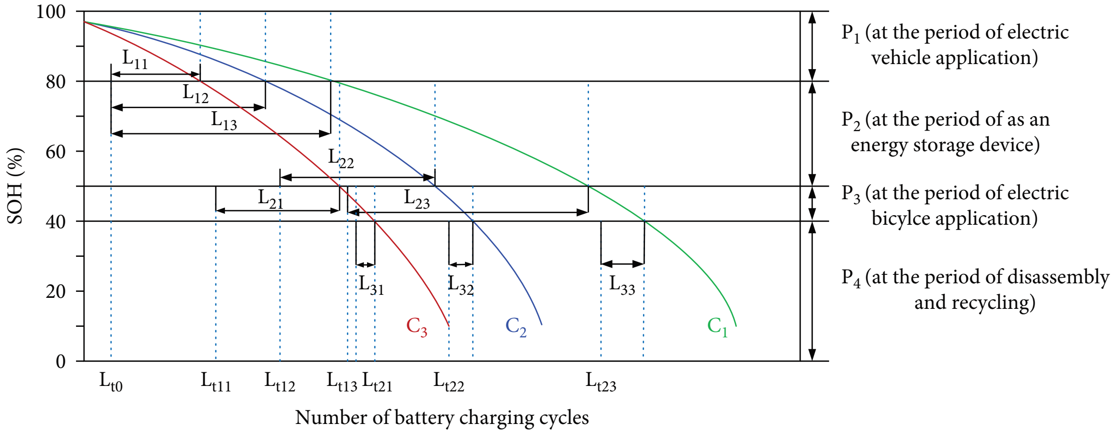

Figure 3: Comparison chart of EV power battery life under different management modes.

power performance and maximum load mass, the performance parameters of EVs are almost the same as those of ICE vehicles, and even the power performance is better than that of ICE vehicles. However, in terms of curb weight, EVs have to integrate a large number of battery cells in order to improve their endurance, resulting in a large curb weight, which increases their inertia, which is easy to slow down its acceleration and increase its braking distance under the same condition. Second, from the perspective of the operating range and energy replenishment time, EVs have obvious disadvantages compared with ICE vehicles, which is also the most serious restriction on the development of EVs, such as fewer charging points, long waiting times in lines, occupied charging location, damaged charging equipment, and no fixed parking space, which leads to the inability to install private charging piles. It brings a lot of trouble to the use of electric cars. However, it usually takes only 2–3 min for ICE vehicles to refuel, and gas stations can be seen everywhere. From this point of view, the convenience of EVs can not be compared with ICE vehicles. Third, from the perspective of comprehensive use cost in the early stage of car purchase, the cost of ICE vehicles is slightly higher than that of EVs, and because the maintenance cost of ICE vehicle 4S stores is significantly higher than that of EVs, it seems that with its use, the cost of ICE vehicles is more higher than that of EVs, but because ICE vehicles have a history of more than 100 years, ICE car repair shops of all sizes can be found everywhere, their maintenance costs are very low, it is also a common choice for non-new car owners. However, due to the strong technical monopoly of EVs and some monopoly agreements of EV 4S (for example, no maintenance at the 4S store, no warranty), the owners can only choose the 4S store with a higher price for maintenance, which will lead to the continuous high price of EV maintenance, which will lead to the continuous high price of EV maintenance. In addition, when charging in many places, the owners of EVs need to pay parking fees in addition to charging fees, and because charging takes a long time, if they cannot wait on the spot, they also need to pay extra taxi fees. Another very important factor is that in the event of a collision, the repair cost of EVs is much higher than that of ICE vehicles.

