Zhenpo Wang

Annual Report on the Big Data of New Energy Vehicle in China (2022)

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Foreword by Xiangmu Zhang

The automobile industry, as an important pillar industry of China's national economy, plays an important supporting role in the stable and positive development of the macroeconomy and is an essential cornerstone of China's goals of ensuring "stability in employment, financial operations, foreign trade, foreign investment, domestic investment, and expectations" and "security in job, basic living needs, operations of market entities, food and energy security, stable industrial and supply chains, and the normal functioning of primary-level governments." In recent years, in the face of such adverse factors as foreign geopolitical conflicts and the impact of COVID-19, the Chinese government has insisted on strategic guidance and given play to its institutional advantages, unblocked domestic circulation, promoted the formation of both domestic and foreign circulations, and speeded up the construction of an efficient, standardized, fair and fully open national unified market, to comprehensively promote the transformation of China's automobile industry to become bigger and stronger. China's new energy vehicle (NEV) industry is leading the development of global vehicle electrification.

I. The electrification of vehicles is unstoppable, and NEVs are accelerating their penetration. In 2021, the sales volume on China's NEV market was 3.521 million units, accounting for 52.2% of the global market and ranking first worldwide for seven consecutive years. NEVs have become an important force in the electrification transformation of the global automotive industry.

II. The NEV camp has expanded, and China's brands have made breakthroughs. BYD's annual sales volume exceeded one million vehicles and entered a new stage of trillion-yuan market value in 2022, giving birth to a world-class automobile enterprise in China; the new car-making forces represented by Nio, Xiaopeng, and Lixiang initially gained a firm foothold and maintained a high-speed growth trend.

III. The upstream and downstream of the industry chain are fully connected, basically realizing independent control. From critical materials to vehicle manufacturing, critical equipment, and recycling, the NEV industry chain is interconnected from upstream to downstream, forming a safe, controllable, collaborative, and efficient NEV industry system. The core technologies of the battery, motor, and electric control are basically independently controllable.

While China's NEV industry has made significant achievements, it also can be seen that due to the continuous impact of COVID-19, issues such as hindering the circulation of parts, local protection, and regionalization have affected the enterprises to become bigger and stronger, which have become obstacles to the rapid growth of the NEV industry. Therefore, accelerating the establishment of national unified market system rules, breaking local protection and market segmentation, opening up the critical blockage that restricts the economic cycle, promoting the smooth flow of commodity factor resources in a broader range, and facilitating the construction of efficient, standardized and fully open national unified market under fair competition are vital for China's automotive industry to accelerate its progress toward an automotive powerhouse. To accelerate the establishment of a unified national market layout, we will mainly focus on the following aspects:

1. Make up for shortcomings and strengthen the construction of the supply chain system. Under the background of internal circulation, China's auto brands need to accelerate the independent research and development of key components and technologies, make up for shortcomings, improve and smooth the industrial chain, accelerate the synergistic effect between the upstream and downstream of the industrial chain, and promote China's automobile industry to leapfrog development.

2. Establish consistency rules and strictly implement the "one list for the whole country" management model. By maintaining the unity, seriousness, and authority of the *Negative List for Market Access*, China will gradually establish a unified national NEV consumer market and strengthen and optimize the automobile brands.

3. Effectively utilize global factors and market resources to connect domestic and international markets better. China will promote institutional openness, enhance its influence in global industrial chains, supply chains and innovation chains, participate in new advantages in international competition and cooperation, assist in exporting automobiles and component products, and enhance its voice in international economic governance.

The operation of a unified national market in China not only puts higher requirements for the high-quality development of China's NEV industry, but also provides vast opportunities. Accompanied by the successive introduction of national standards for a unified automobile market, the automobile industry will accelerate the decisive role of the market in resource allocation, accelerate the evolution of the new forms, new modes, and new ecologies of the automobile industry, and accelerate the rise of "high-grade, high-precision, advanced" technological innovation enterprises. The unified national market will also help export NEVs and key component products and participate in and form new advantages in international competition.

Beijing, China Xiangmu Zhang
June 2022

Foreword by Fengchun Sun

At present, adherence to green and low-carbon development has become an important direction for international economic and social development, and more than 120 countries and regions worldwide have reached a consensus on carbon neutrality. China, as a responsible power, has been committed to accelerating the transformation of its energy structure, promoting green and low-carbon development, and actively contributing to global climate governance. General Secretary Xi Jinping made a solemn commitment to "carbon dioxide emission and carbon neutrality" to the international community at the general debate of the 75th Session of the United Nations General Assembly, reflecting China's determination and its commitment as a great power to achieve the goals set out in the *Paris Agreement*.

However, it is also seen that China is still in the process of industrial development, and there is still significant room for rigid growth in transportation energy consumption and carbon emissions. The inherent pressure, structural pressures, and trend pressure of carbon emissions in the automotive industry have not been alleviated, and the stress and difficulty of China's decarbonization transformation far exceed that of developed countries. Therefore, accelerating the green and low-carbon development in the transportation field, establishing a carbon management mechanism in the transportation field, forming a policy support system based on the carbon trading system, and taking into account the decarbonization transformation and industrial upgrading, have become essential measures for implementing China's "carbon peaking and carbon neutrality" goals, ensuring energy security, and promoting high-quality industrial development.

I. Accelerate the decarbonization of the transportation energy system and improve the emission reduction efficiency in transportation. China will step up the promotion and application of NEVs in an orderly manner and speed up the electrification of vehicles with high energy consumption, such as heavy-duty trucks; give full play to the advantages of separating the vehicle and battery for battery swapping-type heavy-duty trucks to reduce the purchase cost, performing flexible battery swapping without range anxiety, and achieving safe and controllable centralized charging, and explore ways to promote the commercialization and application of electric heavy-duty trucks; explore different charging application scenarios, actively encourage the residential area charging service model with intelligent and orderly slow charging as the primary and emergency fast charging as the auxiliary, form moderately advance expressway and urban and rural public charging networks with fast charging as the main and slow charging as the auxiliary, and encourage the promotion and application of battery swapping modes in public areas of bus, taxis, and heavy-duty truck.

II. Build an intelligent transportation system to assist in the transformation of efficient transportation modes. China will build an intelligent transportation system based on cloud-controlled intelligent driving to achieve collaborative control of the "person-vehicle-road-cloud" system, which not only provides effective information for a single vehicle's decision-making but also enables autonomous control of all traffic participants throughout the entire road section, around the clock, and in all scenarios by global governance based on existing vehicle-road collaboration. China will explore urban intelligent management and operation, helping to improve transportation efficiency while effectively reducing carbon emissions. We will accelerate the construction of intelligent connected vehicle infrastructure and accelerate the large-scale commercial process of cloud control basic platforms, basic maps, and high-precision positioning technologies, to lay a solid foundation for the construction of the intelligent transportation system.

III. Promote the integration of transportation and energy systems into the carbon chain for low-carbon development in a coordinated manner. China will establish a green power supply system that matches the demand for new energy transportation, adjust the power structure, and increase the proportion of green power; give full play to the demand for grid interaction of distributed energy storage such as new energy vehicles, accelerate the development of vehicle-to-grid (V2G) demonstration projects, effectively regulate the consumption of intermittent fluctuating energy such as wind power, realize the large-scale application and safety supervision of intelligent dispatching technology, big data, and artificial intelligence technology, effectively promote the peak shaving and valley filling of electric power, promote the consumption of renewable energy, and promote the integration and safe development of energy grid, power grid, and transportation network.

IV. Establish a carbon asset management mechanism in the transportation field, and promote the NEV industry to be included in the national carbon emissions trading market. For the NEV industry, China will establish a complete life cycle carbon emission standard system including parts production, equipment manufacturing, transportation, infrastructure construction and operation, scrapping, recycling, and other links, form scientific and standardized carbon quota and carbon accounting methods, including the NEV industry into the national carbon emissions trading market, to effectively facilitate the promotion and application of energy-saving and low-carbon technologies in the form of carbon trading, promote the infrastructure construction such as charging and swapping facilities, and promote low-carbon and sustainable development in the transportation sector.

The *Annual Report on the Big Data of New Energy Vehicle in China (2022)*, based on real-time operation big data of NEVs in China, presents readers with an overview of the characteristics of China's NEVs regarding technological progress, industrial development, vehicle operation, and charging laws. With rich charts, detailed data, and survey results, this report not only gives readers a comprehensive understanding of the annual operation characteristics and user habits of NEVs in China, but also puts forward relevant suggestions to promote the healthy and sustainable development of the NEV industry, providing an important reference for government departments to formulate policies and for automobile enterprises to make strategic decisions. More importantly, the publication of this report will better promote the efforts of the Chinese government in facilitating the promotion and application of clean energy vehicles worldwide and will play an essential role in promoting China's brands to better go forward to the international.

Beijing, China
June 2022

Fengchun Sun

Preface

2021 marks the beginning of the 14th Five Year Plan and an important year for China to embark on a new journey toward the Second Centenary Goal. At an important milestone in China's transition from a major country to a powerful country in the automobile industry, substantial breakthroughs have been made in the transformation of the automobile industry. As an important driving force for leading the growth of the automobile market, NEVs have shown a good situation of dual improvement in market size and development quality. The market demand for NEVs shows an explosive growth trend, with the annual production and sales exceeding 3.5 million units, with a YoY increase of more than 1.5 times, and the annual market penetration rate exceeding 13.4%; China's brands are thriving and breaking through, with diversified products, continuous improvement of sales channels, and constantly improving product quality, and they have successfully achieved a leap from price/performance ratio to quality/price ratio, further enhancing their leading role in the transformation of global automotive electrification.

While the NEV industry has made remarkable achievements, we are also facing challenges such as chip shortage, rising prices of battery raw materials, and the need to improve the capacity utilization of NEVs. At the same time, severe challenges, such as sporadic outbreaks of the COVID-19 pandemic in China and foreign geopolitical and regional conflicts, will continue to exist in the short term. In the face of many influence factors, relying on the rapidly developing multi-source big data resources and online big data technologies, enabling industrial development and building a digital ecosystem have become important measures to lead the healthy development of the NEV industry chain and cross-industry integration.

The Annual Report on the Big Data of New Energy Vehicle in China (2022) upholds the principle of being based on the overall situation and highlighting the hot spots and relies on the big data of the real-time operation of more than 6.5 million NEVs on the National Monitoring and Management Platform for NEVs. Based on covering the annual routine research contents such as vehicle promotion and application, vehicle technology progress, vehicle operation, vehicle charging, vehicle battery swapping, and FCEVs, this report further focuses on the development hot spots of the NEV industry in 2021, aiming to summarize the current hot spot status and development trend of the industry from the perspective of big data research, detailed as follows:

I. Add ecological research on battery swapping and summarize the results of the pilot promotion of battery swapping. After years of precipitation, policies, capital, and technology in battery swapping have made concerted efforts. This report focuses on sorting out and analyzing the policies of the battery swapping industry, the promotion and operation characteristics of vehicles, and the promotion characteristics and technical economics of pilot cities for battery swapping, to provide detailed data support and promotion experience reference for the layout of the battery swapping field by relevant entities in the industrial chain.

II. Compare the demonstration characteristics of FCEVs, and summarize the demonstration results of the Winter Olympics. 2021 is the year of the Winter Olympics. This report evaluates the demonstration results of the Winter Olympics through data acquisition, analysis, and judgment on the promotion, operation, and hydrogen refueling of FCEVs. It makes comparisons with the operation characteristics of BEVs, and parallel comparisons among demonstration urban agglomerations, to provide scientific decision support for the large-scale demonstration and promotion of FCEVs.

III. Focus on PHEVs and evaluate the operation characteristics of vehicles in EV mode. In the short to medium terms of the transformation and development of the automotive industry, PHEVs shoulder the mission of rapid energy conservation and carbon reduction in the automotive industry. This report provides a comprehensive and in-depth analysis of the promotion status of PHEVs and typical urban vehicle operation and charging characteristics, aiming to provide a reference for the sound development of the PHEV industry.

IV. Add the analysis on application scenarios of charging in townships and expressway holidays to improve the charging experience with big data empowerment. Based on the existing charging application scenarios, this report adds the analysis of charging behaviors before and after holidays at township charging stations and expressway charging stations, aiming at guiding users to reasonably choose their charging time, balancing the utilization efficiency of charging facilities, and enhancing the charging service experience.

The *Annual Report on the Big Data of New Energy Vehicle* has been published in English for two consecutive years, and this is the second time. We hope that this report cannot only record the historical development of the NEV industry but also promote and lead its sound and sustainable development in the future, and we also hope that it can provide rich basic information and important references for governments, upstream and downstream enterprises in the NEV industry chain, industry research institutions, scientific research institutes, and ordinary readers, making big data truly serve and promote the development of the NEV industry.

We would like now to express our sincere appreciation for the solid support and assistance provided by the managers, experts, and relevant scholars of the National Big Data Alliance of New Energy Vehicles (NDANEV), the National Monitoring and

Management Platform for NEVs, the National Engineering Research Center of Electric Vehicles of Beijing Institute of Technology, the Ministry of Industry and Information Technology Equipment Industry Development Center, Beiqi Foton Motor Co., Ltd, Foton AUV Bus Company, the National New Energy Vehicle Technology Innovation Center, the Power Battery Laboratory of China North Vehicle Research Institute, Dongchedi, and Ruiyan International Information Consulting (Beijing) Co., Ltd. Without their support, this report may not be successfully published. Meanwhile, under the support of the project "Research on Sustainable Development and Carbon Trading Strategy for Energy Saving and New Energy Vehicles in China" of the Chinese Academy of Engineering, this report has obtained some research results on carbon trading, which have been included herein.

However, due to the author's limited knowledge, this report may need to be revised in depth and breadth, and suggestions and corrections from experts and readers are welcomed!

Beijing, China　　　　Zhenpo Wang

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Chapter 1
Summary

Based on the real-time operation big data of 6.655 million new energy vehicles by the end of December 2021 of the National Monitoring and Management Platform for New Energy Vehicles (hereinafter referred to as the "National Monitoring and Management Platform"), this report objectively and profoundly analyzes the market characteristics, vehicle operation characteristics, vehicle charging characteristics and other industry concerns of new energy vehicles, summarizes the characteristics and puts forward relevant development suggestions, which has specific reference value and significance for relevant government departments, research institutes, universities and enterprises in China's automobile industry.

1.1 Overview of the Development of New Energy Vehicle (NEV) Market

1.1.1 General Development Situation of Global New Energy Vehicle (NEV) Market

The global new energy vehicle (NEV) market maintained a rapid growth trend in sales in 2021, especially in China. With the guidance of environmental protection laws and policies of various countries, the NEV industry in major countries in the world showed intensified competition, and the penetration rate of automobile electrification has increased rapidly (Fig. 1.1). In 2021, the global sales of NEVs reached 6.75 million, which doubled compared with 2020. The NEVs sales in typical countries such as China, Germany, the United States, Britain, and France, exceeded 300,000 (Fig. 1.2); China's NEV market has achieved a breakthrough, and in 2021, the sales of NEVs reached 3.521 million, accounting for 52.1% of the global market, ranking first in the world for seven consecutive years and becoming an essential force in the electric transformation of the global automobile industry.

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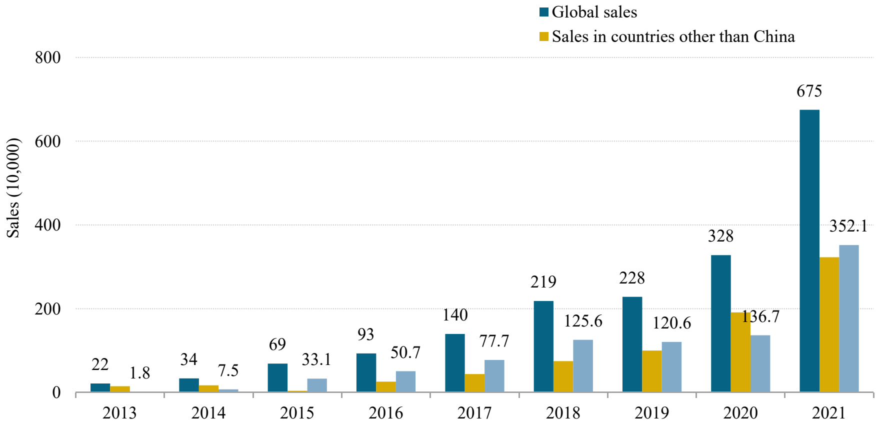


Fig. 1.1 Global sales of NEVs over the years. *Source* China Association of Automobile Manufacturers (CAAM) for sales data of NEVs in China; EV-volumes for sales data of NEVs in countries other than China

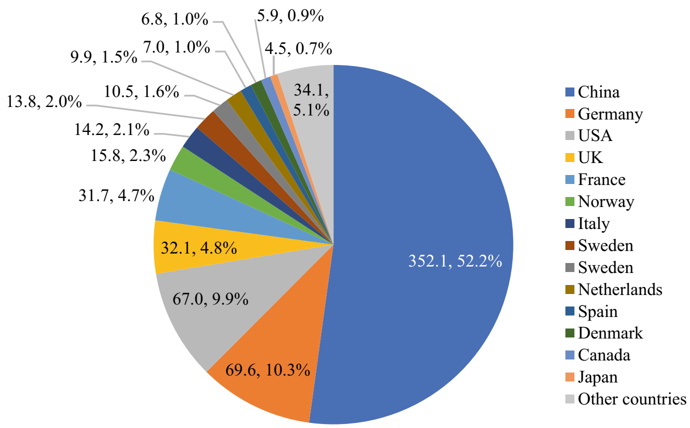


Fig. 1.2 TOP15 countries in global NEVs sales in 2021 and their share (10,000 vehicles, %). *Source* China Association of Automobile Manufacturers (CAAM) for sales data of NEVs in China; EV-volumes for sales data of NEVs in countries other than China

1.1.2 General Development Situation of New Energy Vehicle (NEV) Market in China

1. **China has made remarkable achievements in automobile electrification transformation, and the sales and access volume of NEVs in the market are proliferating**

The scale of China's NEV industry is expanding, with an accelerating upward market penetration curve (Fig. 1.3). Driven by multiple factors such as diversified product supply and increased consumer awareness, China's NEV market reached a new record high in 2021, with annual market sales of 3.521 million, up 157.6% year-on-year, showing an explosive growth trend in market demand and ushering in a complete market inflection point; the market penetration rate of NEVs continues to rise, reaching 13.4% in 2021, with an increase of 8% compared with 2020. The market penetration rate of NEVs continues to increase, reaching 13.4% in 2021, with an increase of 8% compared with 2020.

From the access characteristics of NEVs to the National Monitoring and Management Platform in previous years (Fig. 1.4), the access volume of NEVs generally showed a trend of rapid growth in scale. There was concentrated access in 2018 and 2019, with the annual access rate exceeding 100%. The marketization of NEVs has accelerated in an all-around way.

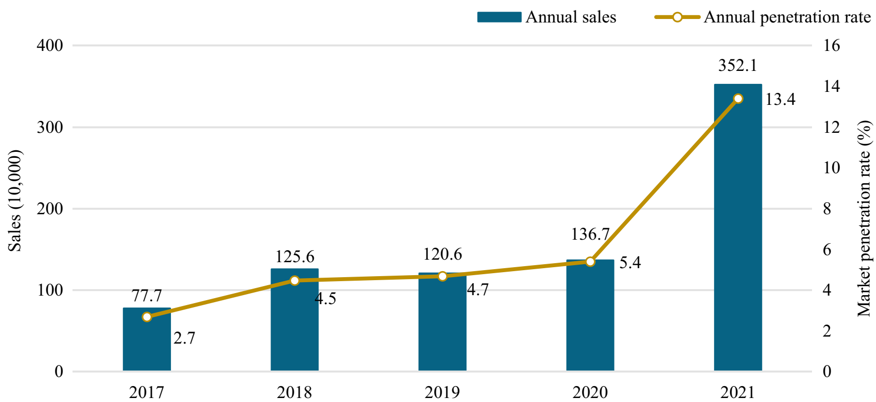


Fig. 1.3 Sales of NEVs in China over the years and growth rate. *Source* China Association of Automobile Manufacturers (CAAM)

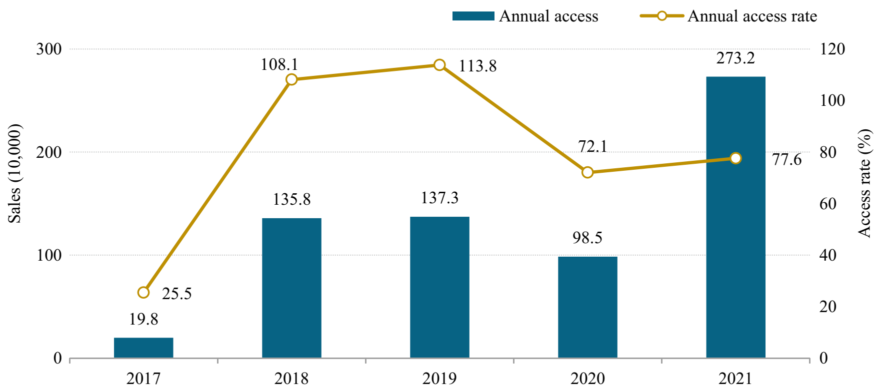


Fig. 1.4 NEV access volume of the National Monitoring and Management Platform over the years

From the change of NEV holdings over the years (Fig. 1.5), as of the end of 2021, the NEV holdings reached 7.84 million, showing a rapid growth trend; the rapid growth of the NEV holdings has driven the steady growth of the cumulative NEV access to the National Monitoring and Management Platform (Fig. 1.6), and as of 2021, the cumulative NEV access reached 6.655 million. The cumulative access rate reached 84.9%, indicating that 84.9% of NEVs nationwide had their safety status monitored in real-time.

The rapid growth of the scale of the NEV industry has led to a rapid increase in the electrification rate of vehicles. According to the data of the Ministry of Public

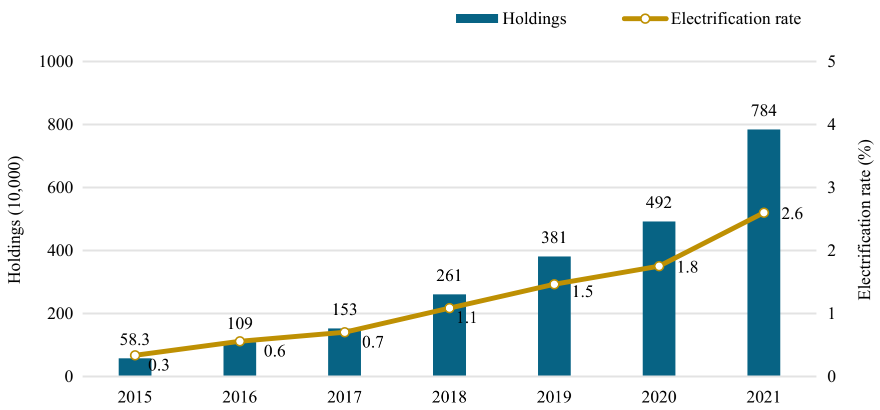


Fig. 1.5 Changes in the NEV holdings and the electrification rate of vehicles in China over the years. *Note* Electrification rate of vehicles = NEV holdings/current vehicle holdings. *Source* The Ministry of Public Security

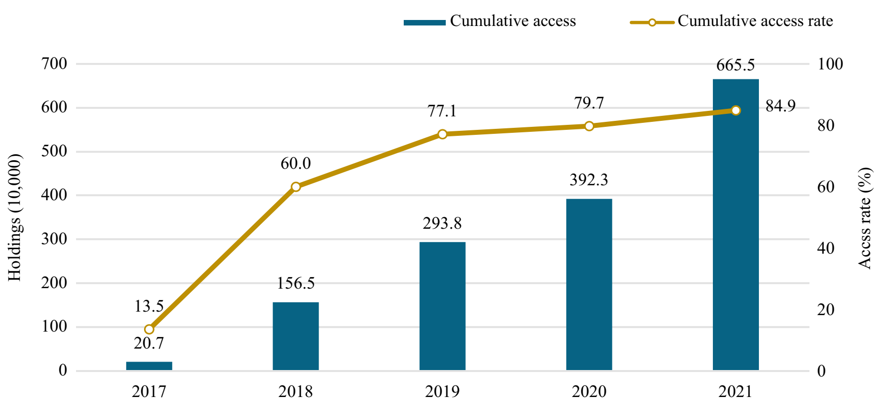


Fig. 1.6 Cumulative access volume of NEVs to the National Monitoring and Management Platform over the years. *Note* Cumulative access rate of vehicles = cumulative access volume of NEVs/current NEV holdings

Security, the vehicle holdings nationwide were 302 million in 2021, and the proportion of NEV holdings to vehicle holdings showed a rapid growth trend yearly, from 0.3% in 2015 to 2.6% in 2021, with an increase of 2.3%.

2. **The promotion of NEVs in different provinces has its characteristics. Guangdong Province has the highest promotion scale of NEVs, while Shanghai has the highest electrification rate**

By the end of 2021, the TOP10 provinces with cumulative access volume of NEVs nationwide had a total of 4,645,000 NEVs accessed, with a national share of 69.8% (Fig. 1.7). The promotion scale of NEVs in Guangdong Province has exceeded one million to 1.05 million NEVs accessed, accounting for 15.8% of the country; followed by Zhejiang and Shanghai, with a total access volume of 605,000 vehicles and 532,000 vehicles respectively, accounting for 9.1 and 8.0% of the country. According to the electrification rate of all provinces (autonomous regions and municipalities directly under the Central Government), the cumulative access volume of NEVs in Shanghai accounted for 12.1% of the local vehicle holdings, ranking first in China.

3. **The promotion of NEVs in first-tier cities has achieved remarkable results; the electrification rate of second-tier cities and below has excellent potential**

By the end of 2021, Shanghai, Shenzhen, Beijing, and Guangzhou ranked the TOP4 in the cumulative access volume of NEVs in the TOP15 cities (Fig. 1.8), with the cumulative access volume of NEVs all above 350,000, accounting for more than 5% of the whole country respectively. Among them, the cumulative access volume of NEVs in Shanghai was 532,000, accounting for 8.0% of the country. From the electrification rate of each city, Liuzhou was far ahead of the first-tier cities, with NEVs accounting for 20.3% of Liuzhou's vehicle holdings. Other cities such as Chongqing, Wuhan, Xi'an, and Chengdu had a relatively low electrification rate, with excellent demand potential for NEVs to replace traditional fuel vehicles.

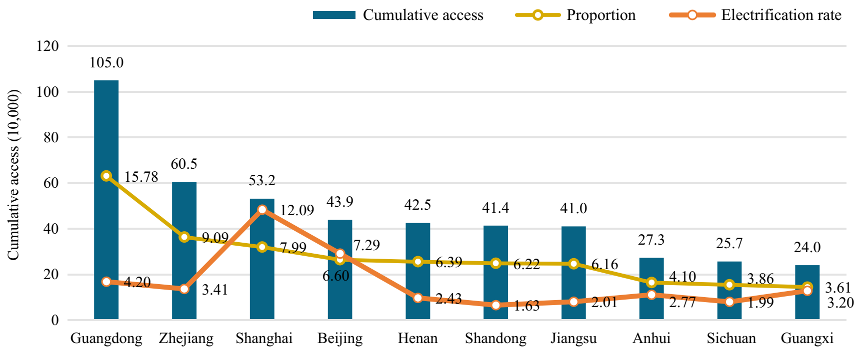


Fig. 1.7 Cumulative access and proportion of NEVs in the TOP10 provinces. *Note* The data on vehicle holdings in all provinces (including autonomous regions and municipalities directly under the Central Government) in 2020 are from the China Statistical Yearbook (2021)

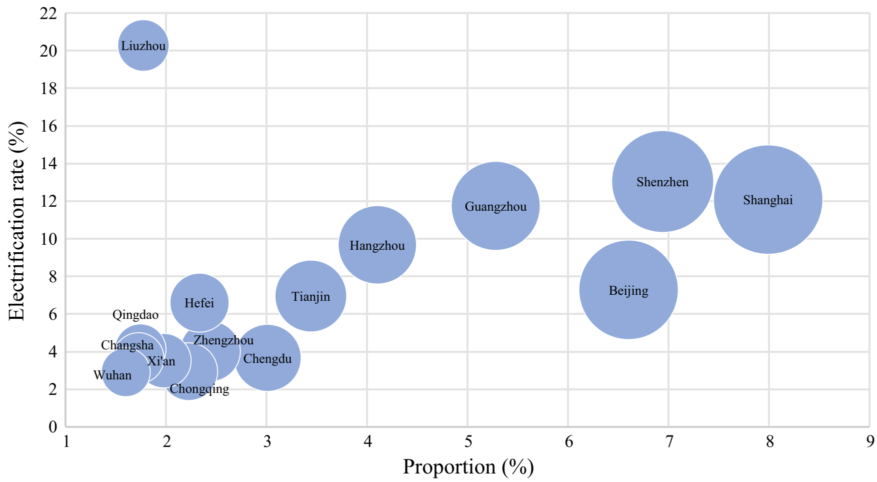


Fig. 1.8 Cumulative access and electrification rate of NEVs in the TOP15 cities. *Note* Bubble size indicates the cumulative access volume of NEVs in each city by the end of 2021; The data of vehicle holdings are from the data of vehicle holdings of the Ministry of Public Security in 2020

4. **The new energy passenger car has become more and more market-oriented, and private purchase has become a significant driving force**

New energy passenger cars dominate the NEV market, with the market share increasing yearly. In light of the changes in the access structure of various types of vehicles on the National Monitoring and Management Platform over the years, new energy passenger cars dominate the market and show a rapid expansion trend in their market share. In 2021, the access volume of BEV-passenger cars and PHEV-passenger cars accounted for 75.9% and 17.4% of the national NEVs, respectively, increasing by 4.3% and 2.6% respectively compared with 2020 (Fig. 1.9). The market share of BEV-commercial vehicles is shrinking rapidly due to the small increment.

Consumer demand in cities not subject to purchase restrictions is robust, and the market share of new energy passenger cars is increasing yearly. Under the stimulation of consumption promotion policies and countryside NEV promotion activities, the awareness and recognition of NEVs by users in cities not subject to purchase restrictions have gradually increased, contributing to the surge of consumer demand in these cities. According to the statistics of the National Monitoring and Management Platform on the proportion of access volume of cities subject to purchase restrictions and not subject to purchase restrictions over the years, the market share of new energy passenger cars in cities not subject to purchase restrictions in 2021 was 66.4%, 6.9% higher than that in 2020, showing an increasing trend in the market share (Fig. 1.10).

According to the access characteristics of NEVs in the TOP15 cities in 2021 (Fig. 1.11), the cities subject to purchase restrictions, like Shanghai, Shenzhen, Guangzhou, Hangzhou, and Beijing, ranked among the forefront, with robust

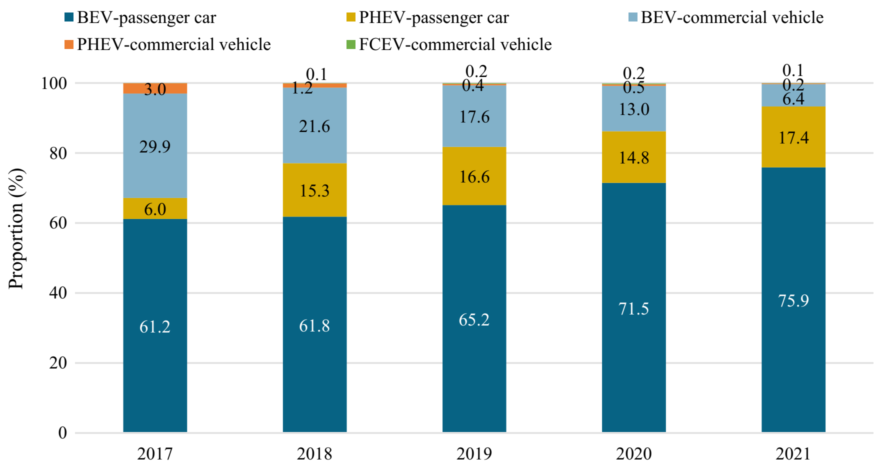


Fig. 1.9 Proportion of access volume of NEVs of different types over the years

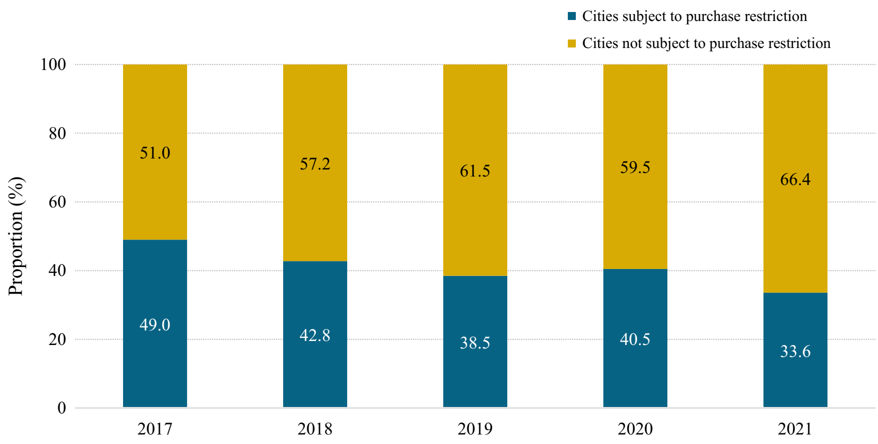


Fig. 1.10 Changes in the proportion of access volume of new energy passenger cars in cities subject to purchase restrictions and cities not subject to purchase restrictions

consumer demand. Among them, the annual access in Shanghai reached 265,000 vehicles, ranking first, accounting for 9.7% of the country. Judging from the proportion of new energy private cars to local NEVs in the TOP15 cities, the proportion of new energy private cars in the TOP15 cities was over 50%, and the proportion of new energy private cars in Liuzhou and Wenzhou was significantly higher than that in first-tier cities, of 90.3% and 85.2% respectively.

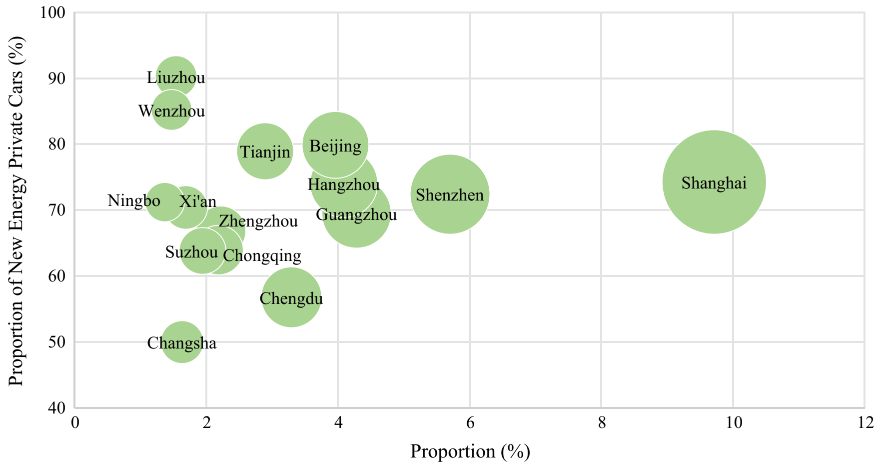


Fig. 1.11 NEV access and proportion of private cars in the TOP15 cities in 2021. Note: ① Bubble size indicates the access volume of NEVs in each city to the National Monitoring and Management Platform in 2021; ② Proportion of new energy private cars = annual access volume of new energy private cars in the city/annual access volume of NEVs in the city

1.2 NEV Operation Characteristics of China in 2021

For this report, an overall assessment is made from the operation characteristics, charging characteristics, battery swapping characteristics, fuel cell electric vehicles (FCEV), and plug-in hybrid electric vehicles (PHEV).

1.2.1 NEV Operation Characteristics

As of December 31, 2021, the cumulative mileage covered by NEVs was up to 218,856,000,000 km.

According to the National Monitoring and Management Platform data, as of December 31, 2021, the cumulative mileage covered by NEVs was 218,850,000,000 km. By the power type of vehicles, the cumulative mileage covered by BEVs was up to 184,328,000,000 km, accounting for 84.22%, including 125,830,000,000 km (57.5%) covered by BEV-passenger cars, 34,306,000,000 km (15.68%) covered by PHEVs and 223,000,000 km (0.1%) covered by FCEVs. The NEVs have been in the large-scale demonstration and promotion stage (Fig. 1.12).

Regarding application scenarios, the cumulative access volume of private passenger cars was up to 4.059 million, accounting for more than 60% of the whole country, and the cumulative mileage covered by vehicles brought by the large-scale promotion of passenger cars was significantly ahead of that covered by vehicles in other application scenarios. As of December 31, 2021, the cumulative mileage

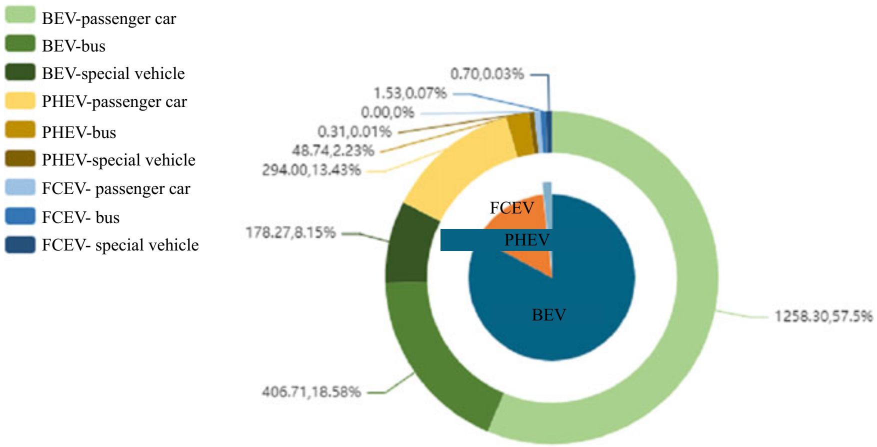


Fig. 1.12 Distribution of cumulative mileage of vehicles of different types (100,000,000 km, %)

covered by private passenger cars was up to 62,160,000,000 km, accounting for 28.4%; in the field of commercial vehicles, the cumulative mileage covered by buses and logistics vehicles stood out, 41,788,000,000 km and 17,380,000,000 km respectively, accounting for 19.09% and 7.94% respectively (Fig. 1.13).

The average daily mileage in segments had somehow increased in 2021, with a significant increase in the average daily mileage of passenger cars.

The segments had been affected by the COVID-19 pandemic in the past three years, and the average daily mileage of vehicles had fluctuated to some extent. In

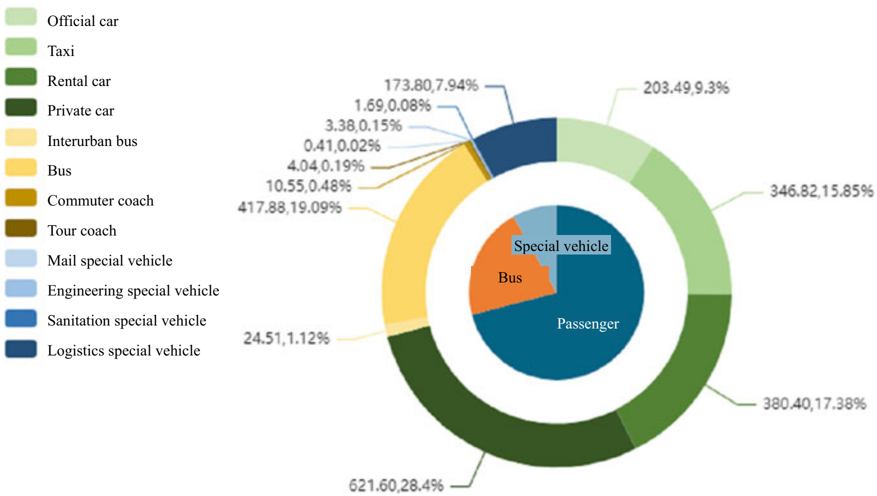


Fig. 1.13 Distribution of cumulative mileage of vehicles in different application scenarios (100,000,000 km, %)

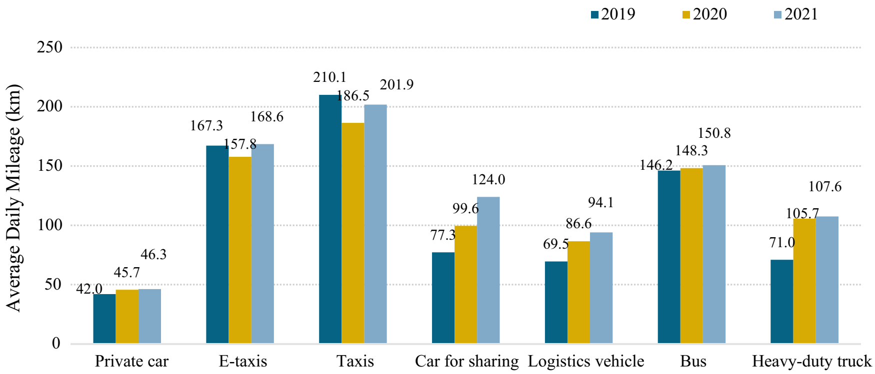


Fig. 1.14 Average daily mileage of NEVs in key segments over the years. *Note* Heavy-duty trucks**:** vehicles with an inherent label of "special vehicle" in the National Monitoring and Management Platform, with total mass ≥ 12,000 kg according to the standard GA801-2014 of the Ministry of Public Security, selected as the research object of the heavy-duty truck segment

2020, the average daily mileage of e-taxis and taxis decreased compared with 2019. Since 2021, the average daily mileage of all segments has increased to varying extents. Among them, in the field of passenger cars, the average daily mileage covered by e-taxis, taxis, and cars for sharing increased significantly year-over-year, of 168.6 km, 201.9 km and 124 km in 2021, respectively, with an increase of 6.8%, 8.3% and 24.4% year-over-year (Fig. 1.14).

The average monthly mileages of vehicles in segments had somehow increased, with a rapid increase in the average monthly mileage of vehicles in the public sector and more prominent energy saving and carbon reduction effect at the vehicle operating end.

The average monthly mileage of vehicles in segments had somehow increased in 2021 (Fig. 1.15). In the field of passenger cars, the average monthly mileage of e-taxis, taxis, and cars for sharing was 4265 km, 4839 km, and 3103 km, respectively, with a significant increase of 19.1%, 16.3%, and 18.8% compared with 2020; in the field of commercial vehicles, the average monthly mileage of logistics vehicles and heavy-duty trucks was 2270 km and 2425 km respectively, with an increase of 4.7% and 8.8% compared with 2020. The average monthly mileage of vehicles in the public sector was stable over the years, and the effect of energy saving and carbon reduction at the vehicle operating end was more prominent.

1.2.2 NEV Charging Characteristics

1. **Characteristics of changes in vehicle charging methods**

The proportion of average monthly fast charging times in each segment is increasing yearly, except for private cars.

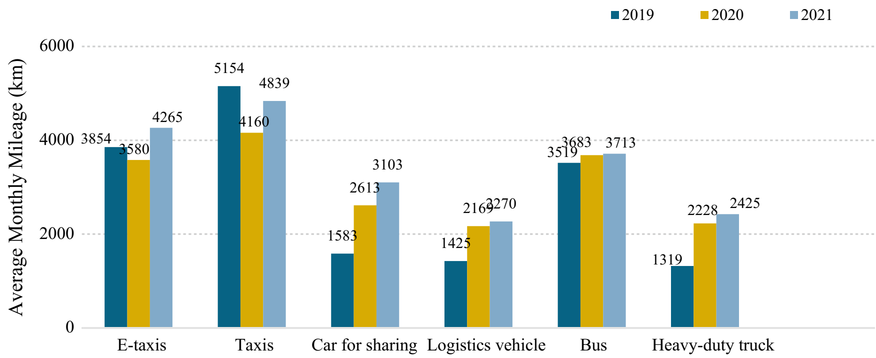


Fig. 1.15 Average monthly mileage of NEVs in key segments over the years

Each segment's average monthly fast charging times were increasing yearly except for private cars, judging from the changes in the proportion of average monthly fast charging times over the years (Fig. 1.16). Specifically, regarding the distribution of fast charging times in each segment, the fast charging times for e-taxis, taxis, cars for sharing, logistics vehicles, buses, and heavy-duty trucks accounted for more than 50% in 2021.

2. **Characteristics of charging duration**

The average single-time charging duration of vehicles in key segments in the past two years decreased compared with 2019.

Vehicles' average single-time charging duration in each key segment in the past two years decreased compared with 2019 (Fig. 1.17). The average single-time charging duration for private cars was 3.7 h, showing a year-on-year decline compared with 2019 and 2020; the fast-charging segments such as e-taxis, taxis, cars for sharing, buses and heavy-duty trucks accounted for a higher proportion of fast charging times,

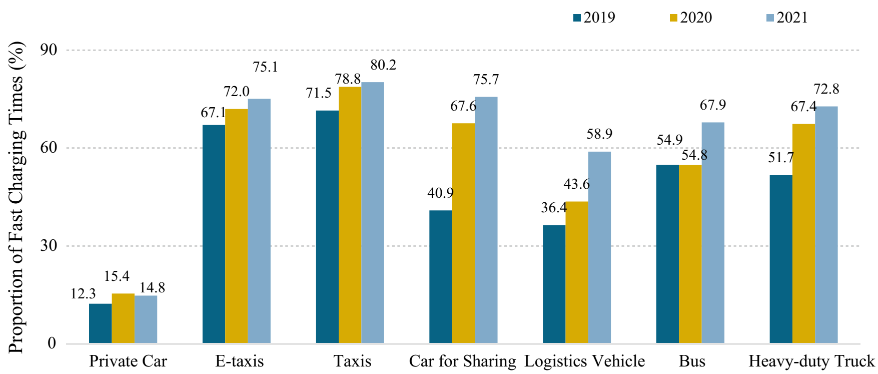


Fig. 1.16 Proportion of fast charging times in key segments over the years

and the average single-time charging duration for vehicles was shorter, ranging from 1 to 2 h. The average single-time charging duration in key segments is closely related to the proportion of fast charging times. We can find the higher the proportion of fast charging times, the shorter the average single-time charging duration (Fig. 1.18).

3. **Characteristics of vehicle charging times**

In 2021, vehicles' average monthly charging times in each segment had somehow increased, with the average monthly charging times of operating vehicles increasing significantly. The NEVs play an increasingly important role in the regular operation of the public sector.

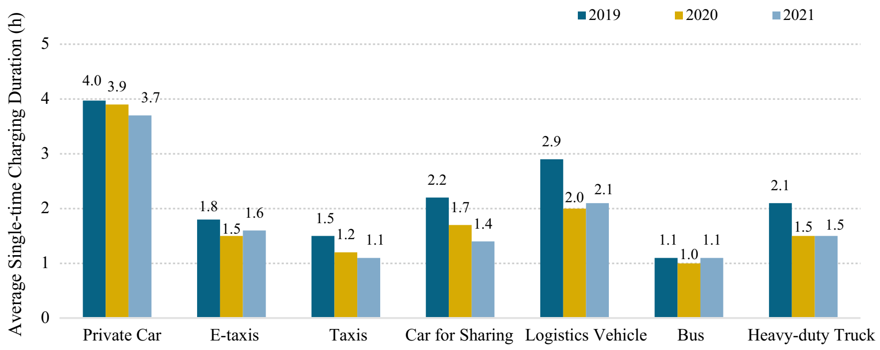


Fig. 1.17 Average single-time charging duration in key segments over the years

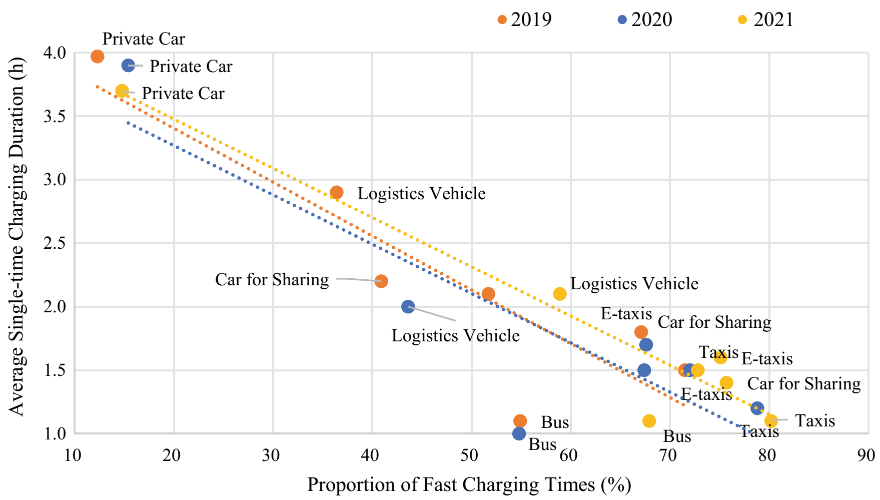


Fig. 1.18 Relationship between the average single-time charging duration and the proportion of fast charging times in key segments over the years

The average monthly charging times of vehicles in each segment had somehow increased (Fig. 1.19), and among them, the increases in average monthly charging times of taxis, cars for sharing, and buses were great, which were 43.4, 68.9, 38.4%; the monthly charging times were closely related to the monthly mileage (Fig. 1.20), and the monthly charging times of taxis, buses and e-taxis were the highest, as their monthly mileages were longer. The NEVs gradually replace traditional fuel vehicles in the regular operation of the public sector and play an increasingly important role, further contributing to the low carbonization of transportation.

4. **Initial state-of-charge (SOC) characteristics**

The average initial SOC of vehicle charging in segments was the same, and the initial SOC of commercial vehicle charging was higher.

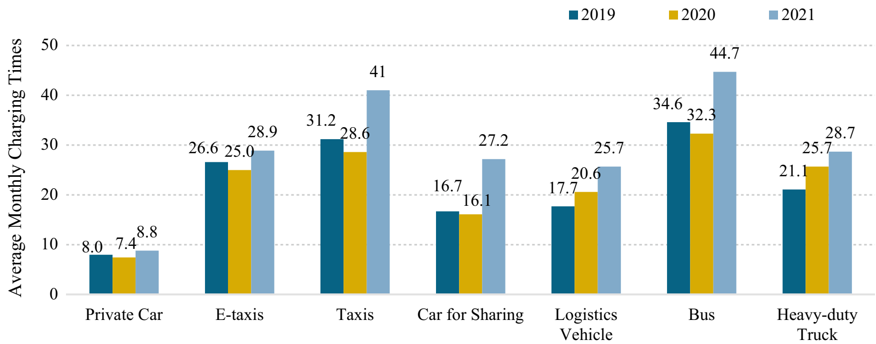


Fig. 1.19 Average monthly charging times in key segments over the years

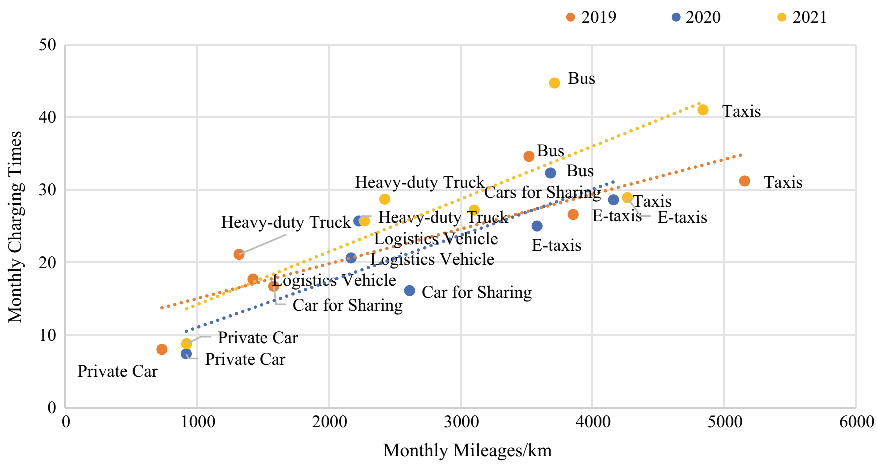


Fig. 1.20 Relationship between monthly charging times and monthly mileages in key segments over the years

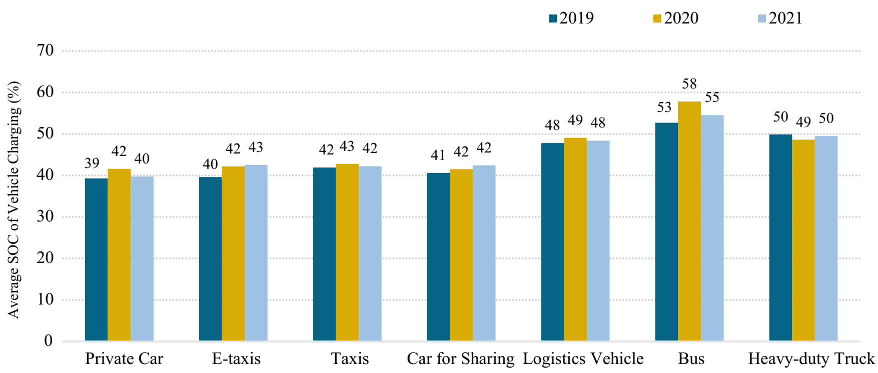


Fig. 1.21 Average initial SOC in key segments over the years

The average initial SOC of vehicle charging in segments over the past three years was the same (Fig. 1.21). In commercial vehicles, the average initial SOC of logistics vehicles, buses, and heavy-duty trucks was generally slightly higher than that of passenger cars, which was closely related to the operation rules of commercial vehicles and the use of special charging piles for charging.

1.2.3 Operation Characteristics of BEVs of Battery-Swapping Type

With the deepening of global energy reform, “changing from oil into electricity” has become the general trend. However, the need to improve the charging experience due to the unbalanced layout of charging facilities for NEVs is still one problem that restricts the rapid development of NEVs. According to the statistics of vehicle charging characteristics of some high-speed charging stations along the expressways of Beijing-Tianjin-Hebei, Jiangsu-Zhejiang-Shanghai, and Beijing-Shanghai, the charging times along the expressways during the National Day of 2021 were significantly higher than that during non-holiday periods. The rapid increase in the number of vehicles charged in a short period and the long charging duration of vehicles have become important factors affecting the convenience of charging during a specific period.

In recent years, the battery-swapping mode has achieved good demonstration and application results in private cars, taxis, and heavy-duty trucks. The battery swapping mode can effectively meet the demand of NEVs for power supply efficiency. With the diversified application of battery swapping scenarios, as of the end of 2021, more than 100,000 BEVs of battery-swapping type had been accessed in China, including 88,000 BEV-private cars of battery-swapping type and 33,000 BEV-taxis of battery-swapping type, accounting for a large proportion of vehicles of battery-swapping type; the heavy-duty trucks of battery-swapping type were still in the demonstration operation stage, and their access increased rapidly in 2021, with the cumulative access up to 941 vehicles. According to the regional concentration distribution of vehicles of battery-swapping type, the heavy-duty trucks of battery-swapping type in Tangshan City, Hebei Province, had been rapidly promoted, with cumulative access of up to 378 vehicles.

The battery swapping mode reduces the first purchase cost of BEVs and improves the operation efficiency of vehicles. The "separation of vehicle and battery" mode expects to become a practical path for the electrification of the public sector. According to the battery swapping characteristics of the vehicles of battery-swapping type on the National Monitoring and Management Platform, the vehicles of battery-swapping type have much potential in power supply efficiency. The initial SOC of battery swapping for the vehicles of battery-swapping type is generally lower than the initial SOC of charging, and the battery swapping can be completed in 3–5 min. From the perspective of the total cost of the vehicle application cycle, the first purchase cost of BEV-heavy-duty trucks is relatively high. Purchasing vehicles with leasing batteries and adopting the battery swapping mode are suitable for short-distance transportation scenarios such as short-haul in mining areas, port traction, plants, and urban waste transportation. The new business model solves the problem of high first-purchase costs and is more economical than fueled heavy-duty trucks. The low electricity price further reduces operating costs, becoming an effective solution for cleaning heavy-duty trucks under the "Carbon Peaking and Carbon Neutrality" strategy.

1.2.4 Operation Characteristics of Fuel Cell Electric Vehicles (FCEVs)

FCEVs are demonstrated and promoted on a large scale in demonstration urban agglomerations, and the industry is ushering in rapid development. With the implementation of the "Carbon Peaking and Carbon Neutrality" strategy and the demonstration and application policy of FCEVs, the technology of the fuel cell industry has been continuously improving, and the hydrogen energy and fuel cell industry has developed rapidly all over the country. In 2021, the enthusiasm of local governments to develop hydrogen energy continued to rise. Various provinces successively put forward development goals and action plans around expanding hydrogen energy supply channels, building hydrogenation infrastructure, focusing on developing core components, and strengthening vehicle demonstration, popularization, and application, and the market scale of FCEVs in various places proliferated. According to the data of the National Monitoring and Management Platform, as of the end of 2021, 7737 FCEVs had been accessed in China, and the application scenarios of vehicles had gradually expanded from a single application scenario of buses to application scenarios of interurban buses, commuter coaches, logistics vehicles, engineering vehicle, with a significant trend of diversification of scenarios.

