The Industrial Structure and Operating Model of Emerging Electric Vehicle Charging Infrastructure in China

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Abstract. Electric vehicle is very important for future China car industry. This essay analysis the current electric vehicle market in China by referring real-world example and demonstrating relevant figures. Finally, the essay reaches the conclusion that there is a huge change of electric vehicle in China, the integration of upstream and midstream becomes closer, and more innovation is occurring.

Keywords: Electrical vehicle charge; change; innovation; cooperation; integration.

1. Introduction

Electric vehicles have become an important part of the implementation of sustainable development strategies and the global energy transformation. The global electric vehicle industry expands rapidly. The Chinese government has issued several encouraging policies to promote the industrialization of electric vehicles. As of June 2022, New Energy Vehicles accounted for 21.6% of China's car market.[1] China's New Energy Vehicle ownership exceeds 10 million units. [2] With the rapid rise of the electric vehicle industry, the demand for charging infrastructure also increased rapidly. The electric vehicle charging infrastructure industry in China has experienced the introduction stage and now experiencing a growth stage. The operating model is a foundation for execution, which translates strategic intent into operational capabilities in the charging infrastructure industry. Based on the perspective of the industrial chain, this paper will classify enterprises into upstream, midstream, and downstream, and analyze the evolution of operating models in the introduction stage and expansion stage, to provide a new perspective for electric vehicle charging businesses, and also offer a reference for the theoretical research.

2. Literature Review - Current Status of research on the charging infrastructure industry operating model

Some scholars suggest that the operation mode is the main factor affecting the marketization process of the charging infrastructure industry. Because the reconstruction of the industrial value chain caused by the addition of new stakeholders in the industry is accompanied by the emergence and application of new operation modes, it is difficult to make profits only by relying on the business mode of simply providing charging services and charging service fees. Therefore, some scholars have built a morphological matrix analysis framework based on the analysis of innovative elements of charging infrastructure operation mode in different scenarios, which provides a reference for further exploration of sustainable operation mode.[3] In addition, considering the interest distribution of stakeholders in the supply chain, some scholars calculated that the cooperative game of stakeholders is an effective way to maximize interests by using the Shapley distribution model[4]. From the perspective of sharing economy, some scholars also concluded that the cooperation between charging operators and other intermediary service providers of industrial chain providers is an effective mechanism to maximize resource utilization, promote the construction of the charging infrastructure industry, and solve the imbalance of vehicle pile ratio. [5]

3. The market scale of electric vehicle charging infrastructure in China

According to CCTIA (China Electric Vehicle Charging Technology and Industry Alliance) statistics, as of May 2022, the number of charging piles in China has reached 3.581 million, an increase of 91.5% year-on-year. [6] By the end of 2021, the ratio of electric vehicles to public charging piles in China has reached 6.8:1. The ratio of electric vehicles to private charging piles is about 3.7: 1. [7]