(b) Short Life. Battery life is a key factor affecting the cost performance of EVs. It is generally believed that when battery charge capacity is reduced to 80% or less of the rated capacity indicates its failure. As far as the most widely used lithium battery for EV power batteries in China, its capacity decay is its inherent property, affected by complicated factors [36–38]. Wang et al. [39] have found that the current capacity decay of most batteries is roughly exponential decay. The speed of the decay depends on the stability of the battery material and the rate of side reactions. It is also affected by many factors, such as ambient temperature, deep discharge, and attenuation is an irreversible process. At present, most EVs in China use lithium batteries with high energy density. However, lithium batteries with high energy density are particularly vulnerable to fire or even explosion in the event of collision. At the same time, their performance is also particularly vulnerable to the impact of the operating temperature environment. In addition, the battery life will also be affected by different temperature environments [40–43]. The daily use of EV batteries, under the combined effect of multiple factors, shows a continuous decay in capacity at different speeds. When the decay is too serious to meet the daily use required by the users, it has reached its actual service life. However, due to the lack of technical knowledge of general users, coupled with nonstandard battery management and various uncertain and harsh charging and discharging environments, the battery capacity decay is often accelerated, resulting that its lifetime is much lower than the expected design life. The application stages of EV power batteries in China usually include four periods: P_1 (at the period of EV application), P_2 (at the period of as an energy storage device), P_3 (at the period of electric bicycle application), and P_4 (at the period of disassembly and recycling) [44]. As shown in Figure 3, combining the general state of health (SOH) degradation process of the whole life cycle of EV batteries, we compare EV power batteries under several usage modes. The SOH curves C_1, C_2, and C_3 are in order to represent the battery decay trend in the unified specialized battery management mode, normal general user usage mode, and wrong usage (reckless usage) mode. L_{t0} represents the number of charge/discharge cycles completed when the EV user starts to use the power battery; L_{t11}, L_{t12}, and L_{t13}, in order, represent the number of charge/discharge cycles completed when

Table 5: Comparison of sales of some pure electric vehicle brands in China in the last 6 months.

Ranking	Brand	Sales volume	Ranking	Brand	Sales volume
1.	BYD	1,095,485	85.	Jietu	34
2.	Tesla	261,819	86.	Yema NEV	30
3.	AION	196,330	87.	WM	30
4.	WULING	178,356	88.	DS	25
5.	LI	127,775	89.	EXEED	21
6.	Chang'an	83,141	90.	KIA	13
7.	Volkswagen	75,766	91.	YEMA	10
8.	NIO	59,669	92.	JEEP	3
9.	Denza	51,536	93.	PEUGEOT	2
10.	Nezha	50,305	94.	CITROEN	1

the power battery starts to be applied as an energy storage device under C_3 mode, C_2 mode, and the C_1 mode; L_{t21}, L_{t22}, L_{t23}, in order, represent the number of charge/discharge cycles completed by the power battery when the power battery starts to be applied in the electric bicycle under C_3 mode, C_2 mode, and the C_1 mode. The comparison reveals that the battery life in the period of EV application (basically this is the life of an EV).$L_{11} < L_{12} < L_{13}$, and similarly, in the subsequent stage of the application of energy storage devices period, $L_{21} < L_{22} < L_{23}$, and in the the period of electric bicycle application, $L_{31} < L_{32} < L_{33}$. As we can see, all stages without professional management will reduce the actual battery life. Moreover, more importantly, specialized unified management of power batteries will also enhance their safety, stability, and reduce environmental pollution.

In summary, battery systems of EVs urgently need a unified, professional, and standardized management team to improve their safety and lifespan. In addition, the design of the battery box for EVs shall consider not only the temperature control requirements but also moisture-proof, impact-resistant, and explosion-proof. Currently, there is no recognized widespread design standard of battery box structures with comprehensive performance. Therefore, it is necessary to standardize battery management by adopting a relatively optimal standardized design based on the optimized solution of technical problems based on today's best practices.