The first and second batches of demonstration urban agglomerations represented by Beijing-Tianjin-Hebei Urban Agglomeration, Shanghai Urban Agglomeration, Guangdong Urban Agglomeration, Hebei Urban Agglomeration, and Henan Urban Agglomeration were established one after another in 2021, and the five demonstration urban agglomerations have their characteristics in vehicle promotion and application. As of December 31, 2021, the five demonstration urban agglomerations had 5629 FCEVs accessed, accounting for 72.8% of the cumulative access volume of FCEVs in China. Regarding vehicle promotion structure, the proportion of FCEV-buses promoted in the Beijing-Tianjin-Hebei Urban Agglomeration, Hebei Urban Agglomeration, and Henan Urban Agglomeration was significantly higher than that of special vehicles (Fig. 1.22); the promotion scale of FCEV-special vehicles in the Shanghai Urban Agglomeration and the Guangdong Urban Agglomeration was significantly higher than that of FCEV-buses; as of December 31, 2021, the cumulative mileage of FCEVs in various demonstration urban agglomerations was 142.602 million km, with the total travel duration of 5.333 million h. Among them, the cumulative mileage of FCEVs in the Guangdong Urban Agglomeration was 76.069 million km, with a cumulative travel duration of 2.584 million h; the cumulative mileage of the Beijing-Tianjin-Hebei Urban Agglomeration and the Shanghai Urban Agglomeration was 10.912 million km and 21.785 million km respectively, with the cumulative travel duration of 356,000 h and 744,000 h respectively.

As a symbol for China to show the world the promotion achievements of China's FCEVs, the Beijing Winter Olympics achieved outstanding results in vehicle promotion and operation. As of the end of February 2022, Beijing Winter Olympics had

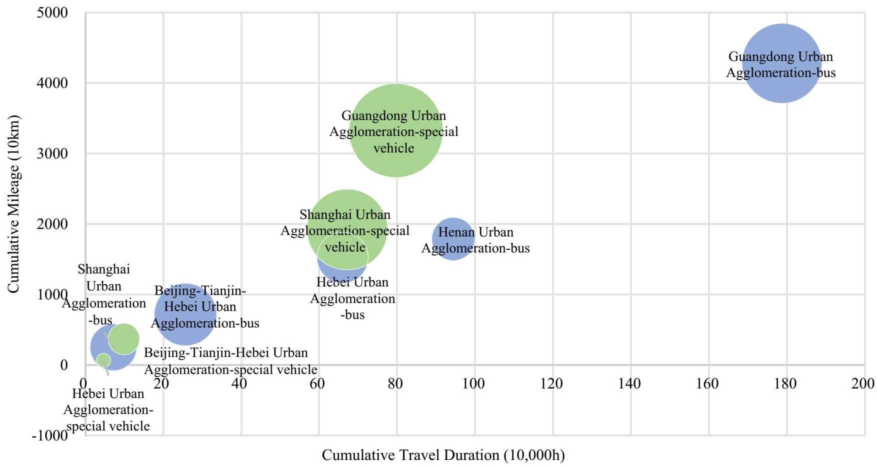


Fig. 1.22 Cumulative mileage and travel duration of vehicles in FCEV demonstration urban agglomerations. *Note* ① Bubble size indicates the cumulative access volume of different FCEVs in each city as of 2021; ② In the above figure, blue indicates FCEV-buses, and green indicates FCEV-special vehicles

put more than 1300 FCEVs into use as the main transport capacity to carry out multi-scenario demonstration operation services; in February 2022, the number of FCEVs running in the Winter Olympics reached 137,400, with an increase of 66.67% from the previous month. The demonstration operation of vehicles in the Olympic Games was fully guaranteed, demonstrating China's contribution to the field of low-carbon transportation.

1.2.5 Operation Characteristics of Plug-In Hybrid Electric Vehicles (PHEVs)

China's PHEVs have gradually shifted from a supply-side drive to a supply-consumption dual drive. According to the National Monitoring and Management Platform data, 1.107 million PHEVs had accessed the National Monitoring and Management Platform as of December 31, 2021. In 2021, the domestic PHEV market maintained a high-speed growth trend, with 480,800 PHEVs accessed, creating a new high in the past years; private purchases were the leading consumer in the PHEV market. PHEV-private cars accounted for 93.2% of the national PHEVs in 2021, with an increase of 8.1% compared with 2019; the market demand of third-tier cities and below gradually released, and the access volume of PHEV-private cars in third-tier cities and below accounted for 28.40% in 2021, with an increase of 8.1% compared with 2019.

The PHEVs were used frequently, with the online rate being high. In 2021, the average online rate of PHEVs was 93.0%, significantly higher than that of BEVs and FCEVs. By vehicle type, the online rate of private cars, e-taxis, and taxis was significantly higher than that of other types of vehicles. The average daily mileage of private cars and e-taxis in EV Mode was higher, and the utilization rate of EV Mode was higher. The charging duration of PHEVs was stable, and the vehicles mostly used slow charging to supplement the power. The average single-time charging duration of PHEV-passenger cars was stable at about 3.0 h over the years, mainly in slow charging mode, and the fast charging duration was maintained at about 0.5 h.

1.3 Conclusion and Prospect

After years of cultivation, China's NEVs, with continuously improved technical level, increasingly abundant product supply, gradually matured and stabilized industrial chain, and accelerated industrialization and marketization of NEVs in an all-round way, have become a new growth driver to promote the high-quality development of the automobile industry. Meanwhile, the "Carbon Peaking and Carbon Neutrality" strategy puts forward new requirements for China's NEV industry, which involves many upstream and downstream links of the industrial chain. Under the new development situation, the industry must take multiple measures simultaneously, make overall plans and make systematic progress to further promote the NEV industry's high-quality and long-term prospering development. This report, based on the real-time operation big data of more than 6.5 million NEVs on the National Monitoring and Management Platform, concludes the relevant suggestions for the development of the NEV industry by profoundly analyzing the industrial development characteristics, technological progress achievements, vehicle operation and charging characteristics and industrial development hotspots, to provide decision-making reference for policy-making departments and related enterprises.

1. **Continue to improve the support policies for the NEV industry, build a carbon emission monitoring platform for the industry based on the National Monitoring and Management Platform, and establish a sound automobile energy conservation and emission reduction system in the post-subsidy era**

The major economies and countries in the world have set the goals of carbon peaking and carbon neutrality, and the automobile industry's electrification transformation has accelerated. As a strategic emerging industry, China's NEV industry has achieved a historic leap from "following" to "paralleling" and then to partially "overtaking," which plays an essential leading role in implementing the "Carbon Peaking and Carbon Neutrality" strategy, the national energy development strategy, the strategy of building a country with solid transportation network and the strategy of building a country with robust automobile industry. The national financial subsidies for new energy vehicles will be completely withdrawn in 2023. In the post-subsidy era, it is urgent to speed up the introduction of support and encouragement measures on the demand side by relying on the market mechanism to maintain the first-mover advantage of China's new energy automobile industry. On the one hand, we should develop a carbon reduction incentive mechanism for the operating end of new energy automobiles based on use intensity, and form a double-track mechanism integrating points trading of new energy automobile products and carbon reduction incentive policy for new energy automobiles, while exploring a subsidy and incentive mechanism for accurate measurement and dynamic evaluation of carbon reduction for enterprises and individuals, speeding up the technological iteration of enterprises, and encouraging users to apply low-carbon vehicles. On the other hand, relying on the massive new energy automobile operation big data resources of the national regulatory platform, we will establish and improve the carbon emission standard system and management system of the automobile industry, and establish an industry-level carbon emission monitoring mechanism on the application side based on the carbon emission measuring standards, thus making every endeavor to promote the comprehensive low-carbon and zero-carbon development in the transportation field.

2. **Strengthen the vehicle safety supervision, give full play to the NEV big data monitoring efficiency, promptly interface with enterprises to investigate potential safety hazards, and improve the quality and safety level of NEVs**

The NEV is the strategic direction of the automobile industry transformation and upgrading, and safety is the key to the development of the NEV industry. On April 8, 2022, the Ministry of Industry and Information Technology, the Ministry of Public Security, the Ministry of Transport, the Ministry of Emergency Management, and the State Administration for Market Regulation jointly issued the *Guidelines on Further Strengthening the Construction of New Energy Vehicle Safety System* (hereinafter referred to as "the Guidelines"), which puts forward safety supervision requirements from the aspects of improving the safety management mechanism, ensuring the product quality and safety, improving the monitoring platform efficiency, optimizing the after-sales service capabilities, strengthening the accident response and handling, and improving the network security system. The National Monitoring and Management Platform, by digging deep into the value of NEV big data and using big data to strengthen safety supervision, strengthen accident reporting and deepen investigation and analysis, further promotes the digital safety supervision of NEVs, which is of great significance for innovating the safety supervision mode and improving the level of social public services. Next, we should fully utilize the vehicle big data resources on the National Monitoring and Management Platform, on the one hand, by conducting vehicle fault analysis to identify safety hazards and handle them properly promptly, and on the other hand, by researching the theory and key technologies of vehicle cloud collaborative big data early warning and failure recognition based on the new-generation information technology, to break through the challenges of safety assessment and early warning in the application process of power batteries, and further improve the quality and safety level of products. Besides, we will assist enterprises in establishing a safety condition monitoring platform for NEVs, to continuously improve the safety and early warning capability of NEVs.

3. **The operating vehicles are used frequently, and the electrification of vehicles contributes more to energy conservation and carbon reduction in the transportation field. We should resolutely promote the comprehensive electrification of vehicles in the public sector to help achieve the goal of "Carbon Peaking and Carbon Neutrality"**

From the perspective of various application scenarios, the proportion of access volume of new energy private cars is increasing yearly, while the proportion of accessed vehicles in the public sector is decreasing year after year, which needs increasing attention. According to the comparison of vehicle mileage and access in various fields on the National Monitoring and Management Platform, in 2021, the access volume of vehicles in China's public sector (including buses, taxis, logistics vehicles, e-taxis, car for sharing) accounted for only 26.8%. However, the average monthly vehicle mileage in the public sector was 3824.6 km, 4.7 times that of a private car. The vehicles in the public sector were used frequently, and the improvement of the electrification rate contributed more to carbon emissions. In 2021, the State Council and the Ministry of Industry and Information Technology issued a circular to promote the comprehensive electrification of vehicles in the public sector. Local governments and related enterprises should actively implement the provisions, introduce support and guidance measures in an all-around way, develop and produce marketable vehicles in the public sector, innovate the operation mode, resolutely promote the comprehensive electrification of vehicles in the public sector, and help achieve the goal of "Carbon Peaking and Carbon Neutrality."

4. **In the field of charging facilities, the charging service experience of NEV users will be continuously improved, and the use environment of charging facilities will be optimized with a refined operation mode**

After years of development, China's charging infrastructure construction has entered the stage of pursuing both quantity and quality, and the charging infrastructure support capacity has been continuously improved. In China's infrastructure system, a charging infrastructure system covering special charging and battery swapping stations, intercity and urban public charging and battery swapping networks, and unit and individual charging facilities has been formed, realizing "effectively supporting the promotion and use demand of NEVs." However, there are still some problems in charging infrastructure, such as unbalanced regional development of charging piles, long waiting times at expressway charging stations on holidays, and insufficient service guarantee capacity of charging facilities in urban and rural areas. Next, local governments should continue to improve the collaborative service guarantee capability of infrastructures, focusing on the following aspects: (1) Optimize the layout of charging and battery swapping networks, improve the charging and battery swapping service guarantee capability in urban and rural areas, and accelerate the improvement of expressway fast charging networks; (2) Fully rely on the big data resources of charging infrastructures, and further optimize the network layout of urban charging infrastructures in combination with vehicle operation data, charging hotspot data and power grid distribution capacity; (3) In view of the congestion of expressway charging stations on holidays, guide the charging of expressway vehicles based on time sharing control and classification differences to create a charging service environment that separates passenger cars and trucks and improve the expressway charging experience on holidays; and (4) Support the construction and operation demonstration of orderly high-power charging stations, and expand the large-scale application of intelligent and orderly charging.

Chapter 2
Promotion and Application of New Energy Vehicles

2021 is the first year of the "14th Five-Year Plan" and the first year of fully marketizing NEVs. NEVs have become the development highlight of the automobile industry, and the industrial development presents a good situation with a double improvement of market scale and development quality. This report, based on the NEV access data on the National Monitoring and Management Platform, concludes China's promotion experience in the NEV industry from two dimensions of vehicle access characteristics and vehicle technology progress, which has important reference significance for us to predict the industrial development trend and promote the stable development of the NEV industry.

2.1 Development Status of China's New Energy Vehicle (NEV) Industry

The sales volume of NEVs in China in 2021 was 3,521,000, the annual access rate of NEVs on the National Monitoring and Management Platform was 77.5%, and the industry growth exceeded expectations.

According to the data of CAAM (Table 2.1), the sales volume of NEVs in China in 2021 was 3,521,000, with a YoY increase of 157.5%. The sales volume of passenger cars was 3,334,000, accounting for 94.7%. Among them, the sales of BEV-passenger cars increased significantly by 173.5% on a year-on-year basis to 2,734,000, i.e., 77.6% of the total sales of NEVs; the sales of PHEV-passenger cars were 600,000, with a YoY increase of 143.2%. Compared with last year, the sales of new energy commercial vehicles increased by 5.3% to 187,000, mainly due to the rapid growth of BEV-commercial vehicles.

According to the access data of the National Monitoring and Management Platform in 2021, the annual access volume of NEVs (excluding PHEVs) in 2021 was 2,732,000, with an annual access rate of 77.6%. The annual access volume of new energy commercial vehicles was 183,000, with the access rate up to 97.9%. Among

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2022)*,
https://doi.org/10.1007/978-981-99-6411-6_2

Table 2.1 Sales of NEVs in China in 2021

	Sales (10,000)	Access (10,000)	Access rate (%)
NEVs (Total)	**352.1**	**273.2**	**77.6**
New energy passenger cars (Subtotal)	**333.4**	**254.9**	**76.5**
BEV	273.4	207.4	75.9
PHEV	60.0	47.5	79.2
New energy commercial vehicles (Subtotal)	**18.7**	**18.3**	**97.9**
BEV	18.2	17.5	96.2
PHEV	0.3	0.6	200.0
FCEV	0.2	0.2	100.0

Source The sales data is from the China Association of Automobile Manufacturers (CAAM), and the access data is from the National Monitoring and Management Platform

them, the access rate of BEV-commercial vehicles was 96.2%, and due to the delay in access to the National Monitoring and Management Platform, the access rate of PHEV-commercial vehicles and FCEV-commercial vehicles exceeded 100%.

In 2021, the monthly sales of NEVs hit record highs, and the market penetration curve rising accelerated.

China's NEVs entered a new stage of accelerated development in 2021, with the monthly sales significantly higher than that in 2020 (Fig. 2.1), and the monthly sales of NEVs repeatedly hit record highs. In December 2021, the monthly market sales of NEVs reached 531,000. Driven by the enrichment of product supply and the gradual improvement of consumer recognition, the market demand for NEVs remained robust.

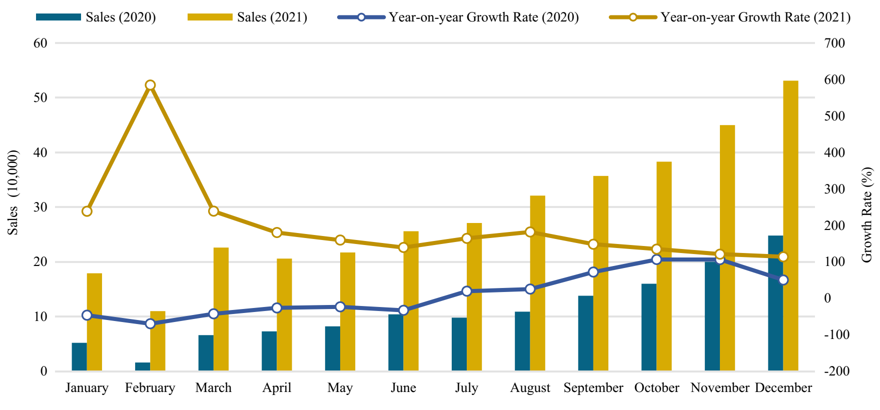


Fig. 2.1 Monthly sales growth of NEVs in China. *Source* China Association of Automobile Manufacturers (CAAM)

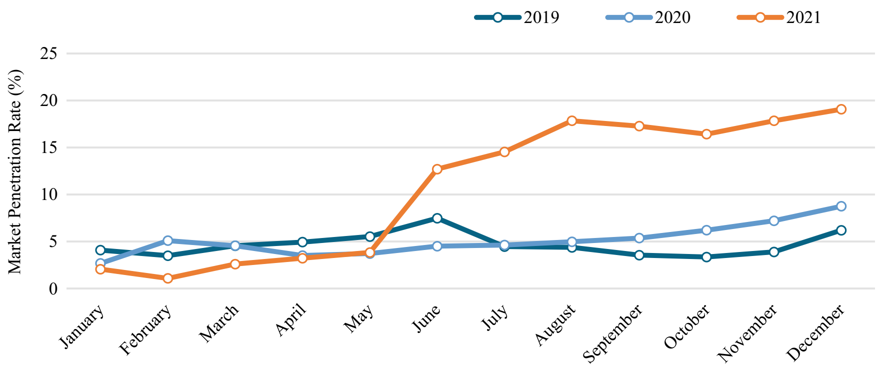


Fig. 2.2 Monthly market penetration rate of NEVs in China over the years. *Source* China Association of Automobile Manufacturers (CAAM)

The monthly market penetration curve rising of NEVs accelerated, and the industry's tipping point came. According to the trend of the monthly market penetration rate of NEVs in 2021 (Fig. 2.2), after June 2021, the monthly market penetration rate of NEVs remained above 12%, and in December, it reached the highest level in the whole year to 19.1%.

According to the trend of monthly access characteristics of NEVs on the National Monitoring and Management Platform (Fig. 2.3), the monthly access volume of NEVs in 2021 was significantly higher than that in each month in 2020. The access volume of vehicles grew rapidly and synchronously with the growth of the NEV market. Judging from the changes in monthly access, in January and February 2021, the access rate of NEVs showed apparent large-scale access, and the access volume of NEVs was significantly higher than the sales of NEVs; in Q4 of 2021, the access volume of NEVs showed a noticeable tail-raising trend.

2.2 Overall Access Characteristics

Based on the cumulative access characteristics of NEVs and vehicle access characteristics over the years on the National Monitoring and Management Platform, this report focuses on such dimensions as market concentration, production concentration, and regional concentration, which is of great significance for summing up the promotion experience of the NEV industry and promoting the high-quality development of the industry.

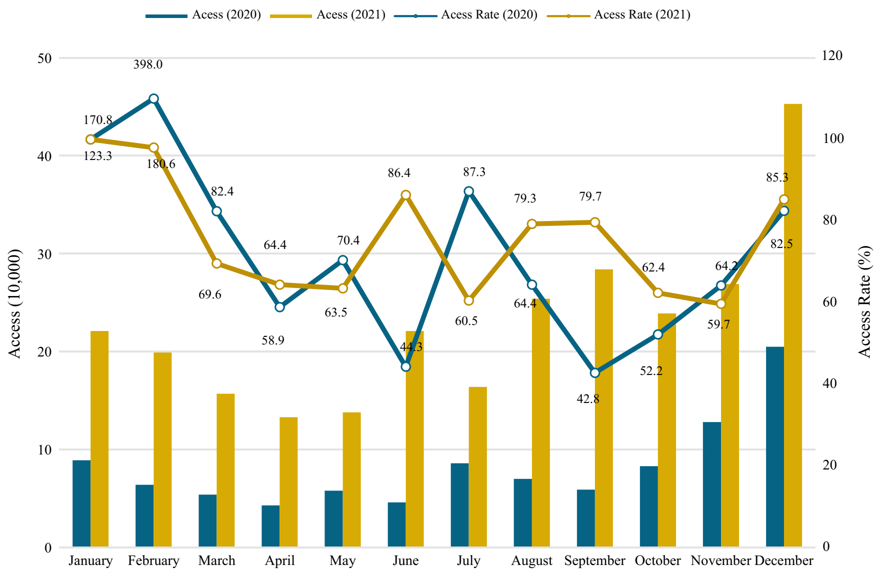


Fig. 2.3 Monthly access volume of NEVs in China over the years. *Note* Access rate = NEV access to the national monitoring and management platform/sales of NEVs in the same period

2.2.1 Overall Access Characteristics of Vehicles

As of December 31, 2021, 6,655,000 NEVs had been accessed to the National Monitoring and Management Platform, including 5863 models accessed by 306 enterprises. From different vehicle types (Fig. 2.4), the access volume of passenger cars, buses, and special vehicles was 5,708,000, 443,000, and 504,000, respectively, accounting for 85.8%, 6.6%, and 7.6%, respectively, with passenger cars dominating the proportion.

According to the cumulative access characteristics of vehicles in application scenarios, the cumulative access volume of private passenger cars accounted for more than half. As of December 31, 2021, the cumulative access volume of private passenger cars reached 4,059,000, accounting for 61.0% of the total access volume of vehicles to the National Monitoring and Management Platform, followed by official vehicles, rental cars, logistics vehicles, and urban buses, with cumulative access volume of 655,000, 645,000, 480,000 and 378,000 respectively, accounting for 9.8%, 9.7%, 7.2%, and 5.7% respectively.

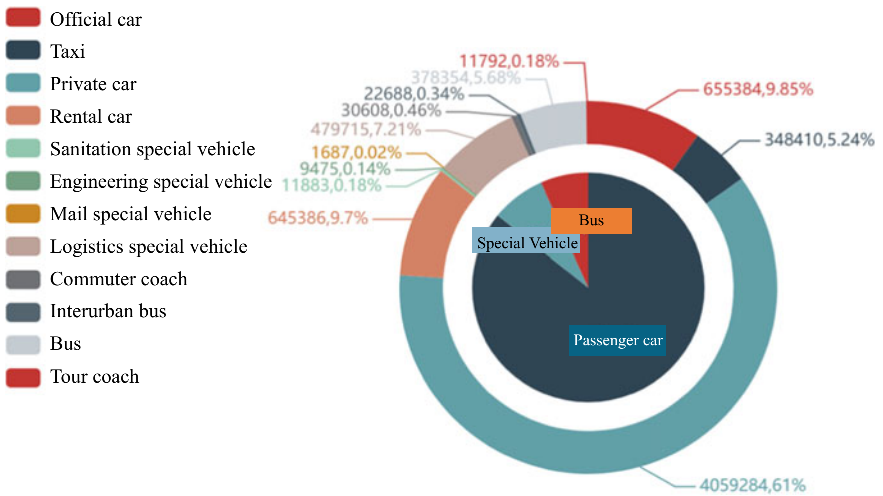


Fig. 2.4 Cumulative access and proportion of NEVs for different purposes (vehicles, %)

2.2.2 Vehicle Access by Region

1. **Characteristics of Vehicle Promotion Concentration by Province**

The number and access share of provinces with cumulative access exceeding 300,000 vehicles increased significantly in 2021 compared with the previous two years.

Judging from the cumulative access volume of NEVs in provinces (autonomous regions and municipalities directly under the Central Government) on the National Monitoring and Management Platform (Table 2.2), the number of provinces with cumulative access exceeding 300,000 vehicles was increasing yearly. In 2021, seven provinces/cities had cumulative access exceeding 300,000 vehicles, namely Guangdong, Zhejiang, Shanghai, Beijing, Henan, Shandong, and Jiangsu. The cumulative access volume of vehicles in the above provinces/cities were 3,875,000, accounting for 58.3% of the access volume in China.

In 2021, the promotion scale of NEVs in the TOP10 provinces had increased rapidly, and the promotion and application effect in Guangdong was significant.

In the past three years, the promotion of NEVs in all provinces of China has achieved remarkable results (Fig. 2.5), and the access volume of NEVs in the TOP10 provinces has increased rapidly in 2021. By the end of 2021, a total of 4,645,000 NEVs had been accessed in the TOP10 provinces, accounting for 69.8% of the access volume in China, where Guangdong, Zhejiang, and Shanghai ranked among the top three, and by the end of 2021, 770,000 NEVs had been accessed in the three provinces/cities, accounting for 11.6% of the access volume in China.

According to the proportion of NEV promotion-type structures in each province (Fig. 2.6), the cumulative access proportion of new energy passenger cars in Guangxi,

Table 2.2 Number of provinces with different promotion levels of NEVs and their proportion of access

Cumulative access level (10,000)	2019		2020		2021	
	Number of province (Nr.)	Cumulative access proportion (%)	Number of province (Nr.)	Cumulative access proportion (%)	Number of provinces (Nr.)	Cumulative access proportion (%)
0 ~ 5	12	5.8	11	4.6	9	2.5
5–10	10	28.1	5	10.6	3	3.8
10–20	6	32.6	8	27.8	7	17.3
20–30	2	16.6	4	23.6	5	18.1
30–50	1	16.9	2	16.7	4	25.4
> 50	0	0	1	16.7	3	32.9

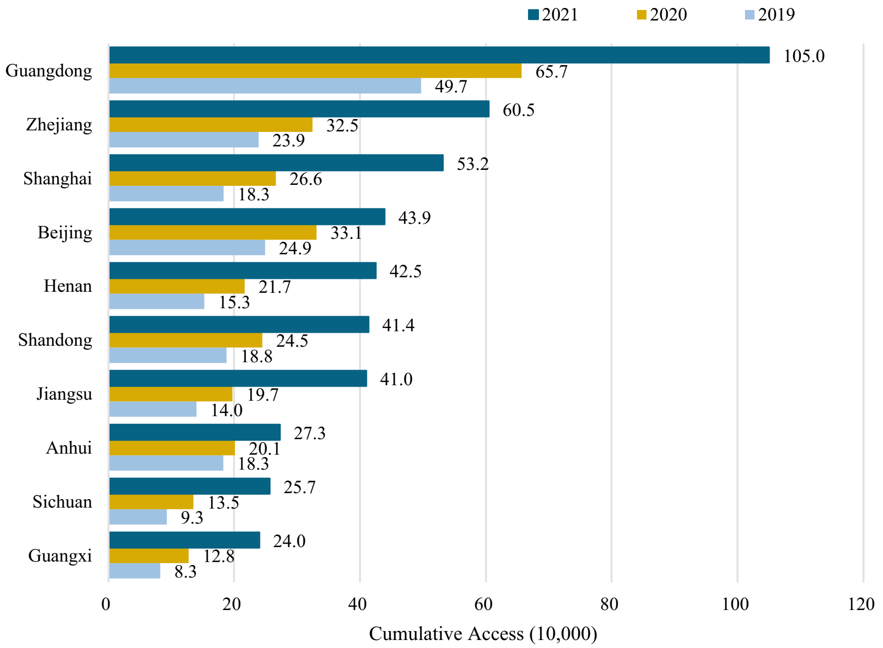


Fig. 2.5 Cumulative access volume of NEVs in the TOP10 provinces over the years. *Note* The cumulative access volume of each province in 2021 is taken as the ranking standard

Shanghai, Zhejiang, and Shandong was over 90%, among which Guangxi was dominated by the promotion of BEV-small passenger cars, with the cumulative access accounting for 95.12%.

In the field of new energy vehicles by type, the promotion of vehicles by type in Guangdong ranked first in the country.

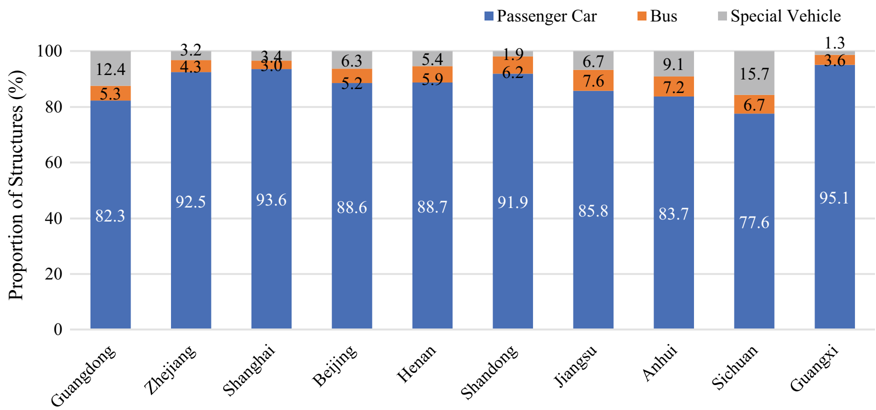


Fig. 2.6 Proportion of cumulative access structures of NEVs by type in the TOP10 provinces

According to the cumulative access characteristics of vehicles by type over the years (Table 2.3), new energy passenger cars' cumulative access volume was obviously higher than that of buses and logistics vehicles. According to the changes in the cumulative access volume of new energy passenger cars over the years, the cumulative access volume of new energy passenger cars in the TOP5 provinces increased from 1,125,000 in 2019 to 2,690,000 in 2021, and that in the TOP10 provinces increased from 1,671,000 in 2019 to 4,085,000 in 2021.

According to the changes in the cumulative access characteristics of new energy buses over the years, the cumulative access volume of new energy buses in Guangdong, Jiangsu, Zhejiang, Shandong, Henan, and Hunan ranked in the forefront, and

Table 2.3 Cumulative access characteristics of NEVs by type in each province

Type of vehicle	Cumulative access volume of each province (including autonomous region/municipality directly under the Central Government) in 2019 (Number of Vehicles)	Cumulative access volume of each province (including autonomous region/municipality directly under the Central Government) in 2020 ((Number of Vehicles)	Cumulative access volume of each province (including autonomous region/municipality directly under the Central Government) in 2021 ((Number of Vehicles)
Passenger car	Guangdong 375092 Beijing 212154 Zhejiang 209766 Shanghai 163470 Shandong 163242 Anhui 146153 Henan 119487 Jiangsu 105136 Tianjin 97646 Hebei 75892	Guangdong 503597 Beijing 287530 Zhejiang 286338 Shanghai 240968 Shandong 213784 Henan 174258 Anhui 161167 Jiangsu 153450 Tianjin 133339 Guangxi 128123	Guangdong 863868 Zhejiang 559319 Shanghai 497698 Beijing 389078 Shandong 380155 Henan 377325 Jiangsu 351682 Anhui 228529 Guangxi 228406 Tianjin 209066
Bus	Guangdong 41728 Hunan 20965 Jiangsu 20709 Henan 19483 Shandong 19241 Beijing 18532 Zhejiang 15838 Anhui 13278 Sichuan 12390 Hebei 11856	Guangdong 50613 Jiangsu 25166 Henan 23137 Hunan 22591 Shandong 22434 Zhejiang 21769 Beijing 21114 Anhui 16002 Hebei 15568 Shanghai 14726	Guangdong 55986 Jiangsu 31029 Zhejiang 26243 Shandong 25642 Henan 25093 Hunan 24372 Beijing 22693 Anhui 19635 Hebei 17498 Fujian 17445
Special vehicle	Guangdong 79010 Anhui 23277 Hubei 21917 Sichuan 21551 Shaanxi 20206 Beijing 18558 Shanxi 15940 Jiangsu 13876 Henan 13122 Zhejiang 13081	Guangdong 101735 Sichuan 28878 Anhui 23931 Hubei 23559 Shaanxi 22692 Beijing 22461 Jiangsu 18165 Henan 17631 Shanxi 16828 Zhejiang 15935	Guangdong 130278 Sichuan 40302 Shaanxi 27894 Beijing 27573 Jiangsu 27389 Hubei 26228 Anhui 24813 Henan 22753 Fujian 22670 Zhejiang 19262

the cumulative access volume of new energy buses in the TOP5 provinces increased from 123,000 in 2019 to 164,000 in 2021, and that in the TOP10 provinces increased from 195,000 in 2019 to 266,000 in 2021.

According to the changes in the cumulative access characteristics of new energy special vehicles over the years, the cumulative access volume of new energy special vehicles in the TOP5 provinces increased from 166,000 in 2019 to 253,000 in 2020, and that in the TOP10 provinces increased from 241,000 in 2018 to 369,000 in 2020.

The regional concentration of NEVs by type showed an overall downward trend.

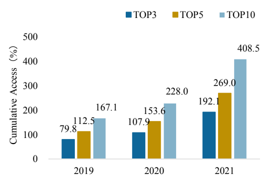
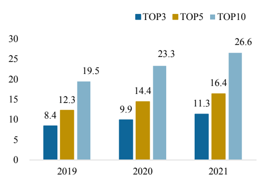
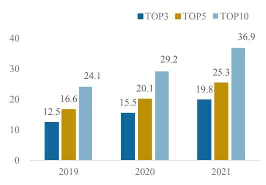
According to the access concentration of vehicles by type over the years (Table 2.4), the cumulative access concentration of various types of NEVs in the TOP3, TOP5, and TOP10 provinces showed an overall downward trend yearly. Among them, the proportion of cumulative access volume of new energy passenger cars in the TOP10 provinces decreased from 72.4% in 2019 to 71.6% in 2021, that of new energy buses in the TOP10 provinces decreased from 61.4% in 2019 to 59.9% in 2021, and that of new energy special vehicles in the TOP10 provinces decreased from 77.3% in 2019 to 73.4% in 2021. The regional concentration of new energy special vehicles was relatively higher than that of new energy passenger cars and buses.

2. **Characteristics of Vehicle Promotion Concentration by City**

In 2021, the promotion scale of NEVs in the TOP10 cities had increased rapidly, and the promotion effect in first-tier cities was significant.

In the past three years, the promotion scale of NEVs in the TOP10 cities had increased rapidly (Fig. 2.7). By the end of 2021, 2,952,000 NEVs had been accessed in the TOP10 cities, accounting for 44.4% of the access volume in China. Shanghai, Shenzhen, Beijing, and Guangzhou ranked at the forefront Regarding cumulative

Table 2.4 Cumulative access and proportion of NEVs of different types in each province

<table>
<tr><th></th><th>Passenger car</th><th>Bus</th><th>Special vehicle</th></tr>
<tr><td>Cumulative access</td><td>
</td><td>
</td><td>
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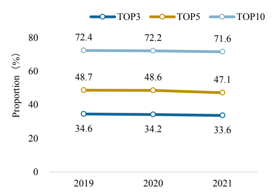
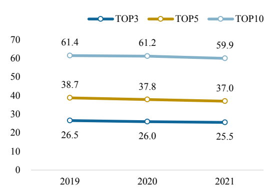
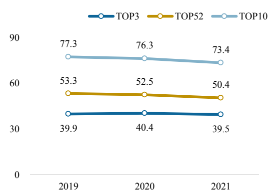
<tr><td>Cumulative access proportion</td><td>
</td><td>
</td><td>
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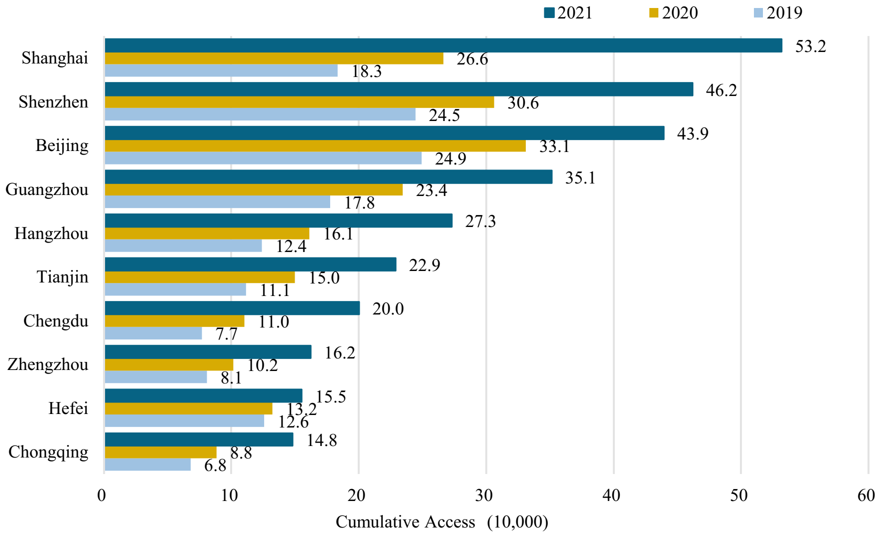


Fig. 2.7 Cumulative access volume of NEVs in the TOP10 cities over the years. *Note* The cumulative access volume of each city in 2021 is taken as the ranking standard

access volume of NEVs, and by the end of 2021, 1,784,0000 NEVs had been accessed, accounting for 26.8% of the access volume in China.

According to the proportion of NEV promotion-type structures in the TOP10 cities (Fig. 2.8), the cumulative access proportion of new energy passenger cars in Shanghai, Hangzhou, Tianjin, and Hefei was over 90%; the cumulative access proportion of new energy commercial vehicles in Shenzhen and Chengdu accounted for more than 20%, and the new energy special vehicle was the primary type promoted.

By the vehicle type, the promotion of NEVs in each city has its own characteristics.

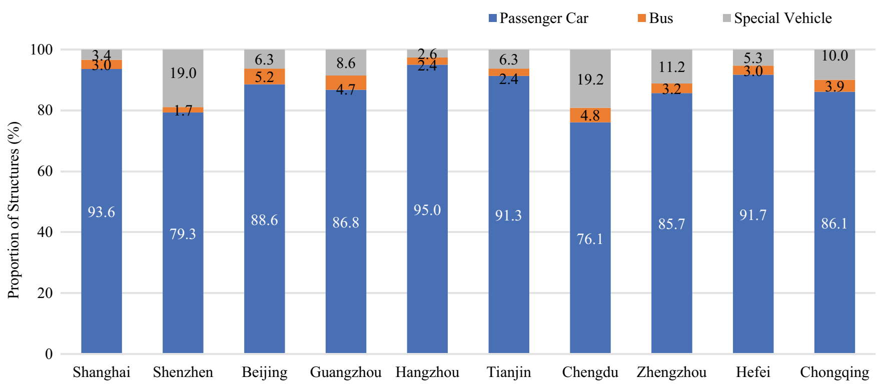


Fig. 2.8 Proportion of cumulative access structures of NEVs by type in the TOP10 cities

According to the cumulative access volume of new energy passenger cars in the TOP10 cities (Fig. 2.9), by the end of 2021, the cumulative access volume of new energy passenger cars in Shanghai, Beijing, and Shenzhen ranked among the forefront, with 498,000, 389,000 and 366,000 respectively, accounting for 8.7%, 6.8%, and 6.4% respectively of the access in China. According to the year-on-year growth rate of new energy passenger car access in each city (Fig. 2.10), the new energy passenger car market in Suzhou, Changsha, Wenzhou, and Zhengzhou proliferated in 2021. Among them, in 2021, the access volume of NEVs in Suzhou had the highest year-on-year growth rate, up to 245.0%.

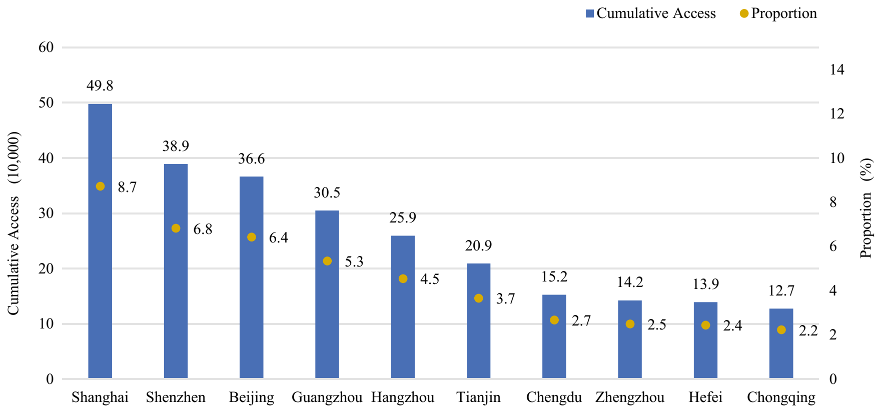


Fig. 2.9 Cumulative access and proportion of new energy passenger cars in the TOP10 cities

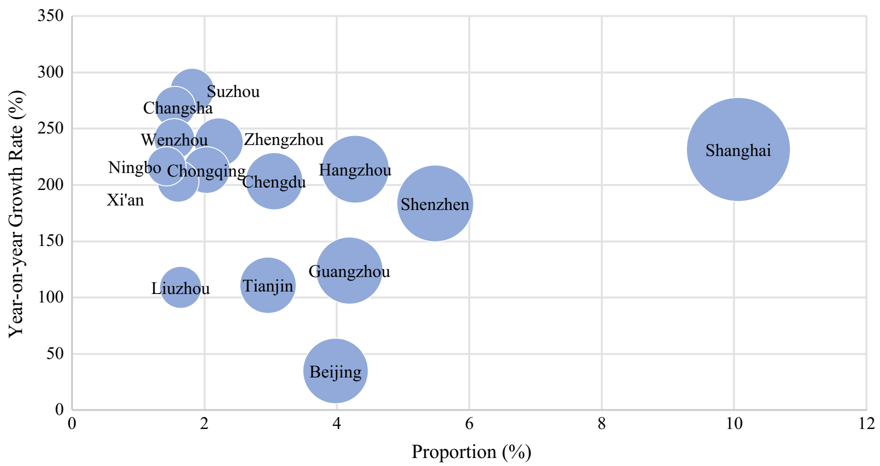


Fig. 2.10 Access volume and growth rate of new energy passenger cars in the TOP15 cities in 2021. *Note* Bubble size indicates a city's annual access volume of new energy passenger cars in 2021

According to the cumulative access characteristics of the TOP10 cities in the field of new energy buses (Fig. 2.11), by the end of 2021, Beijing, Guangzhou, and Shanghai ranked the top three in China, with a cumulative access volume of 23,000, 17,000 and 16,000 vehicles respectively, accounting for 5.1%, 3.7%, and 3.6% respectively of the access volume in China.

According to the year-on-year growth rate of new energy bus access in the TOP15 cities in China in 2021 (Fig. 2.12), the annual growth rate of new energy bus access in Kunming, Shenyang, and Wuhan in 2021 was faster, with a year-on-year growth rate of more than three times.

According to the cumulative access characteristics of the TOP15 cities in the field of new energy special vehicles (Fig. 2.13), by the end of 2021, the cumulative access

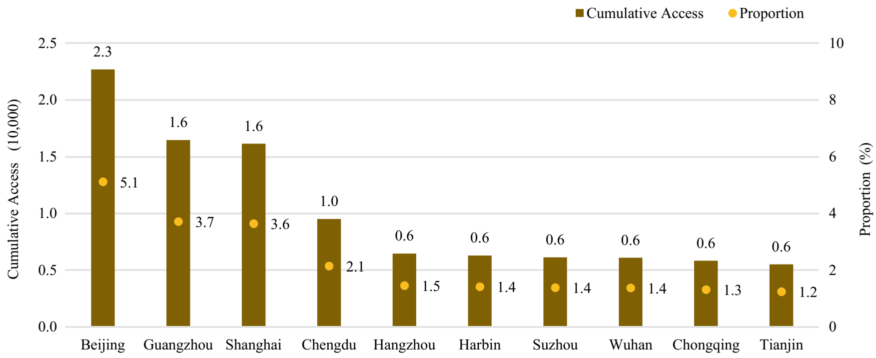


Fig. 2.11 Cumulative access volume and proportion of new energy buses in the TOP10 cities

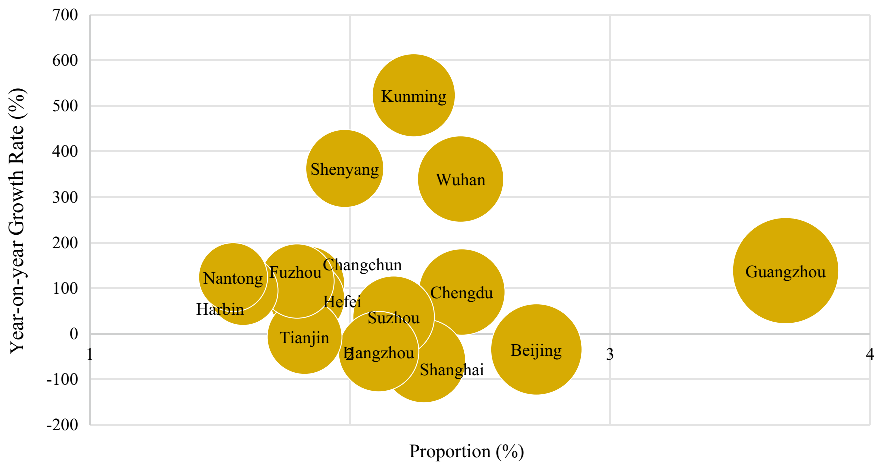


Fig. 2.12 Access and growth rate of new energy buses in the TOP15 cities in 2021. *Note* Bubble size indicates the number of new energy buses accessed by the National Monitoring and Management Platform in 2021

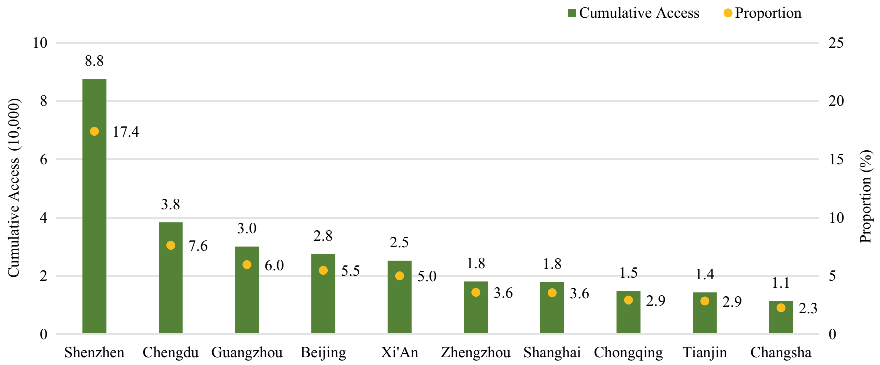


Fig. 2.13 Cumulative access and proportion of new energy special vehicles in the TOP10 cities

volume of new energy special vehicles in Shenzhen was significantly higher than that in other cities, up to 88,000 vehicles, accounting for 17.4% of the access volume in China.

In 2021, the annual access volume of new energy special vehicles in the TOP15 cities in China increased year-on-year (Fig. 2.14). The access growth rate of new energy special vehicles in Quanzhou, Chongqing, and Shanghai in 2021 was significantly higher than that in other cities, with a year-on-year growth rate of more than 2.5 times.

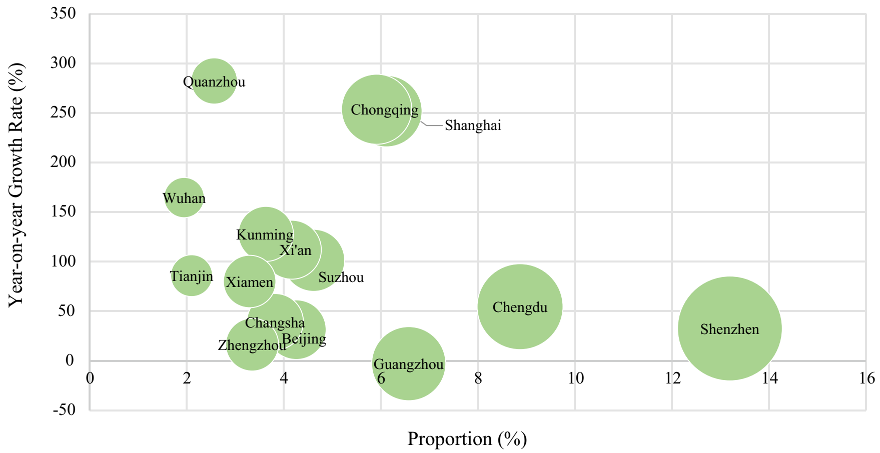


Fig. 2.14 Access and growth rate of new energy special vehicles in the TOP15 cities in 2021. *Note* Bubble size indicates the number of new energy special vehicles accessed by the National Monitoring and Management Platform in 2021

2.2.3 *Market Concentration*

In the past three years, the concentration of NEV access characteristics of the TOP10 enterprises by field had shown an overall downward trend, and the access volume of typical enterprises was outstanding.

From the cumulative access characteristics of different types of vehicles, in the field of passenger cars, the cumulative access volume of the TOP10 enterprises increased from 1,563,000 in 2019 to 3,657,000 in 2021, and the market concentration decreased from 67.7% in 2019 to 64.1% in 2021 (Table 2.5). Among them, BYD performed noticeably well. By 2021, BYD had 1,014,000 new energy passenger cars accessed, accounting for 17.8% of the cumulative access volume of new energy passenger cars in China.

In the field of new energy buses, the cumulative access characteristics of the TOP10 enterprises increased from 220,000 in 2019 to 308,000 in 2021, and the market concentration decreased from 69.6% in 2019 to 69.5% in 2021. Yutong Bus ranked first Regarding promotion volume. As of December 31, 2021, Yutong Bus had 108,000 new energy buses accessed, accounting for 24.3% of the cumulative access volume of new energy buses in China.

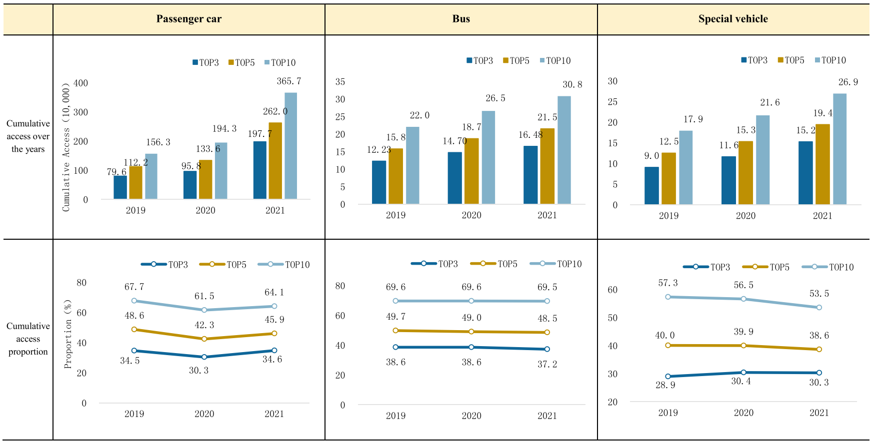
In the field of new energy special vehicles, the cumulative access characteristics of the TOP10 enterprises increased from 179,000 in 2019 to 269,000 in 2021, and the market concentration decreased from 57.3% in 2019 to 53.5% in 2021. Dongfeng Motor had 66,000 new energy special vehicles accessed, accounting for 13.1% of the cumulative access volume of new energy special vehicles in China.

From the change in the concentration of access volume of different types of vehicles in each enterprise (Table 2.6), the concentration of vehicle access volume

Table 2.5 Cumulative access of NEVs of different types of each enterprise

Type of vehicle	Cumulative access of vehicles of the TOP10 enterprises in 2019 (vehicles)	Cumulative access of vehicles of the TOP10 enterprises in 2020 (vehicles)	Cumulative access of vehicles of the TOP10 enterprises in 2021 (vehicles)
Passenger car	BYD 425804 Beijing Auto 190823 BAIC New Energy 179853 SAIC 179755 JAC 145946 Chery Automobile 118290 Jiangnan Automobile 85841 Zhejiang Haoqing 83461 SGMW 76921 Jiangling Holdings 76541	BYD 533672 SAIC 216075 Beijing Auto 208426 BAIC New Energy 189505 JAC 188663 SGMW 170671 Chery Automobile 122180 GAC Motor 111621 Tesla (Shanghai) 103472 Great Wall Motor 98825	BYD 1014128 SGMW 566507 Tesla (Shanghai) 396290 SAIC 334640 JAC 308147 GAC Motor 239556 Great Wall Motor 232875 Beijing Auto 221804 BAIC New Energy 203249 Changan Automobile 139613
Bus	Yutong Bus 80779 BYD 21696 Zhongtong Bus 19846 Foton Motor 17736 Nanjing King Long 17534 CRRC Times 17453 Xiamen Golden Dragon 13159 Guangtong Automobile 12742 Xiamen King Long 11040 Shanghai Sunlong 8365	Yutong Bus 96955 BYD 25190 Zhongtong Bus 24858 CRRC Times 20471 Suzhou King Long 19428 Foton Motor 19331 Guangtong Automobile 18913 Xiamen Golden Dragon 15789 Xiamen King Long 13932 Suzhou King Long 10547	Yutong Bus 107823 Zhongtong Bus 29160 BYD 27783 Xiamen Golden Dragon 25311 CRRC Times 24859 Nanjing King Long 21043 Foton Motor 20751 Guangtong Automobile 19876 Xiamen King Long 17174 Suzhou King Long 14355
Special vehicle	Dongfeng Motor 52807 Shanxi Tongjia 19182 Chery Commercial Vehicle 18471 Xinchufeng Automobile 17335 Chongqing Ruichi 17326 Geely Sichuan Commercial Vehicle 12909 Chenggong Auto 12175 Nanjing King Long 11449 Chengdu Universiade 9017 Zhongtong Bus 8382	Dongfeng Motor 60163 Chongqing Ruichi 30750 Chery Commercial Vehicle 25255 Shanxi Tongjia 19306 Xinchufeng Automobile 17342 Nanjing King Long 17089 Geely Sichuan Commercial Vehicle 15699 Chenggong Auto 12308 Hebei Changan Automobile 9383 Zhongtong Bus 9047	Dongfeng Motor 65951 Chongqing Ruich 51528 Chery Commercial Vehicle 34722 Nanjing King Long 21083 Geely Sichuan Commercial Vehicle 20723 Shanxi Tongjia 19306 Xinchufeng Automobile 17443 Foton Motor 13766 Chenggong Automobile 12308 Brilliance Xinyuan 12129

Table 2.6 Cumulative access and proportion of NEVs of different types of each enterprise



of bus enterprises and special vehicle enterprises in the TOP5 and TOP10 sub-fields showed an overall downward trend; in the field of passenger cars, due to the strong sales growth of Tesla, SGMW, BYD and other star models, the concentration of enterprises in 2021 increased compared with that in 2020.

2.2.4 Production Concentration

In the field of passenger cars and special vehicles, the production of the leading provinces accounts for a relatively large proportion; in the field of buses, the production of major provinces is relatively stable, and the regional concentration of buses has shown an overall downward trend over the years.

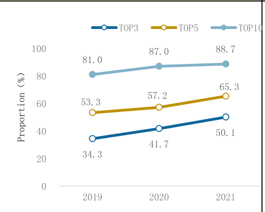
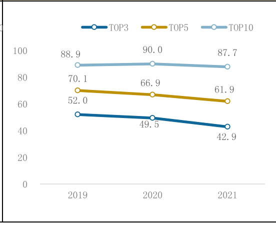
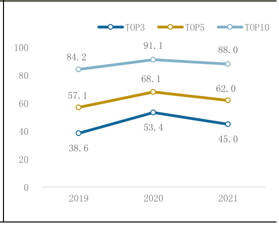
From the production of vehicles of different types over the years (Table 2.7), the production of new energy passenger cars in the leading provinces accounted for a relatively large proportion. In 2021, the production of new energy passenger cars in Shanghai, Guangxi, and Guangdong ranked the top three, accounting for more than 15%, respectively. In the field of new energy passenger cars, the production proportion of new energy passenger cars in the TOP3 provinces, TOP5 provinces, and TOP10 provinces was on the rise, mainly because in the past two years, the production bases of Wuling Hongguang MINI EV, Tesla series models, and BYD's best-selling models were distributed in Shanghai, Guangxi, and Guangdong respectively.

In the field of new energy buses, the production concentration of new energy buses in Henan, Shandong, and Jiangsu was high in 2021, 16.1%, 13.5%, and 13.2%, respectively. From the change of production concentration in the recent three years, the production concentration of new energy buses in the TOP5 provinces showed a slight downward trend (Table 2.8).