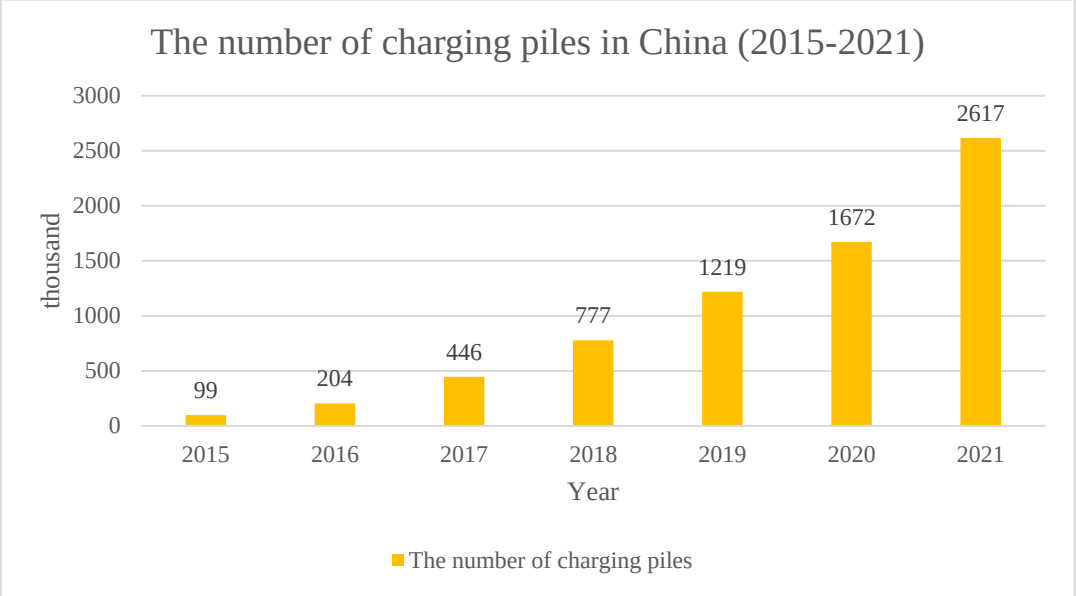

Figure 1. The number of charging piles in China (2015-2021)

4. Operating model from the perspective of industrial chain

The industrial chain of the electric vehicle charging infrastructure industry can be divided into three streams. The upstream of the industrial chain is the charging facility manufacturer; the midstream is the charging station operator; the downstream is the charging pile user, including electric vehicle enterprises and individual consumers.

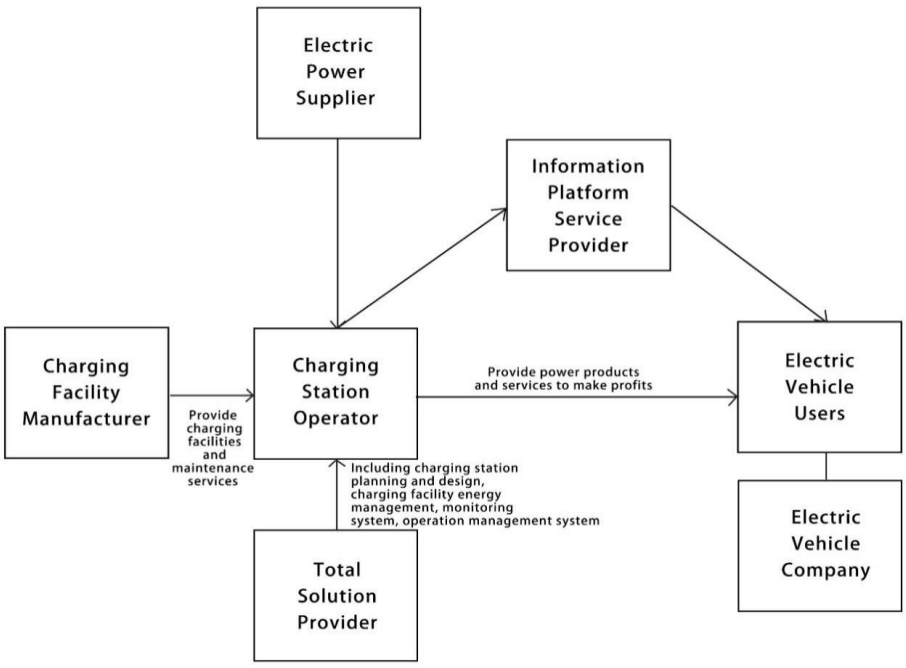

Figure 2. Stakeholder Network in the Charging Infrastructure Industry

Table 1. Composition of China's electric vehicle charging infrastructure industrial chain