(3) Lack of Sincere Cooperation. China's existing development presents the development mode of separate research and mutual competition. EV enterprises are numerous, and the category is complex. Compared with foreign countries, China has more brands and EVs. In addition, under the guidance of various incentive policies and the influx of a large number of new independent brand car-making forces, China's EVs are facing the situation of great development but also facing all kinds of market chaos and problems. According to the statistics on the website of AutoZone (the date of inquiry is June 29, 2023), the sales ranking of pure EVs in China in the past 6 months, we counted the top 10 and the 10 brands at the back end of the sales ranking for comparison, as shown in Table 5. We found that there is a particularly large gap between different brands, and Chinese electric cars present a few dominant situations. Therefore, on the whole, the development of EVs is an effective way to solve the energy crisis at present and in the future. The basic conditions for promotion and development are already available. However, because it is difficult to break through the bottleneck of technology development in the short term due to decentralized research, it is imperative to explore positive and effective promotion and application modes. Car-sharing has seemed to fade in recent years, either out of business or in transition [45]. According to the statistics of researches on the development of shared cars in China, more than 1000 companies in China have entered into the market, and the number of "shared" EVs of most companies is around a few hundred. A large number of companies hope to obtain venture capital from investment institutions to survive. In addition, "shared" cars are different from shared bicycles. Because of the high cost of batteries, it is difficult for general startup enterprises to increase the number of EVs online to meet actual needs. A single profit mode is usually difficult to make up for the high cost of its operation.

4. Discussion and Suggestions

4.1. Suggestions. Through combing and analyzing the relevant standards in China and other countries, the commonly used power battery standards for EVs in China have covered product specifications and dimensions, basic performance requirements, safety requirements, test methods, and recycling. However, the current development mode relying on the slow development of technology to improve the operating range capacity can not meet the actual needs. The research and practical experience of France and Norway are good references for the improvement of the core competitiveness of EVs in China. The France/Norway model is an effective way to solve the battery problem from the perspectives of technology, policy, and mode to find a new mode that is conducive to promoting the division of labor and concentrating the dominant forces to tackle key technologies. We recommend action in the following areas.

4.1.1. Accelerate the Development of National Standards for EV Batteries. Wu et al. [46] have found that the current rate of constant current charging in the current charging cycle is not uniform or clear among multiple standards. In order to find the best comprehensive charging method for specific types of batteries, it is necessary to standardize the charging process and speed up the development of mandatory standards for EV batteries and related fields. Compared with some European countries with small demand for EVs, standardization has more important significance for China, because China's market scale is huge, and there are many automobile enterprises supplying vehicles to the market. Through the standardized management and specification of EV batteries, the cost can be reduced. Through the development and implementation of mandatory standards related to the size and structure of batteries, we can concentrate the dominant forces to tackle key technical problems, so as to improve the efficiency of research and development of EV-related products.

4.1.2. Promote the Close Cooperation of Relevant Institutions. The development and implementation of the standards need the support of relevant policies, and the development plan of the new energy automobile industry has been deliberated and approved. We shall speed up the integration of related resources in the field of EVs, gather advantageous resources, promote the collective tackling of key problems by EV enterprises, the electric power industry, and scientific research institutions, unify the management and operation of batteries, and implement the mode of combining battery leasing with self-charging. Specifically, for managers, the implementation of the power change mode means that consumers only need to buy a car without battery. For this kind of special vehicle without power, corresponding policies shall be issued; for automobile enterprises, it is necessary to speed up the adaptation to new standards, promote standardization, modularization, and serialization of related products, and strengthen technical cooperation between enterprises and focus on research; for the power industry, it is necessary to strengthen the power distribution management, ensure the power supply guarantee of the EV exchange station and give preferential prices; for the battery replacement station, it shall be equipped with standardized battery pack-related products and scientific operation management scheme for daily use, so as to strengthen the scientific management and efficient distribution of batteries.

4.1.3. Promote the Combined Application of Standardization and Smartphone Applications. Smartphone applications have developed very rapidly in China, and it has penetrated into people's production and life. Smartphone applications can promote the integration and better utilization of resources. We shall strengthen the combination of standardization and smartphone applications, that is, to promote the research and application of this technology in the field of battery replacement of EVs under the new development mode. For example, through the design of standardized mobile phone applications or small programs that can be implanted into other applications, EV owners can easily query the battery storage status of peripheral charging or battery changing stations through the relevant applications on their mobile phones, so as to improve the confidence of EV owners under the new development mode.