Table 2.7 Proportion of production of vehicles of different types in TOP10 provinces over the years

Type of vehicle	Proportion of production of each province (including autonomous region/municipality directly under the Central Government) in 2019 (%)	Proportion of production of each province (including autonomous region/municipality directly under the Central Government) in 2020 (%)	Proportion of production of each province (including autonomous region/municipality directly under the Central Government) in 2021 (%)
Passenger car	Beijing 13.3% Anhui 10.6% Shanghai 10.4% Shaanxi 9.7% Hunan 9.3% Zhejiang 7.1% Guangxi 6.1% Guangdong 5.2% Hubei 5.0% Chongqing 4.4%	Shanghai 21.9% Guangxi 11.0% Guangdong 8.8% Anhui 8.2% Beijing 7.2% Hunan 6.9% Shaanxi 6.5% Chongqing 6.4% Jilin 5.7% Hebei 4.3%	Shanghai 19.3% Guangxi 15.4% Guangdong 15.4% Shaanxi 8.6% Chongqing 6.7% Zhejiang 6.2% Anhui 6.0% Hebei 5.6% Jilin 3.3% Hubei 2.2%
Bus	Henan 27.7% Hunan 13.2% Jiangsu 11.2% Shandong 10.1% Fujian 8.0% Beijing 4.7% Guangdong 4.3% Shanghai 3.7% Anhui 3.2% Sichuan 2.9%	Henan 27.0% Hunan 12.0% Jiangsu 10.5% Shandong 8.8% Fujian 8.6% Shanghai 7.7% Guangdong 4.8% Anhui 4.2% Beijing 3.9% Sichuan 2.5%	Henan 16.1% Shandong 13.5% Jiangsu 13.2% Fujian 9.8% Guangdong 9.3% Hunan 8.1% Beijing 5.8% Anhui 4.6% Sichuan 4.1% Shanghai 3.2%
Special vehicle	Anhui 16.9% Chongqing 11.3% Hubei 10.4% Sichuan 9.6% Jiangsu 8.9% Jiangxi 8.9% Hunan 5.9% Shanghai 4.2% Henan 4.1% Beijing 4.0%	Chongqing 34.8% Anhui 9.5% Guangxi 9.1% Hubei 7.7% Shanghai 7.0% Jiangsu 6.1% Fujian 5.1% Hebei 4.7% Henan 4.1% Shandong 3.0%	Chongqing 26.8% Anhui 9.1% Shanxi 9.1% Shanghai 8.8% Fujian 8.2% Beijing 8.0% Guangxi 6.9% Sichuan 5.3% Shandong 3.1% Jiangsu 2.7%

Table 2.8 Proportion of production of vehicles of different types in TOP provinces over the years

Type of vehicle	Passenger car	Bus	Special vehicle
Proportion of production of provinces over the years			

In the field of new energy special vehicles, the production of new energy special vehicles in Chongqing took an invincible lead in 2021, accounting for 26.8% of the production in China. From the production concentration of new energy special vehicles in the TOP3, TOP5 and TOP10 provinces, the production concentration of new energy special vehicles declined in 2021.

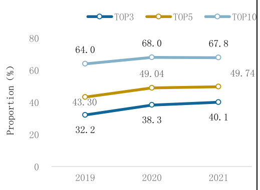
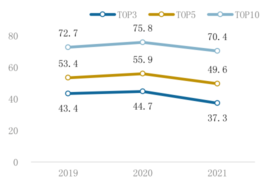
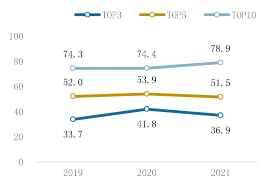
The production concentration of NEV enterprises showed an upward trend, and the production share of typical enterprises was outstanding.

According to the annual production concentration by enterprises (Table 2.9), in the field of passenger cars, BYD's production concentration reached 18.3% in 2021 due to the rich supply of NEV products, ranking first among all enterprises in China, followed by SGMW and Tesla (China), with the vehicle production concentration of 15.0% and 6.8% respectively. In the past three years, the production concentration of the TOP3, TOP5, and TOP10 enterprises in the new energy passenger cars field has shown an upward trend.

Table 2.9 Proportion of production of vehicles of different types in TOP10 enterprises over the years

Type of vehicle	Proportion of production of the TOP10 enterprises in 2019 (%)	Proportion of production of the TOP10 enterprises in 2020 (%)	Proportion of production of the TOP10 enterprises in 2021 (%)
Passenger car	BYD 18.6% Beijing Auto 7.6% SAIC 6.0% JAC 5.6% SGMW 5.5% Dongfeng Motor 4.5% GAC Motor 4.3% Passionate car 4.2% Great Wall Motor 4.1% BAIC New Energy 3.6%	Tesla (Shanghai) 14.3% BYD 13.2% SGMW 10.8% GAC Motor 5.7% Anhui JAC 5.0% FAW-Volkswagen 5.0% Great Wall Motor 3.9% SAIC Volkswagen 3.8% Ideal manufacturing 3.2% BMW Brilliance 3.2%	BYD 18.3% SGMW 15.0% Tesla (Shanghai) 6.8% Great Wall Motor 5.2% SAIC 4.4% Chery New Energy 4.2% GAC Motor 4.0% NIO 3.6% Li Auto 3.5% Xpeng Motors 2.9%
Bus	Yutong Bus 27.0% Zhongtong Bus 8.5% CRRC Times 7.9% BYD 5.3% Foton Motor 4.7% Suzhou King Long 4.4% Xiamen King Long 4.2% Xiamen Golden Dragon 3.8% Nanjing King Long 3.8% Ankai 3.2%	Yutong Bus 26.7% BYD 9.4% Zhongtong Bus 8.6% Sunwin Bus 6.0% Suzhou King Long 5.3% Xiamen King Long 4.9% Ankai 4.2% Foton Motor 3.9% Xiamen Golden Dragon 3.7% Nanjing King Long 3.3%	Yutong Bus 15.9% Zhongtong Bus 13.3% CRRC Electric 8.1% Xiamen King Long 6.3% Suzhou King Long 6.1% Beiqi Foton 5.8% Anhui Ankai Auto 4.5% BYD 3.8% Xiamen Golden Dragon 3.4% Nanjing King Long 3.2%
Special vehicle	Chery Commercial Vehicle 14.5% Nanjing King Long 9.6% Geely Sichuan Commercial... 9.6% Dongfeng Motor 9.5% Chongqing Ruichi 8.8% Changhe Automobile 8.7% BYD 4.0% Hebei Changan Automobile 3.8% Zhengzhou Nissan 3.0% Foton Motor 2.8%	Chongqing Ruichi 25.6% Brilliance Xinyuan 8.9% Dongfeng Motor 7.3% Chery Commercial Vehicle 6.9% Nanjing King Long 5.2% Guangxi Automobile 4.8% Vientiane Automobile 4.5% SGMW 4.2% Hebei Changan Automobile 4.0% Xiamen Golden Dragon 3.0%	Chongqing Ruichi 19.9% Shanxi New Energy Vehicles 9.1% Beiqi Foton 7.9% SAIC MAXUS 7.4% Chery Commercial Vehicle... 7.2% Guangxi Automobile 6.8% Xiamen Golden Dragon 6.6% Brilliance Xinyuan 6.5% Geely Sichuan Commercial... 5.1% Zhejiang New Gonow 2.4%

Table 2.10 Proportion of production of vehicles of different types in TOP enterprises over the years

Type of vehicle	Passenger car	Bus	Special vehicle
Proportion of production of enterprises over the years			

In the field of new energy buses, the production concentration of Yutong Bus and Zhongtong Bus ranked first, with 15.9% and 13.3%, respectively; in the field of new energy special vehicles, the vehicle production concentration of a Chongqing Ruichi enterprise reached 19.9%, ranking first. In commercial vehicles, the production concentration of the TOP3 and TOP5 enterprises showed an overall downward trend in 2021 (Table 2.10).

2.3 Historical Access Characteristics of NEVs to the National Monitoring and Management Platform

2.3.1 Historical Access Characteristics of NEVs

2,732,000 NEVs were accessed to the National Monitoring and Management Platform in 2021, with a substantial YoY increase.

From Table 2.11, 2,732,000 NEVs accessed the National Monitoring and Management Platform in 2021, an increase of 177.4% compared with 2020. According to the comparison between the annual access volume of NEVs and the annual sales of NEVs on the National Monitoring and Management Platform (Table 2.12), the access volume of NEVs in January and February 2022 was significantly higher than the sales of NEVs due to the appropriate delay in the time of NEV access to the National Monitoring and Management Platform, indicating that some NEVs were sold at the end of 2021. However, such vehicles' access to the National Monitoring and Management Platform was in January and February 2022.

The access volume of BEVs accounted for a major proportion, and the volume in each month was more than 100,000 vehicles.

As shown in Table 2.13, 2,249,000 BEVs were accessed in 2021, accounting for 82.3%; the access volume of PHEVs and FCEVs was 481,000 and 2,000, respectively, accounting for 17.6% and 0.1%, respectively. According to the distribution of monthly access throughout 2021 (Fig. 2.15), BEVs' access volume per month was over 100,000. In December 2021, the access volume of BEVs reached 358,000 and

Table 2.11 Access of NEVs in China over the years

Year	2019	2020	2021
National vehicle access (10,000)	137.3	98.5	273.2

Note Due to the supplementary access characteristics of NEVs to the National Monitoring and Management Platform, this report will continuously update the access data of NEVs over the years

Table 2.12 Comparison between access and sales of NEVs from January to February 2022

Type	January	February
NEV Sales (10,000)	**43.1**	**33.4**
BEVs	34.6	25.8
PHEVs	8.5	7.5
NEV Access (10,000)	**51.2**	**34.1**
BEVs	40.9	28.6
PHEVs	10.3	5.6

Source The sales data is from the China Association of Automobile Manufacturers (CAAM), and the access data is from the National Monitoring and Management Platform

Table 2.13 Access volume of NEVs in China in 2021—by power type

Driving type	BEVs	PHEVs	FCEVs
Access volume of NEVs in China (10,000)	224.9	48.1	0.2

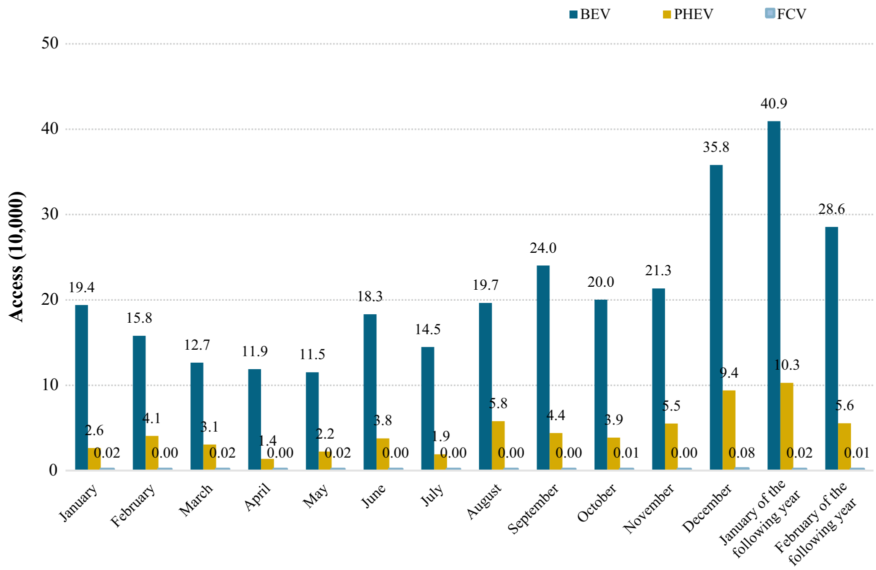


Fig. 2.15 Monthly access volume of NEVs in China in 2021—by driving type

continued the high growth trend to 409,000 in January 2022. Some vehicles sold were affected by the delay in access time.

2.3.2 *Access Characteristics of NEVs Over the Years by Region*

In 2021, the access characteristics of NEVs in all regions of China showed a steady growth trend, with outstanding performance in East China.

East China ranks first regarding NEV access over the years. According to the access in different regions (Fig. 2.16), East China boasts the highest access with a volume of 1,077,000, accounting for 39.4%, followed by South China and Central China with a volume of 559,000 and 390,100, respectively, accounting for 20.5% and 14.3%.

According to the proportion of NEVs in different regions over the years (Fig. 2.17), the proportion of NEVs in East China, South China, Central China, and Southwest China increased in 2021 compared with 2017. Among them, the proportion of access in East China accounted for 39.4% in 2021, up 9.2% compared with 2017; the

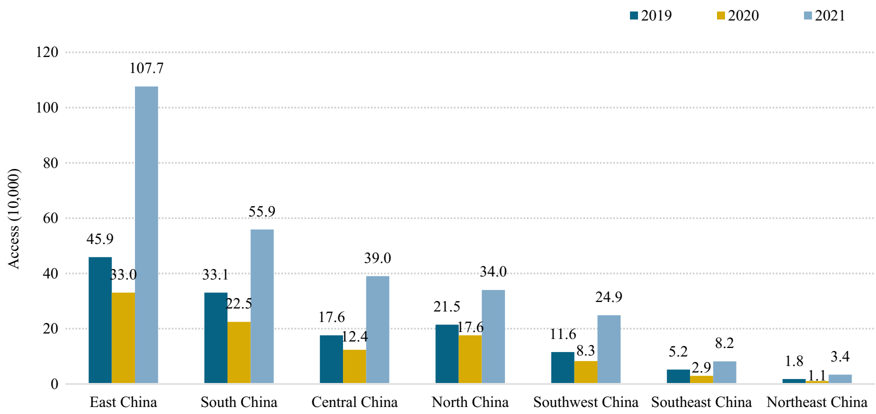


Fig. 2.16 Access of NEVs in different regions of China over the years

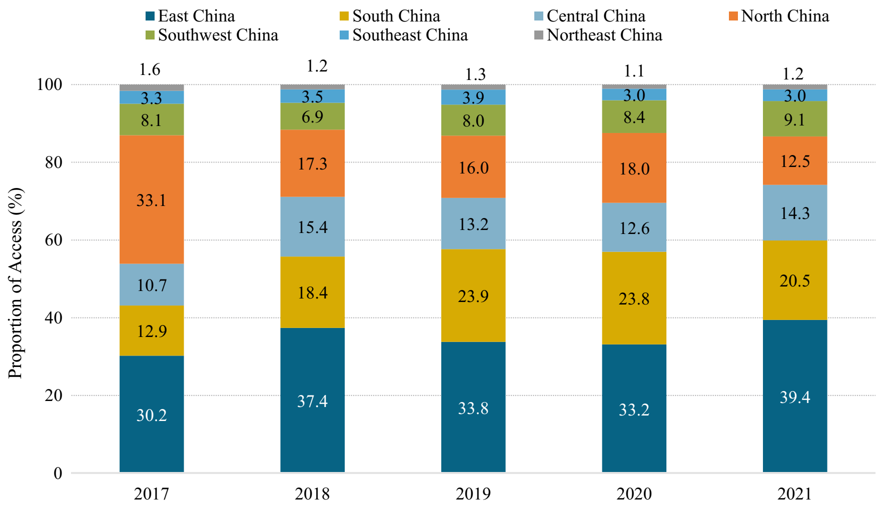


Fig. 2.17 Proportion of access volume of NEVs in different regions over the years

proportion of access in North China showed an apparent narrowing trend, accounting for 12.5% of the access volume in China in 2021, down 20.6% compared with 2017.

The consumer demand in cities of each tier is robust, and the access volume of NEVs in cities of different tiers grew rapidly in 2021; second-tier cities and below have excellent market potential.

According to the access characteristics of cities of different tiers over the years (Fig. 2.18), the consumer demand for cities of each tier had recovered steadily. In 2021, the access volume of NEVs in first-tier cities was the highest, with a volume of 1,040,000, up 1.4 times year-on-year; due to the low base, robust market demand, obviously improved user acceptance and other factors, the access volume of NEVs in other cities increased significantly year-on-year. The access volume of NEVs in fourth-tier and fifth-tier cities increased by 2.2 times and 2.3 times in 2021 compared with 2020.

From the proportion of access in cities of each tier over the years (Fig. 2.19), the proportion of access in first-tier cities had declined from 48.4% in 2017 to 38.1% in 2021, and that in second-tier cities and below proliferated with excellent market potential.

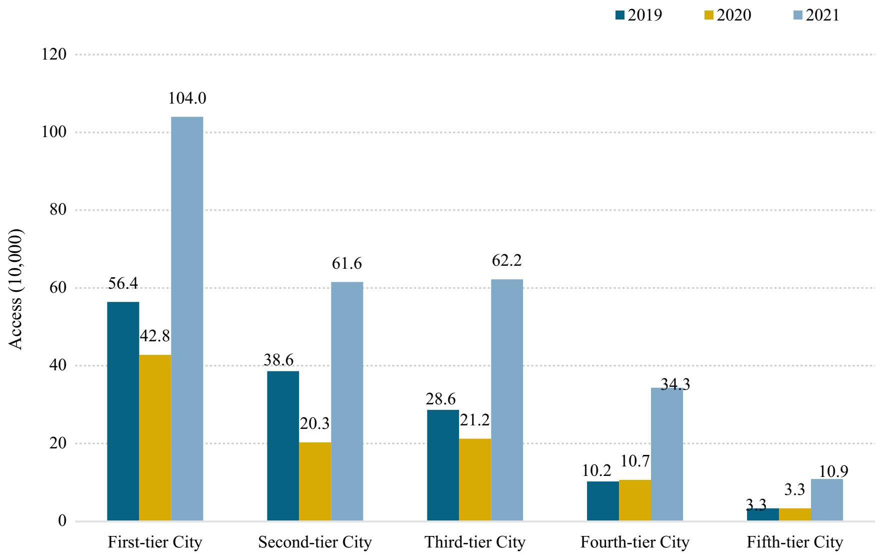


Fig. 2.18 Access of NEVs in cities of each tier in China over the years

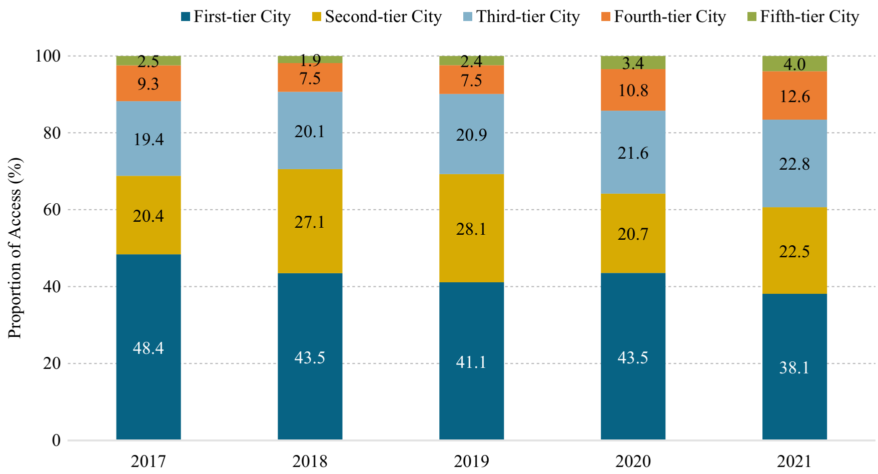


Fig. 2.19 Proportion of access volume of NEVs in cities of different tiers over the years

2.3.3 *Access Characteristics of NEVs Over the Years by Application Scenario*

In order to better study the characteristics of vehicle behaviors in key segments, seven segments, including private cars, e-taxis, taxis, cars for sharing, logistics vehicles, buses, and heavy-duty trucks, are selected by using the big data intelligent analysis technology from the National Monitoring and Management Platform as the key application scenarios for research. The vehicles in the main application scenarios are defined below:

Private cars: vehicles not for online ride-hailing service selected from vehicles with an inherent "private car" label in the National Monitoring and Management Platform as the research object for the private car segment.

E-taxis: vehicles for online ride-hailing service selected from vehicles with an inherent label of "private car," "official car," and "rental car" in the National Monitoring and Management Platform as the research object for the e-taxis segment.

Cars for sharing: vehicles for time-based rental service and long/short-term rental service filtered from vehicles with an inherent label of "rental car" in the National Monitoring and Management Platform as the research object for a segment of cars for sharing.

Taxis: vehicles with an inherent label of "taxi car" in the National Monitoring and Management Platform selected as the research object of the taxi segment.

Logistics vehicles: vehicles with an inherent label of "logistics vehicle" in the National Monitoring and Management Platform selected as the research object of the logistics vehicle segment.

Bus: vehicles with an inherent label of "bus" in the National Monitoring and Management Platform selected as the research object of the logistics vehicle segment.

Heavy-duty trucks: vehicles with an inherent label of "special vehicle" in the National Monitoring and Management Platform, with a total mass $\geq$ 12,000 kg according to the standard GA801-2014 of the Ministry of Public Security, selected as the research object of the heavy-duty truck segment.

From Table 2.14, in 2021, the access volume of private cars was 2,000,000, up 2.3 times year-on-year; that of e-taxis was 89,000; that of taxis was 124,000; that of cars for sharing was 89,000; that of logistics vehicles was 114,000, up 75.7% year-on-year; and that of buses was 54,000, down 10.% year-on-year.

Private purchase has become the main driver for market growth, and the market share of new energy private cars has reached a new high.

According to the National Monitoring and Management Platform data (Fig. 2.20), the proportion of access volume of new energy private cars showed a rapid growth trend. In 2021, the annual access volume of private cars accounted for more than 70% of NEVs, and private purchase has become the main driver for market growth. Comparatively speaking, the access share of other types of vehicles declined relatively in 2021. According to the changes in the past two years, the annual access share of e-taxis and cars for sharing increased slightly, while that of buses and logistics vehicles in commercial vehicles decreased in 2021.

Stimulated by the countryside NEV promotion policy and diversified product supply, the proportion of access volume of new energy private cars in cities of third-tier or below increased rapidly.

According to data on the National Monitoring and Management Platform (Fig. 2.21), the market share of first-tier cities decreased relatively. In contrast, the proportion of access volume of new energy private cars in cities of the third-tier or below increased rapidly in 2021 compared with the previous two years and accounted for 42.4%, with an increase of 12.23% compared with 2018, which is mainly driven by the countryside NEV consumption stimulation policies in various regions. The countryside NEV promotion has become a highlight of market growth.

From the proportion of access volume of new energy private cars in cities subject to purchase restrictions and cities not subject to purchase restrictions (Fig. 2.22), the market share of cities not subject to purchase restrictions increased significantly, accounting for 66.2%, with an increase of 9.2% compared with 2020.

Table 2.14 Vehicle access volume of key segments

Key segment	Access in 2019 (10,000)	Access in 2020 (10,000)	Access in 2021 (10,000)	2021 YoY change (%)
Private car	58.1	59.9	200.0	233.9
e-taxis	2.5	3.5	8.9	156.2
Taxis	9.0	7.3	12.4	70.3
Car for sharing (time-based renting and long/short-term renting)	25.0	5.0	8.9	79.4
Logistics vehicle	12.5	6.5	11.4	75.7
Bus	10.6	6.1	5.4	– 10.2
Other types	19.5	10.4	26.2	152.4
Total	**137.3**	**98.5**	**273.2**	**177.3**

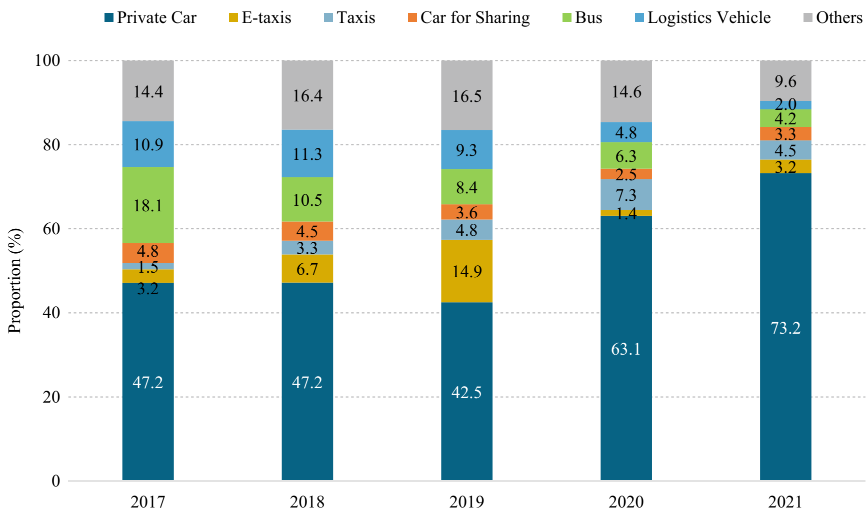


Fig. 2.20 Proportion of access volume of NEVs in segments over the years

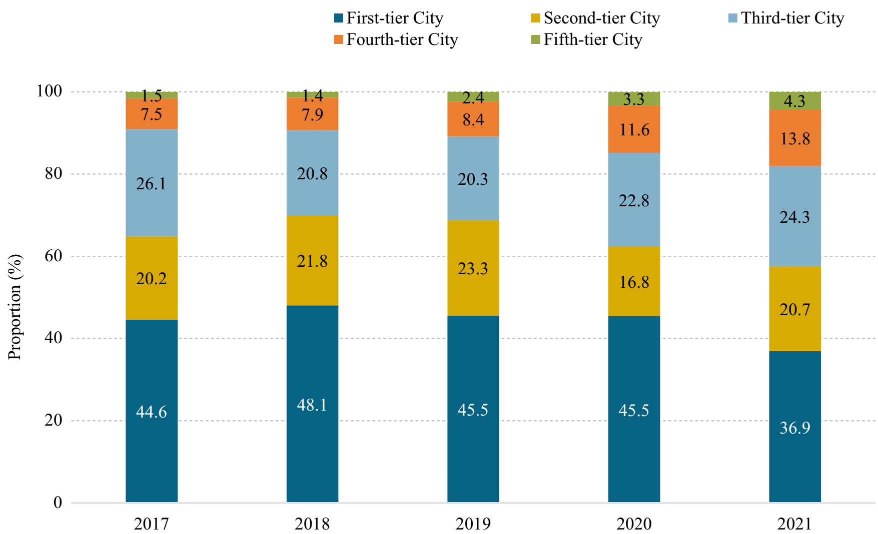


Fig. 2.21 Proportion of access volume of new energy private cars in cities of different tiers

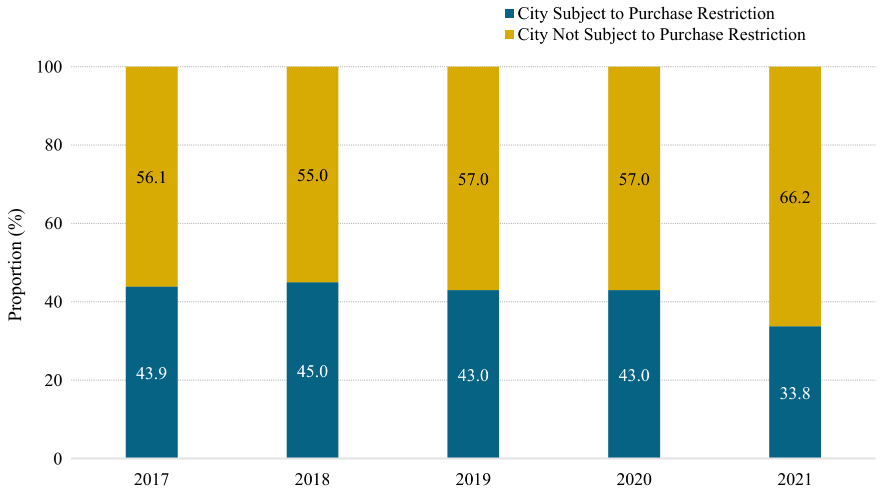


Fig. 2.22 Proportion of access volume of new energy private cars in cities subject to purchase restrictions and cities not subject to purchase restrictions

2.4 Summary

In 2021, despite various factors such as rising prices of raw materials for power batteries, shortage of chips, and multiple outbreaks of epidemics in China, the sales of NEVs still ushered in a good start in the "14th Five-Year Plan". The NEV industry has become the highlight in the development of the automobile industry, and has entered an accelerated development stage and further enhanced its leading role in the electrification of the global automobile industry. According to the vehicle access data on the National Monitoring and Management Platform over the years, the development of the NEV presents the following characteristics:

The market demand for NEVs is robust, and the industry development has entered a new stage driven by the market. As of December 31, 2021, 6,655,000 NEVs had been accessed to the National Monitoring and Management Platform, including 306 5863 models accessed by 306 enterprises. In typical provinces, Guangdong promoted more than 1,000,000 vehicles, becoming the vanguard in the NEV market promotion in China, accounting for 15.8%. Zhejiang and Shanghai had promoted more than 500,000 vehicles, accounting for more than 8.0% in China.

The regional concentration of NEV promotion is decreasing yearly, and the market share of second-tier cities and below is expanding rapidly. In 2021, the sales of NEVs in cities of each tier showed a significant increase, and the share of vehicle promotion in second-tier cities and below expanded rapidly, from 51.6% in 2017 to 61.9% in 2021. The scale of vehicle promotion in cities not subject to purchase restrictions, such as Suzhou, Wenzhou, Changsha, and Ningbo, had proliferated.

The private purchase has become the main driver for market growth, and the market share of new energy private cars has reached a new high. From the proportion of access volume of vehicles of different types over the years, the proportion of access volume of new energy private cars showed a rapid growth trend, and the market share of private purchases exceeded 70% in 2021. Stimulated by the countryside NEV promotion policy and diversified product supply, the market share of new energy private cars in cities of fourth-tier or below increased rapidly. In 2021, the market share of new energy private cars in fourth-tier and fifth-tier cities was 13.8% and 4.3%, respectively, up 6.3% and 2.7% compared with 2017.

Chapter 3
Technical Progress of Vehicles

This chapter, based on the NEV access characteristics on the National Monitoring and Management Platform, makes an in-depth analysis of range, vehicle energy consumption level, power battery technology, and vehicle lightweight characteristics as focuses and summarizes the technical progress of new energy vehicles, providing a significant reference for promoting the technological innovation stable industrial development of NEVs.

3.1 Technical Progress in Range

The range of NEVs is increasing yearly.

According to the changes in the average range of new energy passenger cars in China over the years (Fig. 3.1), the average range of NEVs of different types is increasing yearly. In the past three years, the average range of new energy passenger cars has increased from 270.5 km in 2019 to 320.9 km in 2021. That of BEV passenger cars was 395 km in 2021, a slightly increased compared with 2020, mainly due to the rapid release of small BEV passenger cars such as Hongguang MINIEV in 2021, showing an overall stable annual change in range of BEV passenger cars; that of PHEV passenger cars showed an increasing trend yearly, reaching 86 km in 2021, with a YoY increase of 25.5%.

The BEV passenger cars with a range of more than 400 km are dominant, while the BEV passenger cars with a range of less than 200 km are increasing rapidly.

According to the changes in the average range of BEV passenger cars (Fig. 3.2), the proportion of BEV passenger cars with a low range has shown a rapid growth trend in recent years. The proportion of BEV passenger cars with a range of less than 200 km has increased from 6.7% in 2020 to 20.4% in 2021, mainly due to the rapid growth of the number of small BEV passenger cars; the distribution of vehicles with

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2022)*,
https://doi.org/10.1007/978-981-99-6411-6_3

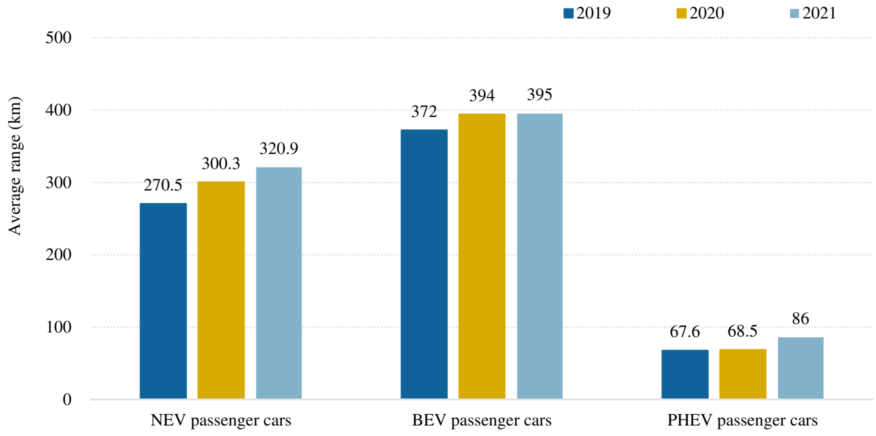


Fig. 3.1 Changes in the average range of NEVs of different types over the years

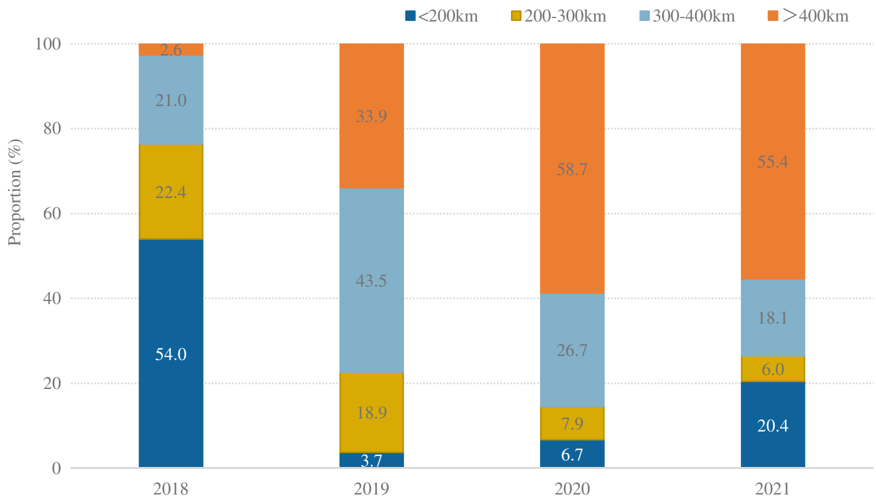


Fig. 3.2 Distribution of BEV passenger cars in different range sections. *Note* The sum of the proportion of vehicles in different range sections of each year equals 100%, which is the same as below

a high range of more than 400 km gradually dominates the market, with a market share of 55.4% in 2021.

The range of Class A and above cars and BEV SUVs has increased rapidly. According to the changes in the average range of BEV passenger cars of different classes (Fig. 3.3), the range of the cars of Class A and above and SUV BEV passenger cars has increased rapidly yearly. In 2021, the average range of A0 + A00 cars was 245.1 km, which decreased by 13.8% compared with 2020. The range of A0 + A00 cars no longer pursued mileage growth but pursued cost performance on the premise

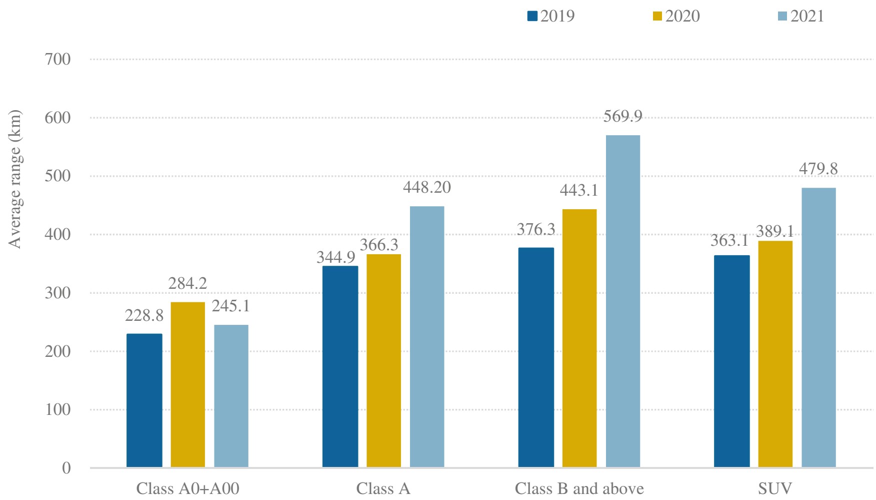


Fig. 3.3 Distribution of average range of BEV passenger cars of different classes

of meeting daily transportation needs and being close to the actual application needs of NEVs; the average range of cars of Class A was 448.2 km, with an increase of 22.4% compared with 2020; the average range of cars of Class B and above was 569.9 km, with an increase of 28.6% compared with 2020, showing a faster growth when compared with the range of vehicles of different classes; the average range of SUV was 479.8 km, with an increase of 23.3% compared with 2020.

3.2 Progress in Lightweight Technology

The curb weight of new energy passenger cars in 2021 has slightly decreased compared with 2020, and the average curb weight of vehicles in the industry has remained stable in the past three years.

According to the average curb weight of NEVs in China over the years (Table 3.1), the average curb weight of new energy passenger cars in 2021 was 1471.1 kg, with a slight decrease compared with 2020. Mainly due to the decrease in curb weight of BEV cars of Class A0 and below, PHEV cars of Class A, and SUVs, the overall curb weight level of new energy passenger cars has been reduced.

Table 3.1 Changes in average curb weight of new energy passenger cars over the years

Year	2019	2020	2021
New energy passenger car Average curb weight (kg)	1477.0	1486.3	1471.1

Table 3.2 Changes in average curb weight of BEV passenger cars over the years

Year	2019	2020	2021
BEV passenger car Average curb weight (kg)	1457.2	1441.0	1378.1

The lightweight technology of BEV passenger cars has achieved significant progress, especially the small BEV passenger cars.

According to the changes in the average curb weight of BEV passenger cars over the years (Table 3.2), the average curb weight of BEV passenger cars in 2021 was 1378.1 kg, with a decrease compared with the previous two years.

For cars of different classes (Fig. 3.4), the lightweight technology of Class A00 + A0 cars has made significant progress, and the average curb weight of Class A cars in 2021 remained the same as the previous year; the average curb weight of Class B and above cars and SUVs in 2021 had improved compared with 2020, suggesting that more intensive research on lightweight technology is required. Overall, BEV passenger cars have higher requirements for lightweight and have become a suitable carrier for the industrialization of aluminum alloy and carbon fiber composite materials. With the gradual decline in the cost of lightweight materials, this segment will provide a rich experience for the broad application of lightweight technology in the traditional automobile industry.

The curb weight of PHEV passenger cars has decreased compared with the previous year.

According to the changes in the average curb weight of PHEV passenger cars over the years (Table 3.3), the average curb weight of PHEV passenger cars in 2021 was 1851.3 kg, with a slight decrease compared with 2020. According to the average distribution of curb weight of PHEV passenger cars of different classes (Fig. 3.5), it can be seen that the average curb weight of Class A cars has shown a decreasing trend yearly, while the curb weight of SUVs has significantly decreased compared with the previous year; the average curb weight of Class B and above cars has proliferated over the years.

3.3 Changes in Energy Consumption Over the Years

The energy consumption level refers to the average electricity consumption of BEVs every 100 km in the operating environment, expressed in kWh/100 km. The calculation formula is as follows:

$$\beta_{bev} = \frac{Q}{L} \times 100$$

where β_{bev} is the electricity consumption per 100 km (kWh/100 km) of an electric vehicle in the actual operating environment, Q is the electricity consumption (kWh) of the electric vehicle, and L is the mileage (km).

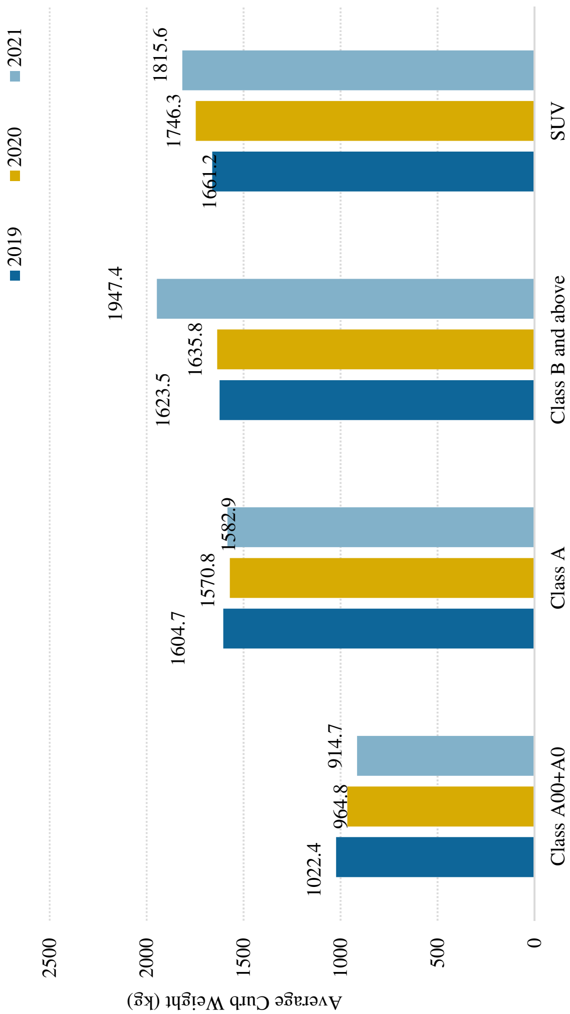


Fig. 3.4 Changes in average curb weight of BEV passenger cars of different classes over the years

Table 3.3 Changes in curb weight of PHEV passenger cars over the years

Year	2019	2020	2021
PHEV passenger car Average curb weight (kg)	1661.7	1891.5	1851.3

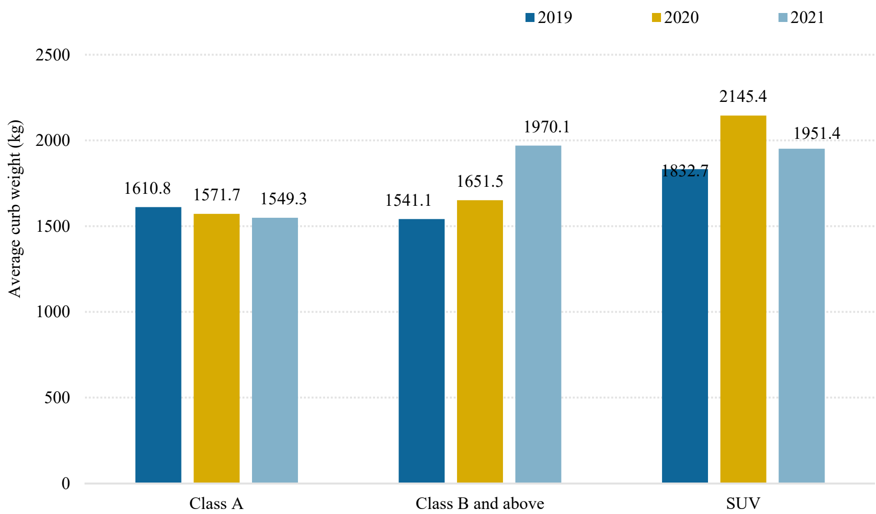


Fig. 3.5 Changes in average curb weight of PHEV passenger cars of different classes over the years

This section, according to the actual operation condition of NEVs on the National Monitoring and Management Platform, summarizes the electricity consumption of BEV passenger cars, buses, and logistics vehicles and analyzes the electricity consumption characteristics of vehicles of different types under different road conditions, providing a significant reference for promoting the technical progress of new energy vehicles in China.

3.3.1 Energy Consumption Evaluation of BEV Passenger Cars

1. Energy consumption evaluation of BEV passenger cars in various regions of China

The average energy consumption of passenger cars in 2021 was 14.6 kWh/100 km, with a decrease of 7.6% compared with the previous year (Table 3.4).

SGMW, Dongfeng Liuzhou, Chery, and other enterprises mainly producing small passenger cars have the lowest energy consumption level. The average energy

Table 3.4 Average energy consumption of passenger cars over the years

Year	2019	2020	2021
Average energy consumption of passenger cars (kWh/100 km)	16	15.8	14.6

consumption of SGMW passenger cars in 2021 was 9.4 kWh/100 km, significantly lower than that of other enterprises (Fig. 3.6).

According to the comparison of the average energy consumption of BEV passenger cars in different regions in 2021 (Fig. 3.7), the energy consumption level of BEV passenger cars in Northeast China, North China, and Northwest China was relatively high, and the vehicle energy consumption level was more than 15 kWh/100 km. The energy consumption level of BEV passenger cars in Central China was 14.1 kWh/100 km, which was lower than that in other regions.

(1) **Northeast China**

In the past three years, the energy consumption level of BEV passenger cars of all classes in Northeast China has shown a downward trend.

The average energy consumption of passenger cars in Northeast China in 2021 was 15.9 kWh/100 km, with a decrease of 14.1% compared with the previous year (Table 3.5). According to the energy consumption level of passenger cars of different classes in Northeast China, the overall energy consumption level of passenger cars of different classes showed a downward trend from 2019 to 2021 (Fig. 3.8). The average energy consumption of Class A00 + A0 cars in 2021 was 11 kWh/100 km, with a decrease of 23.1% compared with 2020 and 29.5% compared with 2019; that of Class A cars in 2021 was 16.1 kWh/100 km, which was the same as that in 2020 and a decrease of 4.7% compared with 2019; that of Class B and above BEV cars in 2021 was 16 kWh/100 km, with a decrease of 5.9% compared with 2020; that of

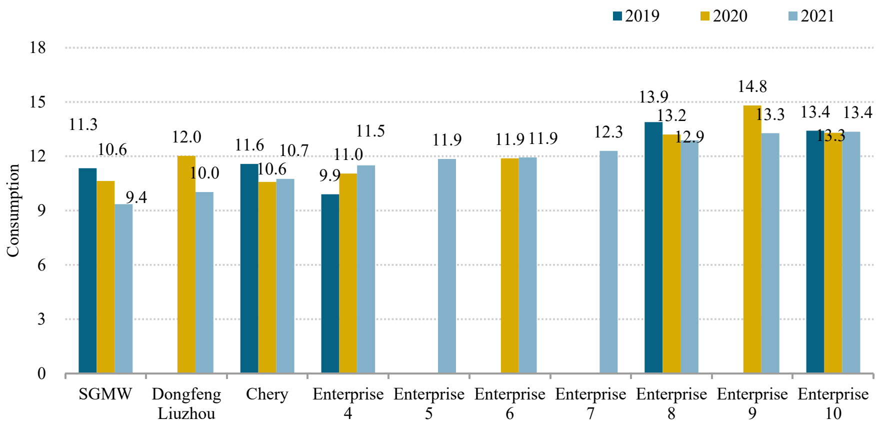


Fig. 3.6 Average energy consumption of key passenger car enterprises

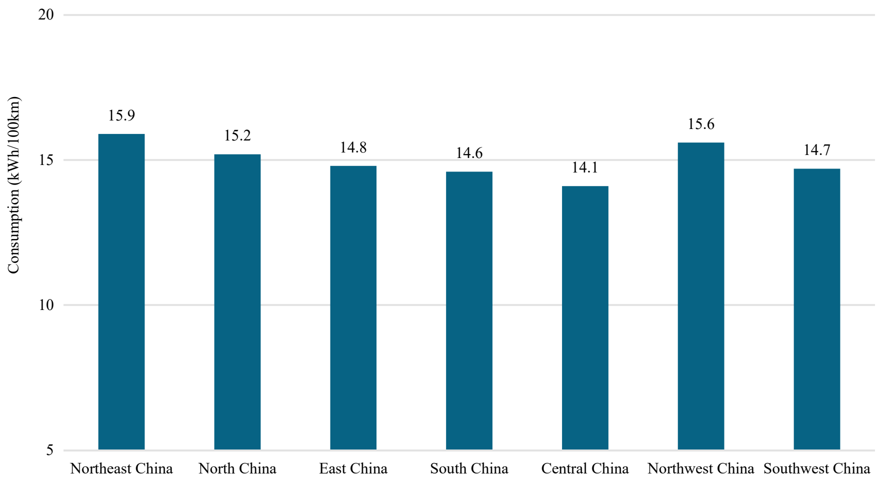


Fig. 3.7 Average energy consumption of BEV passenger cars in various regions of China in 2021

BEV SUVs in 2021 was 20.1 kWh/100 km, with a decrease of 2.4% compared with 2020 and 2.4% compared with 2019.

(2) North China

The energy consumption level of BEV passenger cars in North China has been declining, and that of Class A00 + A0 cars and Class B and above cars has declined significantly.

The average energy consumption of passenger cars in North China in 2021 was 15.2 kWh/100 km, a decrease of 6.7% compared with the previous year (Table 3.6). According to the average energy consumption of passenger cars of different classes in North China (Fig. 3.9), from 2019 to 2021, Class A00 + A0 cars and Class B and above cars showed a significant downward trend. In 2021, the average energy consumption of Class A00 + A0 cars in North China was 10.8 kWh/100 km, with a decrease of 9.2% compared with the previous year, and that of Class B and above BEV cars in North China was 15.6 kWh/100 km, with a decrease of 4.9% compared with the previous year. The average energy consumption of Class A cars and SUVs increased in 2021. Among them, the average energy consumption of Class A cars in North China in 2021 was 16 kWh/100 km, with an increase of 1.9% compared with the previous year, and that of BEV SUVs in North China was 18.6 kWh/100 km, with an increase of 2.8% compared with the previous year.

Table 3.5 Average energy consumption of passenger cars in Northeast China over the years

Year	2019	2020	2021
Average energy consumption of passenger cars (kWh/100 km)	19.5	18.5	15.9

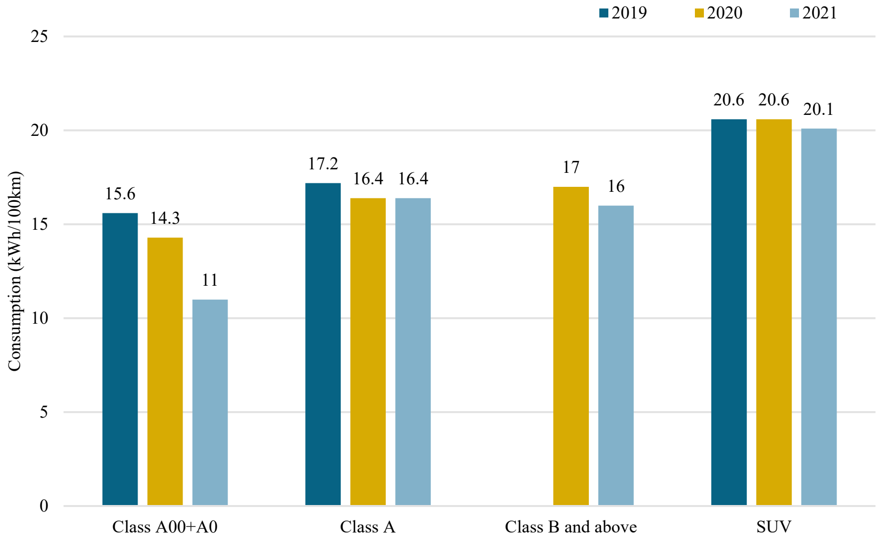


Fig. 3.8 Average energy consumption of passenger cars of different classes in Northeast China

Table 3.6 Average energy consumption of passenger cars in North China

Year	2019	2020	2021
Average energy consumption of passenger cars (kWh/100 km)	16.6	16.3	15.2

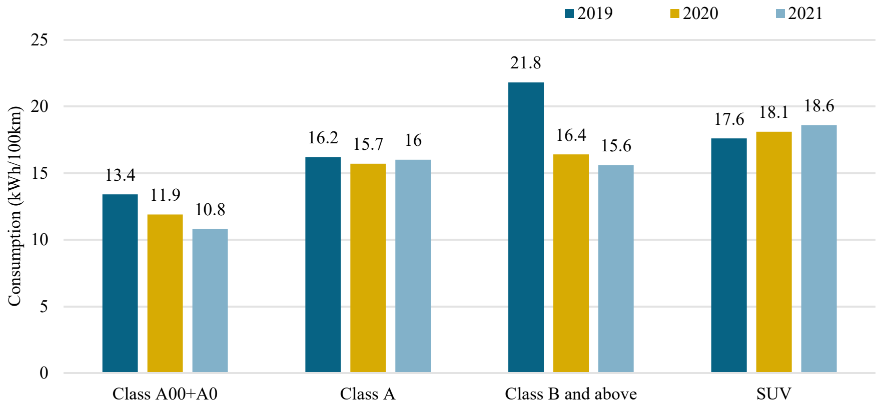


Fig. 3.9 Average energy consumption of passenger cars of different classes in North China

(3) **East China**

In recent three years, the energy consumption level of passenger cars in East China has shown a downward trend, and the energy consumption level of Class A00 + A0 cars and Class B and above cars has shown a significant downward trend.

In 2021, the average energy consumption of BEV passenger cars in East China was 14.8 kWh/100 km, a decrease of 6.9% compared with the previous year (Table 3.7). According to the average energy consumption of passenger cars of different classes (Fig. 3.10), Class A00 + A0 cars and Class B and above cars showed an apparent downward trend. In 2021, the average energy consumption of Class A00 + A0 cars in East China was 10.5 kWh/100 km, with a decrease of 8.7% compared with the previous year, and that of Class B and above BEV cars in East China was 15.6 kWh/100 km, with a decrease of 1.3% compared with the previous year. In the field of passenger cars of other classes, the average energy consumption of Class A cars in 2021 was 16.2 kWh/100 km, with an increase of 2.5% compared with the previous year, and that of BEV SUVs was 19 kWh/100 km, with an increase of 0.5% compared with 2020.

(4) **South China**

In 2021, the energy consumption level of passenger cars in South China has declined, and that of Class A00 + A0 cars has declined significantly.

The average energy consumption of passenger cars in North China in 2021 was 15.2 kWh/100 km, with a decrease of 5.8% compared with the previous year (Table 3.8). In the recent three years, the average energy consumption of Class A00 + A0 cars in South China has shown a significant downward trend (Fig. 3.11). In 2021, the average energy consumption of Class A00 + A0 cars was 10.2 kWh/100 km, with a decrease of 1% compared with 2020 and 13.6% compared with 2019, and that of Class A cars was 15.7 kWh/100 km, with an increase of 3.3% compared with 2020 and 5.4% compared with 2019. From the distribution of average power consumption over the years, in 2021, the average power consumption of Class B and above BEV cars was 15.9 kWh/100 km, with an increase of 3.2% compared with 2020 and a decrease of 2.5% compared with 2019, and that of BEV SUVs was 18.2 kWh/100 km, with a decrease of 0.5% compared with 2020 and an increase of 2.2% compared with 2019.

Table 3.7 Average energy consumption of passenger cars in East China

Year	2019	2020	2021
Average energy consumption of passenger cars (kWh/100 km)	16.0	15.9	14.8

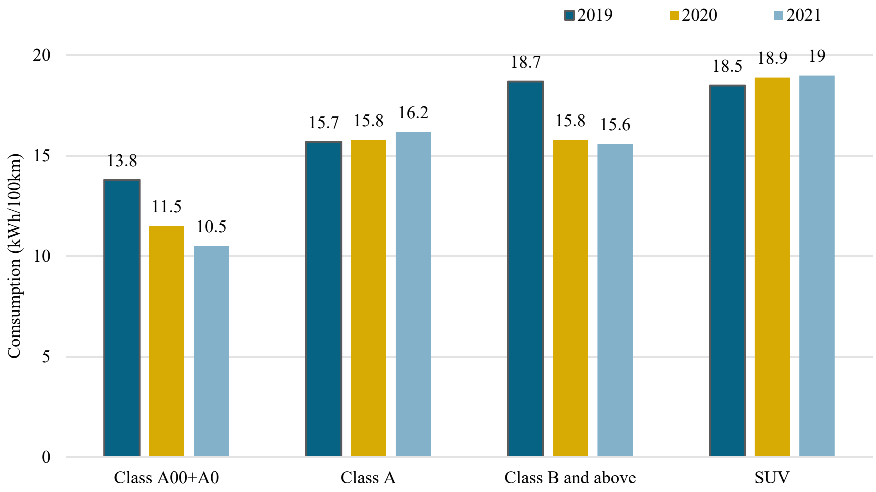


Fig. 3.10 Average energy consumption of passenger cars of different classes in East China

Table 3.8 Average energy consumption of passenger cars in South China

Year	2019	2020	2021
Average energy consumption of passenger cars (kWh/100 km)	15.4	15.5	14.6

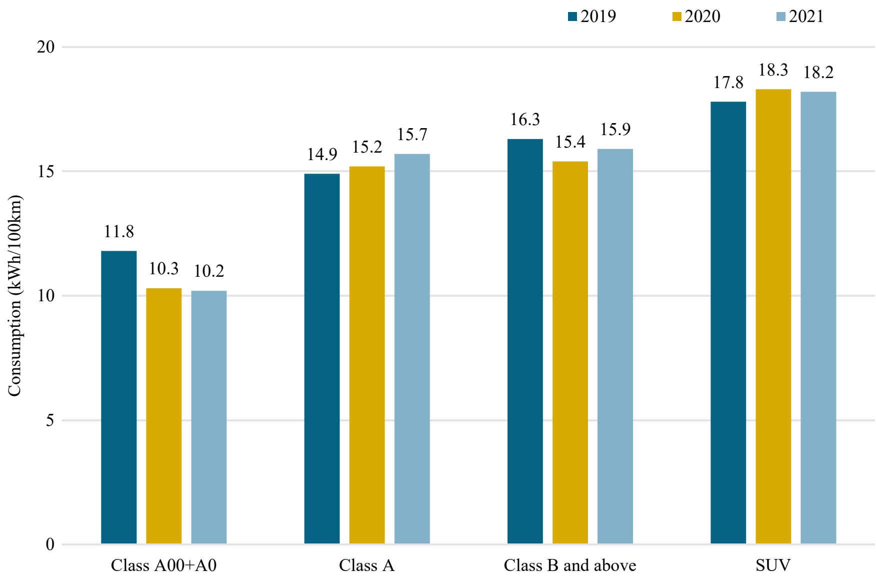


Fig. 3.11 Average energy consumption of passenger cars of different classes in South China

(5) **Central China**

The energy consumption of BEV passenger cars in Central China has shown a significant downward trend, so do Class A00 + A0 cars and Class B and above cars.