Upstream Charging facility manufacturers	Midstream Charging station operator	Downstream Electric vehicle enterprises and individual consumers
Manufacturing charging modules (IGBT, inverter, voltage transformer, rectifier, etc.) KSTAR 科士达 Sinexcel盛弘电气 NARI 国电南瑞 国家电网 STATE GRID 许继集团有限公司	Specialized operation enterprises 特来电 星星充电 云快充 EV POWER 依威能源	TESLA BYD SAIC 上汽集团 SAIC MOTOR NIO 蔚来 小鹏汽车 吉利汽车 GEELY AUTO 长安汽车 KING LONG 金龙客车 东风汽车 DONGFENG MOTOR
Manufacturing active filter equipment 科陆电子 Sieyuan 思源电气 Sinexcel盛弘电气	State-owned enterprise 国家电网 STATE GRID	
Manufacturing monitoring and billing equipment NARI 国电南瑞 国家电网 STATE GRID 许继集团有限公司 炬华科技 SUNRISE	Potevio 中国普天 中国南方电网 CHINA SOUTHERN POWER GRID	
Manufacturing battery maintenance equipment (circuit breakers, fuses, etc.) Bussmann Ferraz Shawmut Nader 良信电器 北元电器	Electric vehicle enterprise TESLA BYD SAIC 上汽集团 SAIC MOTOR NIO 蔚来 小鹏汽车	
Others (charging gun, contactor, connector, watt hour meter, charging pile shell, plug socket, cable, etc.)		Individual consumers

4.1 Upstream of the industrial chain

4.1.1 Raw materials, especially charging modules, are the main cost of charging pile production

In the upstream of the industrial chain, the cost of charging piles consists of raw material cost, manufacturing cost, and labor cost. The cost of raw materials, that is, the cost of hardware equipment input of the charging piles accounts for more than 90% of the total cost of the charging piles. The equipment required by the charging pile mainly includes the charging module, active filter equipment, monitoring and billing equipment, battery maintenance equipment, etc. The charging module is the core equipment of charging piles, accounting for 45-55% of the hardware cost. Taking the DC charging pile as an example, the cost of the charging module accounts for about 50% of the total raw material cost, while the cost of active filter equipment accounts for about 15%, and the cost of monitoring and billing equipment and battery maintenance equipment account for 10%.

4.1.2 The average gross profit margin is declining, and upstream enterprises are expanding to midstream operation business

The entry barrier of charging facility manufacturers is relatively low, and the level of product differentiation is also low. With the increase in market participation, the profit margin of the industry declines. In addition, the electronic components required for manufacturing charging equipment are similar, with low acquisition threshold and high product homogeneity, resulting in no obvious core competitive advantage among the enterprises. For example, the core electronic component that affects the performance of charging modules is IGBT, and IGBT is highly dependent on import, resulting in the convergence and lack of differences in the performance of charging modules. Affected by these two factors, the average gross profit margin of the industry declines. It is precisely because of this that the upstream enterprises of the industrial chain are motivated to extend to the midstream

operation market, and the integration of the upstream and midstream of the industrial chain is becoming increasingly obvious. For example, TGOOD and The State Grid are charging facility suppliers, and they are also major players in the charging pile operation market.

4.2 Midstream of the industrial chain

The midstream operation entities in the charging pile industrial chain can be divided into three categories, including professional operators, governments, and vehicle enterprises. Different types of enterprises have their unique pro and cons in the charging pile operation market. Under the three types of operation entities, the electric charging pile industry has formed six main operating models.

4.2.1 State-dominated Operating Model

State-owned capital serves as the main investment, and state-owned enterprises are responsible for the investment, construction, operation, and maintenance of the charging stations, or cooperate with power grids and specialized charging operators to jointly provide charging services. The representative enterprises are The State Grid and Potevio. The advantage of this model is that state-owned enterprises can make full use of their power resources, and the advantages in power transmission and technical standards, which allows them to effectively guide the operation market of the charging infrastructure industry, effectively coordinate the construction of charging piles, power grid supply, and site resources. The charging facility procurement channel is unimpeded. The disadvantage is that the operation efficiency is low when the government undertakes the construction and operation investment, and it is sensitive to policy changes.

4.2.2 Electric Vehicle Enterprises Dominated Operating Model

The source of investment in this model is social capital. In order to promote electric vehicle products, electric vehicle enterprises provide charging services in the mode of “construction and operation of public charging piles” or “sales plus supporting private charging piles”. The representative enterprises under this model are SAIC and BYD. The advantage of this model is to provide differentiated after-sales services for consumers by providing “car plus charging piles”, which is conducive to the formation of a strong reputation and customer loyalty. The disadvantage lies in the non-core business and high capital investment, which makes it difficult to form a charging network for all customers on the market.