4.2. Feasibility Analysis. For the standardization, it is necessary to objectively analyze the types of EV batteries. According to

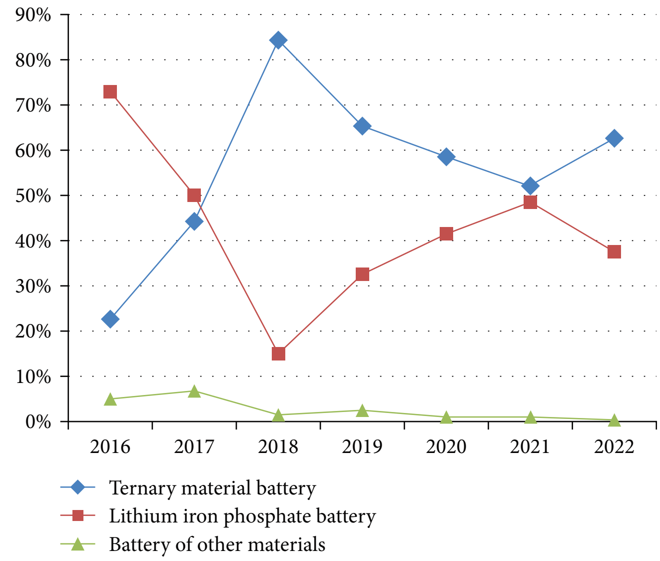

Figure 4: Development trend of battery type of EVs in China in recent years.

the Statistics of Research Department of Power Battery Application Branch, China YiWei Institute of Economics, China's new energy vehicle industry development report, and so on, from 2018 to 2022, ternary materials and lithium iron phosphate batteries are mainly used in EV batteries in China, and the development trend of battery type proportion is shown in Figure 4. We find that although there are various types of batteries involved in the field of EVs, in addition to ternary material batteries and lithium iron phosphate batteries, lithium manganate batteries, lithium titanate batteries, multielement composite cells, and nickel–hydrogen batteries, etc., are also involved, but in the field of EVs, power batteries have gradually developed into ternary materials batteries.

In terms of the business mode of battery product delivery, according to the survey, the current EV battery manufacturers in China mainly have the following product delivery methods: the first is to directly deliver the battery cell to the EV enterprise, who will design and develop the module and organize the production; the second is to deliver the module to the EV enterprise, who will complete the battery pack assembly; the third is to directly deliver the battery packs to the EV enterprise. At present, there are still some differences in the space structure of battery packs stored in different modes, which leads to the low proportion of battery packs directly delivered to EV enterprises at this stage compared with commercial vehicles. Once the standardization lead is achieved, it will directly promote the relevant design improvement, greatly increase the proportion of battery pack delivery, and enhance the comprehensive operating range of EVs, which can quickly solve the bottleneck problem under the current battery technology level.

5. Conclusion

Increasing sales of EVs in China is slow due to the limitation of inherent properties of materials, technology development level, and development mode. This paper analyzes the relevant policies, sales influencing factors, and problems in the development process of EV-related fields in China, combs the related problems restricting its rapid development, analyzes the French standardization strategy and the enlightenment and experience and lessons of EV development, and gives the specific and feasible standard solution to promote the rapid development and popularization of EVs in China at the strategic and policy levels. This study shows that relying solely on policy subsidies is not enough because relevant national incentives and subsidy policies cannot be sustained, and more technical guidance is needed. Through its overall standardization strategy and the use of standardization technology, France is able to quickly solidify, promote, and implement relevant advanced technology achievements, effectively improving the practical application effect of its advanced technology and promoting the implementation of relevant policies, energy conservation and emission reduction, and cost control. Ultimately, improved its competitiveness. Therefore, it is necessary to formulate standards in the relatively leading technical fields and conduct unified management and standardization of EV batteries through standardization. At the same time, it is necessary to strengthen technical cooperation, focus on technical breakthroughs, overcome technical bottlenecks, improve the performance of EVs, and reduce the cost and price of EVs. The content of this paper provides a certain basis and ideas for the future research work. In the next step, it is necessary to further study and analyze the battery structure and size of EVs, such as the blade battery of BYD, which is popular in China, and the Kirin battery designed by NingDe Times and applied in HuaWei's related car models. Therefore, it is a direction to carry out more in-depth research on the basis of this study.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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