The average energy consumption of passenger cars in North China in 2021 was 15.2 kWh/100 km, with a decrease of 5.8% compared with the previous year (Table 3.9). According to the average energy consumption of passenger cars of different classes (Fig. 3.12), from 2019 to 2021, Class A00 + A0 cars and Class B and above cars showed a significant downward trend. In 2021, the average energy consumption of Class A00 + A0 cars was 10 kWh/100 km, with a decrease of 11.5% compared with 2020 and 24.8% compared with 2019, and that of Class B and above BEV cars was 15.6 kWh/100 km, with a decrease of 2.5% compared with 2020 and 27.1% compared with 2019. In the BEV Class A cars and SUVs, the energy consumption per 100 km has increased. In 2021, the average energy consumption of Class A cars was 16.2 kWh/100 km, with an increase of 3.2% compared with 2020 and 3.2% compared with 2019, and that of BEV SUVs was 18 kWh/100 km, which was the same as in 2020 and an increase of 4% compared with 2019.

(6) **Northwest China**

In recent three years, the average energy consumption of Class A00 + A0 cars and Class B and above cars in Northwest China has shown a significant downward trend.

The average energy consumption of passenger cars in North China in 2021 was 15.2 kWh/100 km, a decrease of 6.6% compared with the previous year (Table 3.10). According to the average energy consumption of passenger cars of different classes (Fig. 3.13), from 2019 to 2021, Class A00 + A0 cars and Class B and above cars showed a significant downward trend. In 2021, the average energy consumption of Class A00 + A0 cars was 10 kWh/100 km, with a decrease of 9.9% compared with 2020 and 29.1% compared with 2019, and that of Class B and above BEV cars was 15.6 kWh/100 km, with a decrease of 4.9% compared with 2020 and 22.4% compared with 2019. In 2021, the average power consumption of SUVs was the same as in 2020, which was 19.2 kWh/100 km; that of Class A cars slightly increased to 17.2 kWh/100 km, with an increase of 4.2% compared with 2020.

Table 3.9 Average energy consumption of passenger cars in Central China

Year	2019	2020	2021
Average energy consumption of passenger cars (kWh/100 km)	15.1	14.8	14.1

Table 3.10 Average energy consumption of passenger cars in Northwest China

Year	2019	2020	2021
Average energy consumption of passenger cars (kWh/100 km)	16.7	16.7	15.6

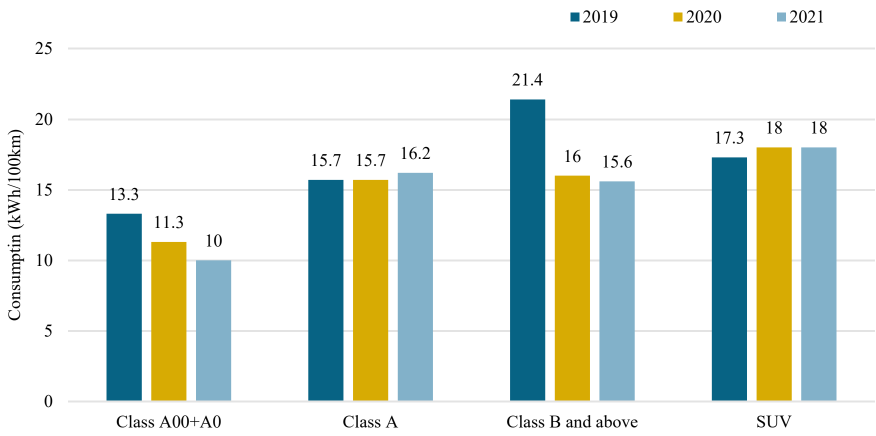


Fig. 3.12 Average energy consumption of passenger cars of different classes in Central China

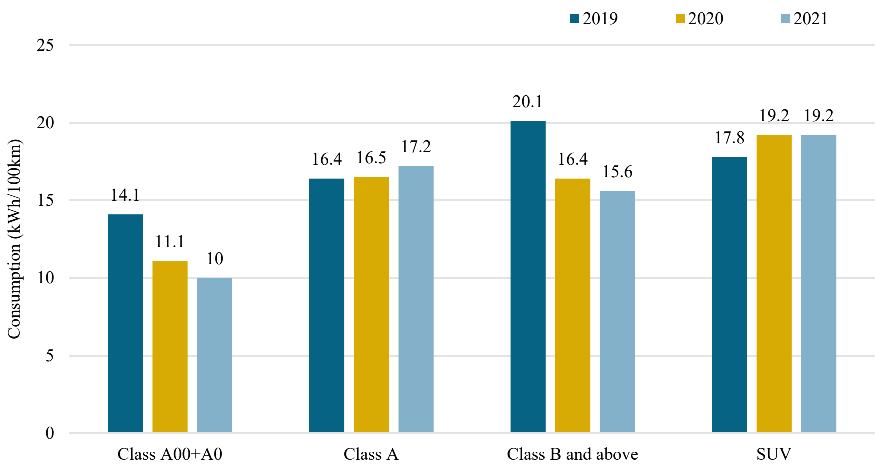


Fig. 3.13 Average energy consumption of passenger cars of different classes in Northwest China

(7) **Southwest China**

In 2021, the energy consumption level of passenger cars in Southwest China has significantly decreased compared with the previous year, with a significant downward trend in the energy consumption of Class A00 + A0 cars, Class A cars, Class B and above cars.

The average energy consumption of passenger cars in North China in 2021 was 15.2 kWh/100 km, with a decrease of 9.3% compared with the previous year (Table 3.11). According to the average energy consumption of passenger cars of different classes (Fig. 3.14), the average energy consumption of Class A00 + A0 cars, Class A cars, and Class B and above cars showed a significant downward trend

Table 3.11 Average energy consumption of passenger cars in Southwest China

Year	2019	2020	2021
Average energy consumption of passenger cars (kWh/100 km)	15.9	16.2	14.7

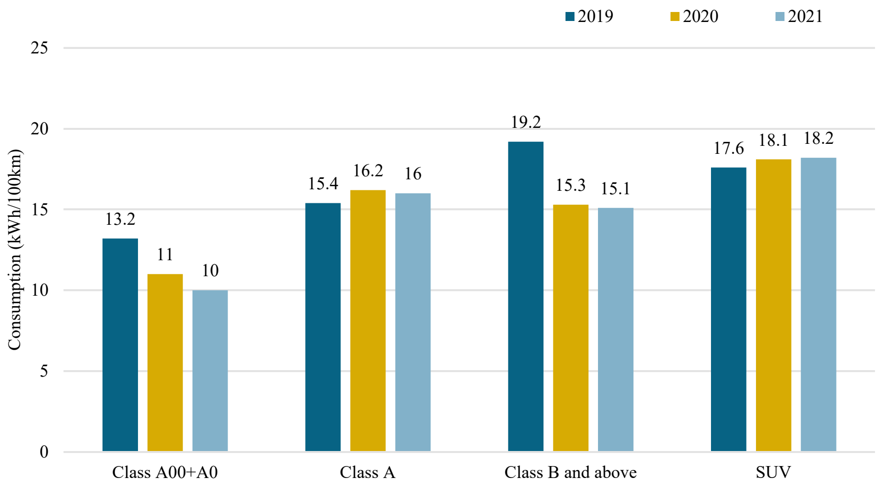


Fig. 3.14 Average energy consumption of passenger cars of different classes in Southwest China

in 2021. In 2021, the average energy consumption of Class A00 + A0 cars was 10 kWh/100 km, with a decrease of 9.1% compared with 2020 and 24.2% compared with 2019; that of Class A cars was 16 kWh/100 km, with a decrease of 1.2% compared with 2020; that of Class B and above BEV cars was 15.1 kWh/100 km, with a decrease of 1.3% compared with 2020 and 21.4% compared with 2019. In 2021, the average power consumption of BEV SUVs slightly increased to 18.2 kWh/100 km, with an increase of 0.6% compared with 2020.

2. **Energy Consumption Evaluation of BEV Passenger Cars of Different Classes**

(1) **Vehicles by Class**

The energy consumption of Class A00 + A0 cars in 2021 was 10.4 kWh/100 km, with a decrease of 16.1% compared with the previous year.

The average energy consumption of Class A00 + A0 cars in 2021 was 10.4 kWh/100 km, with a decrease of 16.1% compared to 2020 and 18.8% compared with 2019 (Table 3.12). From the perspective of key vehicle models, in 2021, Class A00 + A0 cars like Hongguang MINI EV, Ant, and ORA Black Cat had relatively low energy consumption levels of 9.0 kWh/100 km, 10.3 kWh/100 km and 10.6 kWh/100 km, respectively (Fig. 3.15).

The average energy consumption of Class A cars in 2021 was 16.1 kWh/100 km, with an increase of 14.2% compared with the previous year.

Table 3.12 Average energy consumption of Class A00 + A0 cars over the years

Year	2019	2020	2021
Average energy consumption of Class A00 + A0 cars (kWh/100 km)	12.8	12.4	10.4

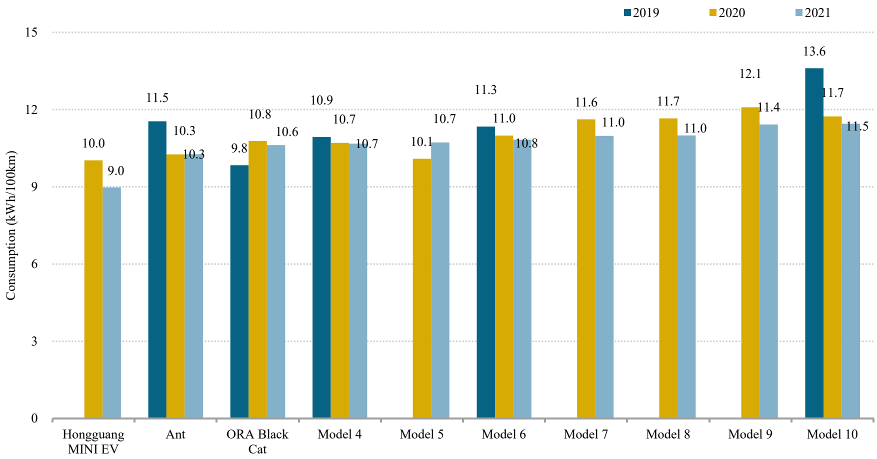


Fig. 3.15 Average energy consumption of key models of Class A00 + A0 cars

The average energy consumption of Class A cars in 2021 was 16.1 kWh/100 km, with an increase of 14.2% compared with 2020 and 11.8% compared with 2019 (Table 3.13). From the perspective of key models, in 2021, the energy consumption levels of Class A cars like LAFESTA EV, BYD e2, and BYD e3 were relatively low, at 13.3 kWh/100 km, 13.6 kWh/100 km, and 13.9 kWh/100 km, respectively (Fig. 3.16).

In 2021, the energy consumption of Class B and above BEV cars was 15.6 kWh/100 km, with a decrease of 7.7% compared with the previous year.

From the distribution of vehicle energy consumption over the years, the average energy consumption of Class B and above BEV cars in 2021 was 15.6 kWh/100 km, with a decrease of 7.7% compared with 2020 and 20.4% compared with 2019 (Table 3.14). From the perspective of key models, MODEL 3, WM Motor E5, and BYD Han EV in 2021 were at low average energy consumption levels of 15.0 kWh/100 km, 15.9 kWh/100 km, and 17.1 kWh/100 km, respectively (Fig. 3.17).

The average energy consumption of BEV SUVs in 2021 was 18.7 kWh/100 km, with an increase of 3.3% compared with the previous year.

Table 3.13 Average energy consumption of Class A cars over the years

Year	2019	2020	2021
Average energy consumption of Class A cars (kWh/100 km)	14.4	14.1	16.1

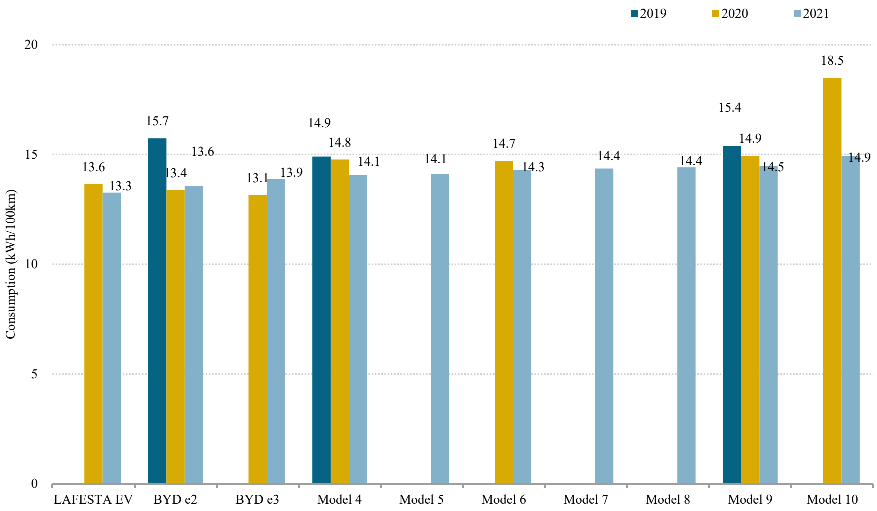


Fig. 3.16 Average energy consumption of key models of Class A cars

Table 3.14 Average energy consumption of Class B and above BEV cars over the years

Year	2019	2020	2021
Average energy consumption of Class B and above cars (kWh/100 km)	19.6	16.9	15.6

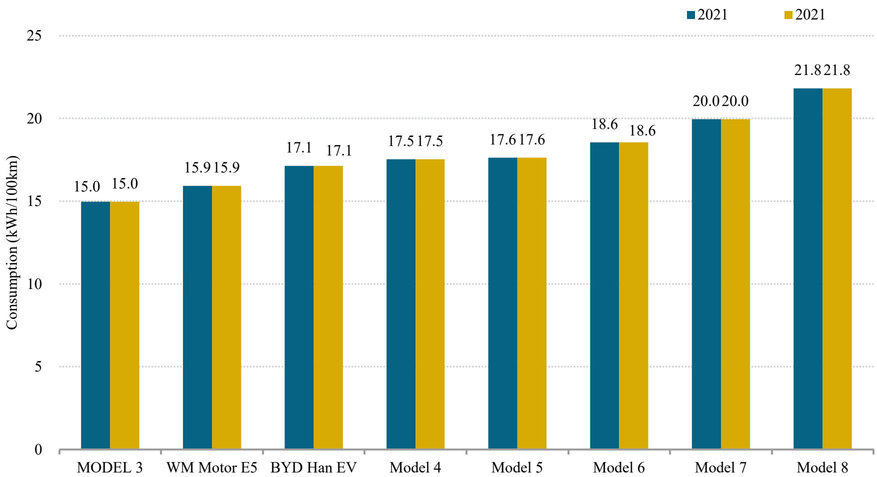


Fig. 3.17 Average energy consumption of key models of Class B and above cars

In 2021, the average energy consumption of BEV SUVs was 18.7 kWh/100 km, with an increase of 3.3% compared with 2020 and 1.1% compared with 2019 (Table 3.15). From the perspective of key SUV models (Fig. 3.18), Fengxing T1 EV, Nezha N01, and Qichen E30 in 2021 were at relatively low energy consumption levels of 9.8 kWh/100 km, 11.0 kWh/100 km, and 11.2 kWh/100 km, respectively.

(2) **Vehicles by Field of Operation**

In the field of BEV passenger cars, the energy consumption level of operating vehicles is generally higher than that of non-operating vehicles.

In 2021, the energy consumption level of BEV passenger cars operating at different speeds was generally higher than that of non-operating BEV passenger cars, especially in the lower and higher speed ranges. There is a significant difference in energy consumption levels between operating and non-operating vehicles at the same speed (Fig. 3.19). The vehicle power consumption curve shows an apparent U-curve from the energy consumption distribution of vehicles in various fields at different speed ranges. Among them, the economic speed range is between 50 km/h and 70 km/h, and the energy consumption level of vehicles in this speed range is relatively low.

Table 3.15 Average energy consumption of SUVs over the years

Year	2019	2020	2021
Average energy consumption of SUVs (kWh/100 km)	18.5	18.1	18.7

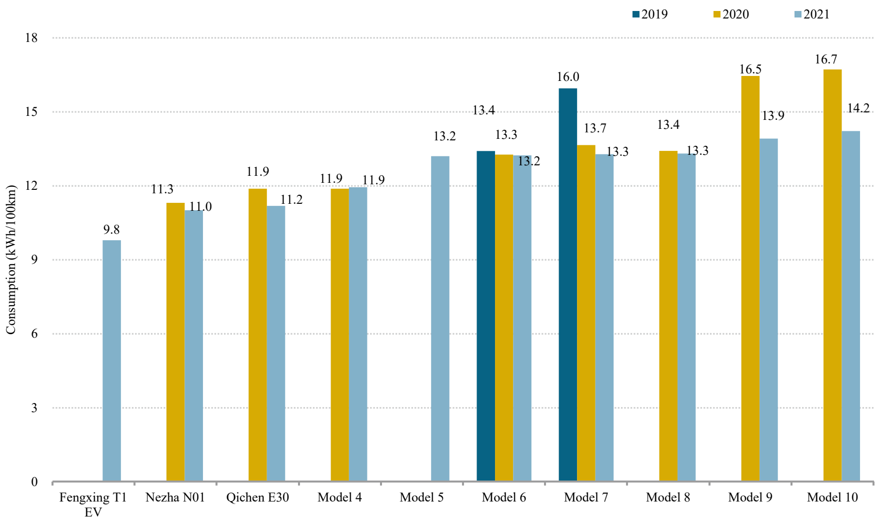


Fig. 3.18 Average energy consumption of key models of SUVs

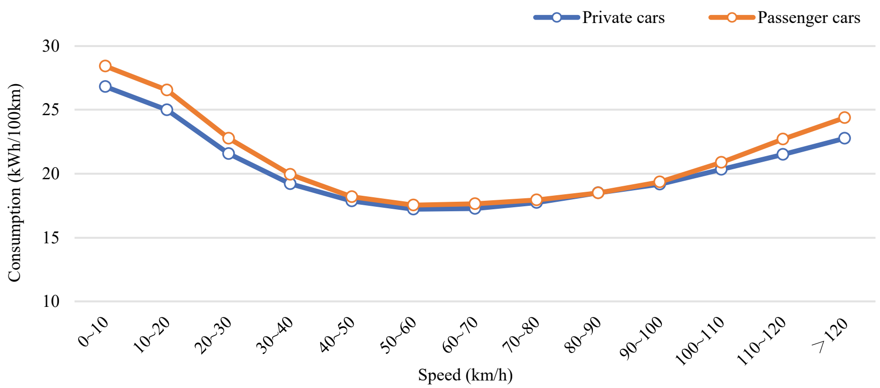


Fig. 3.19 Distribution of energy consumption of passenger cars in different operating scenarios in 2021

3.3.2 Energy Consumption Evaluation of BEV Buses

In 2021, the energy consumption of buses was 58.9 kWh/100 km, with a decrease of 2.5% compared with the previous year.

The average energy consumption of buses in 2021 was 58.9 kWh/100 km, a decrease of 2.5% compared with 2020 (Table 3.16). From the perspective of bus types, the energy consumption level of interurban buses in 2021 was lower than that of other types of buses (Fig. 3.20). From the changes in energy consumption of various vehicle models over the years (Fig. 3.21), it can be seen that the energy consumption level of interurban buses and public buses in 2021 showed a downward trend compared with the previous year. The average energy consumption of interurban buses in 2021 was 54.7 kWh/100 km, with a decrease of 4.8% compared with 2020, and that of public buses was 67.7 kWh/100 km, with a decrease of 8% compared with 2020.

The energy consumption of BEV buses with different lengths varies greatly, and in 2021, the energy consumption of buses with different lengths has decreased compared with 2020.

According to different types of BEV buses with different lengths (Fig. 3.22), the longer the length, the higher the energy consumption level. The overall energy consumption level of BEV buses over 8 m long remains above 50 kWh/100 km, while that of BEV buses over 12 m long is about 100 kWh/100 km. From different years, the energy consumption level of BEV buses in different length sections in 2021 decreased compared with 2020. In 2021, the energy consumption of BEV buses less than 6 m and 6–8 m long was 38.6 kWh/100 km and 44.6 kWh/100 km,

Table 3.16 Average energy consumption of buses over the years

Year	2019	2020	2021
Average energy consumption of buses (kWh/100 km)	59.0	60.4	58.9

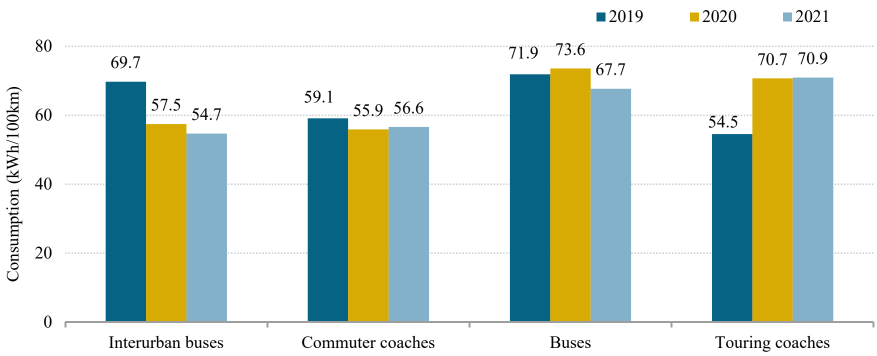


Fig. 3.20 Average energy consumption of BEV buses in different scenarios

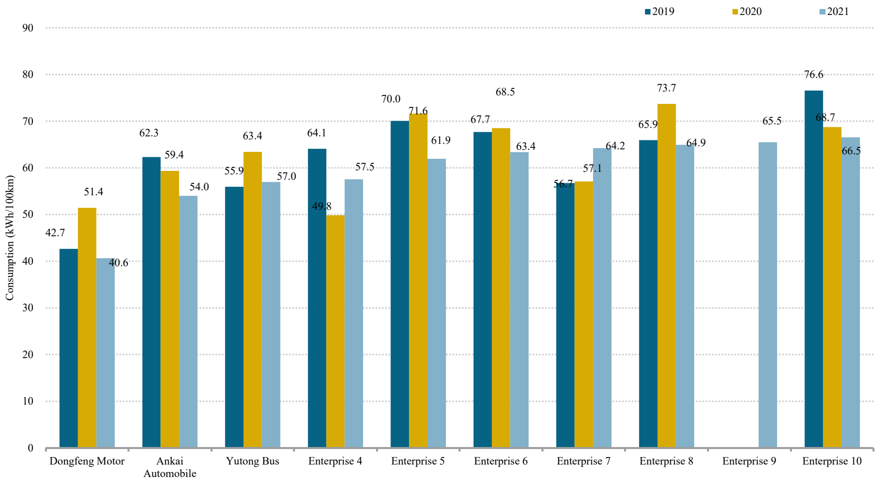


Fig. 3.21 Average energy consumption of key bus enterprises

respectively, with a slight decrease compared with the previous year. The average energy consumption of BEV buses of 8–10 m long was 55.9 kWh/100 km, with a decrease of 9.5% compared with the previous year; that of BEV buses of 10–12 m long was 80.3 kWh/100 km, with a decrease of 7.3% compared with the previous year; and that of BEV buses more than 12 m long was 98.3 kWh/100 km, with a decrease of 5.9% compared with the previous year.

By region, the energy consumption level of BEV buses in Southwest China is generally lower than that of other regions.

According to energy consumption levels of BEV buses in different regions (Fig. 3.23), the energy consumption levels of BEV buses in Northeast China are generally higher than those in other regions in various years. In 2021, the average energy consumption of BEV buses in Northeast China was 77.6 kWh/100 km, with

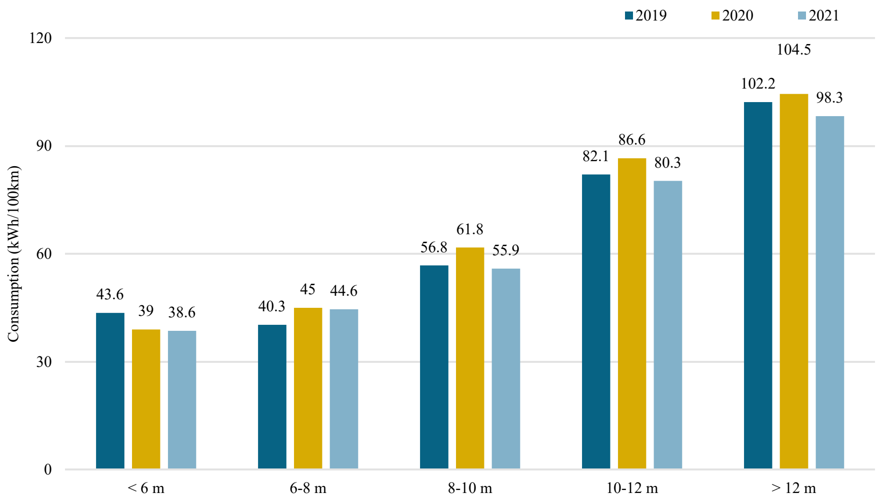


Fig. 3.22 Average energy consumption of BEV buses with different lengths

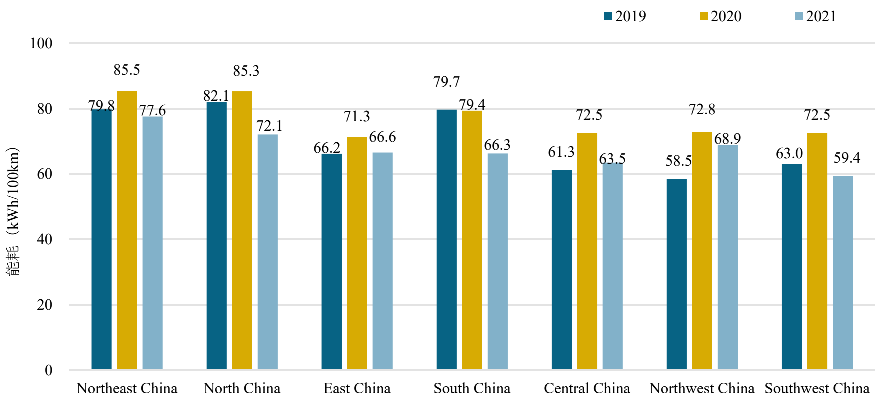


Fig. 3.23 Average energy consumption of BEV buses in different regions

a decrease of 9.2% compared with the previous year. In other regions, the energy consumption level of BEV buses in Southwest China in 2021 was relatively low, at 59.4 kWh/100 km, with a decrease of 18.1% compared with the previous year.

In the field of BEV buses, the energy consumption level of buses shows an apparent U-shaped curve at different speeds, with an economical speed ranging from 50 to 70 km/h.

The energy consumption distribution of BEV buses in 2021 showed an apparent U-shaped curve at different speeds (Fig. 3.24). The vehicles maintain a high level of energy consumption in low-speed ranges below 30 km/h and high-speed ranges above 100 km/h. The buses have a low energy consumption level in the 50 to 70 km/h, which is the economical speed range.

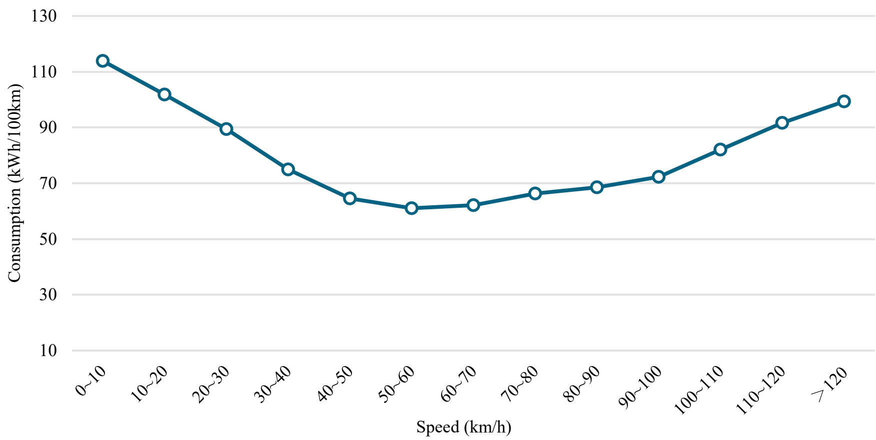


Fig. 3.24 Energy consumption distribution of BEV buses in different speed ranges in 2021

3.3.3 Energy Consumption Evaluation of BEV Logistics Vehicles

In 2020, the energy consumption of BEV logistics vehicles was 30.1 kWh/100 km, with a decrease of 10.9% compared with the previous year.

This section selects 43 companies with an annual sales volume of over 1000 logistics vehicles. The calculation results show that the average energy consumption of BEV logistics vehicles in 2021 was 30.1 kWh/100 km, with a decrease of 10.9% compared with 2020 (Table 3.17). From the distribution of key logistics vehicle enterprises (Fig. 3.25), the energy consumption of such enterprises as Changan Automobile, Chongqing Ruichi, and Chery was low in 2021.

The heavier the total mass of the vehicle, the higher the energy consumption of the vehicle.

From the average energy consumption of BEV logistics vehicles in different tonnage ranges over the years (Fig. 3.26), the higher the vehicle's total mass, the higher the vehicle's energy consumption. The average energy consumption of BEV logistics vehicles with a capacity of over 12t is significantly higher than those in other ranges. According to the changes in the energy consumption of vehicles in different ranges over the years, the energy consumption of vehicles in each range showed a downward trend in 2021. In 2021, the average energy consumption of BEV logistics vehicles below 4.5t was 25.4 kWh/100 km, with a YoY decrease of 6.3%; that of

Table 3.17 Average energy consumption of logistics vehicles over the years

Year	2019	2020	2021
Average energy consumption of logistics vehicles (kWh/100 km)	33.3	33.8	30.1

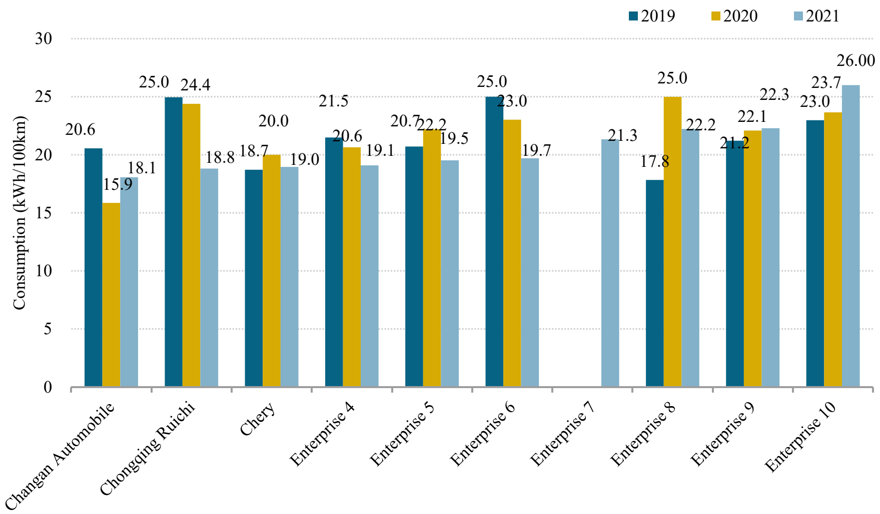


Fig. 3.25 Average energy consumption of key logistics vehicle enterprises

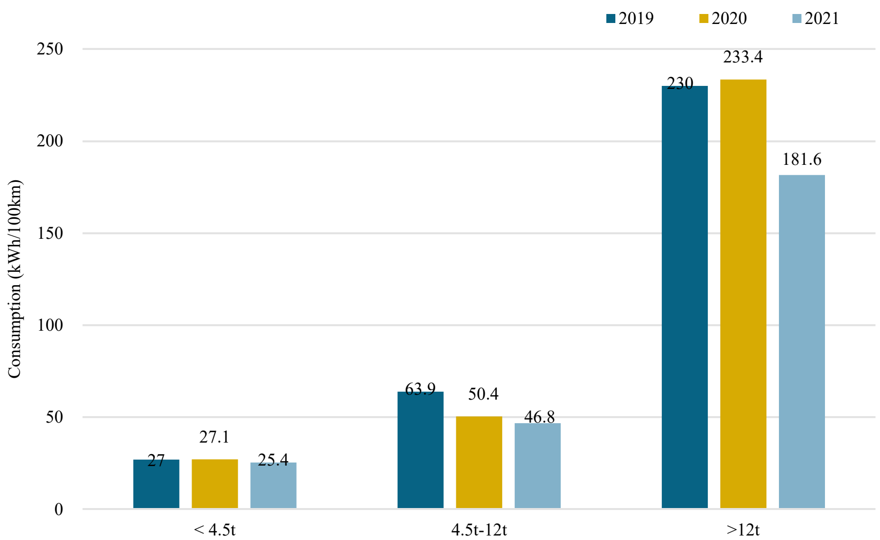


Fig. 3.26 Average energy consumption of BEV logistics vehicles in different tonnage ranges

4.5-12t BEV logistics vehicles was 46.8 kWh/100 km, with a YoY decrease of 7.1%; that of BEV logistics vehicles over 12t was 181.6 kWh/100 km, with a YoY decrease of 22.2%.

The overall energy consumption of BEV vehicles in Northeast China is significantly higher than that in other regions.

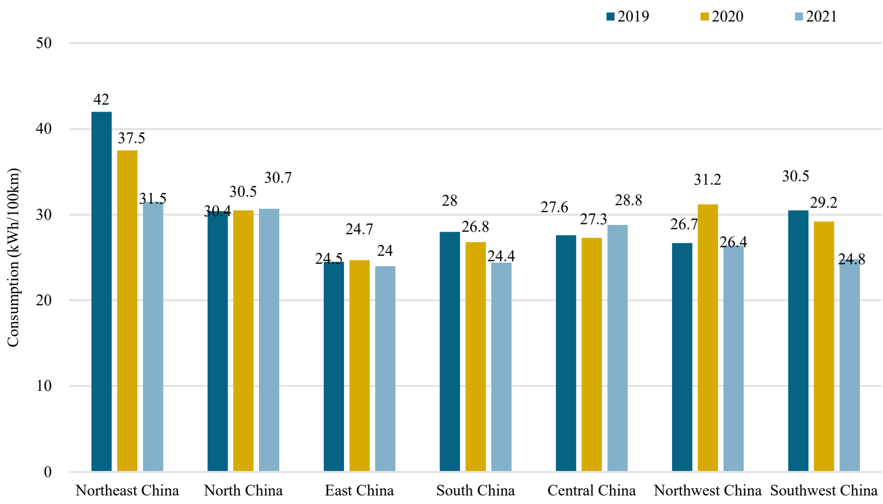


Fig. 3.27 Average energy consumption of BEV logistics vehicles in different regions

According to the energy consumption of BEV logistics vehicles in different regions (Fig. 3.27), the average energy consumption of BEV logistics vehicles in Northeast China in 2021 was 31.5 kWh/100 km, significantly higher than that in other regions. The energy consumption in East China, South China, and Southwest China remains low, and the energy consumption was below 25 kWh/100 km in 2021.

According to the changes in energy consumption in various regions over the years, the energy consumption of vehicles in Northeast China, East China, Northwest China, and Southwest China in 2021 declined on a YoY basis. In 2021, the average energy consumption of BEV logistics vehicles in Northeast China was 31.5 kWh/100 km, with a YoY decrease of 16%; that of BEV logistics vehicles in East China was 24 kWh/100 km, with a YoY decrease of 2.8%; that of BEV logistics vehicles in South China was 24.4 kWh/100 km, with a YoY decrease of 9% compared with the previous year; that of BEV logistics vehicles in Northwest China was 26.4 kWh/100 km, with a decrease of 15.4% compared with the previous year; that of BEV logistics vehicles in Southwest China was 24.8 kWh/100 km, with a decrease of 15.1% compared with the previous year.

In the field of BEV logistics vehicles, the economic speed range is relatively wide, and the energy consumption of vehicles in the 50–80 km/h range is less than 30 kWh.

In 2021, BEV logistics vehicles had higher energy consumption in low-speed ranges below 20 km/h and high-speed ranges above 110 km/h, both above 40 kWh/100 km (Fig. 3.28). The speed of BEV logistics vehicles was above 20 km/h, and the energy consumption of vehicles gradually decreased, reaching the range of 50–80 km/h. The energy consumption of BEV logistics vehicles per 100 km was less than 30 kWh, which was in the economic speed range.

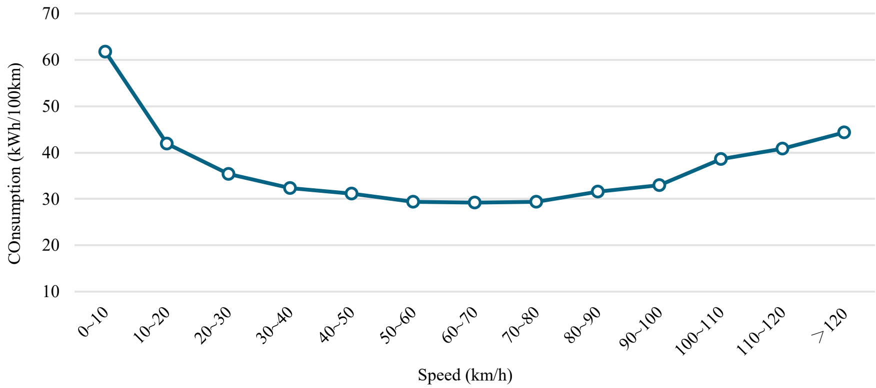


Fig. 3.28 Energy consumption distribution of BEV logistics vehicles in different speed ranges in 2021

3.4 Annual Technical Characteristics of Power Batteries

3.4.1 Power Battery Industry Status Quo

As of the end of 2021, the cumulative installed power capacity of power batteries accessed to the National Traceability Platform is 418.6 GWh.

The National Monitoring and Power Battery Recycling and Utilization Traceability Integrated Management Platform for New Energy Vehicles (hereinafter referred to as "National Traceability Platform") takes new energy vehicles as the reporting subject under the traceability rules of information of new energy vehicle power battery, and the management links involved include production (vehicle production, i.e., battery installation stage), sales, maintenance, out-of-service. Each link records the complete lifecycle traceability information of power batteries from installation and use to out-of-service and recycling.

According to the analysis of data collected on the National Traceability Platform and based on vehicle production time statistics, as of December 31, 2021, a total of 8.681 million new energy vehicles have been accessed, with 12.354 million supporting battery packs and over 418.6GWh supporting battery capacity (Fig. 3.29).

As of December 31, 2021, the TOP10 vehicle production enterprises with battery access to the National Traceability Platform have 4.735 million battery packs accessed, with an installed power capacity of 171.0 GWh, accounting for 49.6% of China's installed power capacity (Fig. 3.30). Among them, BYD Auto (including BYD Automobile Industry Co., Ltd. and BYD Auto Co., Ltd.), Tesla (Shanghai) Co., Ltd. and Zhengzhou Yutong rank the top three regarding the battery access. BYD has a battery access proportion of up to 18.6%, with a high market concentration.

According to the battery installation enterprises corresponding to the vehicle manufacturers on the National Traceability Platform (Table 3.18), BYD Auto mainly

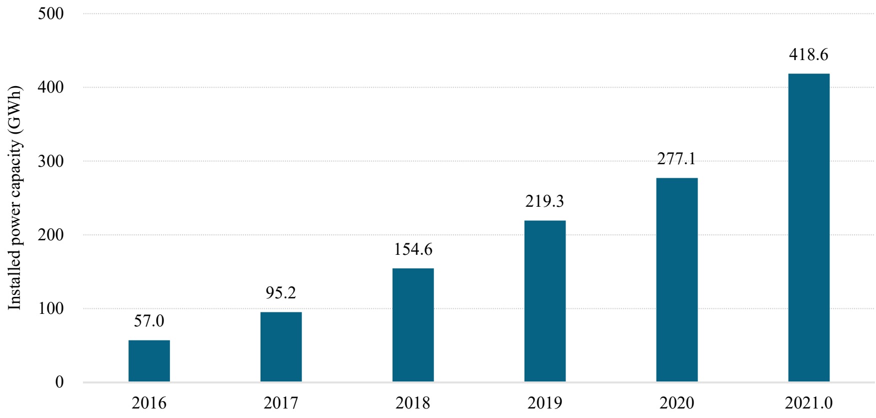


Fig. 3.29 Accumulated installed power capacity of power batteries accessed to the National Traceability Platform over the years. *Note* There is a small time lag in the access volume of new energy vehicles on the National Traceability Platform, and the installed power capacity data over the years has been updated

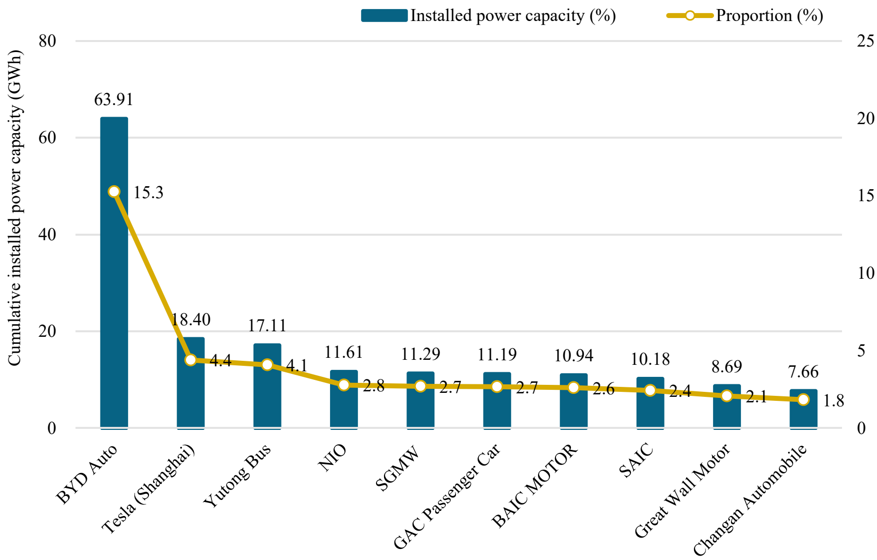


Fig. 3.30 Cumulative installed power capacity of the TOP10 vehicle manufacturers with battery access

relies on its battery supply; other vehicle manufacturers take CATL as the leading battery supplier, and there is a trend of supplier diversification.

From the perspective of battery manufacturers, as of December 31, 2021, the cumulative installed power capacity of the TOP10 battery suppliers in China was 248.7 GWh, accounting for 72.2% of the total cumulative power capacity in China,

Table 3.18 Overview of main battery suppliers corresponding to vehicle manufacturers

Vehicle manufacturer	Main battery installation enterprises
BYD Automobile Industry Co., Ltd. BYD Auto Co., Ltd.	BYD, Chongqing FinDreams
Tesla (Shanghai) Co., Ltd.	CATL, Panasonic, LG Chem
Zhengzhou Yutong Bus Co., Ltd.	CATL, MGL, Lishen Battery
NIO Co., Ltd.	ZENIO, CATL, XPT (Nanjing) Energy Storage
SGMW Automobile Co., Ltd.	SINOEV, Gotion High-Tech, Key Power
GAC Passenger Car Co., Ltd.	CALB, CATL
BAIC MOTOR Corporation., Ltd.	CATL, Farasis Energy (Ganzhou)
SAIC	CATL, United Auto Battery System
Great Wall Motor Company Limited	CATL, Svolt
Chongqing Changan Automobile Company Limited	CALB, CATL, Lishen Battery

with CATL and BYD firmly occupying the top two (Fig. 3.31). Among them, CATL has the largest cumulative installed battery power capacity, accounting for 34.0% of the total cumulative power in China. The number of installed vehicles has reached 2.346 million. CATL has continued to explore the international market, and its market competitiveness has continued to increase. BYD has achieved rapid sales growth and steadily ranked second in installed power capacity, showing a strong development trend of a leading enterprise.

3.4.2 Installation Structure Change by Material Type

Ternary battery is still the main body of the power battery market, and the matching proportion of the LFP battery market has increased significantly.

According to the cumulative installed power capacity structure of power batteries on the National Traceability Platform (Fig. 3.32), the ternary battery is the mainstream battery type. As of the end of 2021, ternary batteries' cumulative installed power capacity accounted for 55.9%, followed by LFP batteries, accounting for 42.3%.

Regarding the installed power capacity structure of different types of power batteries over the years (Fig. 3.33), according to the statistics of China Automotive Power Battery Industry Innovation Alliance, in 2021, the market share of LFP batteries was more substantial than that of ternary batteries, and the installed capacity of LFP batteries accounted for 51.7%; the installed power capacity of ternary batteries accounted for 48.1%, with a decrease of 13% compared with 2020. New technologies such as LFP CTP technology and battery pack internal structure innovation effectively hedge the pressure of rising raw material costs and further boost the promotion of LFP batteries in a broader range.

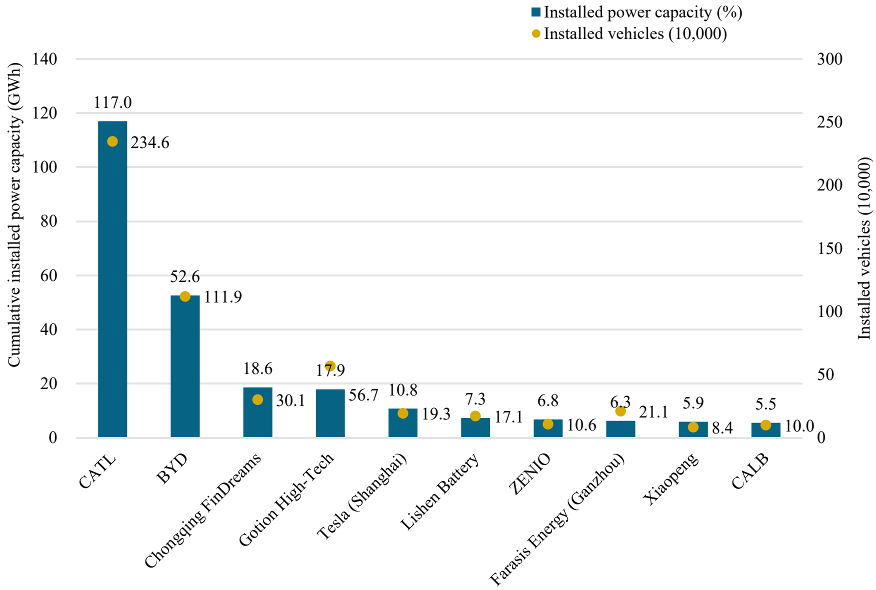
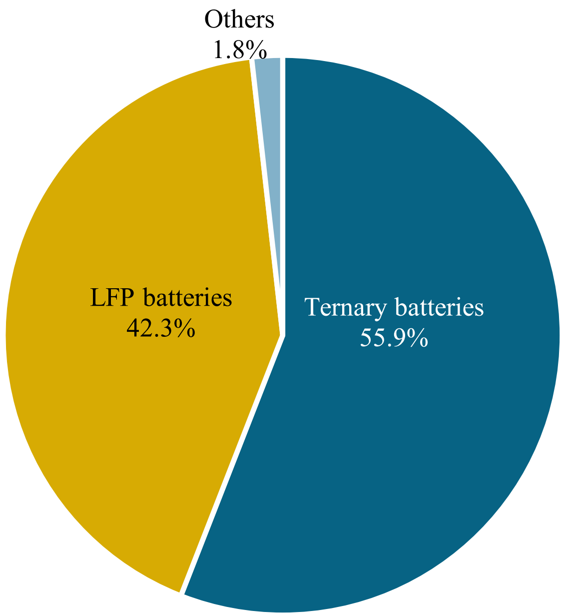


Fig. 3.31 Cumulative installed power capacity of the TOP10 battery manufacturers

Fig. 3.32 Proportion of cumulative installed power capacity of different types of power batteries



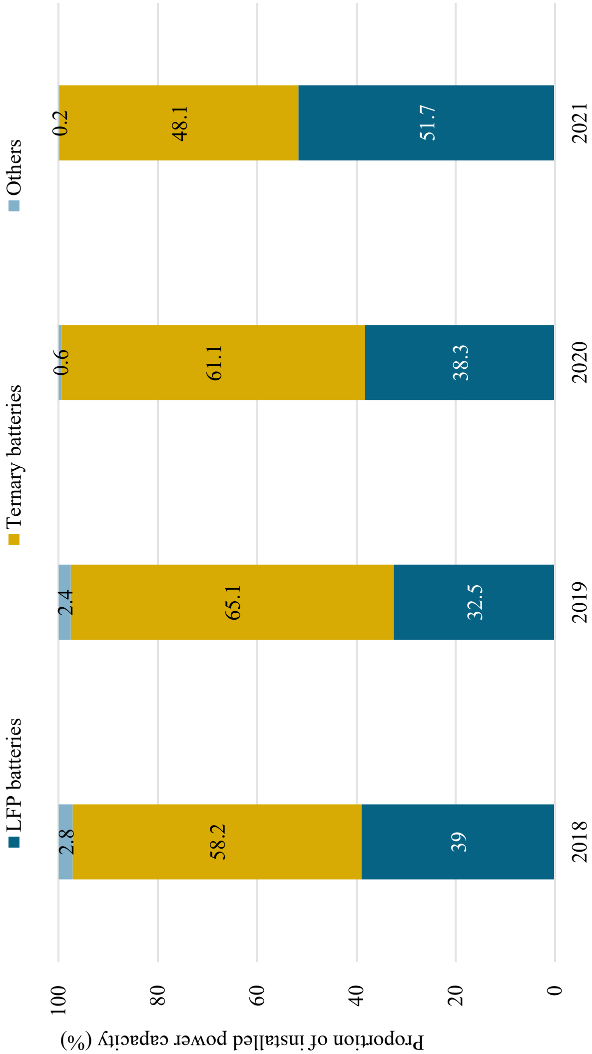


Fig. 3.33 Changes in the proportion of installed power capacity of different types of power batteries over the years

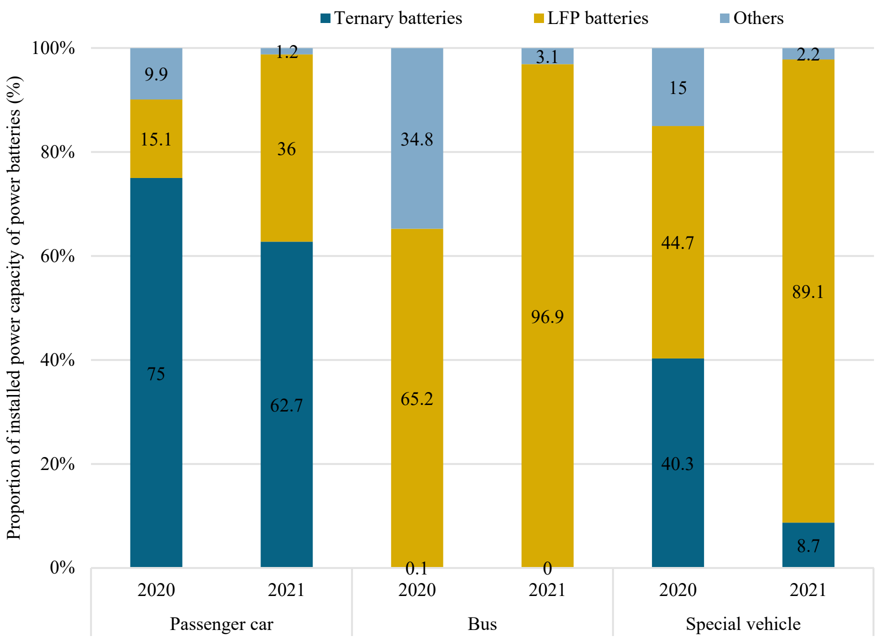


Fig. 3.34 Structural changes in installed power capacity of power batteries for different types of vehicles

In the field of passenger cars, the installed power capacity of LFP batteries has proliferated; in the field of commercial vehicles, the installed power capacity of LFP batteries is dominant.

The use scenarios will be different because of the different energy density, safety, and price of batteries made of different materials. According to the changes in the installed power capacity of power batteries of different types of vehicles on the National Traceability Platform (Fig. 3.34), in the field of passenger cars, in 2021, the installed power capacity of ternary batteries accounted for the main proportion, and that of LFP batteries showed rapid growth, with an increase of 20.9% compared with 36.0% in 2020. In commercial vehicles, LFP batteries have achieved comprehensive installed coverage due to their advantages in economy and safety.

3.4.3 Change of Installed Structure by Form Type

Power battery companies in China mainly produce square batteries, with a small share of pouch batteries and cylindrical batteries.

As of December 31, 2021, the cumulative access volume of square batteries on the National Traceability Platform was the largest, with 9.86 million packs accessed, with a total power of 299.2 GWh, accounting for the main proportion of the national

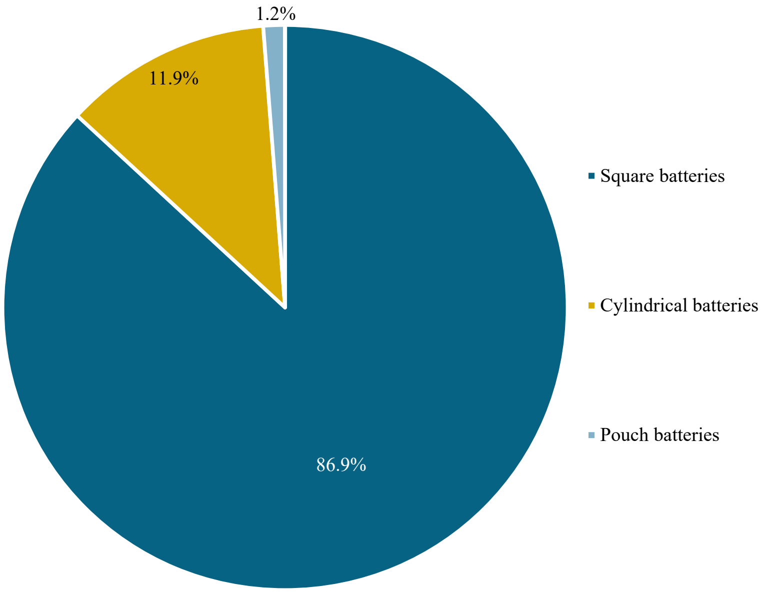


Fig. 3.35 Proportion of cumulative power capacity accessed of different forms of batteries

power battery market at 86.9% (Fig. 3.35). The square battery has a high grouping rate and energy density, making it more suitable for the current market demand, followed by cylindrical batteries with relatively mature development technology. A total of 1.677 million packs of cylindrical batteries have been accessed, with a total power of 40.9 GWh, accounting for 11.9%. According to the changes in the access structure of different forms of batteries over the years, the access volume of square batteries accounted for more than 80% in the past three years, occupying a major market share (Fig. 3.36).

3.4.4 Change in Energy Density of Power Batteries

From the changes in energy density of power batteries for different types of vehicles over the years (Fig. 3.37), in the field of BEV passenger cars, the individual energy density and system energy density of BEV passenger cars in 2021 were 211 Wh/kg and 149 Wh/kg, respectively, with an increase of 24.85% and 41.90% compared with 2016; in the field of BEV buses, the individual energy density and system energy density of BEV buses in 2021 were 173 Wh/kg and 154 Wh/kg, respectively, with an increase of 39.52% and 85.54% compared with 2016. With the improvement of battery-supporting technology and group efficiency requirements, small modules are

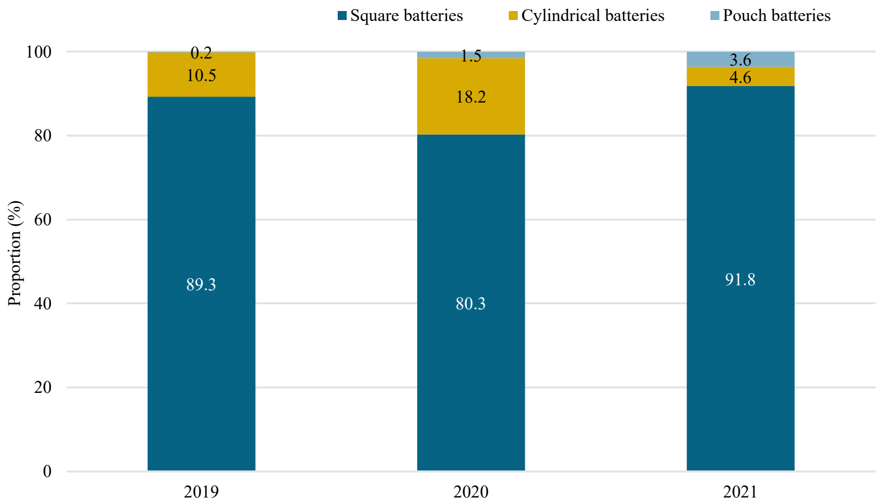


Fig. 3.36 Proportion of power capacity accessed of different forms of batteries over the years. *Note* There is a slight time lag in the access volume of new energy vehicles on the National Traceability Platform, and the installed power capacity data over the years has been updated

gradually evolving towards large modules, and power battery systems are gradually transitioning from traditional battery packs to CTP, CTC, and skateboard forms. The energy density of power batteries will improve, and high integration and high energy density will become the development trend of BEV platforms.