4.2.3 Specialized Operator Dominated Operating Model

Enterprises specializing in charging pile investment, construction, operation, maintenance, or charging facility manufacturers provide charging and related value-added services. The representative enterprises under this model are TELD, EV Power. The advantage of this operating model lies in commercial operation, intending to maximize economic benefits and high operation efficiency. The disadvantage is that the barriers to entry are low, but it has high requirements for the capital scale, the discourse power in the energy industry, and the technology and resources accumulated in the energy field.

4.2.4 Cooperative Operating Model

Electric vehicle enterprises cooperate with specialized operators to give full play to their respective advantages to provide charging and various value-added services. The representative enterprises under this model are cooperation between TELD and BMW, and cooperation between TELD and BAIC. The advantage is the integration of advantages from both parties, which can expand the market for electric vehicle enterprises and ensure the business orders of specialized operators. The disadvantage lies in the difficulty in the close cooperation between electric vehicle enterprises and specialized operators.

4.2.5 Joint Venture Operating Model

Charging pile investors, specialized operators, and site resource parties cooperate to invest in shares, integrate resources of all parties, and provide charging service. Representative enterprises are

Star Charge, Wanbang Energy. The advantage is that for each party, the requirements for capital scale, technical reserves, and land resources are reduced. The integration of multiple resources is conducive to effectively improving construction efficiency. The disadvantage is that this operating model is easy to be imitated, which has a high risk of the uneven distribution of profits.

4.2.6 Phased Lease Operating Model

Specialized operators provide oriented charging services for ride-hailing vehicles and time phased rental cars. Representative enterprises are Win Sky, BAOJIA. The advantage is that it is highly targeted, which is conducive to ensuring the utilization rate of charging facilities, and the disadvantage is that it is difficult to cover individual consumers.

Among the above-mentioned six operating models, Specialized Operator Dominated Operating Model is the current mainstream operating model for charging stations, which accounts for more than 75% of the market share of public charging station operation, followed by the state-owned enterprises, which account for about 20-25% of the market share. Since electric vehicle enterprises do not take developing the charging infrastructure market as their core business, the market share of electric vehicle enterprises in the charging infrastructure market is relatively low, accounting for less than 5%.

4.3 Downstream of the industrial chain

Under the current market pattern, the competitive environment of electric vehicle enterprises is becoming increasingly fierce, which promotes the enthusiasm of electric vehicle enterprises to seek differentiated competition. Cooperating with charging infrastructure operators in the midstream of the industrial chain to build and operate charging infrastructures is expected to strengthen the competitive advantage of electric vehicle enterprises.

In the past four years, although China's auto market was suffering from the COVID epidemic, the shortage of chip supply, the continuously increasing raw material cost, and other adverse factors, it still achieved positive growth in 2021, reversing the downward trend for three consecutive years since 2018. The driving force of the annual growth of the auto market mainly came from the growth of electric vehicles and high-end vehicle markets. In 2021, the sales volume of new energy vehicles in China was 3.521 million, with a year-on-year increase of nearly 1.6 times. The sales volume of new energy vehicles accounted for 13.4%, with a year-on-year increase of 8%. [8]

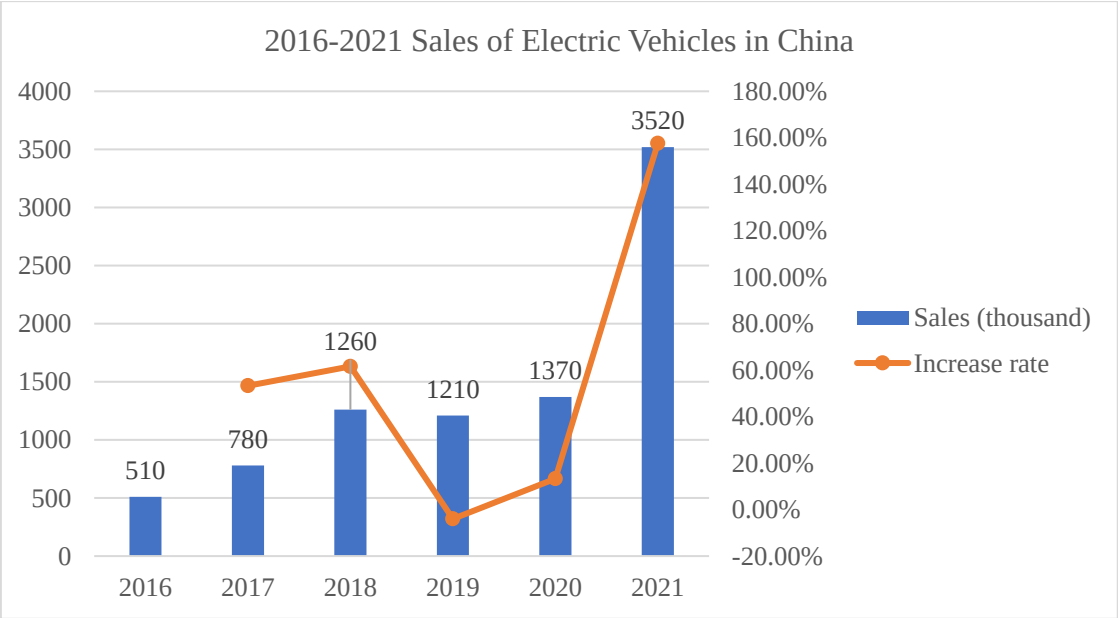

Figure 3. 2016-2021 Sales of Electric Vehicles in China (iResearch, 2022)

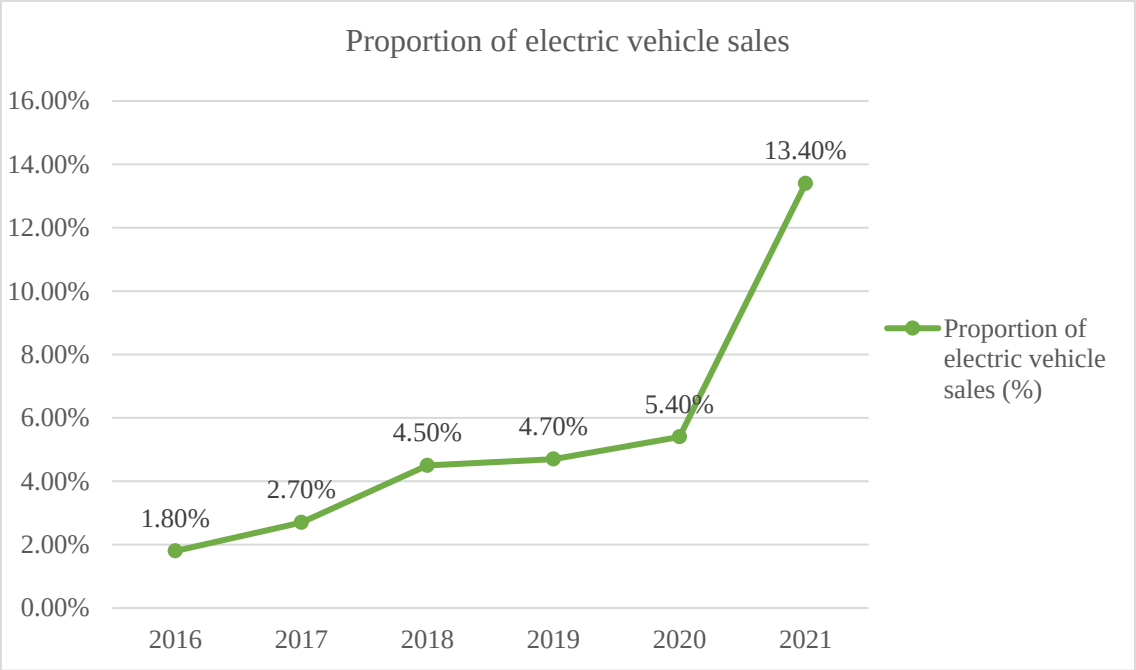

Figure 4. 2016-2021 Proportion of electric vehicle sales in China (iResearch, 2022)