3.5 Summary

By summarizing the evolution and changes in vehicle technology of new energy vehicles on the National Monitoring and Management Platform over the years, the technological progress of the new energy vehicle industry presents the following characteristics:

The technology of new energy passenger cars has made remarkable progress, the overall range of vehicles has increased yearly, and lightweight technology has made remarkable progress. The overall range of new energy passenger cars shows a steady growth trend. In recent years, the average range of new energy passenger cars has increased from 270.5 km in 2019 to 320.9 km in 2021; in the field of BEV passenger cars, due to the rapid growth of the scale of small BEV passenger cars, the average range of vehicles decreased slightly; according to the changes in the average range ratio of BEV passenger cars over the years, in 2021, both vehicles with high range and low range showed an expanding trend. Vehicles with a high range above 400 km gradually dominate the market, and their market share reached 55.4% in 2021. The proportion of BEV passenger cars with a range below 200 km

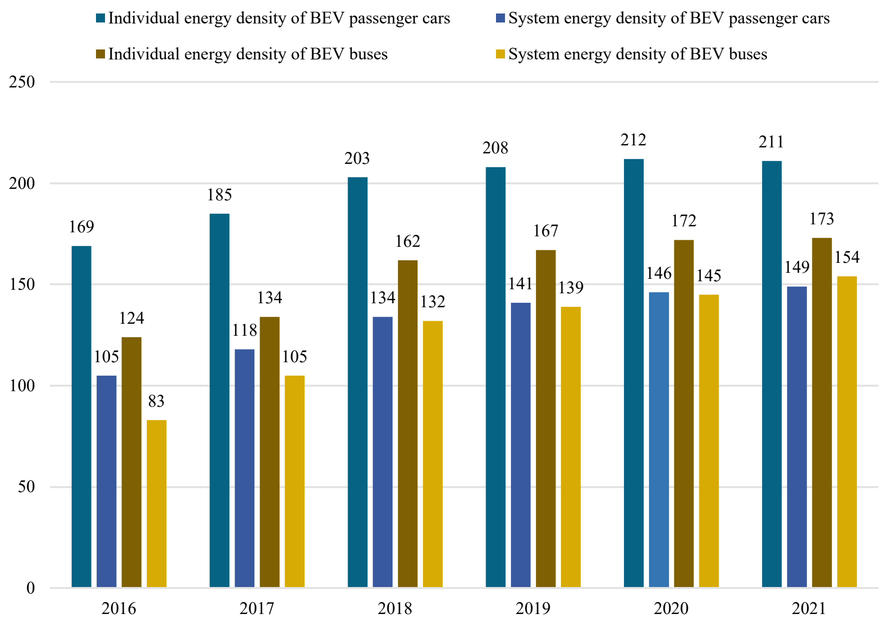


Fig. 3.37 Changes in energy density of individual and system power batteries for different types of vehicles over the years. *Source China Automotive Industry Development Annual Report* of the Ministry of Industry and Information Technology Equipment Development Center of China

increased from 3.7% in 2019 to 20.4% in 2021; in the field of vehicle lightweight, the lightweight technology of BEV passenger cars has made remarkable progress, and small BEV cars have performed better. In 2021, the average curb weight of BEV passenger cars was 1478.1 kg, which decreased compared with the previous two years.

In the field of power battery assembly, the LFP battery has returned strongly. New technologies such as LFP CTP technology and battery pack internal structure innovation effectively hedge the pressure of rising raw material costs and further boost the promotion of LFP batteries in a broader range. In 2021, the installed power capacity of LFP batteries accounted for 51.7%, with an increase of 13.4% compared with 2020. Regarding types, the installed power capacity of ternary batteries for BEV passenger cars still dominates the market, but the installed power capacity of LFP batteries shows rapid growth. In the field of commercial vehicles, LFP batteries dominate the market. In the future, with the continuous optimization of the battery system structure, the whole vehicle design will accelerate the trend of integration and platformization and further promote the progress of vehicle lightweight and energy consumption levels.

Regarding vehicle lightweight, the overall curb weight of new energy passenger cars shows a downward trend yearly. Small BEV passenger cars have outstanding performance. In 2021, the average curb weight of new energy

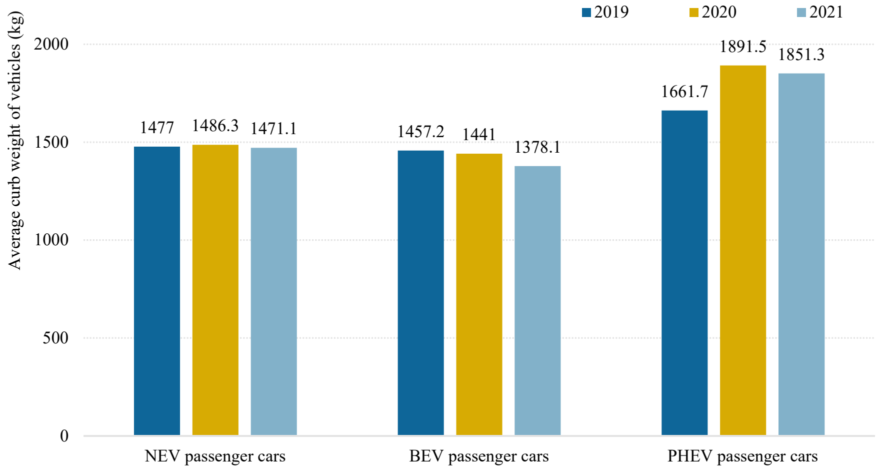


Fig. 3.38 Changes in average curb weight of new energy vehicles over the years

passenger cars was 1471.1 kg, slightly lower than that in 2020 (Fig. 3.38). The average curb weight of BEV passenger cars was 1378.1 kg, 4.4% lower than that in 2020. The average curb weight of Class A00 + A0 cars was 914.7 kg, with a YoY decrease of 4.4%.

Regarding vehicle energy consumption level, the energy consumption level of different types of BEV vehicles shows a downward trend. According to the actual operation of different types of vehicles on the National Monitoring and Management Platform (Fig. 3.39), in 2021, the average energy consumption of passenger cars was 14.6 kWh/100 km, with a decrease of 7.6% compared with 2020; that of BEV buses was 67.7 kWh/100 km, with a decrease of 8% compared with 2020; and that of BEV logistics vehicles was 30.1 kWh/100 km, with a decrease of 10.9% compared with 2020.

From BEV passenger cars of different classes, the energy consumption level of Class A00 + A0 cars and Class B and above cars has shown a gradual downward trend in recent three years. From different classes, in 2021, the average energy consumption of Class A00 + A0 cars was 10.4 kWh/100 km, with a decrease of 16.1% compared with 2020 (Fig. 3.40); that of Class B and above BEV cars was 15.6 kWh/100 km, with a decrease of 7.7% compared with 2020. Compared to 2020, the energy consumption level of Class A cars and SUVs increased in 2021. Among them, the average energy consumption of Class A cars was 16 kWh/100 km, with an increase of 14.2% compared with the previous year, and that of BEV SUVs was 18.6 kWh/100 km, with an increase of 3.3% compared with the previous year.

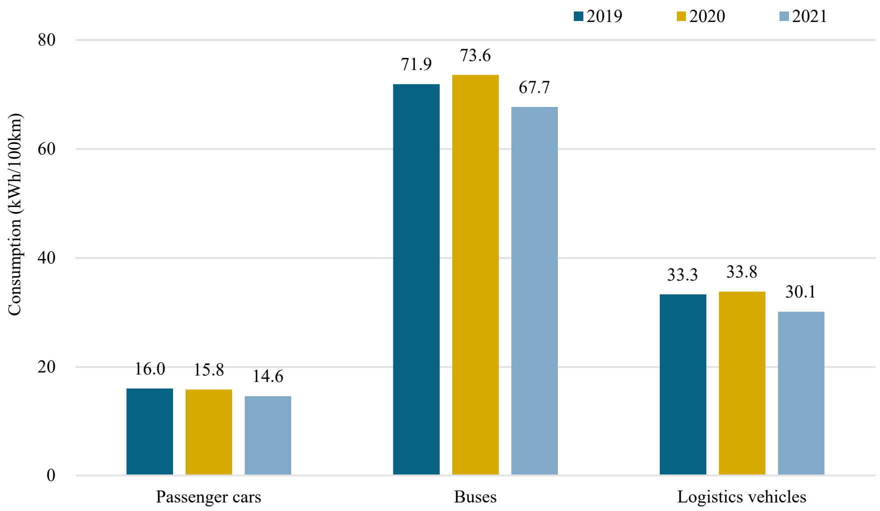


Fig. 3.39 Average energy consumption of BEVs of different types over the years

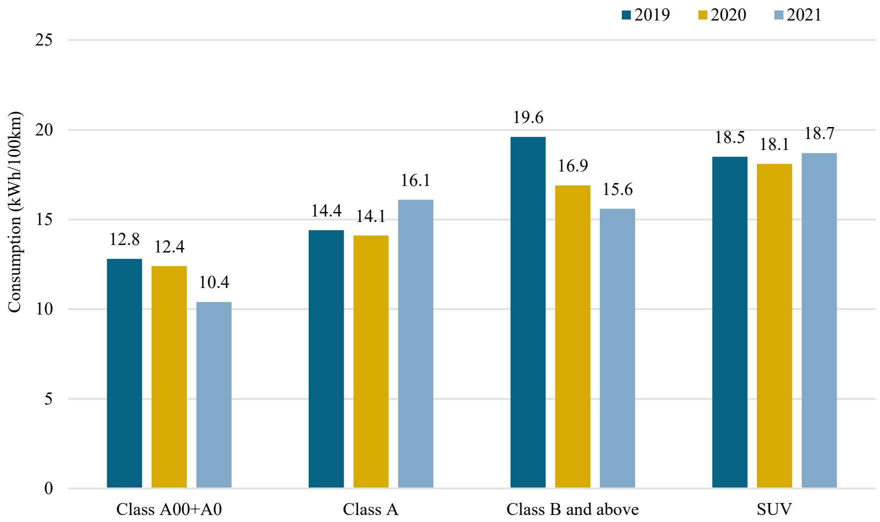


Fig. 3.40 Average energy consumption of BEV passenger cars of different classes over the years

Chapter 4
Operation of New Energy Vehicles

As of December 31, 2021, 6,655,000 NEVs have been accessed to the National Monitoring and Management Platform. This chapter, based on the real-time operation data of millions of NEVs on the National Monitoring and Management Platform, analyzes the operation characteristics of vehicles in the seven major segments, including private cars, e-taxis, taxis, cars for sharing and rental service, logistics vehicles, buses, and heavy-duty trucks, providing important research basis and references for the study and evaluation of the electrification characteristics and the construction of an intelligent traffic system (ITS).

4.1 NEV Online Rate in 2021

Vehicle online rate refers to the ratio of the number of vehicles running in the current period to the cumulative vehicle access, which reflects the use of vehicles in the current period. The higher the online rate of the vehicle, the higher the demand for the use of the vehicle and the higher the utilization rate of the vehicle. On the contrary, it means there is a certain idle situation of vehicles in the current period. Through an analysis of the overall online rate of vehicles on the National Monitoring and Management Platform and the vehicle online rate in key markets in the past three years, this section summarizes the current utilization rate of NEVs in China's NEV market.

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2022)*,
https://doi.org/10.1007/978-981-99-6411-6_4

4.1.1 NEV Online Rate in China

The average monthly online rate of NEVs in 2021 was 81.8% and has increased continuously for three consecutive years.

The average monthly online rate of NEVs in China is gradually stabilized. According to the data from the past three years, the average monthly online rate had increased steadily for two consecutive years: in 2021, it was 81.8%, increased by 1.8% compared with 2019 and by 0.7% compared with 2020 (Table 4.1).

According to the monthly online rate distribution of vehicles over the years (Fig. 4.1), the online rate fluctuated wildly in 2019 and 2020 (especially in the first five months). In 2021, the online rate of vehicles was balanced each month, indicating that the use of vehicles tends to be routine and stable.

Considering the driving type of vehicles, the online rate of PHEVs is higher than that of BEVs and FCVs.

As shown in Table 4.2, in 2021, the average online rate of PHEVs was significantly higher than that of BEVs and FCVs, and PHEV users used vehicles more frequently; BEVs followed the PHEVs in the average monthly online rate with a value of 79.7%; FCVs had a relatively low average monthly online rate of 72.0%. FCVs are currently in large-scale demonstration operation, and the vehicle types are mainly commercial vehicles. The average online rate in 2021 was 72%, close to the average value of BEVs of 79.7%, and the vehicle operation effect was good.

Table 4.1 Average monthly online rate in China

Year	2019	2020	2021
Average online rate in China (%)	80.0	81.1	81.8

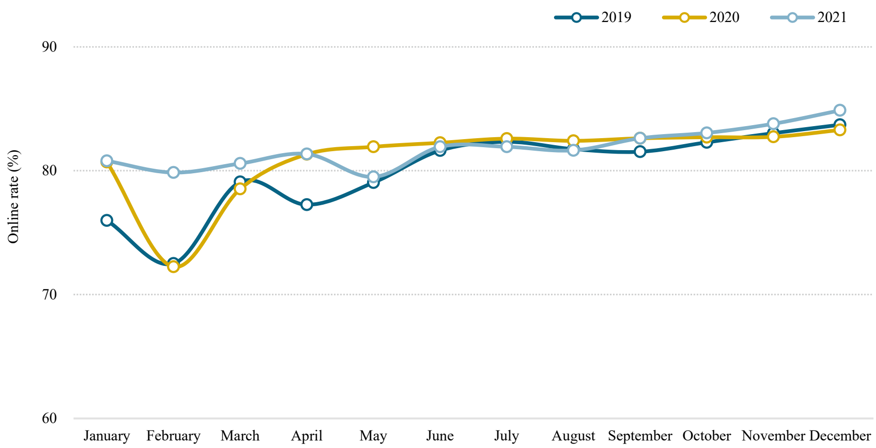


Fig. 4.1 Monthly online rate of NEVs in China-by driving type

Table 4.2 Average online rate of China in 2021—by driving type

Driving type	BEV	PHEV	FCV
Average online rate in China (%)	79.7	93.0	72.0

4.1.2 Online Rate in Each Region in China

The gap between the online rates of vehicles in different regions in China has gradually narrowed, and the average monthly online rate of vehicles in Northeast China is generally higher than that in other regions.

From the average monthly online rate of vehicles in all regions of China (Fig. 4.2), the average monthly online rate in other regions continues to increase slightly, except for Northeast China and North China. In 2021, the average monthly online rates of vehicles in Northeast China and South China were 86.3% and 85.6%, respectively, which were generally higher than other regions; the average monthly online rate in North China was 78.3%, which was relatively low. The average online rate in Northeast China was higher than that in other regions, mainly because the cumulative access ratio of commercial vehicles (buses, logistics vehicles, and other types of special vehicles) in Northeast China was significantly higher than that in other regions, and the frequency of vehicle attendance was higher (Fig. 4.3).

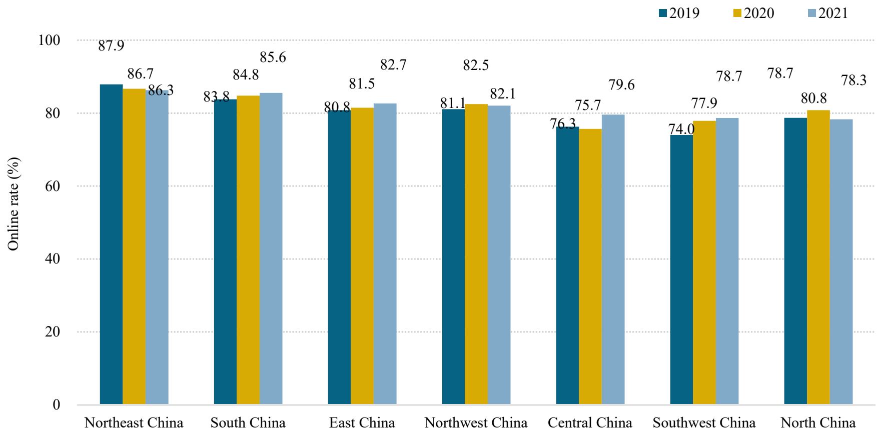


Fig. 4.2 Average monthly online rate of new energy vehicles in various regions of China

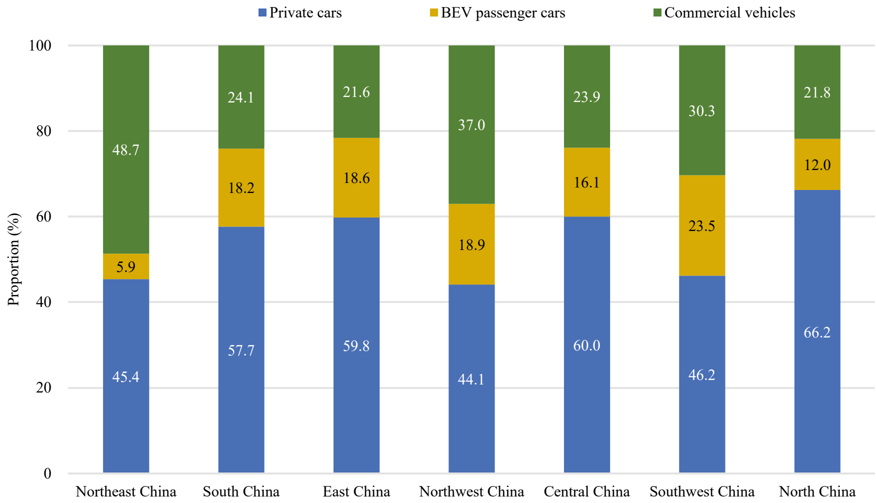


Fig. 4.3 Proportion of cumulative access volume of new energy vehicles of different types in China

4.1.3 Online Rate in Cities at All Tiers in China

The difference in the average monthly online rate of vehicles in cities at all tiers has been significantly reduced, and the online rate of fifth-tier cities is significantly higher than that of other cities.

Judging from the average monthly online rate of vehicles in cities at all tiers in China, the average monthly online rate of vehicles in cities at all tiers is increasing yearly, and the difference between the average monthly online rates of vehicles in first-and second-tier cities was gradually narrowing in 2021. Specifically, Regarding the monthly average online rate of vehicles in each region (Fig. 4.4), the annual monthly average online rate of fourth and fifth-tier cities was significantly higher, indicating a high demand for vehicles; at the same time, the base of NEV holdings in fourth and fifth-tier cities is relatively small, making it an important area for future promotion of NEVs. During vehicle promotion, attention shall be paid to the corresponding matching between the vehicle performance and price.

4.1.4 Online Rate of Vehicles in Each Segment

The average monthly online rate of e-taxis is higher than that of other segments.

From the online rate in key market segments (Fig. 4.5), the monthly average online rate of e-taxis in 2021 was the highest, reaching 96.5%; from the annual change of online rate of vehicles, the monthly average online rate of e-taxis, private cars, and heavy-duty trucks is increasing yearly. The online rate truly reflects the demand for

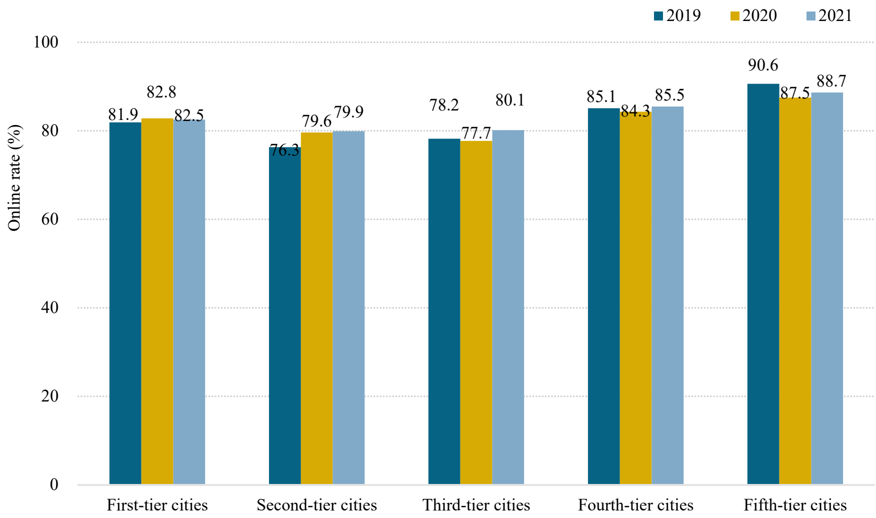


Fig. 4.4 Average monthly online rate of new energy vehicles in cities at all tiers in China over the years

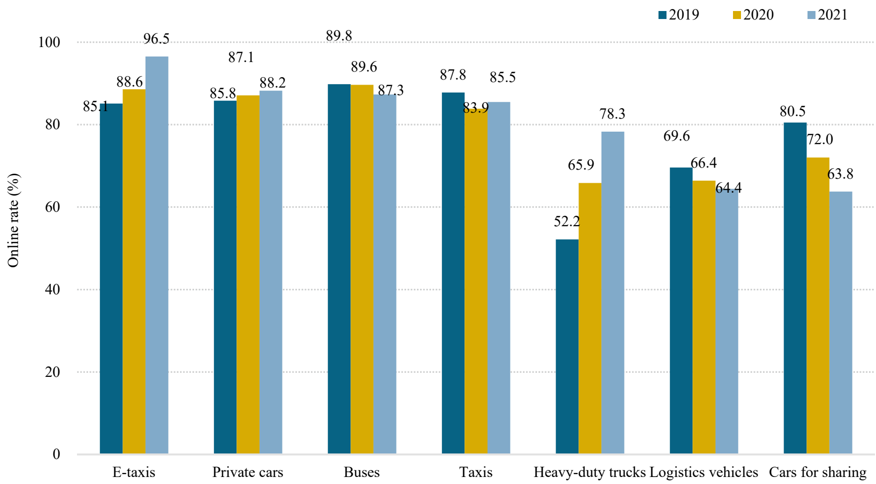


Fig. 4.5 Annual online rate of key segments for NEVs

vehicles. E-taxis and cars for sharing are both new formats in recent years. From 2021, the online rate of e-taxis (96.5%) was much higher than that of cars for sharing (63.8%), and the online rate of cars for sharing is decreasing yearly. From this point, it is necessary to diversify and innovate in the use, parking, and maintenance of cars for sharing to improve the online rate of vehicles and achieve healthy and sustainable development of vehicle operation.

4.2 Operation Characteristics of Vehicles in Key Segments

This section studies the operation characteristics of vehicles in key segments. It summarizes the travel characteristics of users, providing an essential basis for promoting the transition of the development mode of the NEV industry from the policy-driven mode to the market-driven mode. This section divides the NEV market into seven segments for further analysis: private cars, e-taxis, taxis, cars for sharing, logistics vehicles, buses, and heavy-duty trucks. It summarizes the average single-trip travel characteristics, average daily travel characteristics, and average monthly travel characteristics of vehicles in those segments to obtain the travel characteristics of different segments, with the specific indicators and the descriptions as shown in Table 4.3.

4.2.1 Operation Characteristics of Private Cars

1. **Average single-trip travel characteristics of private cars**

The average single-trip travel duration of private cars in 2021 was higher than that of the same period in 2020.

According to the data over the years, in 2021, the average single-trip travel duration of private cars was 0.63 h, with an increase compared with 2019 and 2020 (Table 4.4).

In 2021, the proportion of vehicles with an average single-trip travel duration of 0.5 h significantly increased as the average single-trip travel duration of private cars moves towards higher durations.

Table 4.3 Indicators of NEV market operation characteristics

Analysis dimension	Analysis indicator	Definition
Average single-trip travel characteristics	Average single-trip travel duration	Average travel duration of a single trip
	Average single-trip mileage	Average mileage of a single trip
	Average single-trip speed	Average travel speed of a single trip
Average daily travel characteristics	Average daily travel duration	Average travel duration in a single day
	Average daily mileage	Average mileage in a single day
	Driving time	Distribution of driving time in a single day (24 h)
Average monthly travel characteristics	Average monthly travel days	Average travel days in a single month
	Average monthly mileage	Average mileage in a single month

Table 4.4 Average single-trip travel duration of private cars over the years

Year	2019	2020	2021
Average single-trip travel duration (h)	0.47	0.42	0.63

As the distribution shows (Fig. 4.6), the proportion of private cars with an average single-trip travel duration of less than 0.5 h in China significantly decreased in 2021; the proportion of private cars with an average single-trip travel duration of more than 0.5 h was 56.33%, with an increase of 27.69% compared with 2020.

The average single-trip travel duration of private cars in first-tier cities is longer.

Although the average single-trip travel duration of private cars in various tiers of cities is mainly concentrated within 1 h, it can be seen from Fig. 4.7 that the distribution of average single-trip travel duration of private cars in first-tier cities is mainly between 0.5 and 1 h, accounting for 56.8%, while that in other tiers of cities is mainly within 0.5 h. The main reason for this is due to factors such as large regional areas and frequent traffic congestion in first-tier cities.

In 2021, the average single-trip mileage of private cars was mainly within 20 km, higher than the previous two years.

According to the data (Table 4.5), the average monthly single-trip mileage of private cars in 2021 was higher than that in 2019 and 2020.

The average single-trip mileage of private cars was mainly within 20 km, with the proportion over the years around 80%. The proportion of vehicles with an average single-trip mileage of over 10 km in 2021 was 61.38%, with an increase of 9.71% compared with 2020. Among them, the proportion of vehicles with an average single-trip mileage of 20–30 km increased by 21.1% year-on-year, and that of vehicles with an average single-trip mileage of 30–40 km increased by 17.3% year-on-year, both

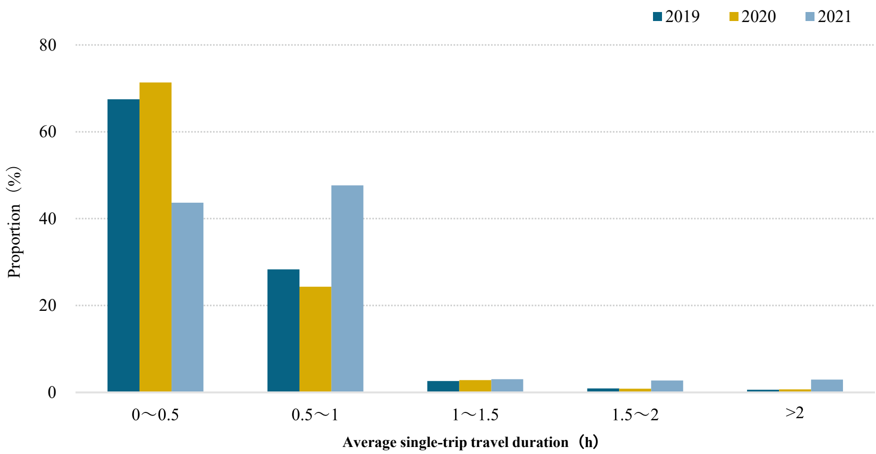


Fig. 4.6 Distribution of private cars of different average single-trip travel durations—by year

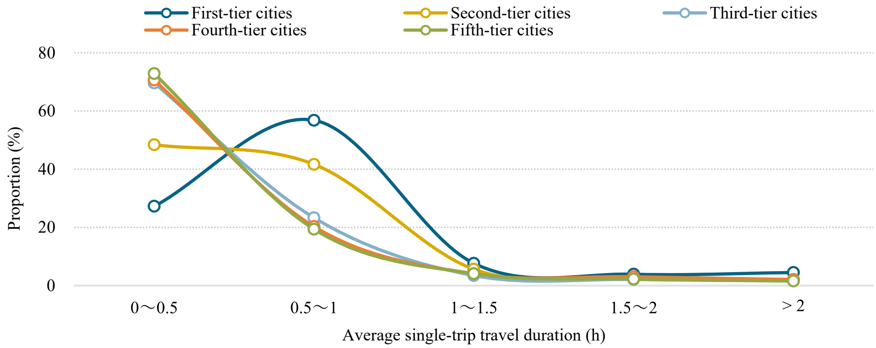


Fig. 4.7 Distribution of private cars of average single-trip travel durations in 2021—by city tier

Table 4.5 Average single-trip mileage of private cars over the years

Year	2019	2020	2021
Average single-trip mileage (km)	13.15	11.44	14.43

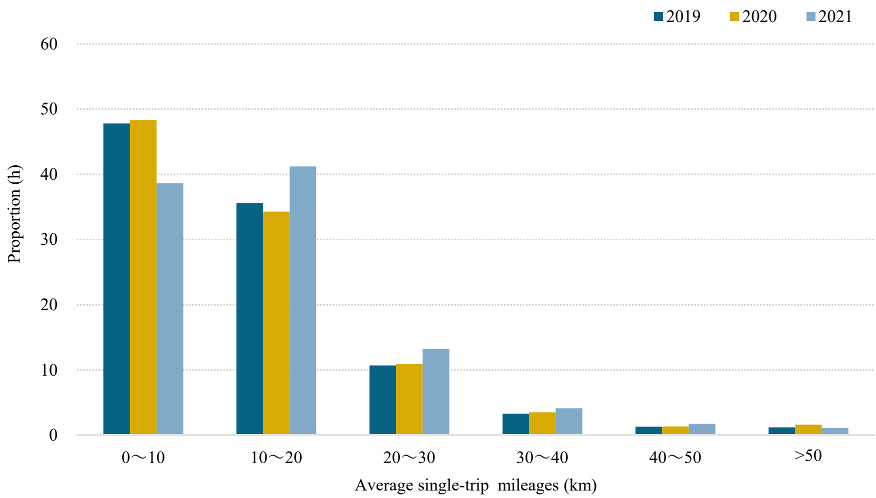


Fig. 4.8 Distribution of private cars of different average single-trip mileages—by year

reaching new highs (Fig. 4.8). Combining this data with the average single-trip travel duration, it can be concluded that the daily travel radius of private cars is gradually increasing.

The distribution of average single-trip mileage of private cars in first-tier and second-tier cities differs from that in other cities. From Fig. 4.9, the proportion of private cars with an average single-trip mileage of not more than 10 km in first-tier

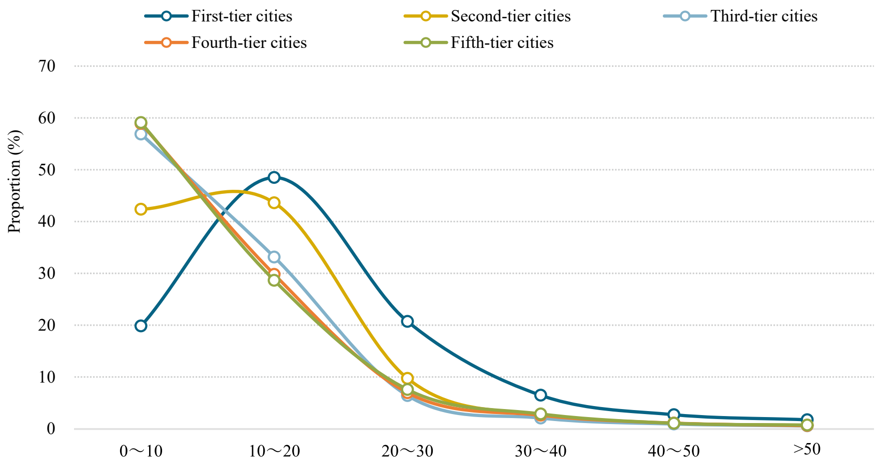


Fig. 4.9 Distribution of private cars of different average single-trip mileages in 2021—by city tier

cities in 2021 was the lowest, followed by second-tier cities, and the curves of third-tier and above cities were coincident, with the average single-trip mileage being more concentrated below 30 km.

The average single-trip speed of private cars is mainly 10–40 km/h; in 2021, it was 23.39 km/h.

The single-trip average speed of private cars in 2021 was 23.39 km/h, with a YoY decrease of 120.6% (Table 4.6). From Fig. 4.10, the average single-trip speed of private cars is mainly in the range of 10–40 km/h. In 2021, the proportion of private cars with an average single-trip speed of 10–30 km/h was 86.1%, and that of cars with low speeds continued to increase compared with 2019 and 2020.

2. **Average daily travel characteristics of private cars**

The average daily travel duration of private cars has shown an increasing trend in the past three years, with an increase of 5.1% compared with last year.

Private cars' average daily travel duration has been maintained at about 1.6 h, with a slow increase in the past three years. The average daily travel duration of private cars in 2021 was 1.66 h, 7.8%, and 5.1% higher than that in 2019 and 2020, respectively (Table 4.7; Fig. 4.11).

The proportion of the monthly average of private cars with an average daily travel duration of more than 2 h in 2021 was proliferating. From the distribution of the average daily travel duration of private cars over the years (Fig. 4.12), the proportion

Table 4.6 Average single-trip speed of private cars-average

Year	2019	2020	2021
Average single-trip speed (km/h)	26.39	29.46	23.39

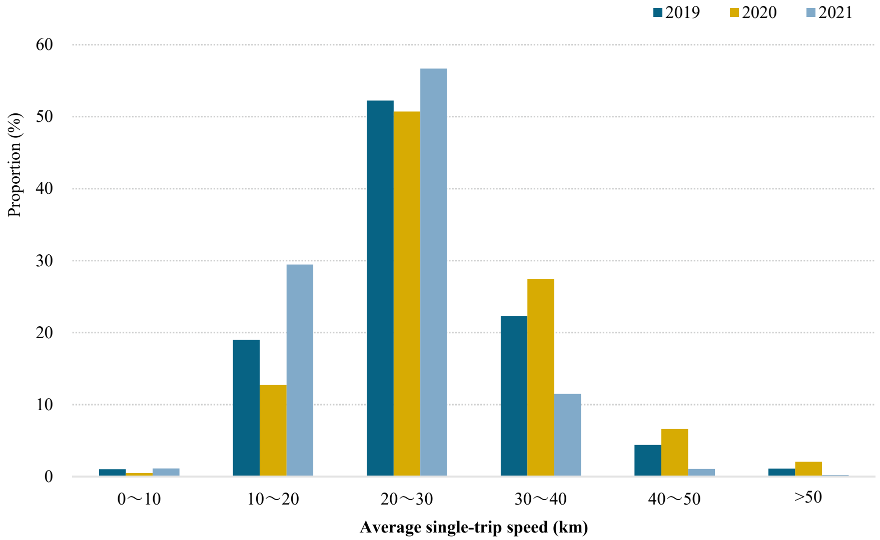


Fig. 4.10 Distribution of private cars of different average single-trip speeds—by year

Table 4.7 Average daily travel duration of private cars-average

Year	2019	2020	2021
Average daily travel duration (h)	1.54	1.58	1.66

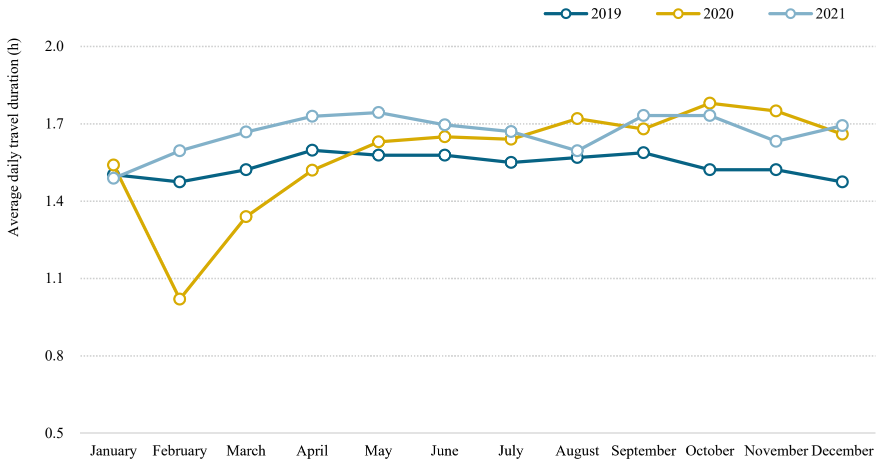


Fig. 4.11 Monthly average of average daily travel duration of private cars over the years

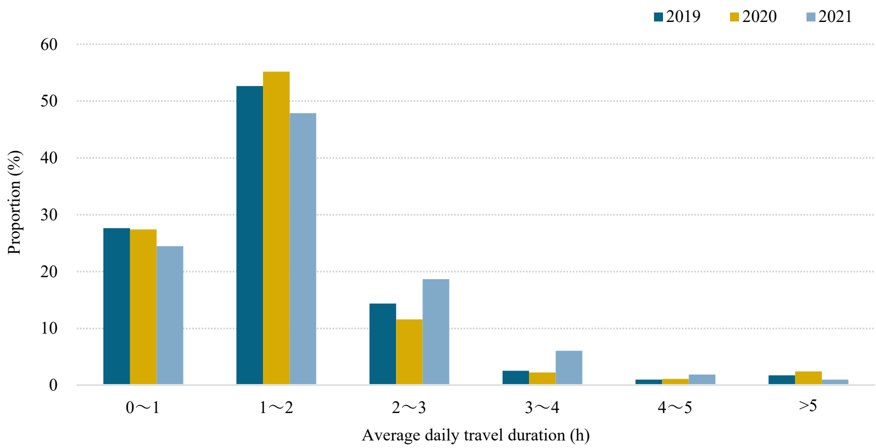


Fig. 4.12 Distribution of private cars of different average daily travel durations—by year

of private cars with an average daily travel duration of more than 2 h in 2021 accounted for 27.6%, with a significant increase compared with 2019 and 2020.

The overall level of average daily mileage of private cars in 2021 was higher than that in previous years.

According to the data (Table 4.8), in 2021, the average daily mileage of private cars was 46.25 km, with a YoY increase of 1.14%, higher than the average level of the past two years.

The distribution (Fig. 4.13) shows that the average daily mileage of private cars is concentrated in the 10–50 km range. The YoY increase of vehicles with an average daily mileage of more than 20 km in 2021 was relatively significant, indicating an increase in the proportion of vehicles traveling between medium and long distances.

From Fig. 4.14, the average daily mileage of private cars in first-tier cities is significantly higher than that in cities of other tiers. The proportion of private cars with an average daily mileage of more than 40 km in first-tier cities accounts for 45.6%, while that in cities of other tiers accounts for the highest proportion of 34.6%, which indicates that the urban size of first-tier cities has a certain impact on travel intensity.

The driving time of private cars exhibits a "double-peak" characteristic, and currently, the primary use is still commuting.

As the distribution shows (Fig. 4.15), the traffic of private cars mainly peaks at two-time points, namely 7:00 and 17:00. During the morning rush hours, the traffic of private cars climbed rapidly after 6:00, especially from 7:00 to 8:00, and reached

Table 4.8 Average daily mileage of private cars

Year	2019	2020	2021
Average daily mileage (km)	42.00	45.73	46.25

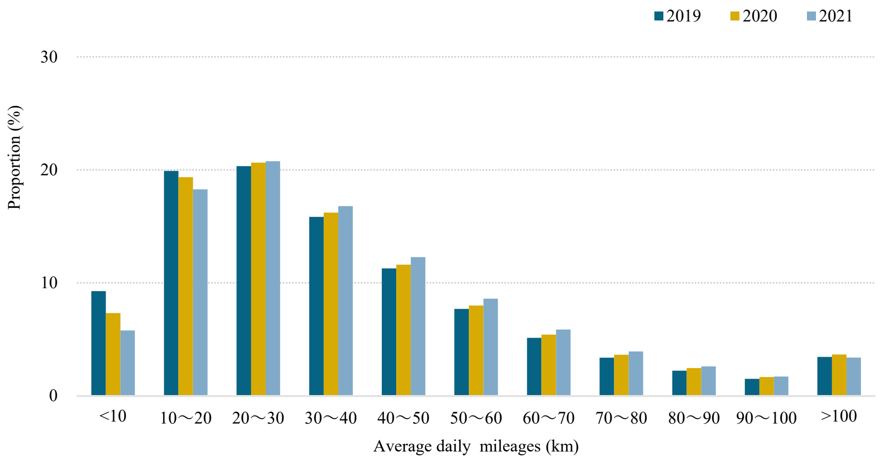


Fig. 4.13 Distribution of private cars of average daily mileage—by year

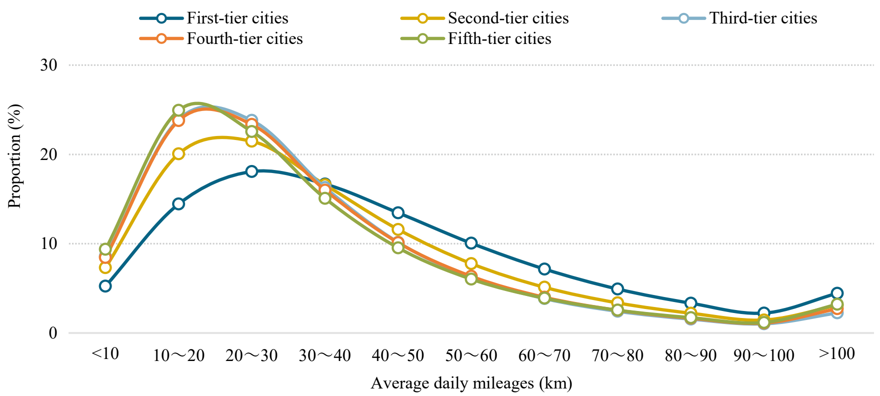


Fig. 4.14 Distribution of private cars of average daily mileage in 2021—by city tier

the peak at 8:00 in 2021; during the evening rush hour, the traffic of private cars is mainly concentrated between 16:00 and 18:00, and the proportion of vehicle travel volume to the total daily volume had been over 23% in the past three years.

The travel patterns in cities at all tiers are mostly consistent (Fig. 4.16), all concentrated in the morning and evening commuting peak hours, indicating that the primary use of new energy private cars in cities at all tiers is commuting.

3. **Average monthly travel characteristics of private cars**

In 2021, the average monthly travel days of private cars had been increasing yearly, with a relatively high proportion of travel for more than 20 days per month.

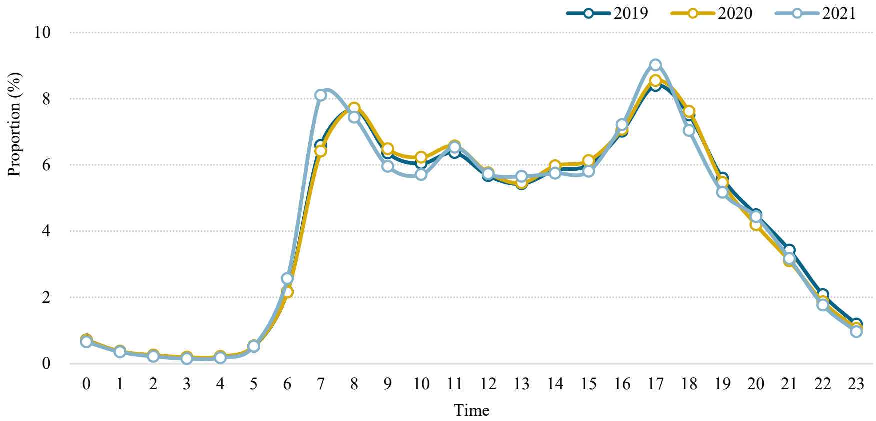


Fig. 4.15 Distribution of private cars based on different driving times

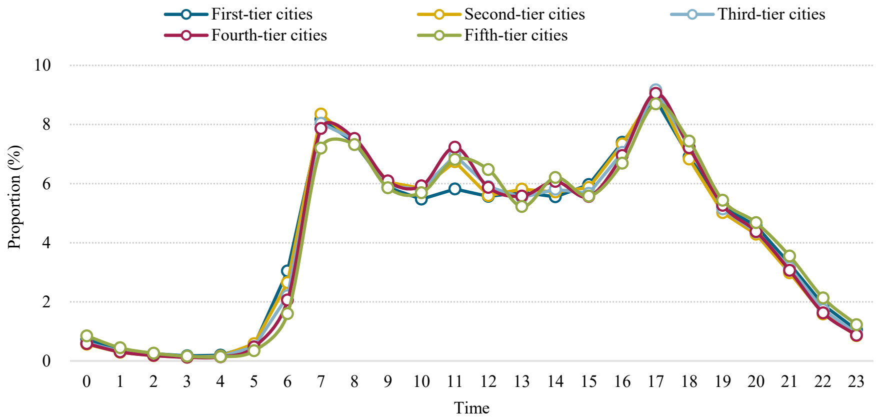


Fig. 4.16 Distribution of driving times of private cars in 2021—by city tier

According to the average monthly travel days of private cars over the years, users' dependence on new energy private cars has steadily increased. As shown in Table 4.9, the average monthly travel days in 2021 were 19.42, 3.80 days, and 0.74 days more than that in 2019 and 2020, respectively.

As the distribution shows (Fig. 4.17), the proportion of private cars with average monthly travel days above 25 in 2021 was the highest, significantly increasing. The

Table 4.9 Average monthly travel days of private cars-average

Year	2019	2020	2021
Average monthly travel days (day)	15.62	18.68	19.42

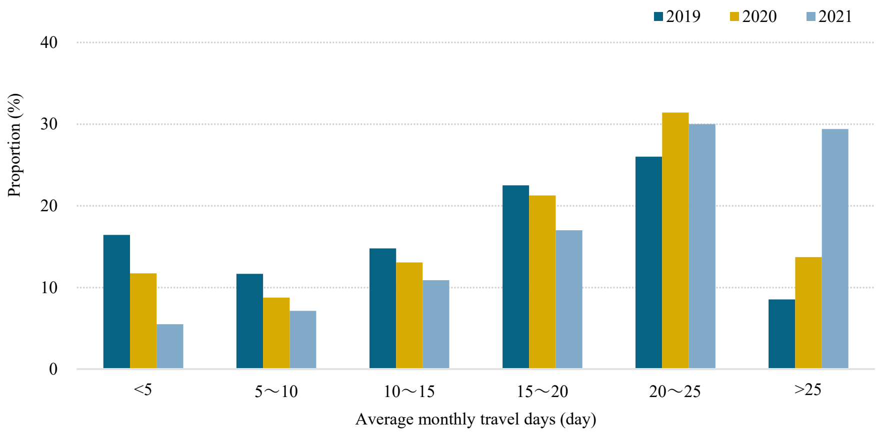


Fig. 4.17 Distribution of private cars of different average monthly travel days—by year

Table 4.10 Average monthly mileage of private cars-average

Year	2019	2020	2021
Average monthly mileage (km)	733.84	918.54	921.70

significant increase in the average monthly travel days of private cars indicates that new-energy passenger cars are increasingly recognized in private applications, and the proportion of users using new-energy private cars as family vehicles is increasing.

In 2021, the average monthly mileage of private cars was 921.70 km, with an increase of 0.34% compared with last year (Table 4.10).

As the distribution shows (Fig. 4.18), the proportion of private cars with average monthly mileage of less than 1000 km is the majority, but with a slight decrease compared with the past two years. The proportion of private cars with average monthly mileage of 1000–3000 km had increased from 22.80% in 2019 to 29.60% in 2021.

4.2.2 Operation Characteristics of E-taxis

1. **Average daily travel characteristics of e-taxis**

The daily travel duration of e-taxis in 2021 was 6.34 h, slightly decreasing compared with 2020.

In the past two years, the average daily travel duration of e-taxis had been maintained at about 6 h. In 2021, the average daily travel duration of e-taxis was 6.34 h (Table 4.11), slightly higher than that in 2020.

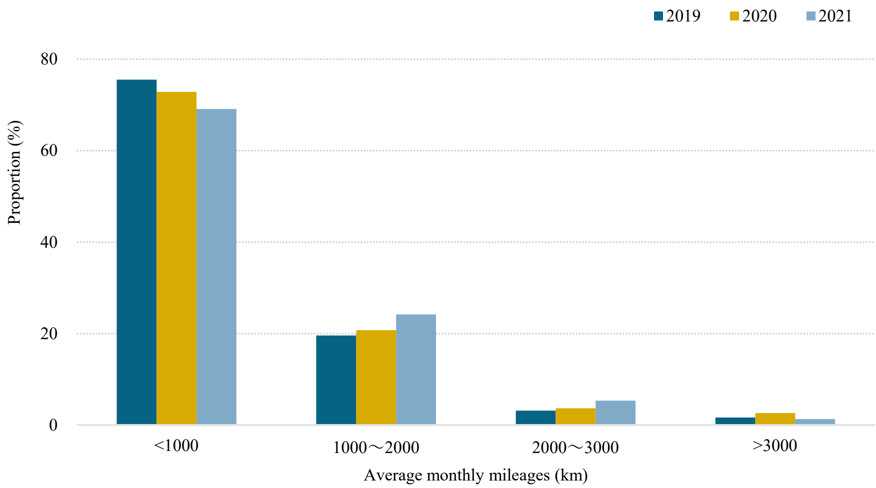


Fig. 4.18 Distribution of private cars of different average monthly mileages—by year

Table 4.11 Average daily travel duration of e-taxis-average

Year	2019	2020	2021
Average daily travel duration (h)	6.99	6.10	6.34

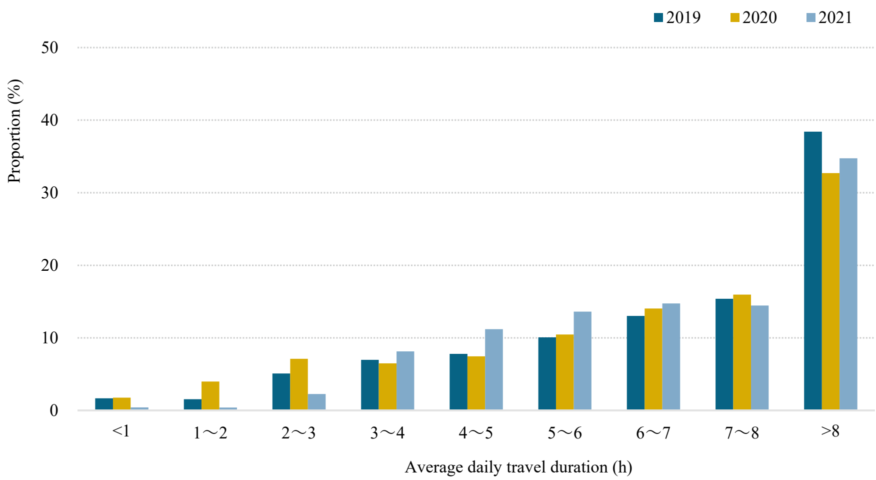


Fig. 4.19 Distribution of e-taxis of different average daily travel durations—by year

As the distribution shows (Fig. 4.19), the proportion of e-taxis with an average daily travel duration of more than 8 h in 2021 was the highest, at 34.75%.

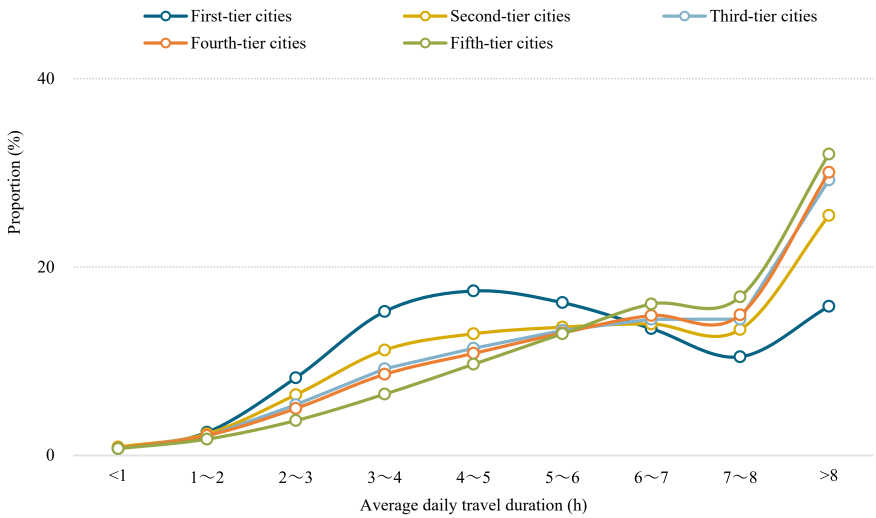


Fig. 4.20 Distribution of e-taxis of different average daily travel durations in 2021—by city tier

From Fig. 4.20, the proportion of e-taxis with an average daily travel duration of over 6 h in first-tier cities is lower than that in cities of other tiers.

The average daily mileage of e-taxis is mainly 100–250 km, highlighting the characteristics of commercial operation. New energy passenger cars are recognized for their economy and convenience when used as e-taxis.

According to the data over the years, the average daily mileage of e-taxis was 168.56 km in 2021, with an increase of 0.78% and 6.81%, respectively, compared with 2019 and 2020 (Table 4.12). According to the monthly change of average daily mileage over the years (Fig. 4.21), the online rate of e-taxis in 2021 was significantly higher than that in 2020, and users' willingness to share travel significantly improved.

The average daily mileage of e-taxis is mainly 100–250 km (Fig. 4.22), accounting for 84.78%. This mileage range mostly conforms to the travel characteristics of commercial vehicles, indicating that new energy passenger cars are recognized for their economy and convenience when used as e-taxis.

The proportion of average daily mileage of e-taxis in the first-tier and second-tier cities is larger in the low mileage range (Fig. 4.23), and the proportion of cities of other tiers in the high mileage range is relatively larger, and the distribution curve is mostly the same.

The driving time of e-taxis is mainly 7:00–21:00, and the driving time distribution is mostly the same each year.

Table 4.12 Average daily mileage of e-taxis-average

Year	2019	2020	2021
Average daily mileage (km)	167.25	157.81	168.56

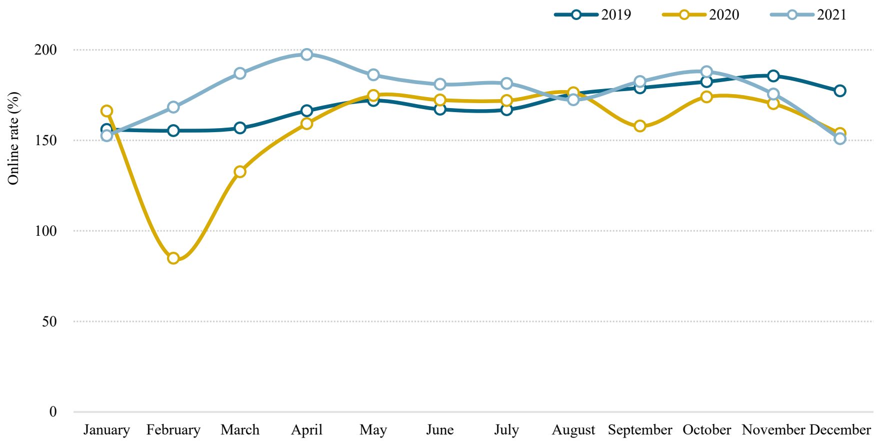


Fig. 4.21 Monthly average of average daily mileage of e-taxis over the years

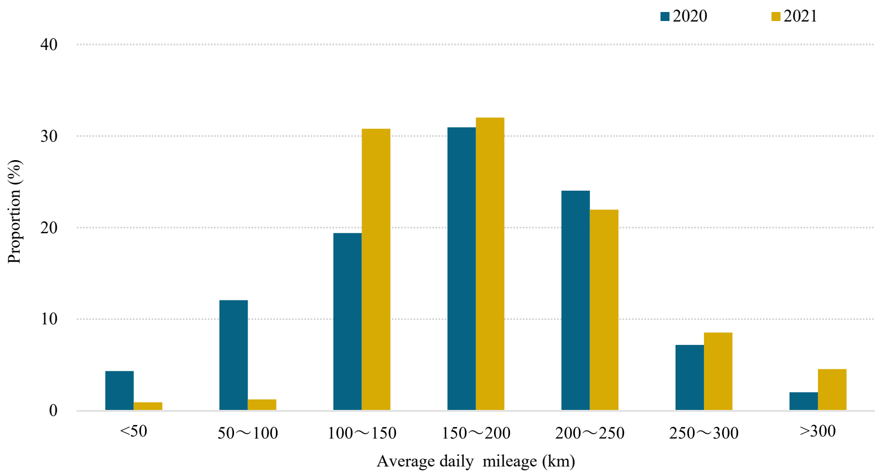


Fig. 4.22 Distribution of e-taxis of different average daily mileages—by year

According to the distribution of driving time (Fig. 4.24), the driving time of e-taxis is mainly 7:00–21:00. In 2021, the proportion of early travel in the morning rush hours was slightly higher than that in previous years, and the proportion of travel between 6:00 and 8:00 was significantly higher than that in 2019 and 2020.