China has thoroughly implemented the *New Energy Automobile Industry Development Plan (2021-2035)*, expanding the new energy vehicle market to the countryside. [9] China has also launched a pilot project of the power exchange mode, optimized and adjusted the "double integral" new deal, which is earlier introduced in September 2017, launched the demonstration application of fuel cell electric vehicles (FCEVs), and promoted the improvement of the level of electrification in the public sector. [10]

Under the background that policy subsidies tend to be stabilized, individual users' willingness to buy vehicles has warmed up. From the perspective of the market competition pattern of new energy vehicle enterprises, the sales volume of new energy buses accounts for the highest proportion, followed by the passenger vehicle market, and the proportion of light, medium, and heavy duty and special purpose vehicles market is relatively low.

5. The trends of the operating model and market competition pattern

"The life cycle of a product is often broken into four stages—introduction, growth, maturity, and decline." [11] The electric vehicle charging infrastructure market experienced the introduction stage between 2009 and 2014. At this stage, the market development was mainly dominated by state-owned enterprises, and the policies were less targeted. Enterprises operated independently, and the business models were relatively simple. The State Grid and China Southern Power Grid assumed the dual roles of operators and power energy suppliers at the same time. The State Grid purchases charging equipment from its subsidiaries. PetroChina and Sinopec use their gas station network resources to invest in the construction and operation of charging stations. Other state-owned enterprises, including Potevio and Huashang Sanyou New Energy Technology, have also adopted this operation mode in the introduction stage.

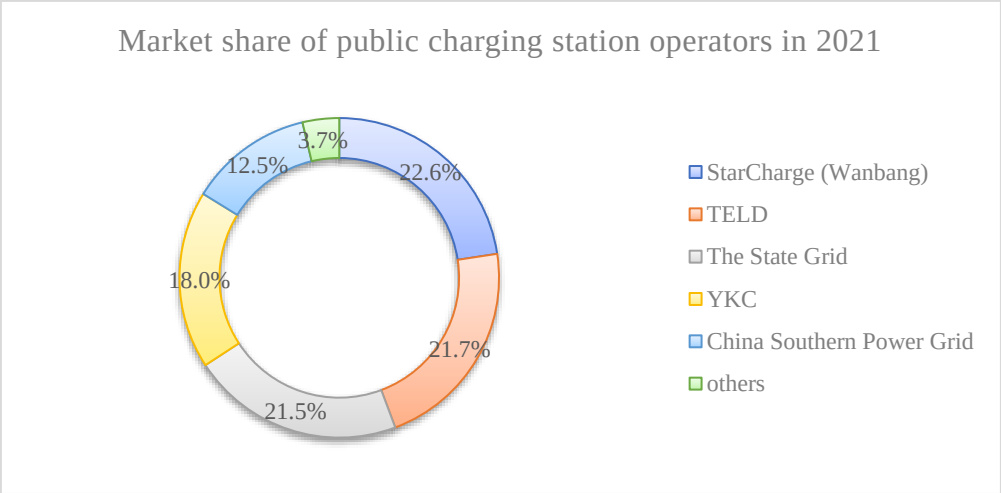

Figure 5. Market share of public charging station operators in 2021 (Shenzhen Electronic Chamber of Commerce, 2021)

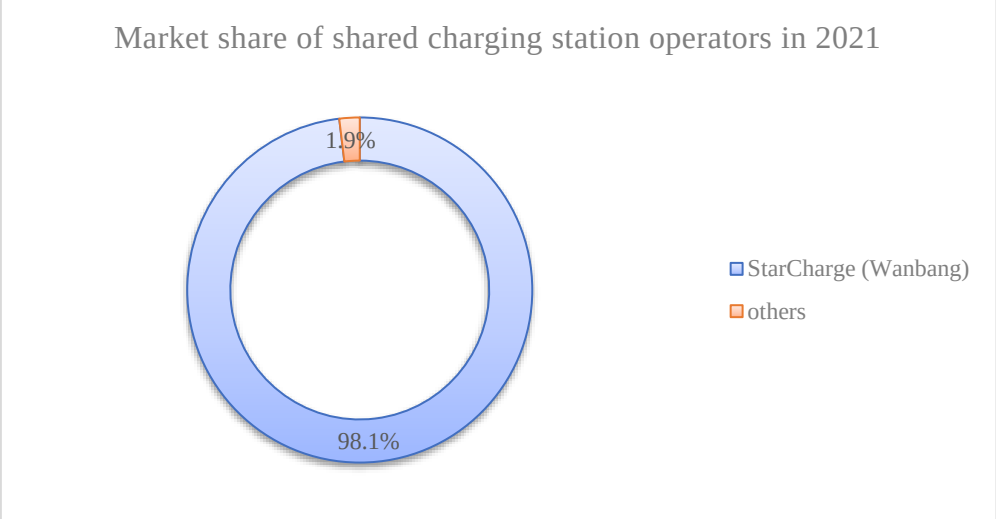

Figure 6. Market share of shared charging station operators in 2021 (Shenzhen Electronic Chamber of Commerce, 2021)

In July 2014, the PRC issued *Guiding Opinions of the General Office of the State Council on Accelerating Promotion and Application of New-Energy Automobiles*, which proposed to encourage the PPP (Public-Private Partnership) model [12]. In 2015, the China Energy Administration issued the *Electric vehicle charging infrastructure development guidelines (2015-2020)*, which further strengthened the importance of the PPP model. [13] The introduction of this policy marked the charging infrastructure industry entering the growth stage. In this stage, the state-owned enterprises withdrew from the dominant position of market share and were replaced by private specialized operators. As of 2021, the five largest operators are StarCharge (Wanbang), TELD, The State Grid, YKC Clean Energy, and China Southern Power Grid, taking 22.6%, 21.7%, 21.5%, 18.0%, and 12.5% of the market share respectively. [14] The entry of social capital has played a positive role in promoting the development of the charging infrastructure industry.

With the development of the charging infrastructure industry, a growing number of stakeholders joining the industrial chain, the network density gradually increases, and the industrial development pattern is gradually changing. With the emergence of a new role of information platform service provider, business from the upstream of the industrial chain is gradually expanding to the midstream, and the gradual participation of enterprises in other industries and emerging technology enterprises has promoted the resource and information flow of the charging infrastructure industry.

In the future, it can be expected that the collaborative support of new technologies and new fields such as big data and 5G will play a role in charging infrastructure services. It is expected that after 2025, as the competitiveness of electric vehicles gradually surpasses that of fuel vehicles, the charging infrastructure market will enter the maturity stage, and the vehicle to charging station ratio can be expected to reach 2:1.

6. Conclusion

Through the above analysis of the industrial chain and operating models of China's charging infrastructure industry, this paper presents the industrial chain structure and operating model framework of the charging infrastructure industry, as well as the changes that have taken place with the development of the industry. Findings suggest that the industrial chain structure, stakeholders, and value elements of the operating model have experienced significant change.

In terms of the industrial chain, the industrial chain of charging infrastructure has experienced an expansion, and both the number of stakeholders and the proportion of private enterprises have increased. New industrial roles emerged in the industrial chain. There is an increasing trend in the integration between the upstream and midstream of the industrial chain. The participation of new stakeholders boosted cross-border cooperation and resource integration.

In terms of the operating model, the innovation of the operating model mainly benefits from the entry of stakeholders such as technology enterprises, Internet enterprises, and financial enterprises. The cross-border cooperation between different enterprises has strengthened the innovation ability of the upstream and midstream of the industrial chain. The diversified charging facilities, usage channels, and settlement methods have improved the convenience of charging station usage for downstream users.

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