2. **Average monthly travel characteristics of e-taxis**

The average monthly travel days of the e-taxis market are increasing yearly, and in 2021, it was 24.6, which is 3 days more than that in 2020.

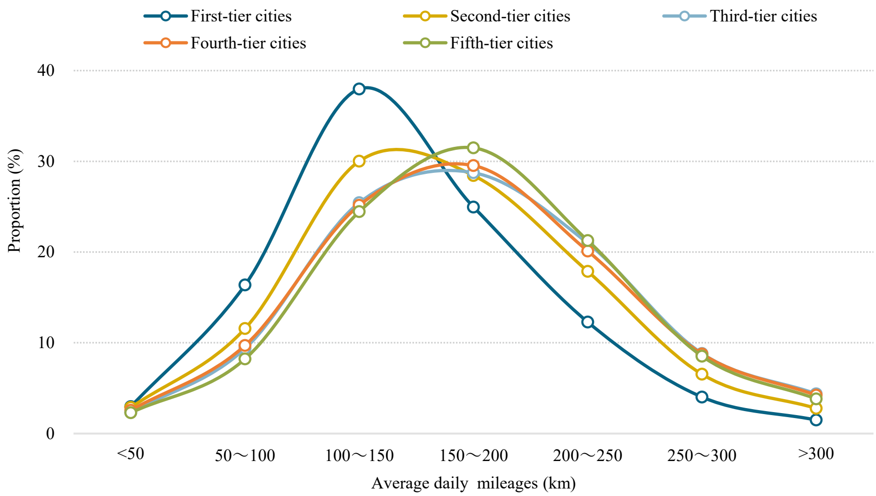


Fig. 4.23 Distribution of e-taxis of different average daily mileages in 2021—by city tier

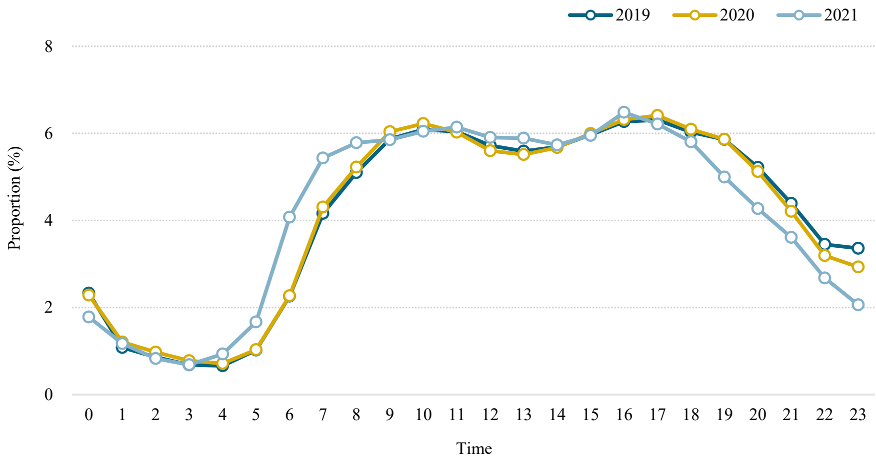


Fig. 4.24 Distribution of e-taxis of different driving times—by year

In the past three years, the average monthly travel days of e-taxis have increased yearly. Specifically, in 2021, the average monthly travel days of e-taxis was 24.60 days, which is 3.83 days and 3 days more than that in 2019 and 2020, respectively (Table 4.13).

In 2021, the proportion of e-taxis with average monthly travel days of more than 25 was 43.32%, close to total attendance. On the one hand, it shows that the market demand for e-taxis is strong, and on the other hand, it shows that the performance

Table 4.13 Average monthly travel days of e-taxis-average

Year	2019	2020	2021
Average monthly travel days (day)	20.77	21.6	24.60

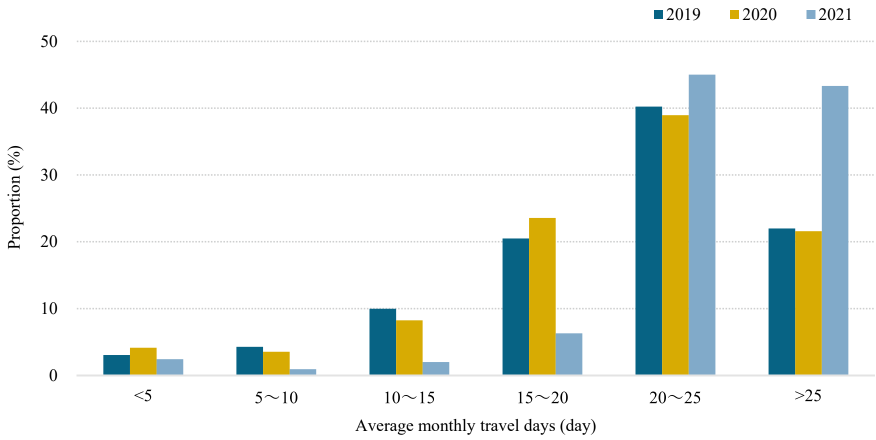


Fig. 4.25 Distribution of e-taxis of different average monthly travel days—by year

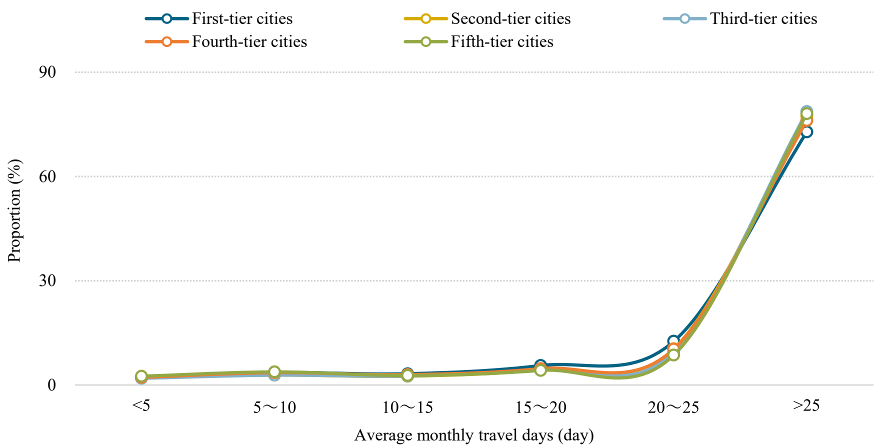


Fig. 4.26 Distribution of e-taxis of different average monthly travel days in 2021—by city tier

of new energy e-taxis can meet the operational demand (Fig. 4.25); the overall trend of the proportion distribution of average monthly travel days in cities of all tiers is consistent (Fig. 4.26).

In 2021, the average monthly mileage of e-taxis increased significantly by 19.1% compared with last year.

Table 4.14 Average monthly mileage of e-taxis-average

Year	2019	2020	2021
Average monthly mileage (km)	3854.08	3580.24	4265.16

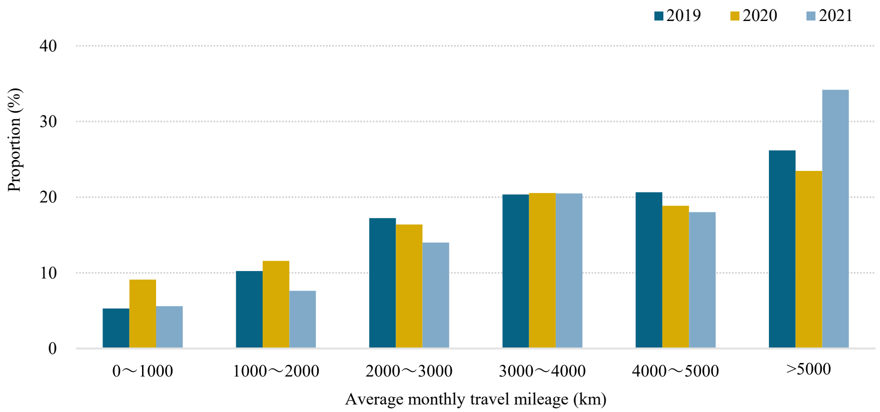


Fig. 4.27 Distribution of e-taxis of different average monthly mileages—by year

According to the data over the years (Table 4.14), the average monthly mileage of e-taxis in 2021 was 4265.16 km, which is 19.13% higher than that in 2020, and still 10.67% higher than that in 2019.

As the distribution shows (Fig. 4.27), the proportion of e-taxis with average monthly mileage of more than 5000 km in 2021 increased significantly, from 23.5% in 2020 to 34.2% in 2021.

From Fig. 4.28, the proportion of e-taxis with an average monthly mileage of more than 5000 km in first-tier cities accounted for 29.15%; the proportion of e-taxis with an average monthly mileage of more than 5000 km in second, third, and fourth and fifth-tier cities was 38.48%, 42.00%, 40.33% and 41.54% respectively, indicating that the proportion of e-taxis for long-distance travel is significantly higher than that in first-tier cities.

4.2.3 Operation Characteristics of Taxis

1. **Average daily travel characteristics of taxis**

The average daily travel duration of taxis in 2021 gradually returned to normal, with a significant increase compared with 2020.

In the past three years, the average daily travel duration of taxis exceeded 7 h, and in 2020, it was only 8.17 h, increasing by 11.01% compared with 2020 (Table 4.15).

Fig. 4.28 Distribution of e-taxis of different average monthly mileages in 2021—by city tier

Table 4.15 Average daily travel duration of taxis-average

Year	2019	2020	2021
Average daily travel duration (h)	8.82	7.36	8.17

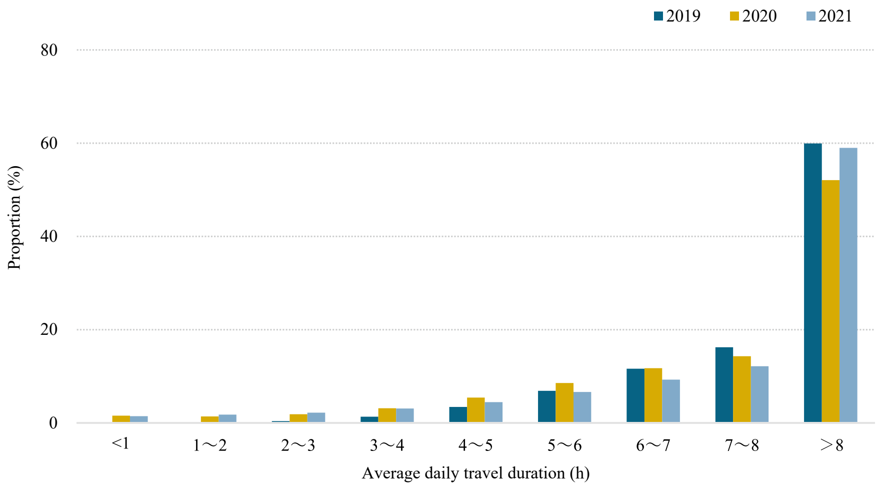


Fig. 4.29 Distribution of taxis of different average daily travel durations—by year

As the distribution shows (Fig. 4.29), the proportion of taxis with an average daily travel duration of more than 8 h increased from 52.06% in 2020 to 58.98% in 2021.

In 2021, taxi operations gradually entered the right track, with an increase in daily mileage compared with 2020.

According to the data over the years, the average daily mileage of taxis in 2021 was 201.88 km, with an increase of 8.27% compared with 2020 (Table 4.16).

According to the monthly changes in average daily mileage over the years (Fig. 4.30), the daily travel of taxis in 2021 mostly remained at the same level as in 2019, and the monthly average daily mileage remained around 200 km, showing a significant improvement compared with the first half of 2020.

As the distribution shows (Fig. 4.31), the proportion of taxis with an average daily mileage of more than 200 km in 2021 was mostly the same as in 2020, at 44.18%.

In 2021, the proportion of taxis with an average daily mileage of 150–250 km in second-tier cities was higher than that in cities of other tires, accounting for 24.67% and 27.69%, respectively; the proportion of taxis with an average daily mileage of more than 250 km in fifth-tier cities was relatively high, possibly due to better traffic conditions and relatively higher average daily mileage (Fig. 4.32).

In 2021, taxis arrived significantly ahead of schedule during morning rush hours, and the proportion of taxis traveling from 5:00 to 8:00 the next day was higher than that in the previous two years.

According to the distribution of driving time of taxis (Fig. 4.33), the driving time of taxis is mainly 6:00–19:00. In 2021, taxis arrived significantly ahead of schedule during morning rush hours, and the proportion of taxis traveling from 5:00 to 8:00 the next day was higher than that in 2019 and 2020.

Table 4.16 Average daily mileage of taxis-average

Year	2019	2020	2021
Average daily mileage (km)	210.07	186.46	201.88

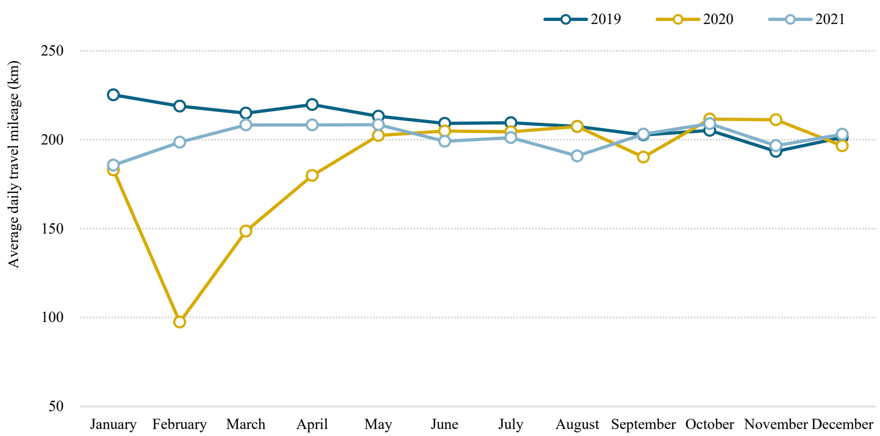


Fig. 4.30 Monthly average of average daily mileage of taxis over the years

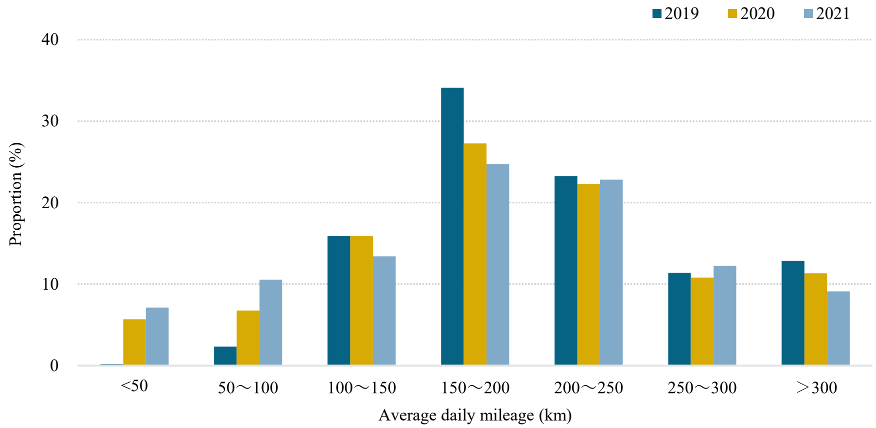


Fig. 4.31 Distribution of taxis of different average daily mileages—by year

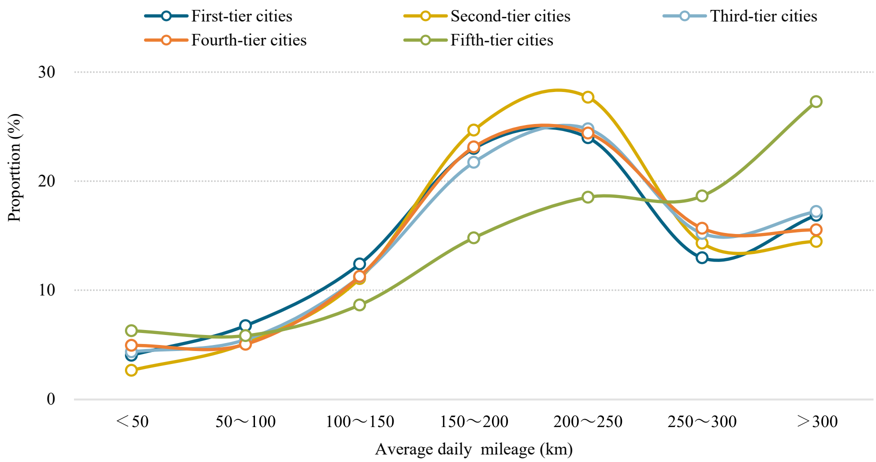


Fig. 4.32 Distribution of taxis of different average daily mileages in 2020—by city tier

2. **Average monthly travel characteristics of taxis**

The average monthly travel days of taxis are mainly 20 + , with an increase in travel days in 2021.

According to the data over the years, the average travel days of taxis in 2021 was 24.91, with a YoY decrease of 11.80% (Table 4.17).

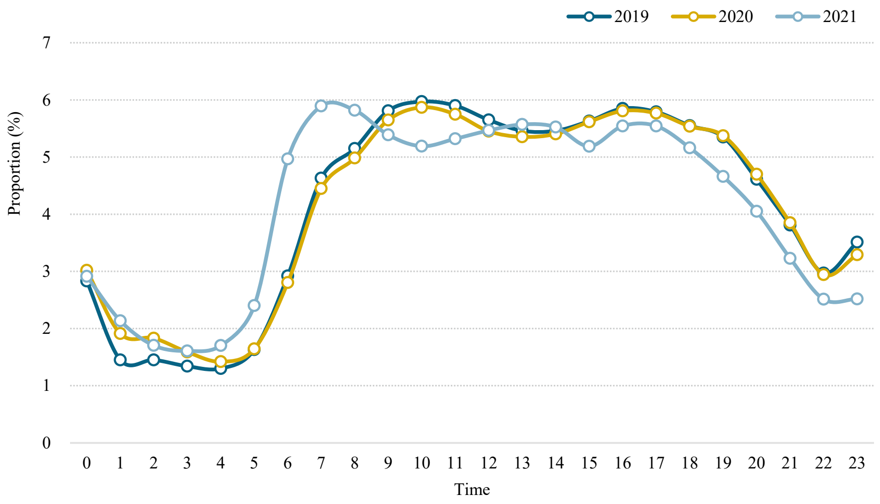


Fig. 4.33 Distribution of taxis of different driving times—by year

Table 4.17 Average monthly travel days of taxis-average

Year	2019	2020	2021
Average monthly travel days (day)	23.07	22.28	24.91

Taxis' average monthly travel days are mainly 20 + (Fig. 4.34). In 2021, the proportion of taxis with an average monthly travel day of more than 25 was 49.33%, a significant increase close to the number of fuel taxis.

The average monthly mileage of taxis in 2021 was 4838.73 km, with an increase of 16.3% compared with 2020 (Table 4.18).

As the distribution shows (Fig. 4.35), the proportion of taxis with an average monthly mileage of more than 5000 km in 2021 was 48.04%, with an increase of 2.07% and 10.45%, respectively, compared with 2019 and 2020. On the one hand, the increase in average monthly mileage is due to the normalization of COVID-19 outbreak control and the increased intensity of user-shared travel. On the other hand, new energy taxis are gradually getting on track due to the rationalization of charging and swapping devices and vehicle matching.

4.2.4 Operation Characteristics of Cars for Sharing

1. **Average single-trip travel characteristics of cars for sharing**

In 2021, the average single-trip travel duration of cars for sharing significantly increased, and users' willingness to travel significantly increased.

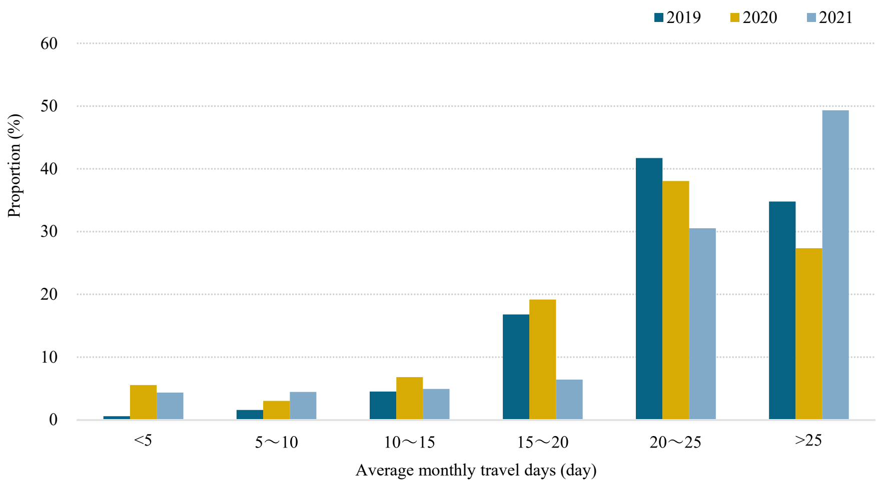


Fig. 4.34 Distribution of taxis of different average monthly travel days—by year

Table 4.18 Average monthly mileage of taxis-average

Year	2019	2020	2021
Average monthly mileage (km)	5154.38	4159.89	4838.73

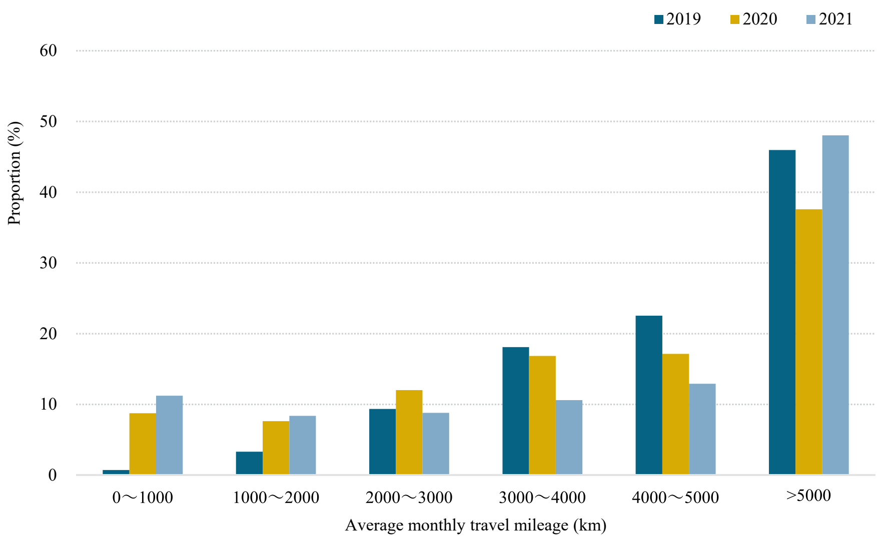


Fig. 4.35 Distribution of taxis of different average monthly mileages—by year

According to the data over the years, the average single-trip travel duration of cars for sharing reached 0.92 h in 2021, with an increase of 0.26 h and 0.34 h compared with 2019 and 2020 (Table 4.19), respectively, indicating a significant increase in average single-trip travel duration. From the distribution of average single-trip travel duration of cars for sharing (Fig. 4.36), the proportion of cars for sharing with an average single-trip travel duration of more than 1 h in 2021 was 45.33%, with a significant increase compared with previous years.

The distribution of travel duration in first-tier cities is relatively scattered (Fig. 4.37), and compared with cities of other tiers, the demand for long-term travel is higher.

The average single-trip mileage of cars for sharing has steadily increased, with a YoY increase of 39.4% in 2021.

According to the data over the years (Table 4.20), in 2021, the single-trip mileage of cars for sharing was 29.07 km, with an increase of 39.42% compared with 2020. From 2019 to 2021, the average single-trip mileage of cars for sharing shifted towards high mileage distribution, and the proportion of cars for sharing with an average single-trip mileage of more than 20 km in 2021 was nearly 50% (Fig. 4.38).

The average single-trip mileage has a significant reference value for the distribution of parking points and charging and swapping facilities for cars for sharing. The proportion of cars for sharing with an average single-trip mileage of more than

Table 4.19 Average single-trip travel duration of cars for sharing-average

Year	2019	2020	2021
Average single-trip travel duration (h)	0.66	0.58	0.92

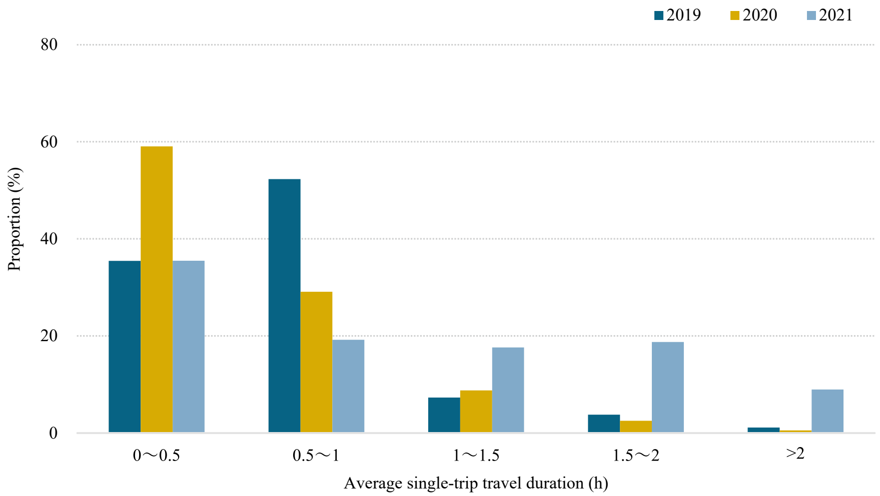


Fig. 4.36 Distribution of cars for sharing of different average single-trip travel durations—by year

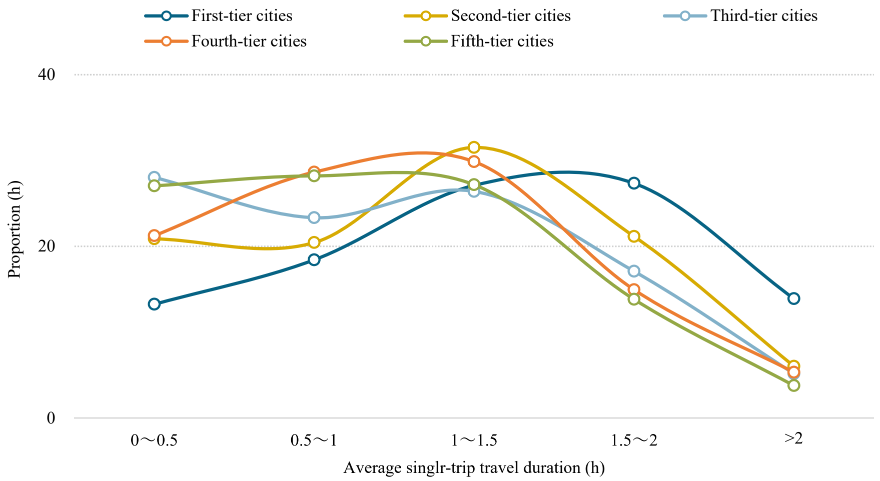


Fig. 4.37 Distribution of cars for sharing of different average single-trip travel durations in 2021—by city tier

Table 4.20 Average single-trip mileage of cars for sharing-average

Year	2019	2020	2021
Average single-trip mileage (km)	18.32	20.85	29.07

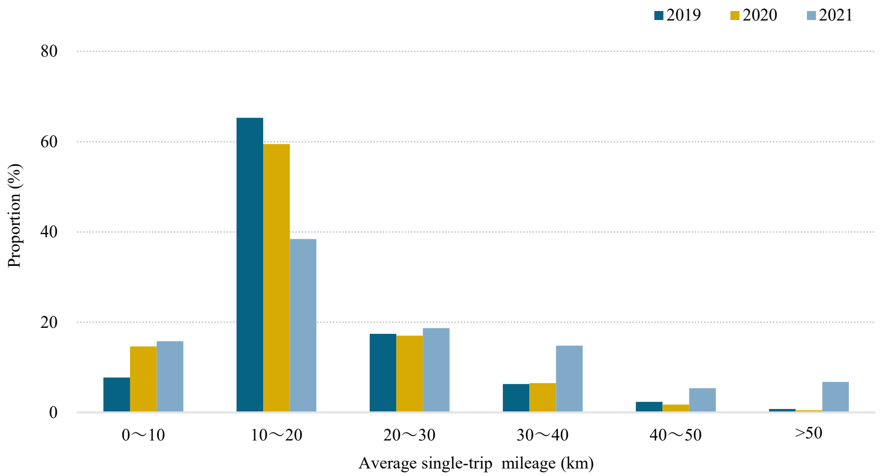


Fig. 4.38 Distribution of cars for sharing of different average single-trip mileages—by year

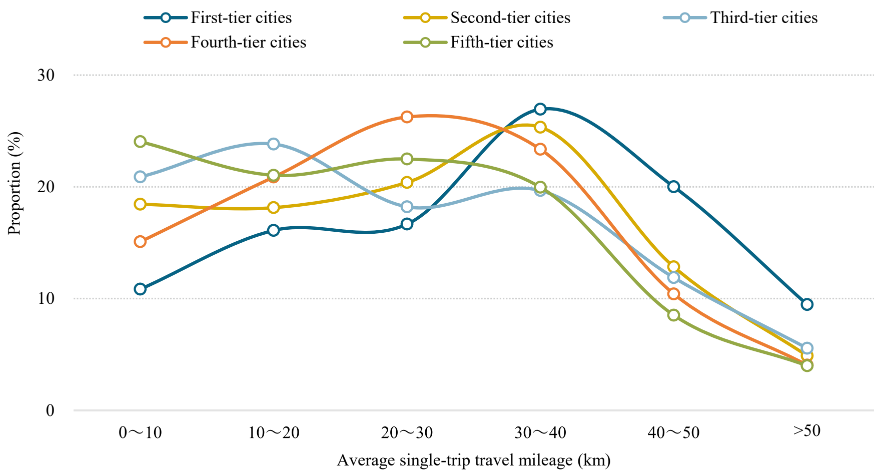


Fig. 4.39 Distribution of cars for sharing of different average single-trip mileages in 2021—by city tier

30 km in first-tier cities reaches 56.4%, which is higher than that in cities of other tiers (Fig. 4.39).

In 2021, the average single-trip speed of cars for sharing was 24.06 km/h, with a decrease of 21.3% compared with 2020.

In 2021, the average single-trip speed of cars for sharing was 24.06 km/h, with a YoY decrease of 21.3% (Table 4.21). Meanwhile, the proportion of cars sharing with an average single-trip speed of less than 30 km/h increased from 55.7% in 2020 to 90.9% in 2021 (Fig. 4.40). Overall, it can be preliminarily concluded that the traffic congestion in cities with newly added cars for sharing in 2021 was relatively severe, or that the designated networks are mainly concentrated in areas with relatively congested urban centers.

2. **Average daily travel characteristics of cars for sharing**

In 2021, the average daily travel duration of cars for sharing was 5.06 h, with a significant increase compared with previous years.

In 2021, the average daily travel duration of cars for sharing was 5.06 h, significantly increasing compared with 2019 and 2020 (Table 4.22). In 2021, the timeshare rental market for short-distance travel was gradually shrinking, with the shared rental market mainly focusing on monthly rentals or long-distance travel during holidays.

From the monthly average daily travel duration over the years (Fig. 4.41), it can be seen that the average daily travel duration in winter is the shortest, which is related to

Table 4.21 Average single-trip speed of cars for sharing-average

Year	2019	2020	2021
Average single-trip speed (km/h)	28.65	30.56	24.06

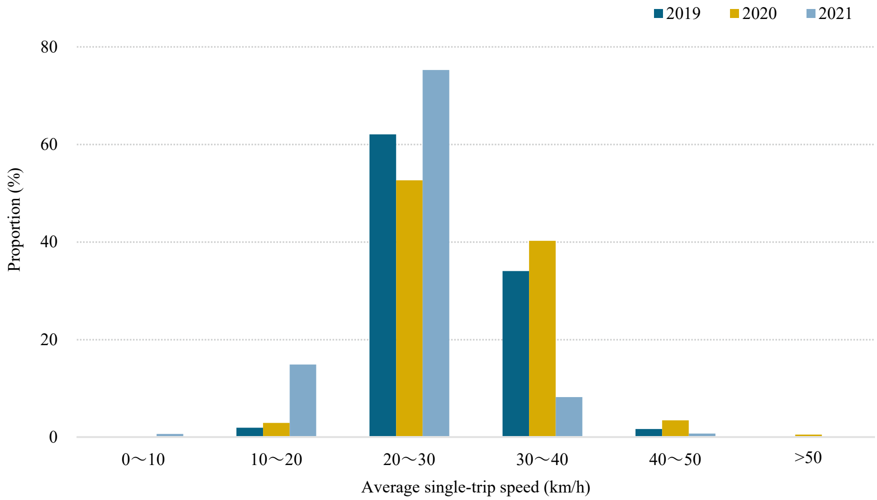


Fig. 4.40 Distribution of cars for sharing of different average single-trip speeds—by year

Table 4.22 Average daily travel duration of cars for sharing-average

Year	2019	2020	2021
Average daily travel duration (h)	2.78	2.74	5.06

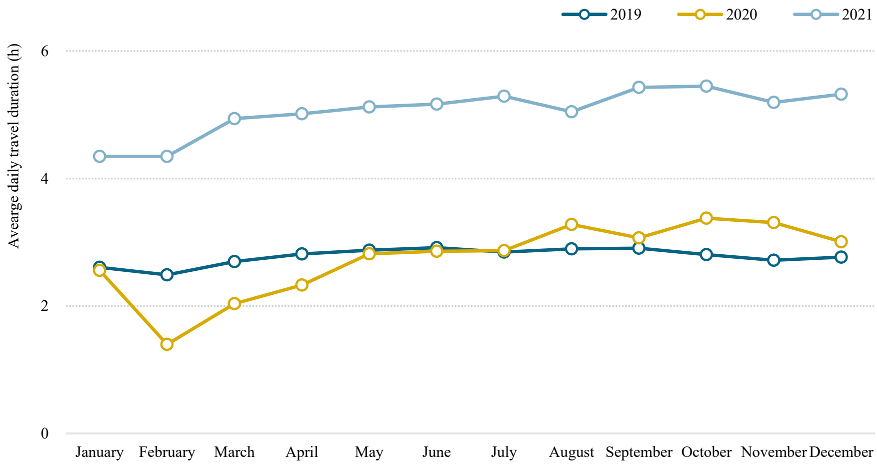


Fig. 4.41 Monthly average of average daily travel duration of cars for sharing over the years

the combined factors of holidays and reduced battery performance in winter. Starting from March 2021, the average daily travel duration of cars for sharing is close to 5 h, stabilizing at more than 5 h.

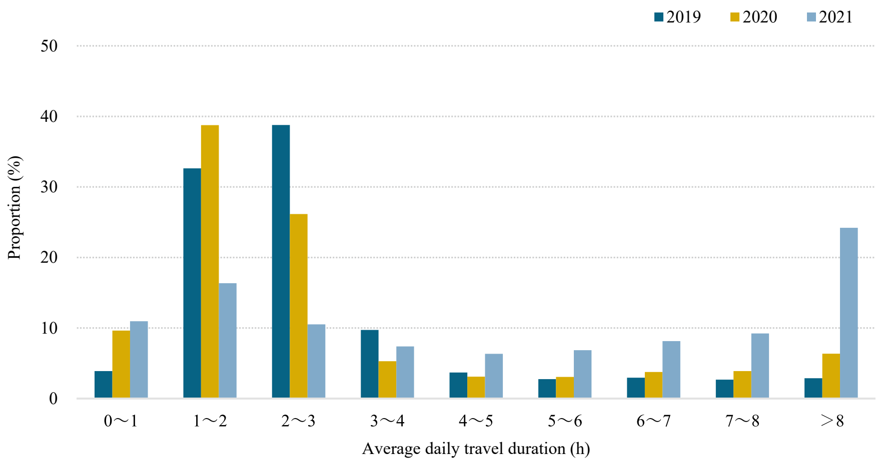


Fig. 4.42 Distribution of cars for sharing of different average daily travel durations—by year

In 2021, the average daily travel duration of cars for sharing was more concentrated in the distribution segments of 1–2 h and above 8 h (Fig. 4.42), indicating that the operation of cars for sharing was concentrated at two distance segments. This phenomenon suggests that operating enterprises should focus on short-distance and long-distance travel regarding the reasonable network layout and user experience improvement.

The distribution of the average daily travel duration of cars for sharing in first-tier cities is somewhat different from cities of other tiers (Fig. 4.43), with each distribution segment relatively average, indicating that vehicle turnover and utilization are slightly better than cities of other tiers.

In 2021, the average daily mileage of cars for sharing was 123.96 km, and more and more car owners are using it for monthly rental or long-distance travel during holidays.

In the past three years, the average daily mileage of cars for sharing in China has increased yearly. In 2021, the average daily mileage of cars for sharing was 123.96 km, with a YoY increase of 24.4% (Table 4.23), but lower than the average daily mileage of taxis (201.88 km) and e-taxis (168.56 km). However, since taxis and e-taxis have no passengers during travel, cars for sharing do not have such a situation. If the daily mileage of cars for sharing can reach the level of e-taxis, it can be considered that the travel of cars for sharing is more efficient, with better operating economy under the same conditions.

As the distribution shows (Fig. 4.44), the proportion of cars for sharing with an average daily mileage of more than 150 km in 2021 was 40.56%, with an increase of 32.82% and 11.22% compared with 2019 and 2020, respectively. The daily mileage is gradually transitioning towards the high mileage range.

There is a significant difference in the distribution of average daily mileage of cars for sharing in first-tier cities compared with that in cities of other tiers (Fig. 4.45).

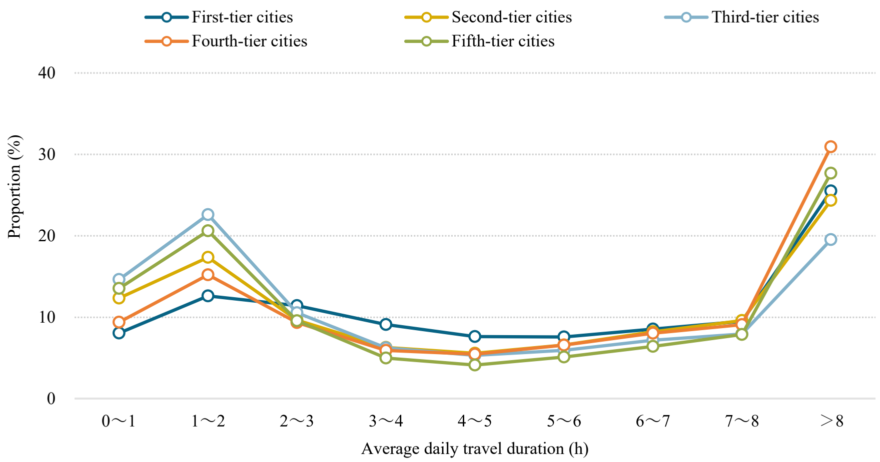


Fig. 4.43 Distribution of cars for sharing of different average daily travel durations in 2021—by city tier

Table 4.23 Average daily mileage of cars for sharing

Year	2019	2020	2021
Average daily mileage (km)	77.30	99.63	123.96

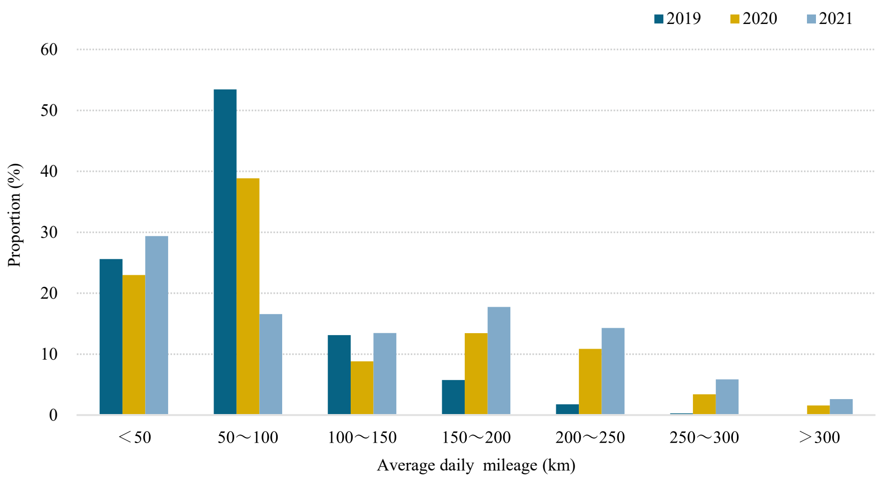


Fig. 4.44 Distribution cars for sharing of different average daily mileages—by year

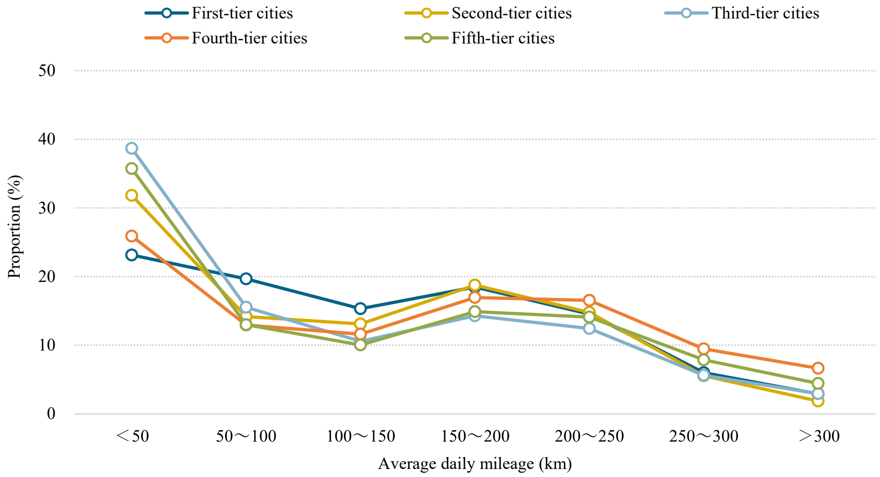


Fig. 4.45 Distribution cars for sharing of different average daily mileages in 2021—by city tier

The proportion of cars for sharing with an average daily mileage of 50 and 150 km in first-tier cities is relatively high, while that of 0–50 km in cities of other tiers is higher.

The proportion of cars for sharing traveling during morning rush hours and forenoon in 2021 was higher than that in 2019 and 2020.

From the distribution of driving time (Fig. 4.46), the driving time of cars for sharing is mainly concentrated during the day. In the past three years, the proportion of cars for sharing traveling during morning rush hours and forenoon has shown an increasing trend yearly. The distribution proportion of cars for sharing traveling between 5:00 and 8:00 in 2021 was significantly higher than that in previous years.

By city tier, the proportion of cars for sharing traveling during the day is relatively high in lower-tier cities; the proportion of cars for sharing traveling from 0:00 to 5:00 the next day in first-tier cities is 11.9%, slightly higher than that in cities of other tiers (Fig. 4.47).

3. **Average monthly travel characteristics of cars for sharing**

In 2021, the average monthly travel days of cars for sharing were 21.74, with an increase of 18% compared with last year (Table 4.24).

According to the data over the years (Fig. 4.48), the average monthly travel days of cars for sharing in 2021 exceeded 20, with a significant increase compared to 2019 and 2020.

As the distribution shows (Fig. 4.49), the proportion of cars for sharing with average monthly travel days of 15 or more increased significantly from 67.60% in 2020 to 73.83% in 2021.

The average monthly mileage of cars for sharing is increasing yearly.

In 2021, the average monthly mileage of cars for sharing was 3103.41 km, with a YoY increase of 18.8% (Table 4.25).

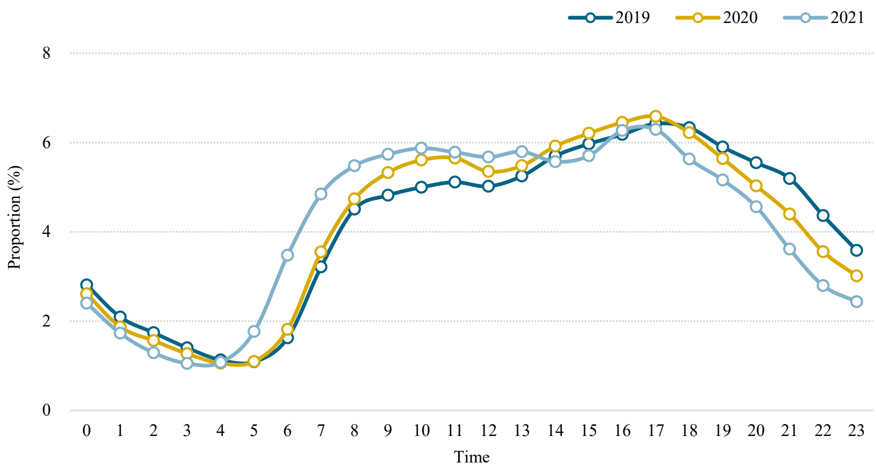


Fig. 4.46 Distribution of cars for sharing of different driving times—by year

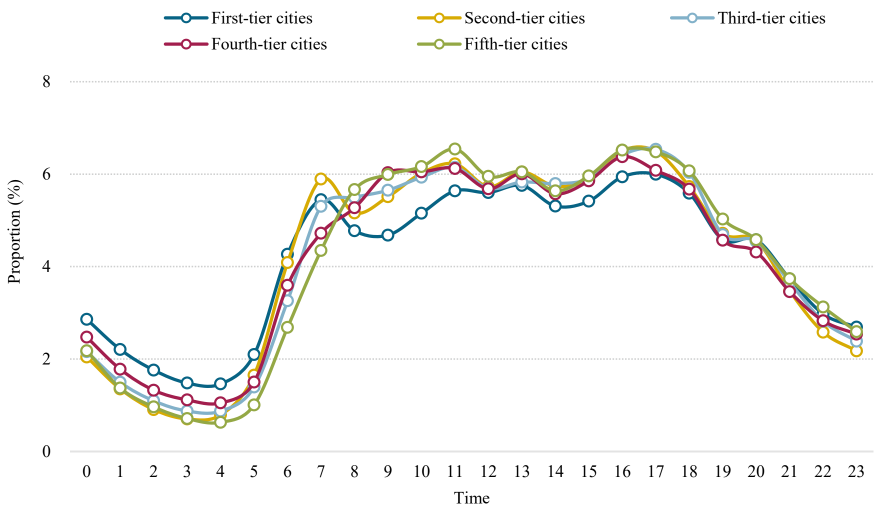


Fig. 4.47 Distribution of cars for sharing of different driving times in 2021—by city tier

Table 4.24 Average monthly travel days of cars for sharing-average

Year	2019	2020	2021
Average monthly travel days (day)	18.57	18.43	21.74

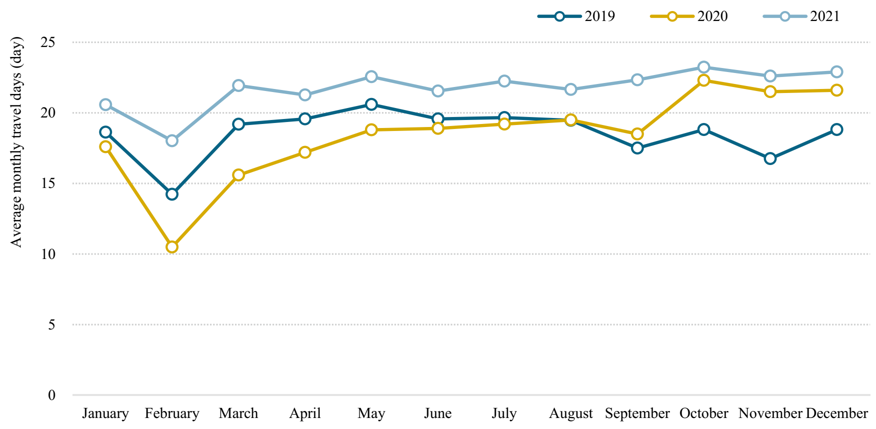


Fig. 4.48 Average monthly travel days of cars for sharing over the years

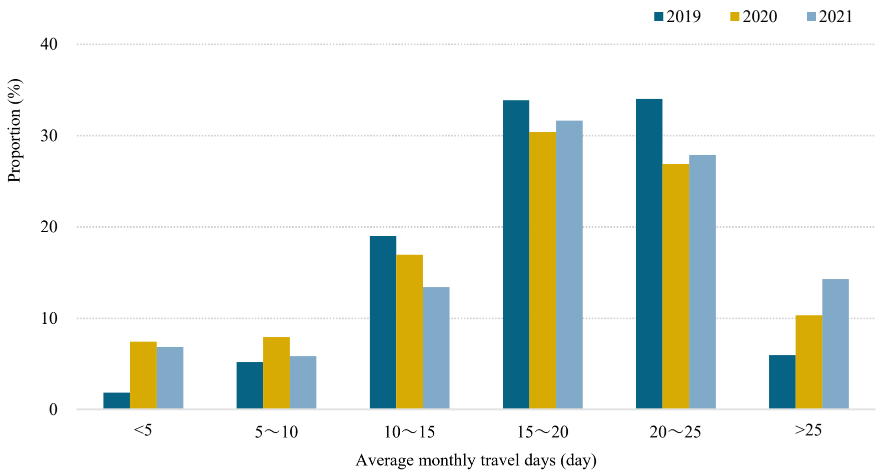


Fig. 4.49 Distribution of cars for sharing of different average monthly travel days—by year

Table 4.25 Average monthly mileage of cars for sharing-average

Year	2019	2020	2021
Average monthly mileage (km)	1582.7	2612.85	3103.41

As the distribution shows (Fig. 4.50), the proportion of cars for sharing with an average mileage of more than 3000 km increased from 28.31% in 2020 to 34.99% in 2021, with an increase of 6.68%, which is mostly in line with the current market situation of daily rental and long-term rental of cars for sharing.

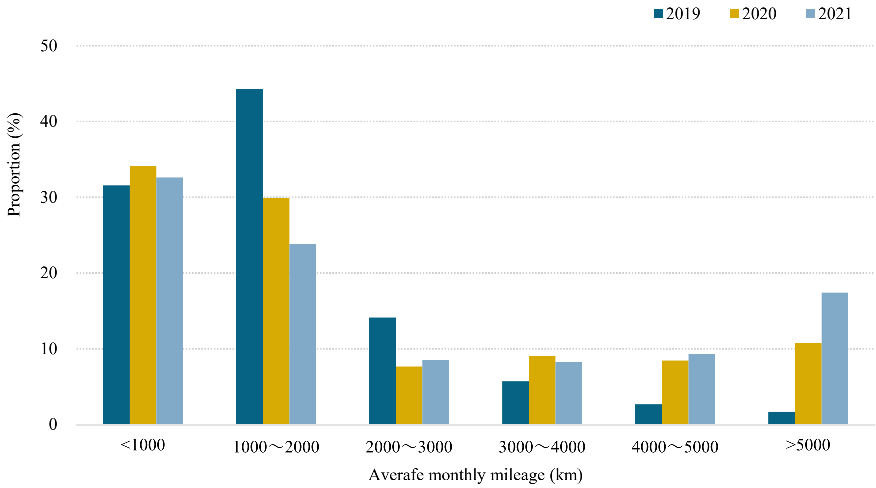


Fig. 4.50 Distribution of cars for sharing of different average monthly mileages—by year

4.2.5 Operation Characteristics of Logistics Vehicles

1. **Average single-trip travel characteristics of logistics vehicles**

The average single-trip travel duration of logistics vehicles in 2021 was 0.87 h, which is significantly improved compared with that in 2019 and 2020.

The average single-trip travel duration of logistics vehicles in 2021 significantly increased (Table 4.26), with an increase of 67.3% and 89.1% compared to 2019 and 2020, respectively. The average single-trip travel duration of logistics vehicles in each month in 2021 was higher than the same period in the past two years, and each month is relatively average without a significant trough, indicating that the use of new energy logistics vehicles is more conventional. In the past three years, logistics vehicles' average monthly mileage has rapidly grown. In 2021, logistics vehicles' average monthly mileage was 2270.33 km, with a YoY increase of 4.7% (Fig. 4.51).

As the distribution shows (Fig. 4.52), the proportion of logistics vehicles with an average single-trip travel duration of more than 1 h in 2021 was 30%, with a significant increase compared with that in 2019 and 2020.

The average single-trip mileage of logistics vehicles in 2021 was 18.96 km, which has increased compared with that in the past two years.

The average single-trip mileage of logistics vehicles has increased significantly compared with the past two years (Table 4.27). In 2021, logistics vehicles' monthly average single-trip mileage exceeded 18 km (Fig. 3.102), far higher than the same

Table 4.26 Average single-trip travel duration of logistics vehicles-average

Year	2019	2020	2021
Average single-trip travel duration (h)	0.52	0.46	0.87

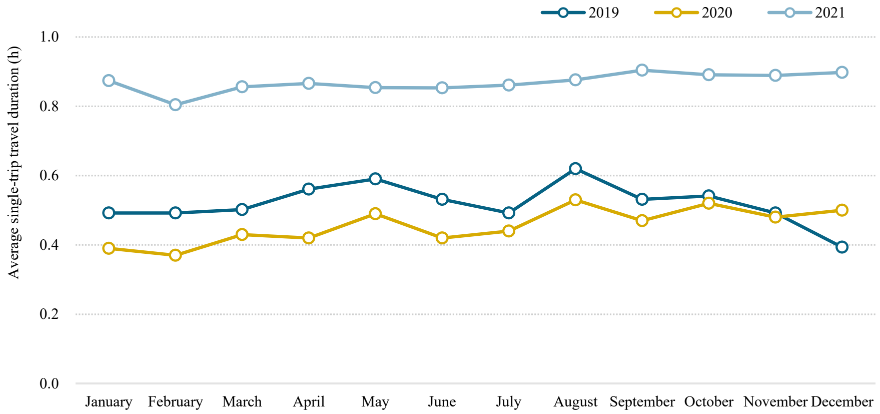


Fig. 4.51 Monthly average of average single-trip travel duration of logistics vehicles—by year

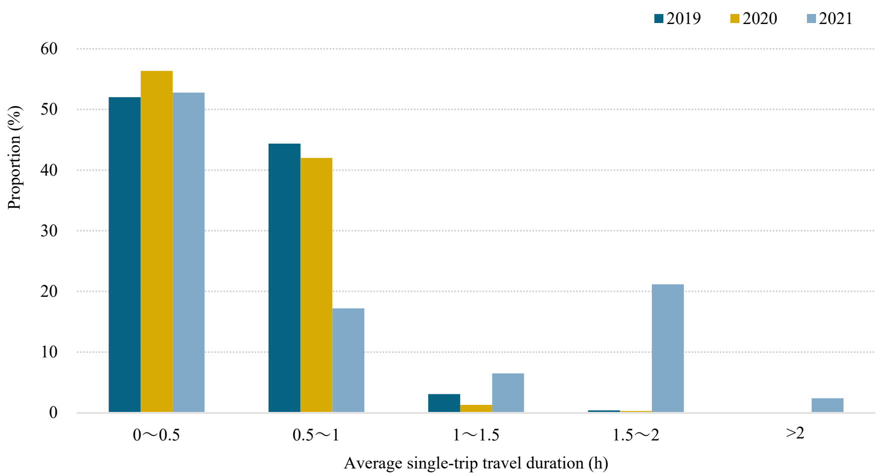


Fig. 4.52 Distribution of logistics vehicles of different average single-trip travel durations—by year

period in the past two years.

As the distribution shows (Fig. 4.53), the proportion of logistics vehicles with an average single-trip mileage of more than 20 km in 2021 was 12.4%, increasing compared with 2019 and 2020.

Table 4.27 Average single-trip mileage of logistics vehicles-average

Year	2019	2020	2021
Average single-trip mileage (km)	13.12	11.29	18.96

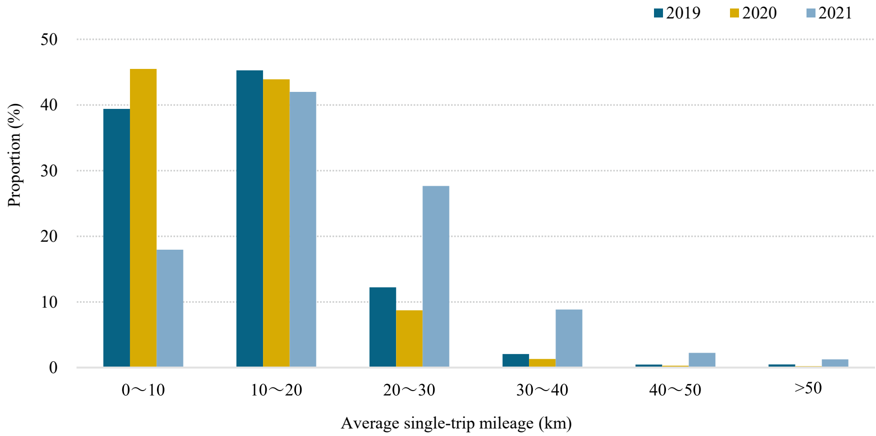


Fig. 4.53 Distribution of logistics vehicles of different average single-trip mileages—by year

The proportion of logistics vehicles with an average single-trip mileage of 20–40 km in first-tier cities is significantly higher than that in cities of other tiers, reaching 43.1%. The distribution mileage of logistics vehicles is relatively high (Fig. 4.54).

The average single-trip speed of logistics vehicles in 2021 was 23.25 km/h, with a decrease compared with last year.

The average single-trip speed in 2021 was 23.25 km/h, with a decrease of 4.6% and 17.3% compared with 2019 and 2020, respectively (Table 4.28). As the distribution shows (Fig. 4.55), the proportion of logistics vehicles traveling at speeds above 30 km/

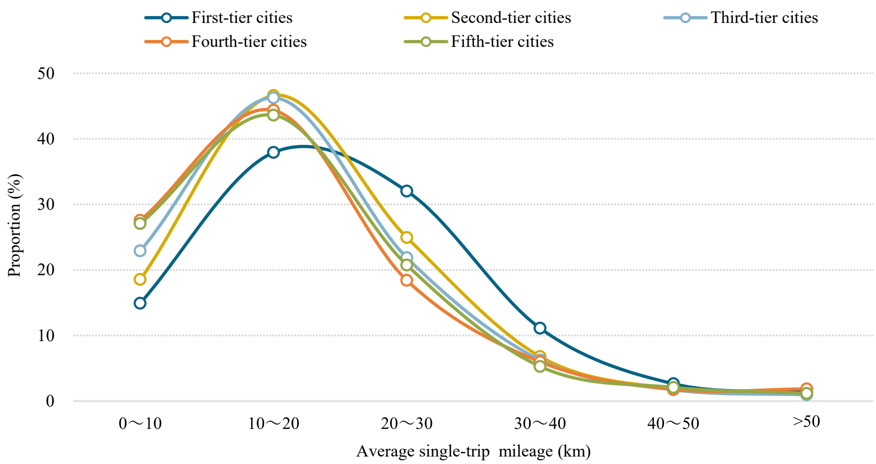


Fig. 4.54 Distribution of logistics vehicles of different average single-trip mileages in 2021—by city tier

h decreased from 26.3% in 2020 to 11.3% in 2021. The regional traffic efficiency of newly arranged logistics vehicles is generally low.

2. **Average daily travel characteristics of logistics vehicles**

The average daily travel duration of logistics vehicles is increasing yearly.

In the past three years, the average daily travel duration of logistics vehicles in China has increased yearly; in 2021, it reached 4.12 h, 1.27 h and 0.88 h longer than 2019 and 2020, respectively (Table 4.29).

According to the monthly average of average daily travel duration over the years (Fig. 4.56), it can be seen that in the past three years, the average daily travel duration of logistics vehicles has rapidly increased, and in 2021, it exceeded the same period in previous years.

As the distribution shows (Fig. 4.57), the proportion of logistics vehicles with an average daily travel duration of more than 4 h gradually increased. The proportion of logistics vehicles with an average daily travel duration of more than 4 h in 2021 was 50.2%, with an increase of 25.3% and 16.5% compared with 2019 and 2020, respectively. The average daily travel duration of logistics vehicles has significantly increased.

Table 4.28 Average single-trip speed of logistics vehicles-average

Year	2019	2020	2021
Average single-trip speed (km/h)	24.36	28.13	23.25

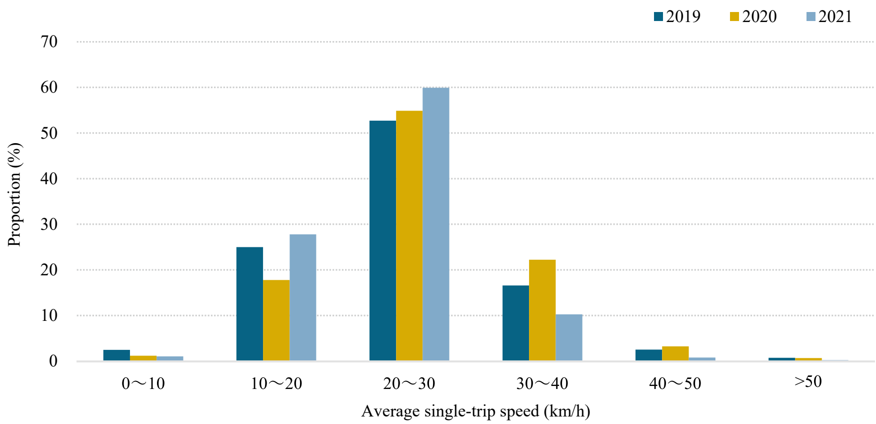


Fig. 4.55 Distribution of logistics vehicles of different average single-trip speeds—by year

Table 4.29 Average daily travel duration of logistics vehicles-average

Year	2019	2020	2021
Average daily travel duration (h)	2.85	3.24	4.12

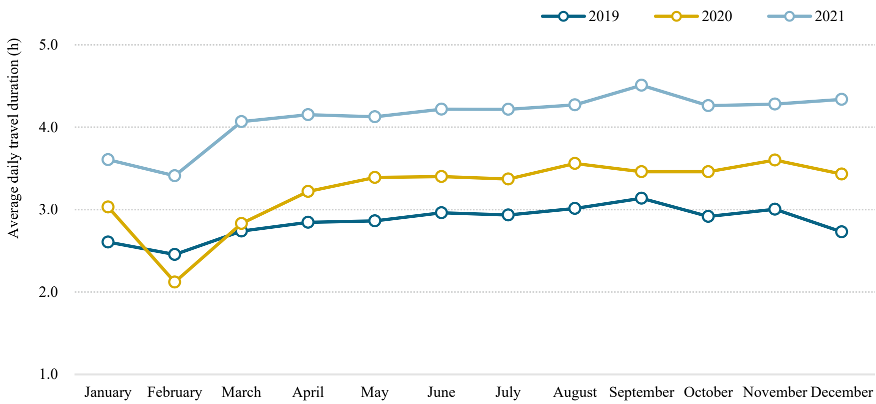


Fig. 4.56 Monthly average of average daily travel duration of logistics vehicles—by year

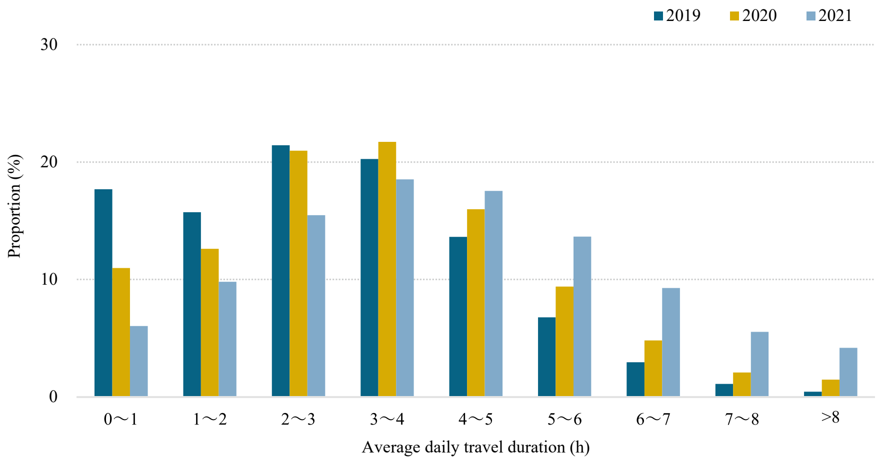


Fig. 4.57 Distribution of logistics vehicles of different average daily travel durations—by year

From Fig. 4.58, the proportion of logistics vehicles with an average daily travel duration of more than 5 h in first-tier cities was 38.1%, significantly higher than that in cities of other tiers. Logistics vehicles' average daily travel duration in third-tier and below cities was more concentrated in 2–4 h.

The average daily mileage of logistics vehicles has shown an increasing trend in the past three years, with an increase of 8.7% compared with 2020.

According to the data over the years (Table 4.30), logistics vehicles' average daily mileage was 94.12 km in 2021, with an increase of 35.4% and 8.7%, respectively, compared with 2019 and 2020, indicating a rapid increase in average daily mileage.

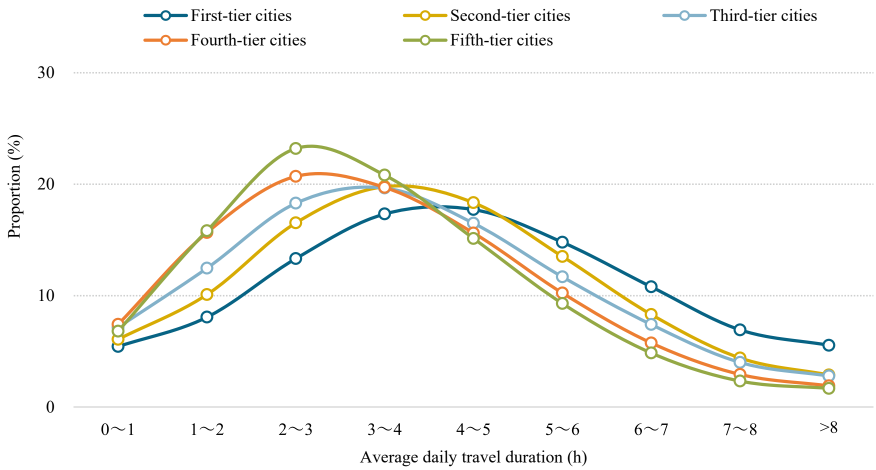


Fig. 4.58 Distribution of logistics vehicles of different average daily travel durations in 2021—by city tier

Table 4.30 Average daily mileage of logistics vehicles-average

Year	2019	2020	2021
Average daily mileage (km)	69.53	86.62	94.12

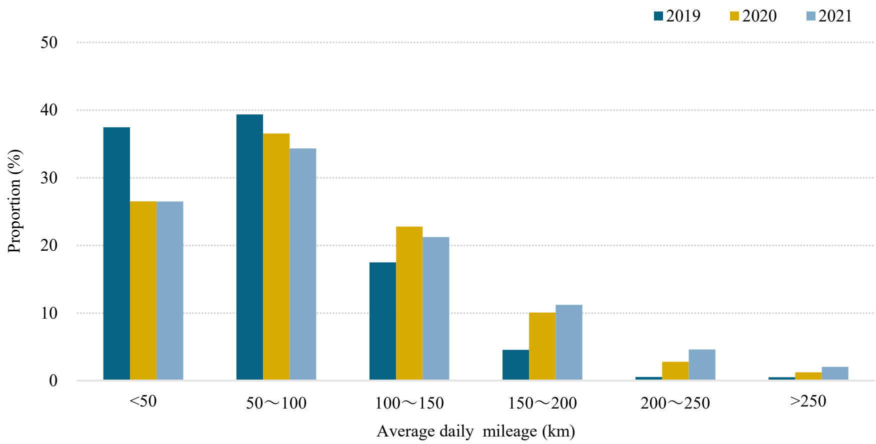


Fig. 4.59 Distribution of logistics vehicles of different average daily mileages—by year

As the distribution shows (Fig. 4.59), the average daily mileage of logistics vehicles is mainly concentrated below 150 km, but the proportion of vehicles with mileage above 150 km in 2021 significantly increased, from 5.7% in 2019 to 17.9% in 2021.

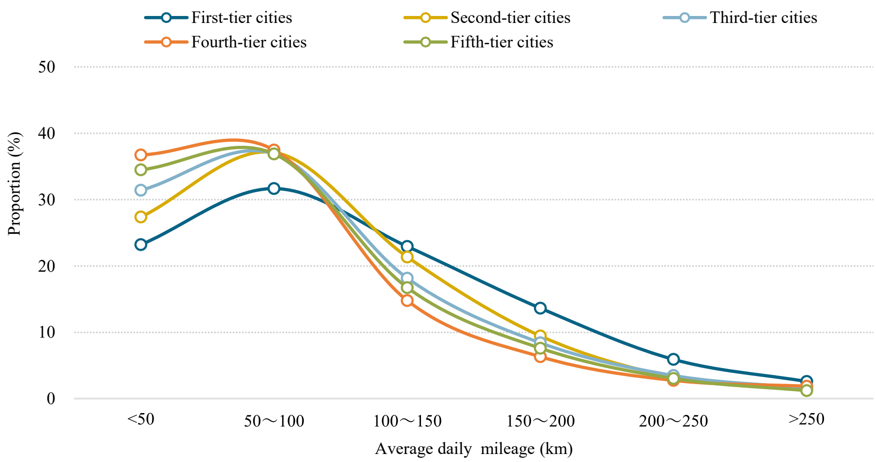


Fig. 4.60 Distribution of logistics vehicles of different average daily mileages in 2021—by city tier

The proportion of vehicles with high average daily mileage in first-tier cities is higher than that in cities of other tiers (Fig. 4.60).

The driving time of logistics vehicles forms peaks during the morning and afternoon working hours.

The driving time of logistics vehicles in 2021 was slightly ahead of that in 2019 and 2020. From the distribution of driving time (Fig. 4.61), two significant peaks formed with 12:00–13:00 as the boundary, ranging from 8:00 to 10:00 and from 15:00 to 16:00, respectively. By city tier, the distribution of logistics vehicles traveling at the two peaks in first-tier cities is lower than that in cities of other tiers and tends to be more average (Fig. 4.62).

3. **Average monthly travel characteristics of logistics vehicles**

The average monthly travel days of logistics vehicles have shown a steadily increasing trend in the past three years, with an increase of 11.7% compared with last year.

In the past three years, logistics vehicles' average monthly travel days have increased yearly. The average monthly travel days of logistics vehicles in 2021 were 21.94, with an increase of 6.32 days and 2.29 days compared with that in 2019 and 2020, and the travel frequency of logistics vehicles significantly increased (Table 4.31).

As the distribution shows (Fig. 4.63), it can be seen that in 2021, over 60% of logistics vehicles traveled for more than 20 days per month, indicating that logistics vehicles are primarily in regular use.

The average monthly mileage of logistics vehicles has shown a steadily increasing trend in the past three years, with an increase of 4.7% compared with last year.

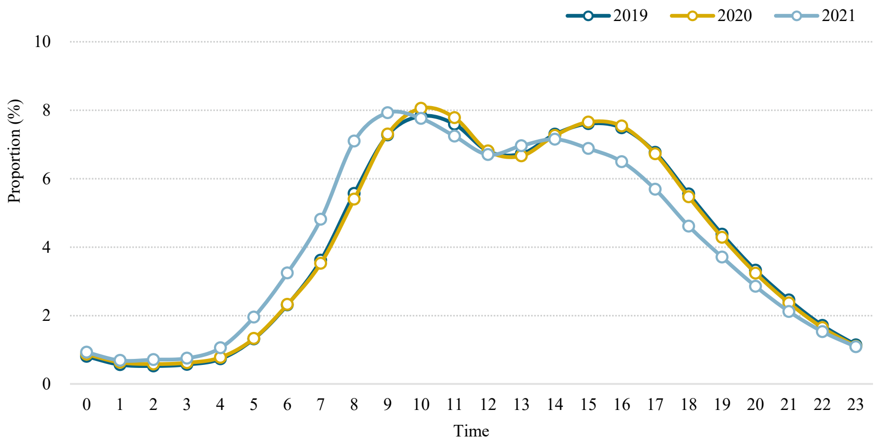


Fig. 4.61 Distribution of logistics vehicles of different driving times—by year

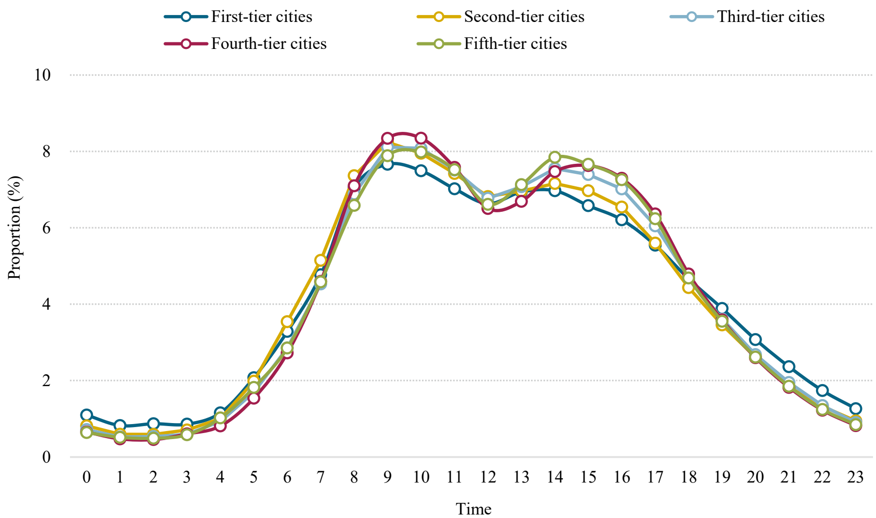


Fig. 4.62 Distribution of logistics vehicles of different driving times in 2021—by city tier

Table 4.31 Average monthly travel days of logistics vehicles-average

Year	2019	2020	2021
Average monthly travel days (day)	15.62	19.65	21.94

Logistics vehicles' average monthly mileage has rapidly grown in the past three years. In 2021, logistics vehicles' average monthly mileage was 2270.33 km, with a YoY increase of 4.7% (Table 4.32).

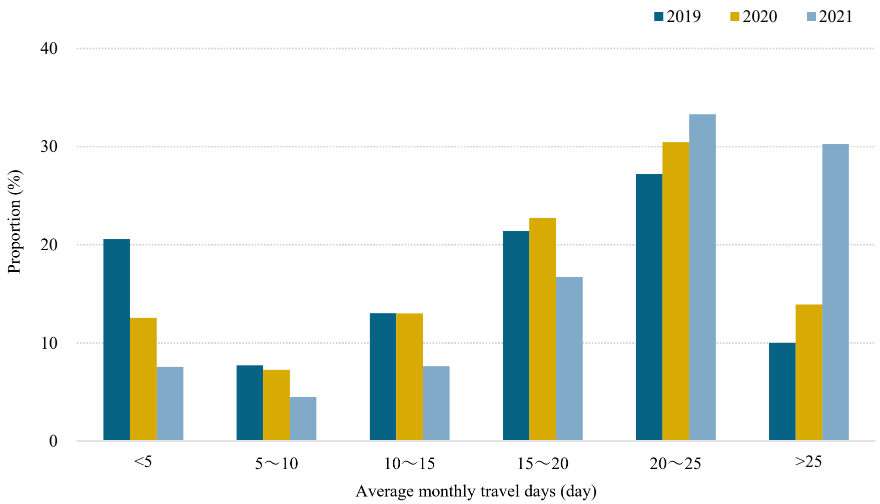


Fig. 4.63 Distribution of logistics vehicles of different average monthly travel days—by year

Table 4.32 Average monthly mileage of logistics vehicles

Year	2019	2020	2021
Average monthly mileage (km)	1425.45	2169.17	2270.33

As the distribution shows (Fig. 4.64), the proportion of logistics vehicles with an average monthly mileage of more than 3000 km rapidly increased from 10.7% in 2019 to 29.2% in 2021, and new energy logistics vehicles are gradually tending towards benign operation.

By city tier, the proportion of logistics vehicles in the high mileage segment in first-tier cities was significantly higher than that in third-tier and below cities. From Fig. 4.65, the proportion of logistics vehicles with average monthly mileage of more than 3000 km in first-tier cities was 33.9%, while that in third-tier and below cities was less than 25%.

4.2.6 Operation Characteristics of Buses

1. **Average single-trip travel characteristics of buses**

In 2021, the average single-trip travel duration of buses was 1.39 h, with an increase of 0.41 h compared with last year.

The average single-trip travel duration of buses in 2021 was 1.39 h, with an increase of 0.23 h and 0.41 h compared with 2019 and 2020, respectively (Table 4.33). The monthly average single-trip travel duration of buses in 2021 significantly

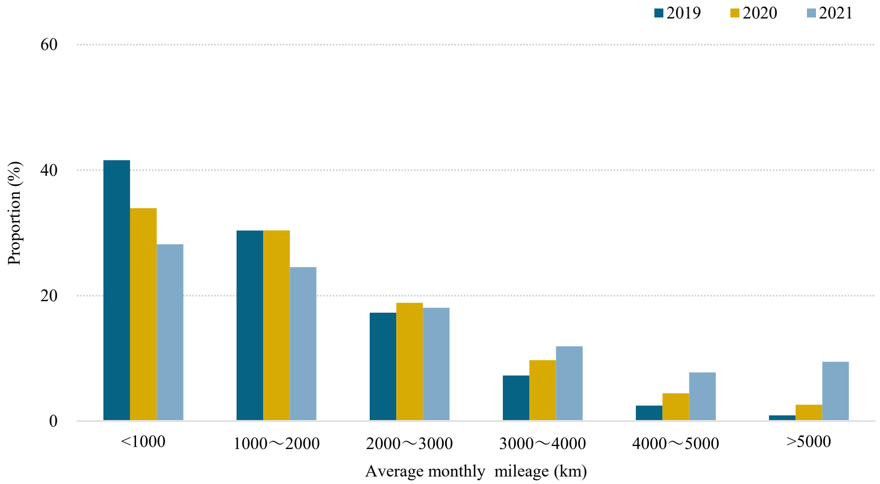


Fig. 4.64 Distribution of average monthly mileage of logistics vehicles—by year

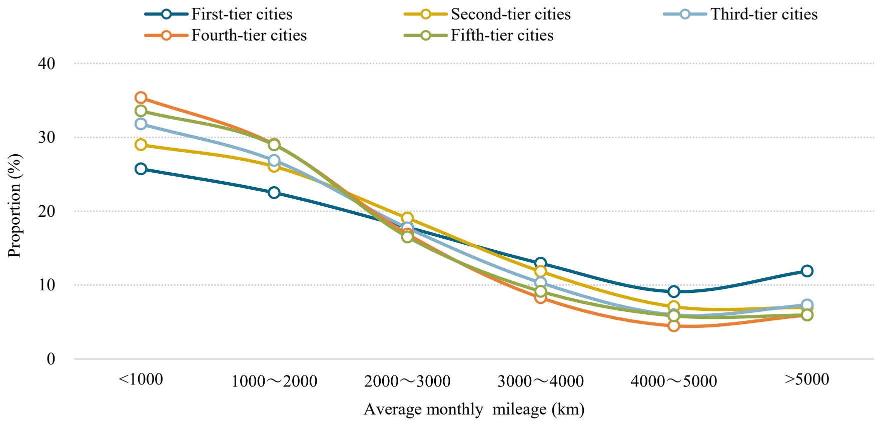


Fig. 4.65 Distribution of logistics vehicles of different average monthly mileages in 2021—by city tier

Table 4.33 Average single-trip travel duration of buses

Year	2019	2020	2021
Average single-trip travel duration (h)	1.16	0.98	1.39

exceeded the same period in previous years (Fig. 4.66). As the distribution shows (Fig. 4.67), the proportion of buses with an average single-trip travel duration of more than 1.0 h in 2021 increased from 39.93 in 2020 to 43.47% in 2021.

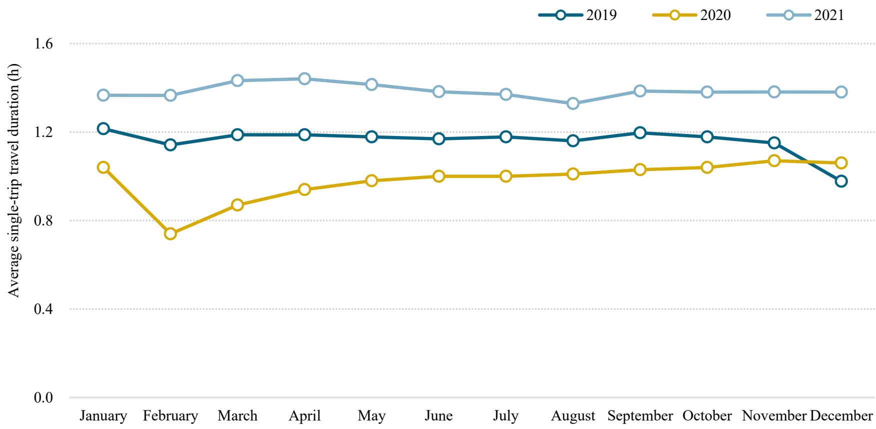


Fig. 4.66 Monthly average of average single-trip travel duration of buses—by year

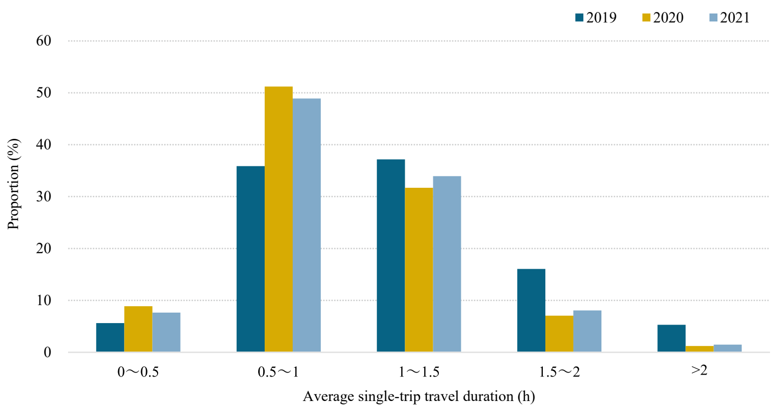


Fig. 4.67 Distribution of buses of different average single-trip travel durations—by year

By city tier, the proportion of buses with an average single-trip travel duration of more than 1.5 h in first to third-tier cities was significantly higher than that in third-tier and below cities (Fig. 4.68).

In 2021, the average single-trip mileage of buses was 25.10 km, returning to pre-COVID-19 level.

In 2021, the average single-trip mileage of buses was 25.10 km, and the travel characteristics of buses returned to the pre-COVID-19 level (Table 4.34). The proportion of buses with an average single-trip mileage of 10–20 km accounted for the majority (Fig. 4.69).

The average single-trip speed of buses over the years has been higher than 20 km/h, and buses in first and second-tier cities are more concentrated in the low-speed segment.

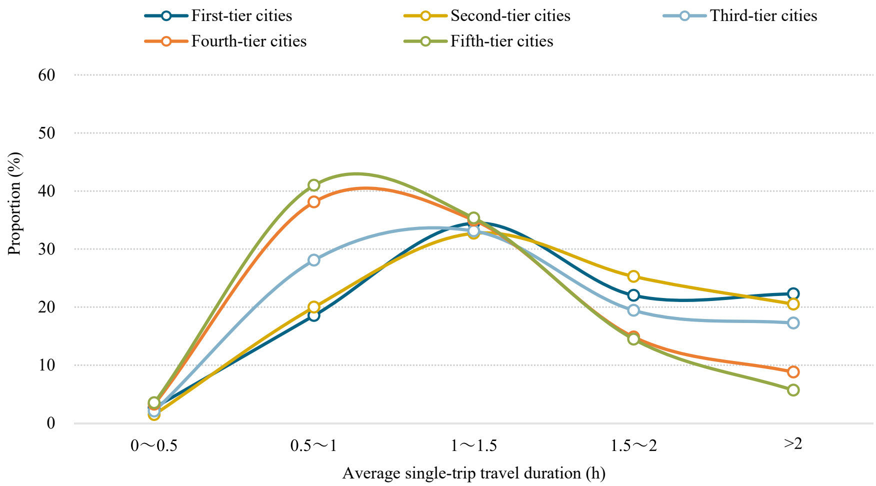


Fig. 4.68 Distribution of buses of different average single-trip travel durations in 2021—by city tier

Table 4.34 Average single-trip mileage of buses-average

Year	2019	2020	2021
Average single-trip mileage (km)	24.76	19.44	25.10

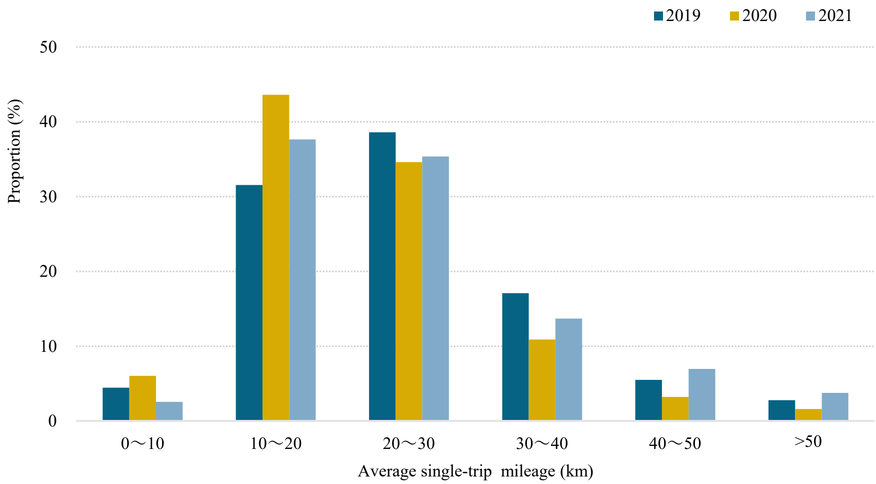


Fig. 4.69 Distribution of buses of different average single-trip mileages—by year

The average single-trip speed of buses in the past three years has been slightly higher than 20 km (Table 4.35), which is mostly the same each year. The proportion of buses with an average single-trip speed of 10–30 km/h accounted for the majority (Fig. 4.70).

The urban traffic environment affects first- and second-tier cities, resulting in a higher frequency of road congestion. The proportion of buses with an average single-trip speed of 10–20 km/h in the low-speed range is relatively more concentrated; on the contrary, the proportion of buses with an average single-trip speed of more than 20 km/h in cities of other tiers is significantly higher than that in first and second-tier cities (Fig. 4.71).

2. **Average daily travel characteristics of buses**

The daily operation of buses has strong regularity, and the average daily travel duration of buses remains stable at around 7 h.

The average daily travel duration of buses has remained relatively stable over the years, with an average daily travel duration of 6.85 h in 2021, which is mostly consistent with previous years (Table 4.36); the proportion of vehicles with an average daily travel duration of more than 8 h accounted for the majority, reading over 30% (Fig. 4.72).

The distribution proportion of buses in first-tier cities is higher during long travel periods. By city tier, from Fig. 4.73, the proportion of buses with an average daily

Table 4.35 Average single-trip speed of buses-average

Year	2019	2020	2021
Average single-trip speed (km/h)	22.18	22.65	22.13

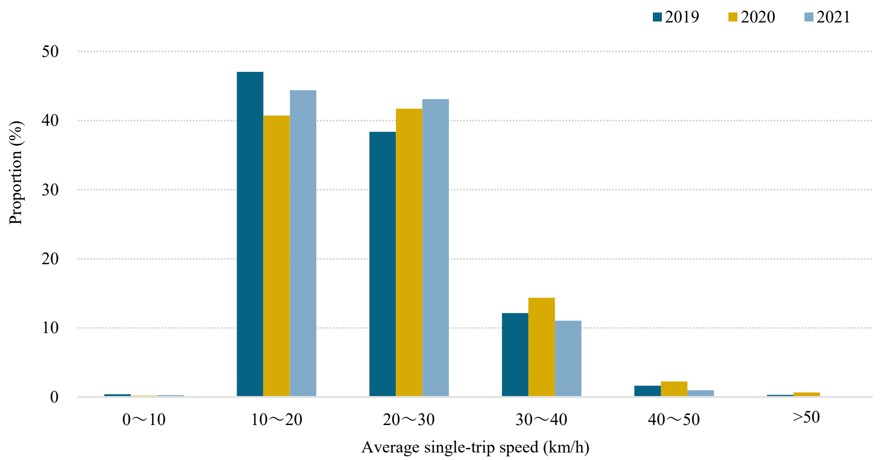


Fig. 4.70 Distribution of buses of different average single-trip speeds—by year

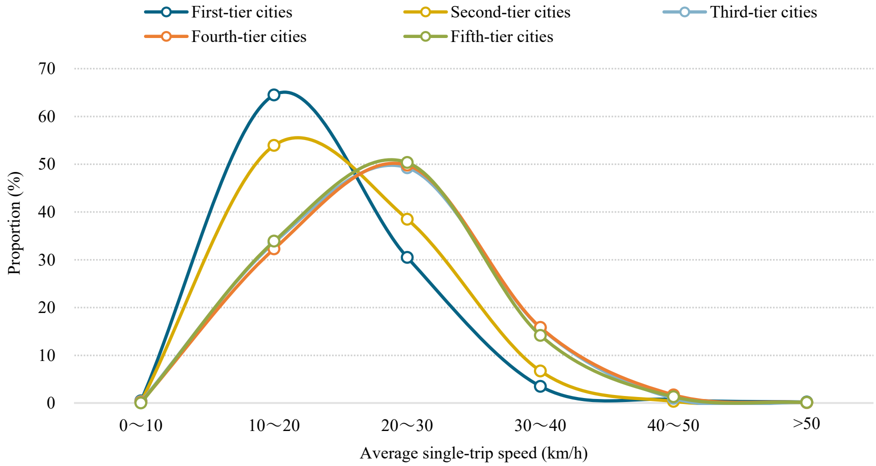


Fig. 4.71 Distribution of buses of different average single-trip speeds in 2021—by city tier

Table 4.36 Average daily travel duration of buses-average

Year	2019	2020	2021
Average daily travel duration (h)	7.01	6.75	6.85

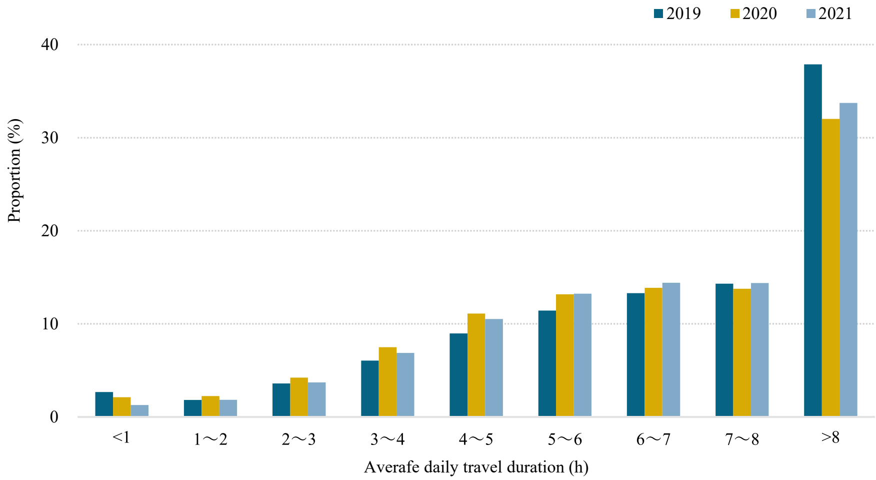


Fig. 4.72 Distribution of buses of different average daily travel durations—by year

Fig. 4.73 Distribution of average daily travel duration of buses in 2021—by city tier

travel duration of more than 8 h in first-tier cities was 42.3%, significantly higher than that in cities of other tiers.

The average daily mileage of buses in 2021 mainly remained unchanged compared with previous years.

The average daily mileage in 2021 was 150.78 km, which mainly remained unchanged compared with previous years (Table 4.37). The average daily mileage of buses concentrated at 100–200 km (Fig. 4.74).

From Fig. 4.75, due to the relatively low average speed, the proportion of buses with average daily mileage within 150 km in first and second-tier cities was slightly higher than that in cities of other tiers.

The proportion of buses for nighttime travel in first-tier cities is relatively high.

From the distribution of driving time of buses over the years (Fig. 4.76), it can be seen that the driving time of buses in 2021 was earlier than that of 2019 and 2020, and the proportion of buses traveling between 8:00 and 16:00 was relatively stable, which is in line with the travel characteristics of buses; the proportion of buses traveling between 18:00 and 23:00 in first-tier cities was 16.6%, slightly higher than that in cities of other tiers, with the latter all below 13% (Fig. 4.77).

3. Average monthly travel characteristics of buses

The average monthly travel days of more than 60% of buses were more than 25 in 2021.

Table 4.37 Average daily mileage of buses-average

Year	2019	2020	2021
Average daily mileage (km)	146.21	148.29	150.78

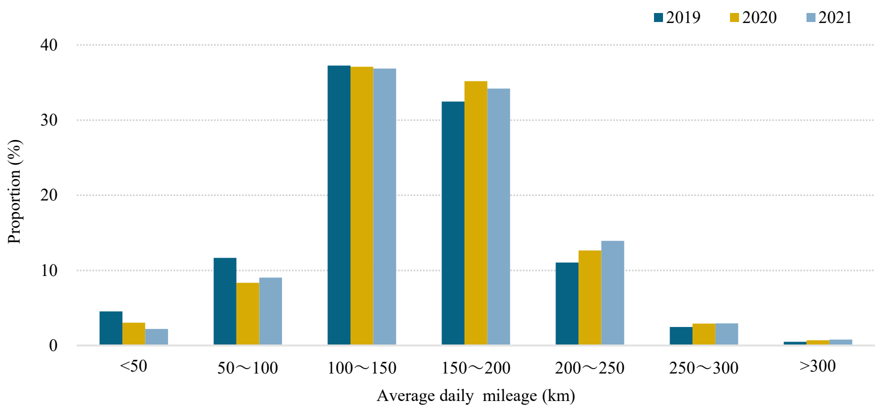


Fig. 4.74 Distribution of buses of different average daily mileages—by year

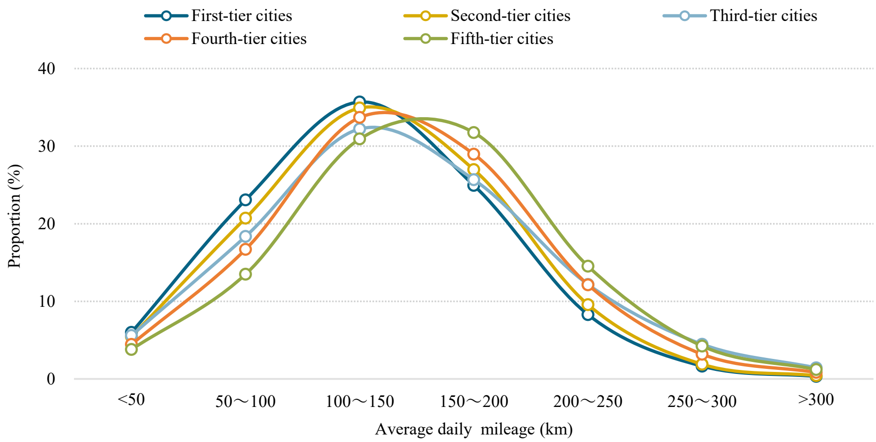


Fig. 4.75 Distribution of buses of different average daily mileages in 2021—by city tier

The average monthly travel days of buses in 2021 were 23.44, mostly the same as in previous years (Table 4.38). The proportion of vehicles with average monthly travel days of 25 significantly increased, from 28.58% in 2020 to 61.74% in 2021 (Fig. 4.78). The operation of new energy buses has become more routine.

The average monthly mileage of buses has been relatively stable over the years, with an average monthly mileage of 3712.63 km in 2021.

In 2021, the average monthly mileage of buses was 3712.63 km, which has been relatively stable over the years (Table 4.39). The proportion of buses with an average monthly mileage of more than 5000 km in 2021 increased compared to 2019 and 2020 (Fig. 4.79).

The proportion of buses with an average monthly mileage of more than 4000 km in fifth-tier cities was higher than that in cities of other tiers (Fig. 4.80).

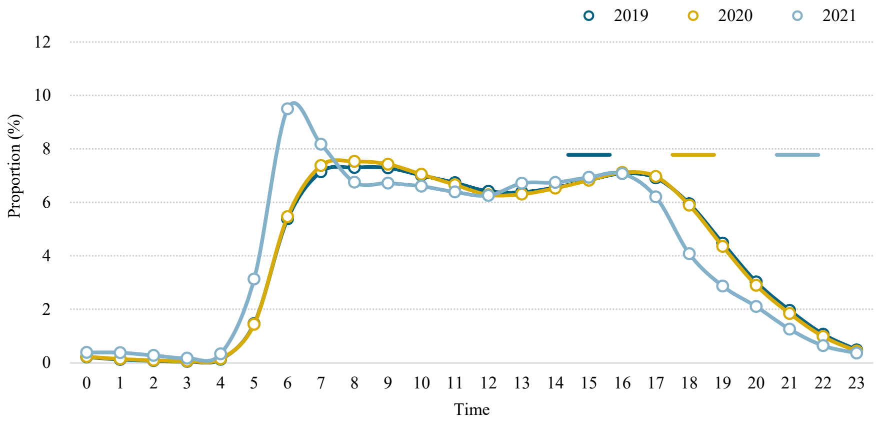


Fig. 4.76 Distribution of buses of different driving times—by year

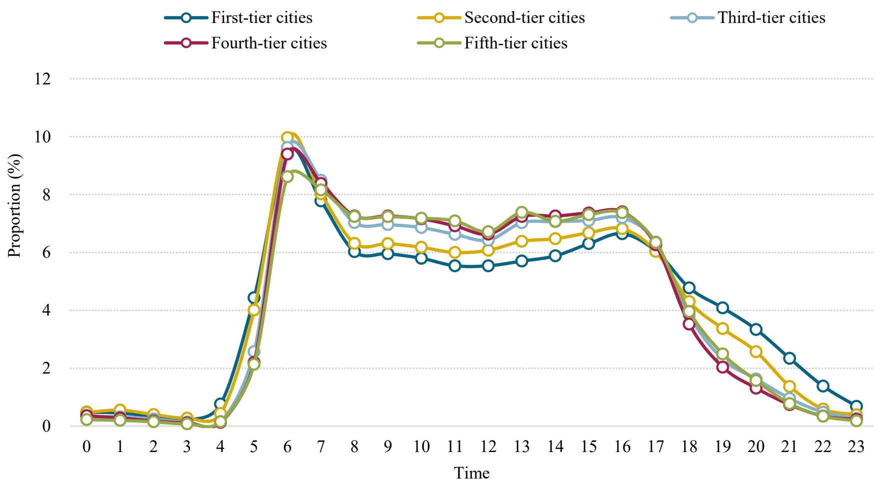


Fig. 4.77 Distribution of buses of different driving times in 2021—by city tier

Table 4.38 Average monthly travel days of buses-average

Year	2019	2020	2021
Average monthly travel days (day)	22.15	22.55	23.44

4.2.7 Operation Characteristics of Heavy-Duty Trucks

1. **Average single-trip travel characteristics of heavy-duty trucks**

The average single-trip travel duration of heavy-duty trucks has remained stable at 1.1 h in the past two years, with a significant increase compared with 2019.

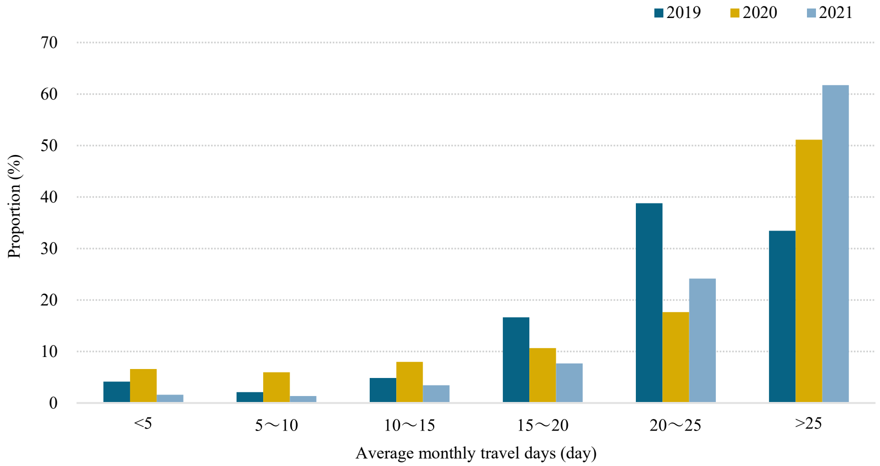


Fig. 4.78 Distribution of buses of different average monthly travel days—by year

Table 4.39 Average monthly mileage of buses-average

Year	2019	2020	2021
Average monthly mileage (km)	3519.06	3682.57	3712.63

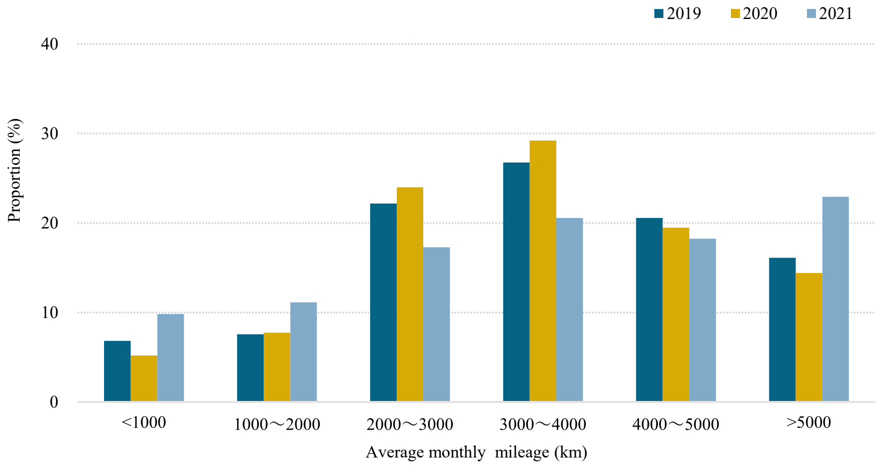


Fig. 4.79 Distribution of buses of different average monthly mileages—by year

In the past two years, the average single-trip travel duration of heavy-duty has remained relatively stable at around 1.1 h, and it was mostly the same as that in 2021 and 2020 (Table 4.40). The proportion of heavy-duty trucks with an average

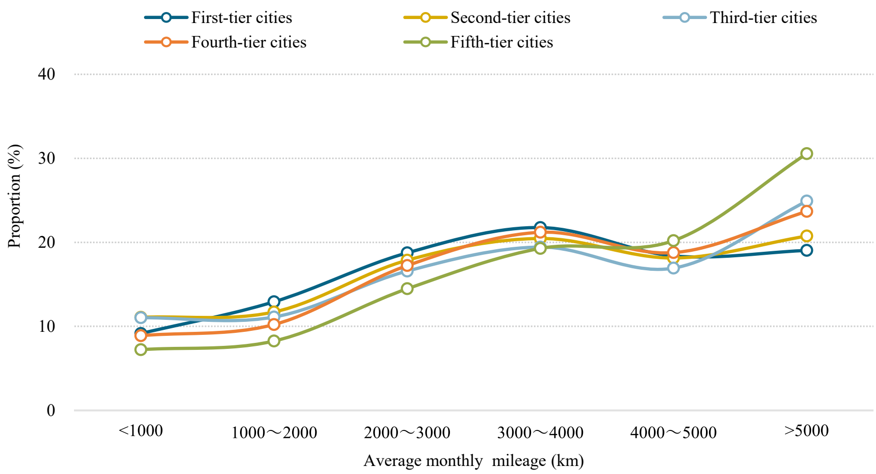


Fig. 4.80 Distribution of buses of different average monthly mileages in 2021—by city tier

Table 4.40 Average single-trip travel duration of heavy-duty trucks-average

Year	2019	2020	2021
Average single-trip travel duration (h)	0.86	1.11	1.10

single-trip travel duration of more than 1.5 h in 2021 was 38.7%, close to 2020 but 9.5% higher than that in 2019 (Fig. 4.81).

The average single-trip mileage of heavy-duty trucks in 2021 remained the same as that in 2020 but higher than that in 2019.

According to the average single-trip mileage of heavy-duty trucks over the years, in 2021, the average single-trip mileage of heavy-duty trucks was 22.97 km, the same as in 2020 (Table 4.41).

Heavy-duty trucks' average single-trip mileage was mainly concentrated within 30 km (Fig. 4.82), with a proportion of 74.53% in 2021. However, the proportion of heavy-duty trucks with an average single-trip mileage of more than 30 km is rising, increasing from 12.5% in 2019 to 25.5% in 2021.

The average single-trip speed of heavy-duty trucks in the past two years has been slightly higher than 20 km (Table 4.42). The average single-trip speed of heavy-duty trucks in 2021 was 20.65 km/h, mostly the same as the previous year.

As the distribution shows (Fig. 4.83), the proportion of heavy-duty trucks with average single-trip speeds of more than 30 km/h increased from 4.1% in 2020 to 7.3% in 2021.

2. **Average daily travel characteristics of heavy-duty trucks**

The average daily travel duration of heavy-duty trucks is increasing yearly.

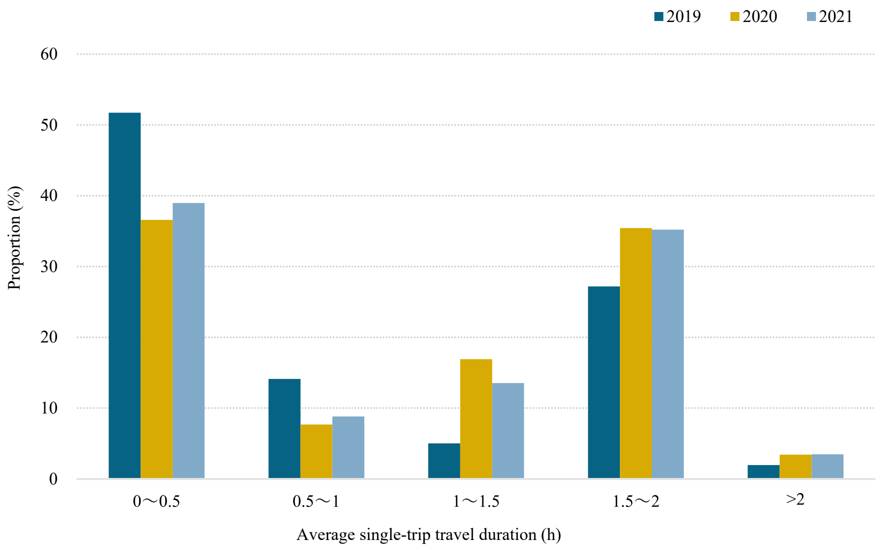


Fig. 4.81 Distribution of heavy-duty trucks of different average single-trip travel durations—by year

Table 4.41 Average single-trip mileage of heavy-duty trucks-average

Year	2019	2020	2021
Average single-trip mileage (km)	15.44	22.98	22.97

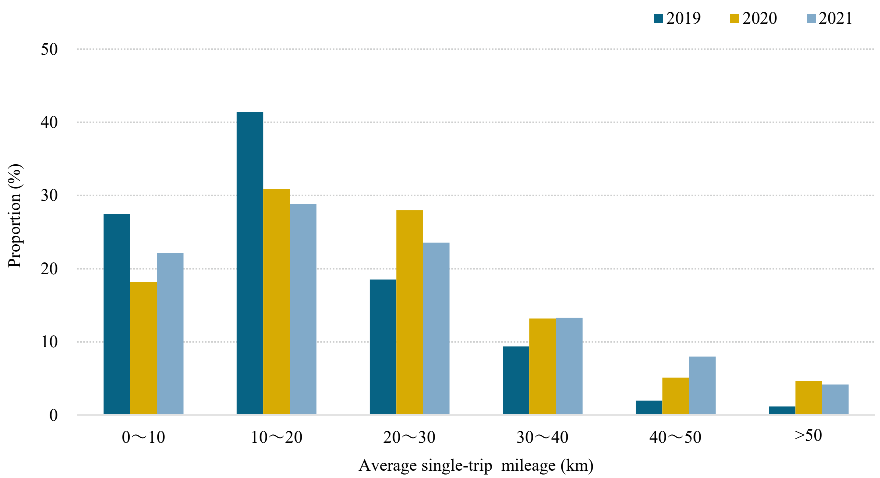


Fig. 4.82 Distribution of heavy-duty trucks of different average single-trip mileages—by year

Table 4.42 Average single-trip speed of heavy-duty trucks-average

Year	2019	2020	2021
Average single-trip speed (km/h)	18.79	20.68	20.65

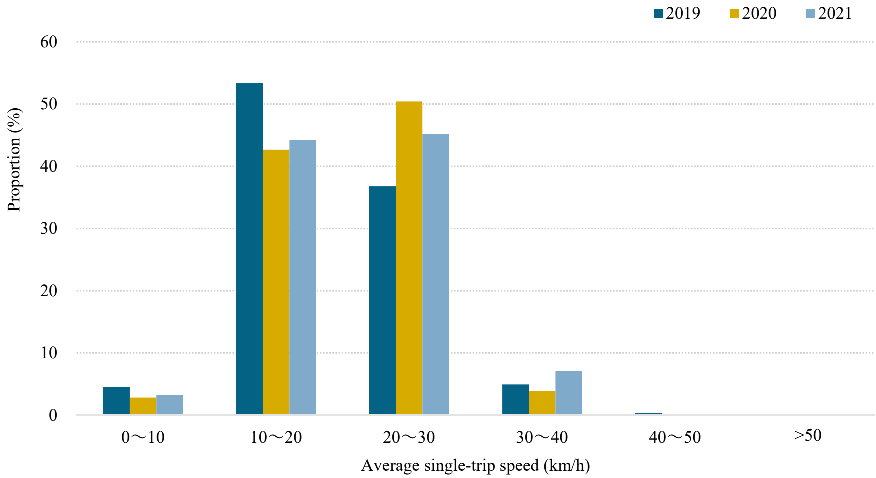


Fig. 4.83 Distribution of heavy-duty trucks of different average single-trip speeds—by year

Table 4.43 Average daily travel duration of heavy-duty trucks-average

Year	2019	2020	2021
Average daily travel duration (h)	3.89	5.12	5.21

Heavy-duty trucks' average daily travel duration has been relatively stable in the past two years. Heavy-duty trucks' average daily travel duration in 2021 was 5.21 h, an increase of 1.8% compared with 2020 (Table 4.43).

According to the monthly average daily travel duration over the years (Fig. 4.84), heavy-duty trucks' average daily travel duration from January to May 2021 was higher than the same period in 2020, then decreased slightly, approaching the same period last year.

According to the distribution of average daily travel duration (Fig. 4.85), the proportion of heavy-duty trucks is relatively scattered; the proportion of heavy-duty trucks with average daily travel duration gradually shifted from low hours to high hours, and the proportion of heavy-duty trucks with an average daily travel duration of 4-7 h increased from 29.9% in 2019 to 49.1% in 2021.

The average daily mileage of heavy-duty trucks has gradually increased in the past three years.

In 2021, logistics vehicles' average monthly mileage was 2270.33 km, with a YoY increase of 1.7% (Table 4.44). Heavy-duty trucks' monthly average daily mileage in 2021 was primarily consistent with the same period in 2020 (Fig. 4.86).

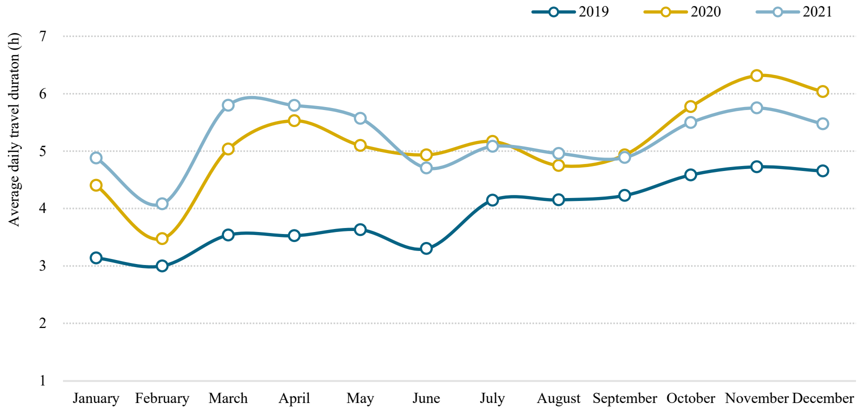


Fig. 4.84 Monthly average of average daily travel duration of heavy-duty trucks—by year

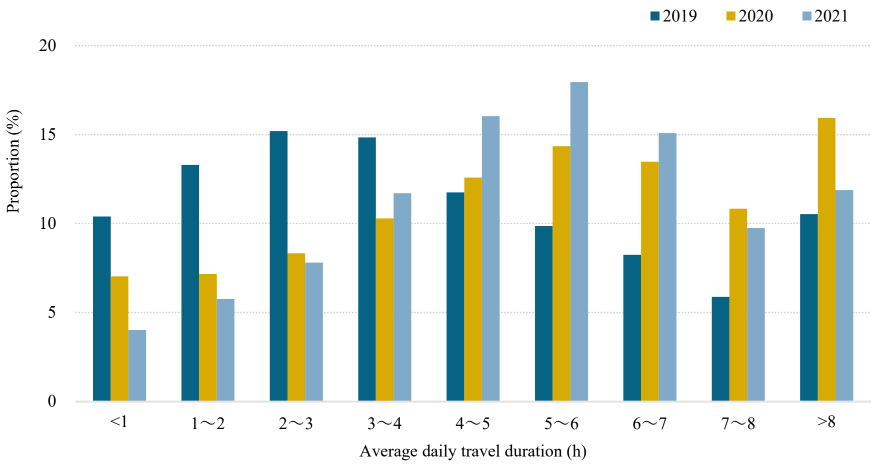


Fig. 4.85 Distribution of heavy-duty trucks of different average daily travel durations—by year

Table 4.44 Average daily mileage of heavy-duty trucks-average

Year	2019	2020	2021
Average daily mileage (km)	71.02	105.73	107.57

As the distribution shows (Fig. 4.87), the proportion of heavy-duty trucks with an average daily mileage of more than 100 km increased from 27.2% in 2019 to 48.4% in 2021.

The proportion of heavy-duty trucks traveling in the early morning has been increasing yearly.

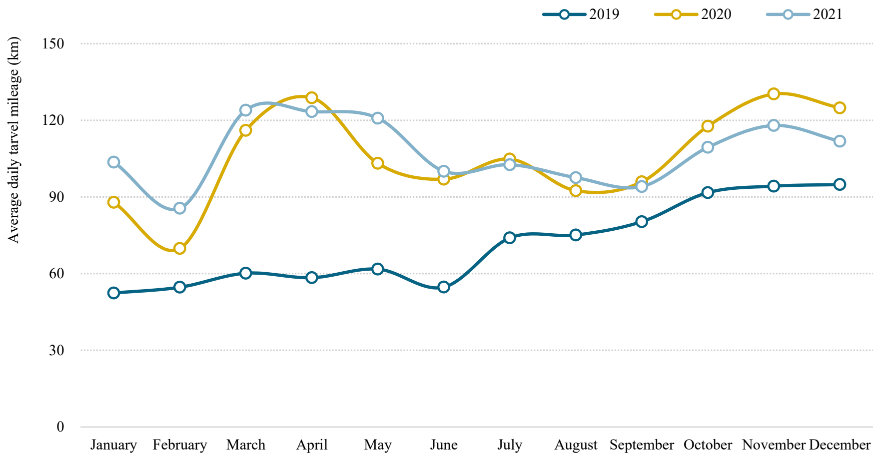


Fig. 4.86 Monthly average of average daily mileage of heavy-duty trucks—by year

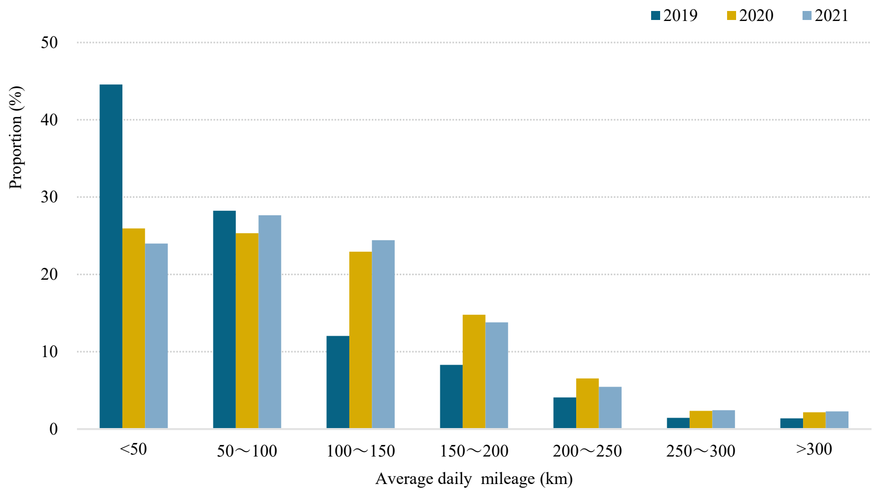


Fig. 4.87 Distribution of heavy-duty trucks of different average daily mileages—by year

According to the distribution of the driving time of heavy-duty trucks over the years (Fig. 4.88), the proportion of heavy-duty trucks with driving time between 0:00 and 7:00 has been increasing yearly, from 15.2% in 2019 to 25.8% in 2021, which is in line with the driving characteristics of heavy-duty trucks.

3. **Average monthly travel characteristics of heavy-duty trucks**

The average monthly travel days of heavy-duty trucks have gradually increased in the past three years.

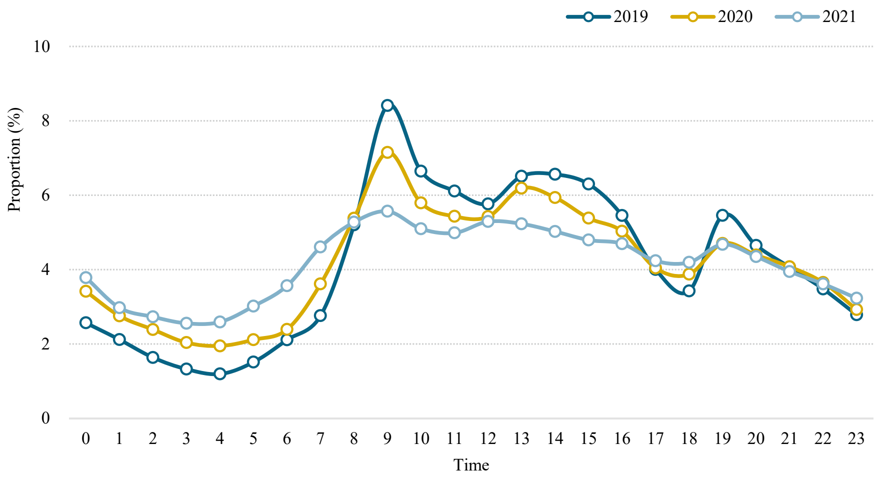


Fig. 4.88 Distribution of heavy-duty trucks of different driving times—by year

In the past three years, the average monthly travel days of heavy-duty trucks have been increasing yearly, and that in 2021 was 20.77, with an increase of 13.6% compared with 2020 (Table 4.45).

According to the monthly average daily mileage over the years (Fig. 4.89), except for February and November, the average daily mileage of heavy-duty trucks in other months of 2021 was higher than that of the same period in 2020.

From the distribution of average monthly travel days of heavy-duty trucks (Fig. 4.90), the proportion of vehicles with an average monthly travel day of more than 20 significantly increased, from 41.9% in 2019 to 66.3% in 2021.

The average monthly mileage of heavy-duty trucks has been increasing yearly, and that in 2021 was 2424.87 km.

The average monthly mileage of heavy-duty trucks in 2021 was 2424.87 km, an increase of 8.8% compared with 2020 (Table 4.46). According to the average monthly mileage over the years (Fig. 4.91), from January to May 2021, the average monthly mileage of heavy-duty trucks was higher than that in the same period in previous years and subsequently decreased; as the distribution shows (Fig. 4.92), the proportion of heavy-duty trucks with an average monthly mileage of more than 2000 km increased from 27.2% in 2019 to 50.8% in 2021.

Compared to other types of vehicles, BEV heavy-duty trucks have a large body and higher requirements for the three electric systems, including motor and electronic control. They need to adapt to more different scenarios, such as uphill and

Table 4.45 Average monthly travel days of heavy-duty trucks

Year	2019	2020	2021
Average monthly travel days (day)	15.37	18.28	20.77

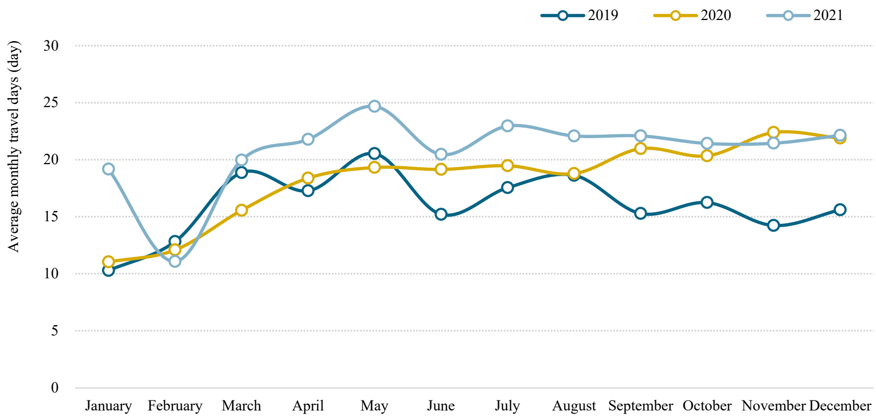


Fig. 4.89 Average monthly travel days of heavy-duty trucks over the years

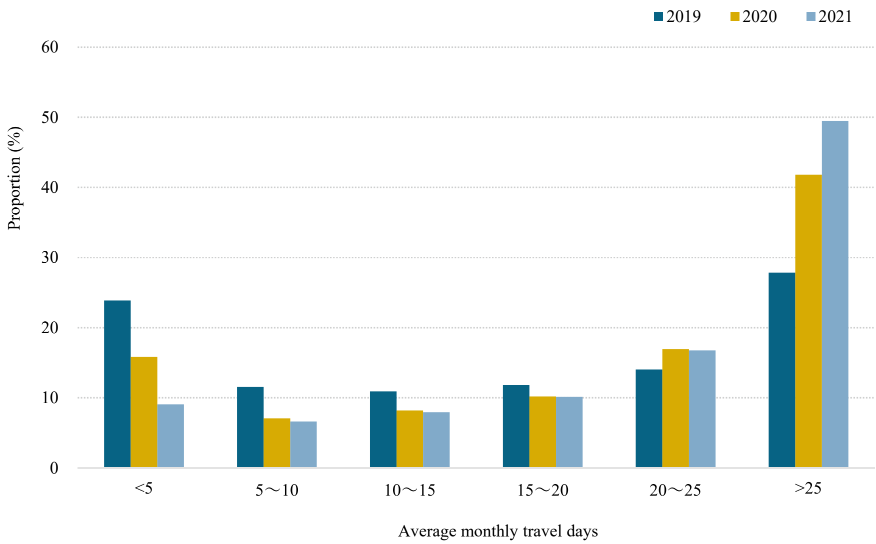


Fig. 4.90 Distribution of heavy-duty trucks of different average monthly travel days—by year

Table 4.46 Average monthly mileage of heavy-duty trucks-average

Year	2019	2020	2021
Average monthly mileage (km)	1318.65	2228.24	2424.87

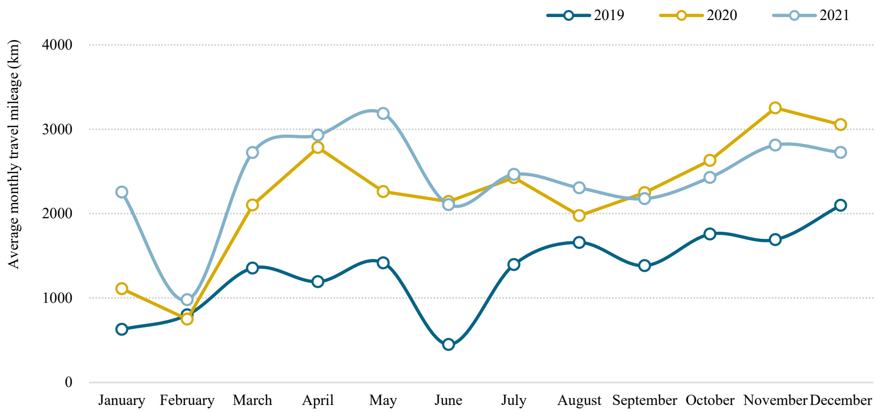


Fig. 4.91 Average monthly mileage of heavy-duty trucks over the years

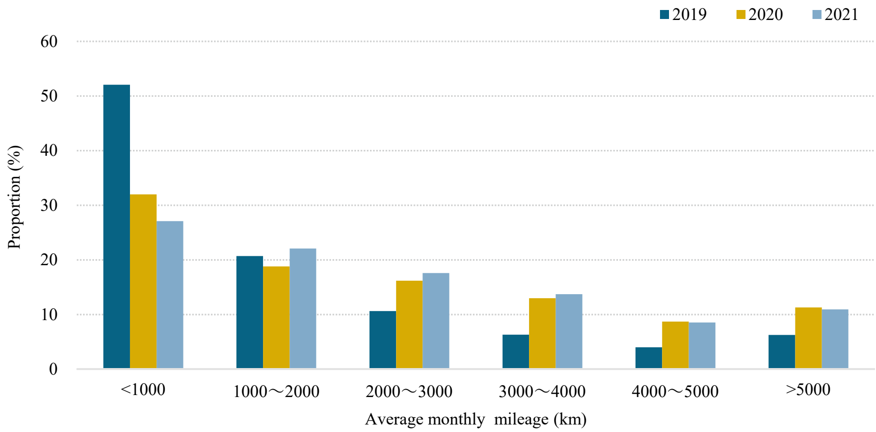


Fig. 4.92 Distribution of heavy-duty trucks of different average monthly mileages—by year

downhill roads, uneven roads, strong winds and snow, and other harsh weather environments. BEV heavy-duty trucks are more suitable for short-distance or fixed-line transportation to avoid sudden situations such as insufficient driving range. In this context, battery-swapping heavy-duty trucks have high promotion and application value. Battery-swapping-type heavy-duty trucks can complete battery swapping in only 3–10 min, resulting in higher operational efficiency; Regarding the economy, the purchase cost is reduced due to the separation of vehicles and electricity. Although the initial purchase cost is still higher than that of fuel-powered heavy-duty trucks, the economic efficiency during the operation process is higher than that of fuel-powered trucks. According to publicly available data, the electricity consumption of battery-swapping-type heavy-duty trucks is 1.2 kWh/km, saving approximately 60 yuan/100 km compared with fuel-powered heavy-duty trucks. Swapping-type heavy-duty trucks have achieved good promotion and application results in multiple scenarios, such as urban transportation, construction sites, mines, and ports. Although the battery swapping mode can accelerate the process of electrification of heavy-duty trucks, there are still many difficulties: firstly, regardless of leasing or purchasing batteries, the current acquisition and operating costs are relatively high; secondly, although the battery swapping time for a single vehicle is relatively short, due to the limited number of battery swapping stations, the waiting time will be extended once there is a queue for battery swapping, and it is uncertain whether there are sufficient backup batteries in the swapping station. Continuous innovation in technology, modes, and other aspects is still needed in the future.

4.3 Summary

1. **Online rate**

The online rate of NEVs in China has continued to grow in the past three years, with basic stability of around 80% in 2020 and 2021. The online rate of PHEVs is higher than that of BEVs and FCVs. It is worth noting that FCV is currently in the initial stage of industrialization and commercial operation, and 2021, its average online rate of 72% is close to 79.7% of BEV, and the vehicle operation tends to be routine.

Fourth and fifth-tier cities have a higher monthly online rate each year, indicating a higher demand for vehicles. At the same time, its holdings are lower than that of first and second-tier cities. Fourth and fifth-tier cities will be key promotion areas for NEVs in the future, and promoting marketable models in combination with the local market environment is necessary.

In each market segment, the monthly average online rate of e-taxis is the highest. e-taxis and cars for sharing are both new business forms emerging in recent years. From 2021, the online rate of the former (96.5%) is much higher than that of the latter (63.8%), and the online rate of the latter is decreasing yearly. From this point, the operators of cars for sharing need to make some breakthrough innovations in network layout, use, parking, and vehicle condition maintenance, and improve the online rate to achieve sustainable development. In the past three years, the online rate of heavy-duty trucks has shown a significant increase trend, with the growth rate ranking first among various segments, indicating that they are in a rapid release of operating demand. The electrification of heavy-duty trucks is significant for China to achieve the "carbon peaking and carbon neutrality" goal.

2. **Operation characteristics of vehicles in key segments**

(1) **Passenger cars**

- **Private cars**

The proportion of private cars with an average single-trip travel duration of more than 0.5 h in China is 56.3%, with an increase of 27.7% compared with that in 2020, which to some extent, indicates an increase in the proportion of long-distance travel of private cars. The average single-trip mileage of private cars was mainly within 20 km, with the proportion over the years around 80%. The proportion of private cars with an average single-trip mileage of more than 10 km in 2021 was 61.4%, with an increase of 9.7% compared with that in 2020. Based on the average single-trip driving time, it can be inferred that the daily travel radius of private cars is gradually increasing.

In 2021, the proportion of private cars with an average monthly travel day of more than 25 increased significantly, and private cars with an average monthly travel day of more than 25 can be considered the primary means of transportation for households. This phenomenon indicates that the proportion of new energy-private cars as the first and only vehicle for households has increased, and the frequency of use has significantly increased.

- **Taxis and e-taxis**

The average daily mileage of e-taxis is mainly 100–250 km, accounting for 84.8%. This mileage range mostly conforms to the travel characteristics of commercial vehicles, indicating that new energy passenger cars are preliminarily recognized for their economy when used as e-taxis. The number of e-taxis with an average monthly mileage of more than 5000 km is proliferating, and the proportion of such e-taxis increased from 23.5% in 2020 to 34.2% in 2021. The main reason for the increase in the proportion of e-taxis in the high average monthly mileage is that with the gradual rationalization of the matching between charging and swapping devices and vehicles, the e-taxis operation is further normalized.

The average daily mileage of taxis is mostly around 200 km, with taxis with an average daily mileage of 100–250 km accounting for the main proportion; the proportion of taxis with an average daily mileage of more than 5000 km in 2021 was 48.04%, with an increase of 2.1% and 10.5% compared with that in 2019 and 2020, respectively.

- **Cars for sharing**

In 2021, the average daily travel duration and average daily mileage of cars for sharing had significantly increased compared with previous years. The average daily travel duration of cars for sharing was 5.1 h in 2021, with an increase of 82.0% and 84.7% compared with that in 2019 and 2020, respectively; the average daily mileage of cars for sharing in 2021 was 124.0 km, with a YoY increase of 24.4%. Due to issues such as heavy assets and relatively low utilization rates in the timeshare rental market, the timeshare rental market is gradually shrinking, while the shared rental market for monthly rental or long-distance travel on weekends and holidays is proliferating, with a significant increase in vehicle operating hours and mileage.

(2) **Commercial vehicles**

- **Logistics vehicles**

The average single-trip travel duration and average single-trip mileage of logistics vehicles in 2021 were 0.87 h and 18.96 km, respectively, which showed an increase compared with that in 2020 and gradually returned to pre-COVID-19 level, indicating that the use of new energy logistics vehicles is gradually becoming more routine. In the past three years, logistics vehicles' average monthly mileage has rapidly grown. In 2021, logistics vehicles' average monthly mileage was 2270.33 km, with a YoY increase of 4.7%. As the distribution shows, the proportion of logistics vehicles with an average monthly mileage of more than 3000 km rapidly increased from 10.7% in 2019 to 29.2% in 2021, and new energy logistics vehicles are gradually tending towards benign operation.

- **Buses**

The daily operation of buses has a strong regularity, and the average daily travel duration remains stable at around 7 h. The average daily mileage is mostly the same as that in previous years, mainly concentrated in 100–200 km; Regarding monthly travel characteristics, the average monthly travel days of over 60% of buses in 2021 was more than 25, and the average monthly mileage has been relatively stable over the years, all of which are above 3500 km. With the normalization of bus operation, new energy buses are gradually replacing more fuel buses and taking on the operation tasks of longer routes.

- **Heavy-duty trucks**

As the distribution shows, in the past three years, heavy-duty trucks' average single-trip mileage was mainly concentrated within 30 km, with a proportion of 74.5% in 2021. However, the proportion of heavy-duty trucks with an average single-trip mileage of more than 30 km is rising, increasing from 12.5% in 2019 to 25.5% in 2021. The increase in average single-trip mileage provides more possibilities for expanding the application scenarios of BEV heavy-duty trucks. In 2021, the average daily travel duration and average daily mileage of heavy-duty trucks were 5.2 h and 107.6 km, respectively, increased compared with previous years, and vehicle operation is gradually becoming more routine. Currently, cities across China face pressure to save energy and reduce emissions and heavy-duty trucks play a crucial role in energy conservation and carbon reduction in transportation. It is necessary to pay practical attention to how to improve the utilization rate of new energy heavy-duty trucks, innovate from the perspectives including ROW, business model, and infrastructure improvement, and evaluate the energy consumption and carbon emissions indicators of new energy heavy-duty trucks from an entire lifecycle perspective, effectively enhancing the responsibility of "Pollution and Carbon Reduction" for new energy heavy-duty trucks.

Chapter 5
Charging of New Energy Vehicles

Charging infrastructure is an important guarantee for the green travel of electric vehicle users and an important support for promoting the development of the NEV industry, promoting the construction of new power systems, and helping to achieve the goal of carbon peaking and carbon neutrality. On January 10, 2022, the National Development and Reform Commission, the National Energy Administration, and other departments jointly issued the *Implementation Opinions of the National Development and Reform Commission and other departments on Further Improving the Service Guarantee Capacity of Electric Vehicle Charging Infrastructure* (FGNYG [2022] No. 53) (hereinafter referred to as the "Implementation Opinions"), which make clears target plans and guidance for guiding the construction of a moderately advanced, balanced, intelligent and efficient charging infrastructure system during the "14th Five-Year Plan" period. This chapter analyzes the charging characteristics of vehicles in different application scenarios, charging behavior in different charging scenarios, and operation characteristics of battery swapping modes, and summarizes the charging laws of electric vehicle users, providing certain research references for further improving the layout and planning of China's charging infrastructures.

5.1 Construction Situation of Charging Infrastructures

5.1.1 Progress in Charging Infrastructure Construction

The construction scale of charging facilities continues to maintain rapid growth, and as of the end of 2021, the UIO of charging infrastructures in China has reached 2.617 million units.

In recent years, China's charging infrastructures have steadily developed from charging technology and standard system to industrial ecology. China has built the world's most extensive charging infrastructure system with the most significant number, radiation area, and comprehensive service vehicles. According to statistics

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2022)*,
https://doi.org/10.1007/978-981-99-6411-6_5

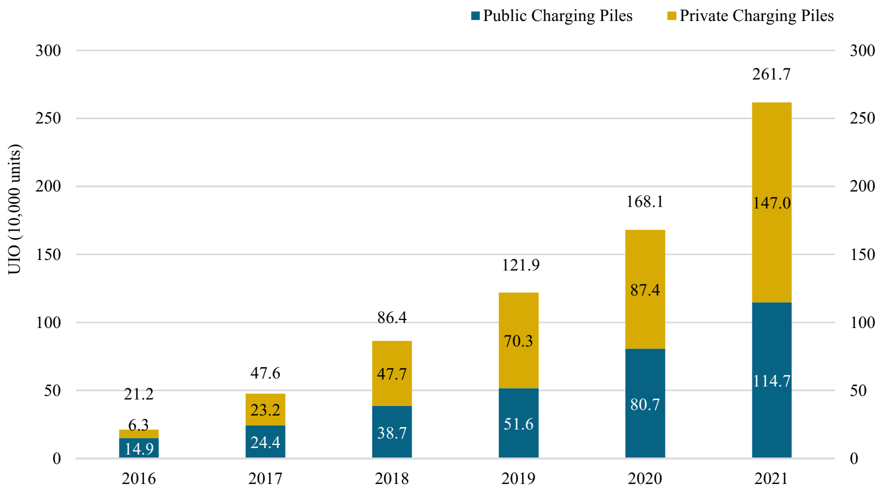


Fig. 5.1 UIO of charging infrastructures in China over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

from the China Electric Vehicle Charging Infrastructure Promotion Alliance (hereinafter referred to as the "EVCIPA") (Fig. 5.1), as of the end of 2021, the scale of charging facilities in China has reached 2.617 million units, with 1298 battery swapping stations, providing strong support for the development of China's NEV industry. With the rapid growth of charging facilities built along with vehicles, the proportion of private charging piles has gradually increased. By 2021, the number of private charging piles reached 1.47 million, accounting for 56.2% of the charging infrastructures in China.

The number of new charging piles has increased significantly. In 2021, the number of new charging piles was 936,000, with the increment ratio of vehicle to pile being 3.7:1.

The number of charging infrastructures and the sales of NEVs showed explosive growth in 2021. The sales of NEVs reached 3.521 million units, with a YoY increase of 157.5%. In 2021, the charging infrastructures increased by 936,000 units compared with 2020 (Fig. 5.2), with the increment ratio of vehicle to pile being 3.7:1. The construction of charging infrastructures can mostly meet the rapid development of NEVs.

In the field of public charging piles, the UIO of AC charging piles accounts for a large proportion of the UIO of public charging facilities. As shown in Fig. 5.3, by the end of 2021, the UIO of AC charging piles reached 677,000, accounting for 59.0% of the UIO of charging infrastructures; the UIO of DC charging piles reached 470,000, accounting for 41.0% of the UIO of charging infrastructures, and there were 589 AC/DC integrated charging piles. In 2020, the new public charging piles were mainly AC charging piles.

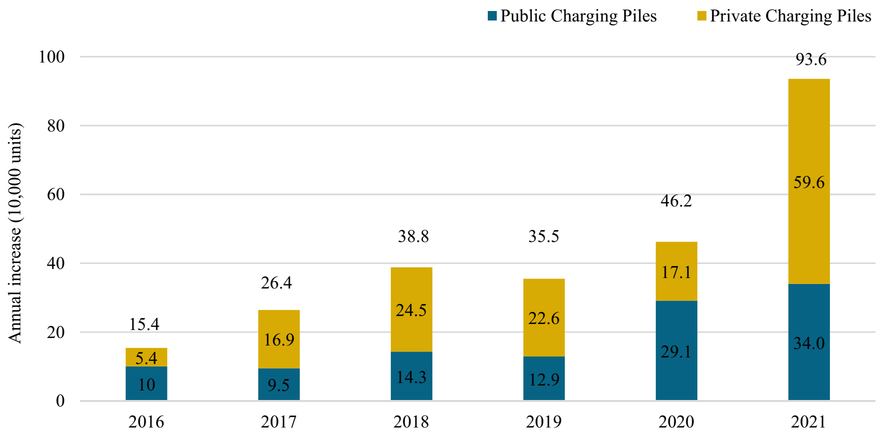


Fig. 5.2 Increment of charging infrastructures in China over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

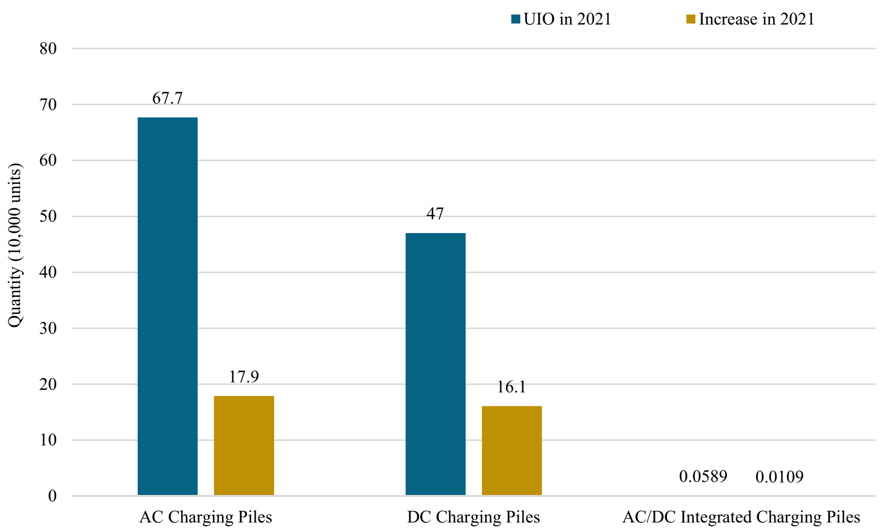


Fig. 5.3 UIO and new additions of public charging piles in China. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

In the private field, the reasons why vehicle enterprises do not build charging piles with vehicles are relatively concentrated. According to the accompanying information of vehicles and piles sampled by the EVCIPA (Fig. 5.4), among the reasons why new energy vehicles were not equipped with charging facilities in 2021, the main reasons for not building charging facilities with vehicles were group users building piles themselves, lack of fixed parking spaces in their residential areas, and lack of coordination from residential properties, accounting for 48.6%, 10.3%, and 9.9%,

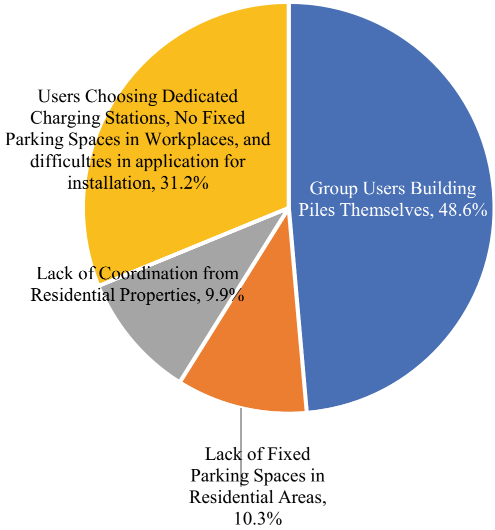


Fig. 5.4 Proportion of reasons why vehicle enterprises did not build charging piles with vehicles in 2021. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

respectively, totaling 68.8%. The proportion of users choosing dedicated charging stations, no fixed parking spaces in workplaces, and difficulties in application for installation and other reasons accounted for 31.2%.

5.1.2 Progress in Charging Technology

The charging technology continues to improve, and the average charging power of the public DC charging piles increases steadily.

As shown in Fig. 5.5, the average charging power of the public charging piles has mostly remained stable, which has remained chiefly at about 9 kW since 2016; the charging power of public DC charging piles has increased rapidly, and since 2019, the average power of public DC charging piles has exceeded 100 kW to meet the requirements of electric vehicles with long driving range and short charging time.

The trend of high power in the field of public charging facilities is gradually emerging.

According to the average power change of the new public DC charging piles over the years (Fig. 5.6), the high-power charging piles with 120 kW and above are proliferating, and the charging piles are gradually developing towards high power.

With the increasingly urgent demand for high-power charging of NEVs, in June 2020, State Grid Corporation of China released the *White Paper on ChaoJi Conductive Charging Technology for Electric Vehicles*, marking the entry of ChaoJi charging technology into a new stage of standard formulation and industrial application. The cable components of ChaoJi conductive charging technology adopt the liquid

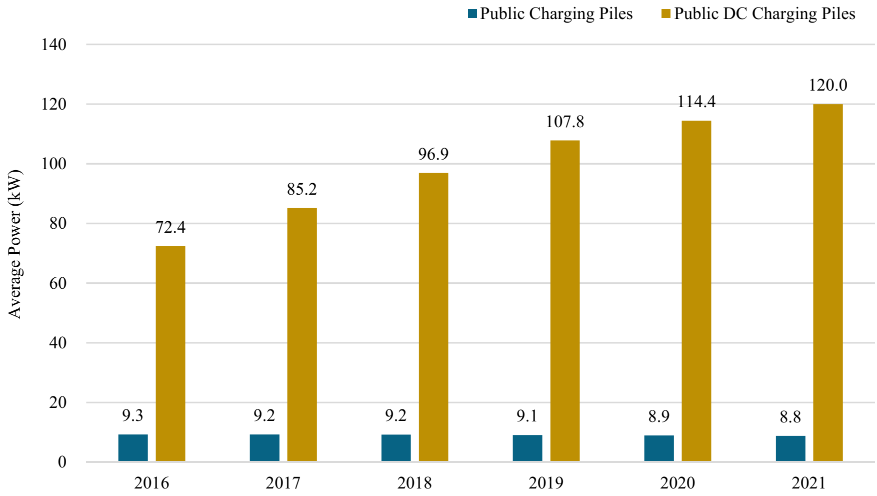


Fig. 5.5 Average power change of charging piles in public fields over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

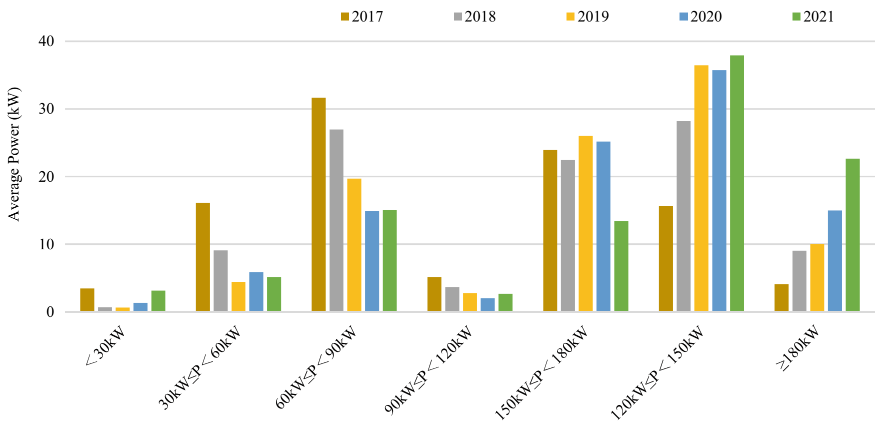


Fig. 5.6 Average power change of new public DC charging piles over the years in China. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

cooling method, with a maximum charging power of 900 kW, meeting the high-power charging needs and making charging as fast as refueling. With the implementation of the new generation of supercharging technology, it will stimulate the release of more super quick-charging models. Since 2020, vehicle enterprises and operators such as BYD, Geely, ARCFOX, Hyundai, GAC, Xiaopeng, Lixiang, Huawei have successively released solutions and models equipped with 800 V high-voltage platforms. ZEEKR, Xiaopeng, and BYD have set the mass production time for 800 V voltage platform models in 2022. With the rapid growth of electrification in new energy enterprises, choosing a high-voltage architecture at the vehicle enterprise level is necessary to achieve high-power fast charging and improve users' charging experience.

5.2 Charging Characteristics of Vehicles in Key Segments

Through analysis of vehicles in six segments, including new energy private cars, BEV e-taxis, BEV taxis, BEV cars for sharing, BEV logistics vehicles, and BEV buses, this section analyzes and summarizes the charging characteristics of vehicles at different periods with the average single-time charging characteristics, average daily charging characteristics and average monthly charging characteristics as focuses (Table 5.1), and draws a conclusion on the vehicle charging laws, intending to provide a reference for the improvement of charging facility policies and the reasonable layout of charging facilities by operators. The specific indicators under analysis are as follows.

5.2.1 Charging Characteristics of New Energy Private Cars

(1) **Average single-time charging characteristics of new energy private cars**

The average single-time charging duration of new energy private cars concentrated at 1–4 h, and the proportion of new energy private cars with an average

Table 5.1 Analysis indicators for NEV segments

Analysis dimension	Analysis indicator	Definition
Average single-time charging characteristics	Average single-time charging duration	Average charging duration of single charging
	Average single-time charging initial SOC	Average initial SOC of single charging
Average daily charging characteristics	Charging time	Distribution of charging time in a single day (24 h)
Average monthly charging characteristics	Average monthly charging times	Average charging times in a single month
	Average monthly fast charging times	Average times of fast charging in a single month
	Average monthly slow charging times	Average times of slow charging in a single month
	Average monthly charge	Average charges in a single month

single-time charging duration of 1–4 h in the past two years has reached over 60%.

In 2021, the average single-time charging duration of new energy private cars was 3.7 h, which is 0.2 h shorter than that in 2020 (Table 5.2). The distribution of vehicles' average single-time charging duration in 2021 was mostly consistent with that in 2020 (Fig. 5.7), with the average single-time charging duration mainly concentrated in 1–4 h.

From the distribution of single-time charging durations for BEV private cars on weekdays and weekends, it can be seen that the average single-time charging durations for BEV private cars are mainly concentrated in 2–5 h. During weekends, the proportion of BEV and PHEV private cars with average single-time charging duration above 8 h is significantly higher than that during weekdays (Fig. 5.8). The average single-time charging duration of PHEV private cars concentrated at 2–3 h, and the distribution of average single-time charging duration of BEV private cars is relatively balanced (Fig. 5.9).

Regarding the charging methods for new energy private cars (Fig. 5.10), the fast charging duration is mainly concentrated within 2 h, with vehicles with a duration within 2 h accounting for 93.3%; the distribution of slow charging duration is relatively dispersed, with vehicles with a duration of 2–6 h accounting for 60%.

The average single-time charging initial SOC of private cars is 39.8%, which is mostly the same as in previous years.

Table 5.2 Average single-time charging duration of new energy private cars over the years

Year	2019	2020	2021
Average single-time charging duration (h)	4.0	3.9	3.7

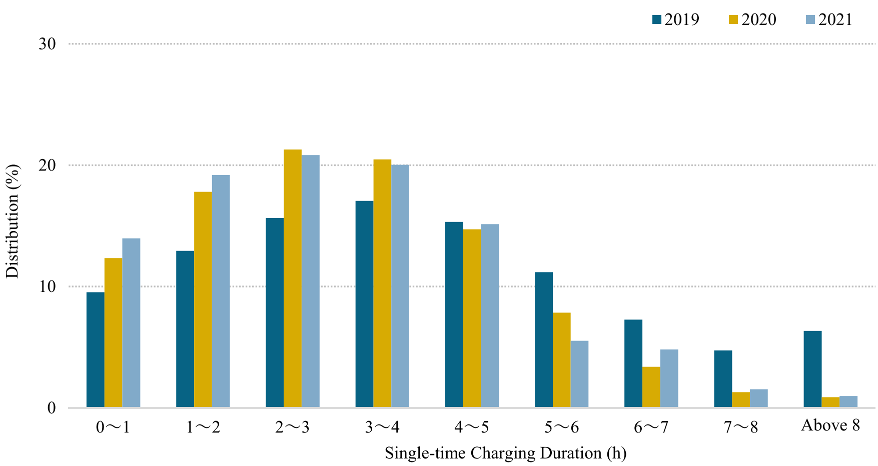


Fig. 5.7 Distribution of average single-time charging duration of new energy private cars—by year

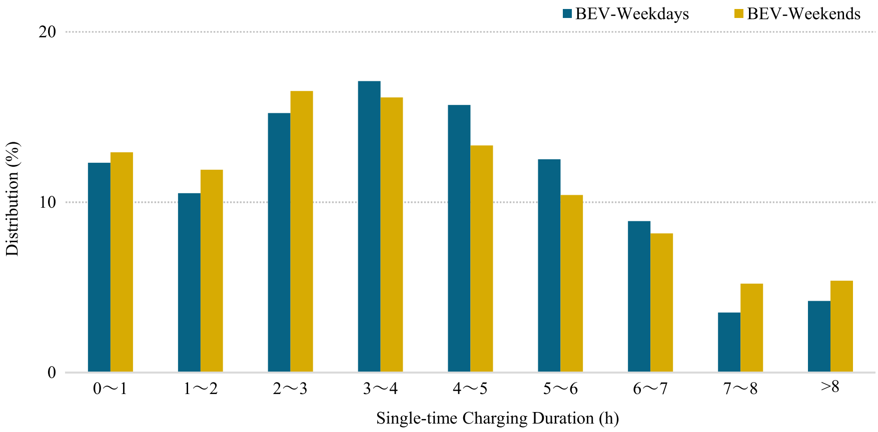


Fig. 5.8 Distribution of average single-time charging duration of BEV private cars in 2021—by weekday and weekend

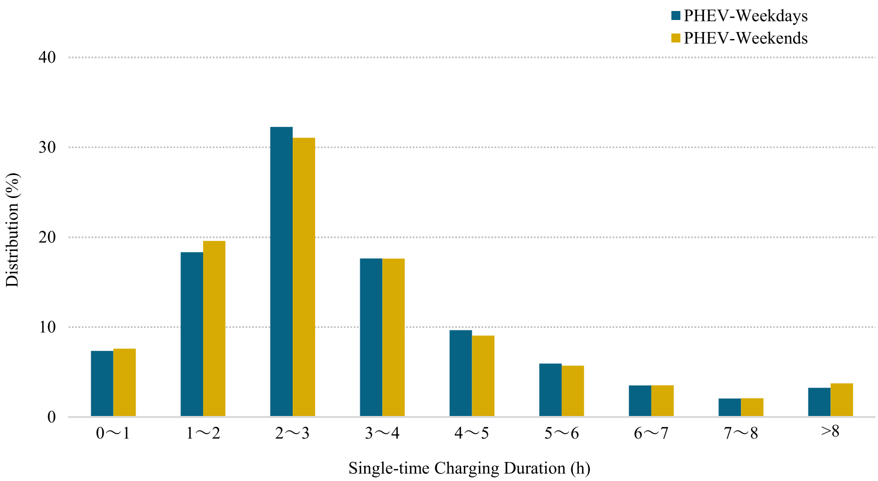


Fig. 5.9 Distribution of average single-time charging duration of PHEV private cars in 2021—by weekday and weekend

According to the data over the years, the average single-time charging initial SOC of new energy private cars in 2021 was 39.8%, which is mostly the same as in previous years (Table 5.3). The proportion of cars with an average single-time charging initial SOC of over 50% for private cars in 2021 was 26.5% (Fig. 5.11), with an increase of 2.7% and 3.9% compared with 2019 and 2020, respectively.

Regardless of BEVs or PHEVs, the proportion of private cars with a charging initial SOC in the low battery range (10–20%) and in the high battery range (70–90%) during weekends was higher than that on weekdays, while the number of private

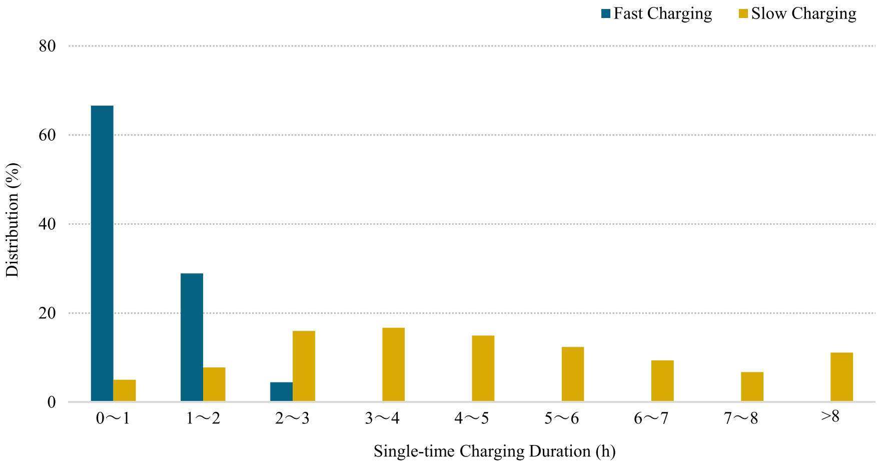


Fig. 5.10 Distribution of average single-time charging duration of new energy private cars in 2021—by fast charging and slow charging

Table 5.3 Average single-time charging initial SOC of new energy private cars over the years

Year	2019	2020	2021
Average single-time charging initial SOC (%)	39.3	41.6	39.8

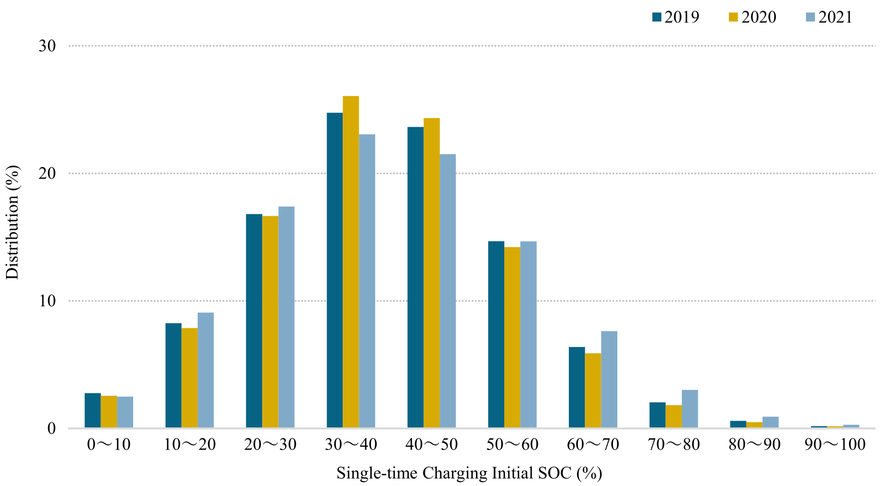


Fig. 5.11 Distribution of average single-time charging initial SOC of new energy private cars—by year

cars charged on weekends in other battery ranges (30–60%) was lower than that on weekdays (Figs. 5.12 and 5.13). The increase in the number of private cars traveling long distances on weekends makes charging reserves in advance more concentrated, resulting in more charging behavior for vehicles in lower and higher SOC ranges. Although commuting is the primary use of new energy private cars, it can already meet the needs of medium to long-distance travel.

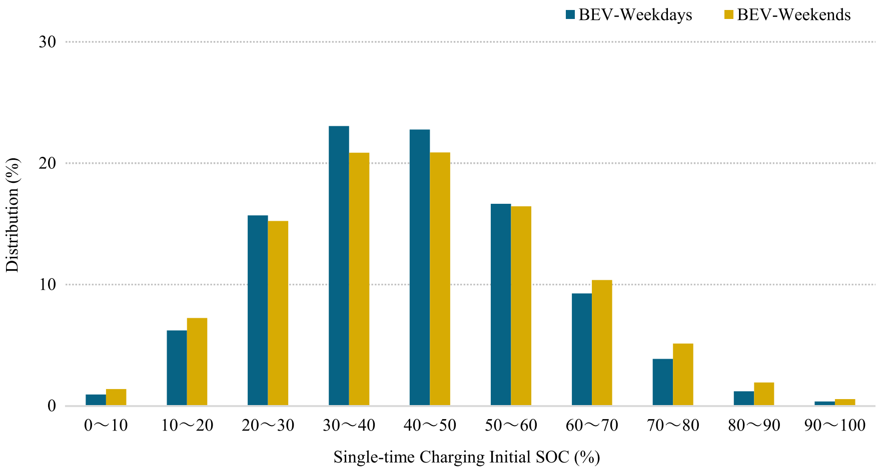


Fig. 5.12 Distribution of average single-time charging initial SOC of BEV private cars in 2021—by weekday and weekend

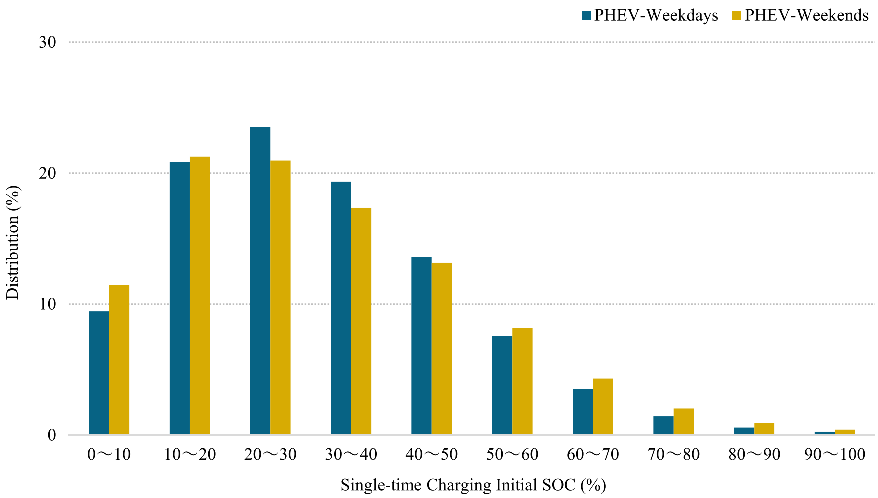


Fig. 5.13 Distribution of average single-time charging initial SOC of PHEV private cars in 2021—by weekday and weekend

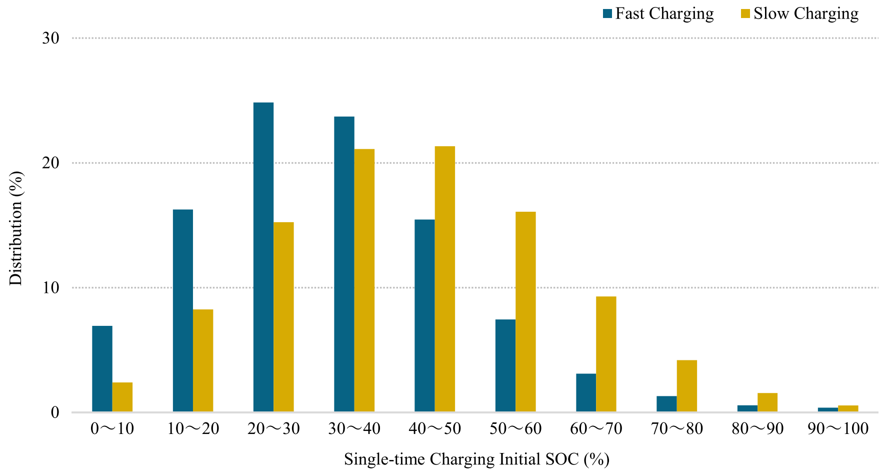


Fig. 5.14 Distribution of average single-time charging initial SOC of new energy private cars in 2021—by fast charging and slow charging

Regarding vehicle charging methods, the average single-time charging initial SOC for fast charging of new energy private cars was more concentrated at 10–50%, with the number of vehicles accounting for 80.3%, which is 14.4% higher than the number of vehicles for slow charging; the average single-time charging initial SOC for slow charging of new energy private cars was more concentrated in 20–60%, with the number of vehicles accounting for 73.8% (Fig. 5.14). Fast charging is more used for fast charging when the battery is low, while slow charging is more used for regular charging.

(2) **Average daily charging characteristics of new energy private cars**

The average daily charging time for new energy private cars in 2021 concentrated during the morning rush hour and at night.

According to the distribution of charging times, in 2021, the charging of new energy private cars concentrated in the morning rush hours and at night. Specifically, the proportion of new energy private cars charged between 7:00 and 9:00 was 16.34%, and that charged between 18:00 and 22:00 was 34.68%, significantly higher than that in other periods (Fig. 5.15). The charging characteristics at commuting destinations (work unit and residence) are apparent.

According to the daily charging characteristics of vehicles on weekdays and weekends, the proportion of BEV and PHEV private cars charged from 7:00 to 9:00 am during the morning rush hours on weekdays was higher than on weekends (Figs. 5.16 and 5.17).

Regarding the charging methods, during the period from 8:00 to 18:00, the proportion of vehicles using the fast charging method was generally higher than that of

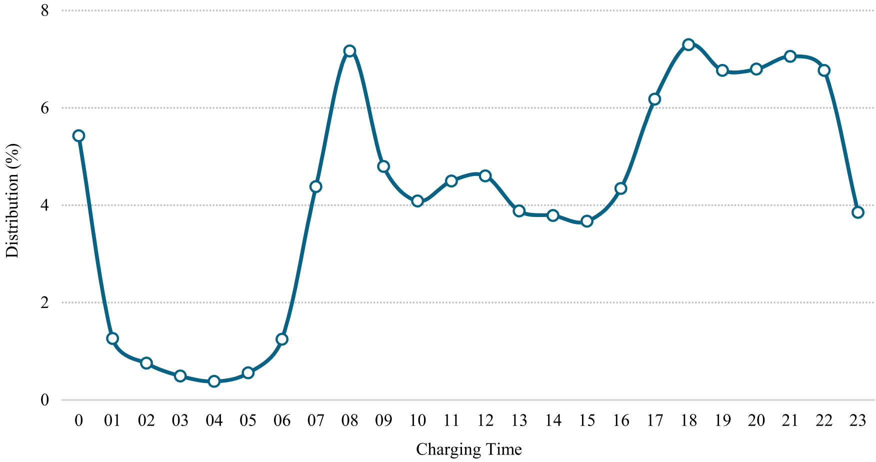


Fig. 5.15 Distribution of charging time of new energy private cars in 2021

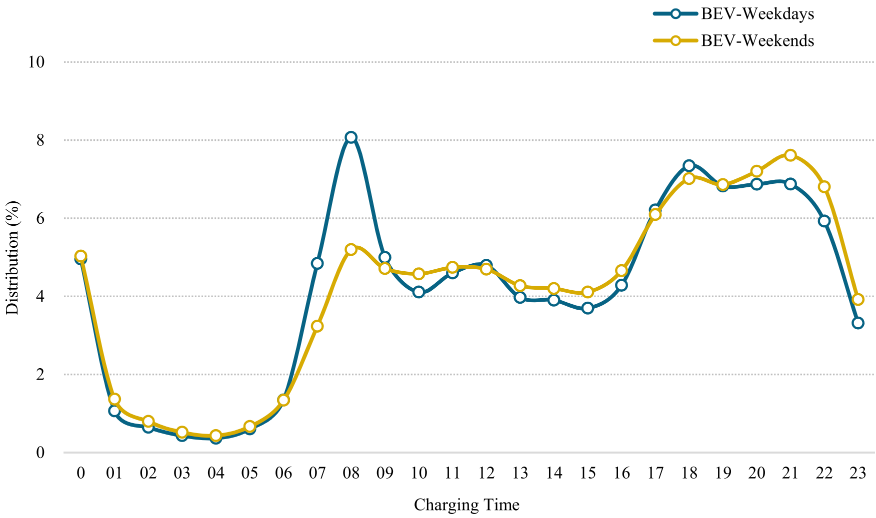


Fig. 5.16 Distribution of charging time of BEV private cars in 2021—by weekday and weekend

vehicles using the slow charging method; from the 18:00 to 24:00 period, more vehicles adopted the slow charging method. The proportion of vehicles using the slow charging method from 18:00 to 22:00 reached 36.3% (Fig. 5.18).

(3) **Average monthly charging characteristics of new energy private cars**

In 2021, the average monthly charging times of new energy private cars were 8.8 times, with an increase from previous years (Table 5.4).

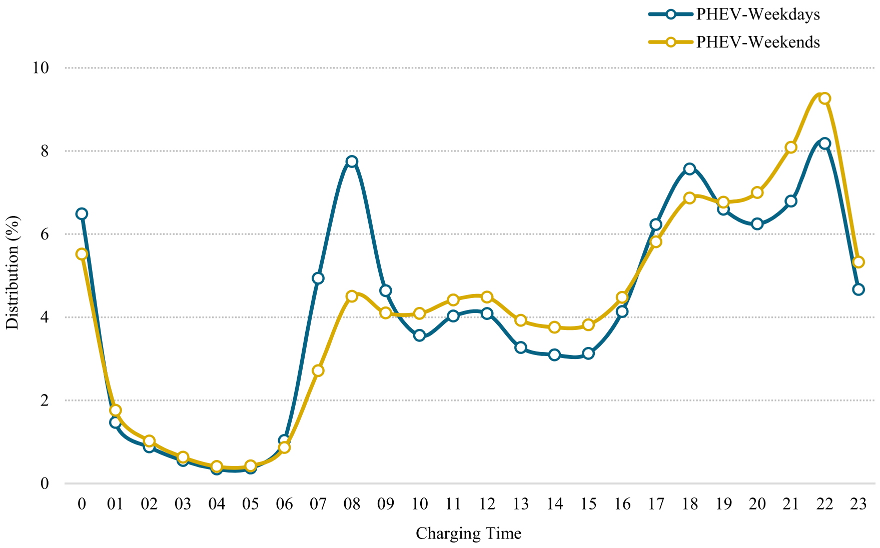


Fig. 5.17 Distribution of charging time of PHEV private cars in 2021—by weekday and weekend

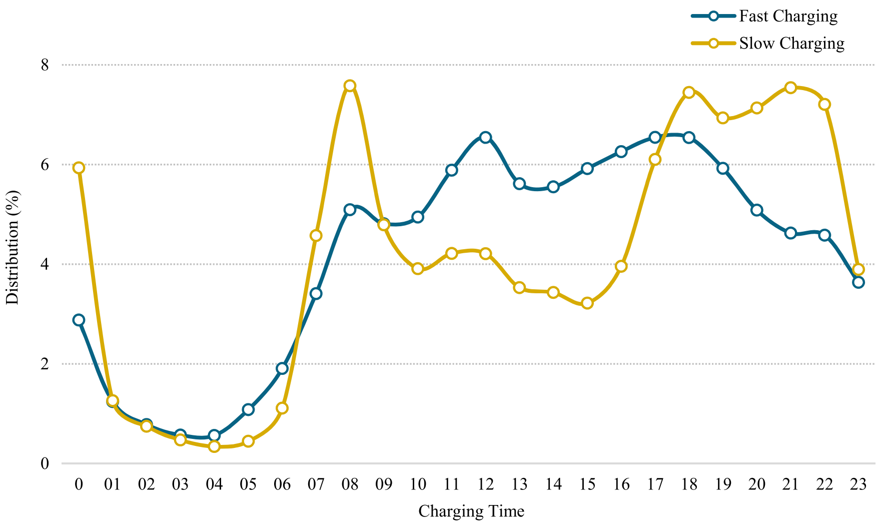


Fig. 5.18 Distribution of charging time of new energy private cars in 2021—by fast charging and slow charging

Table 5.4 Average monthly charging times of new energy private cars over the years

Year	2019	2020	2021
Average monthly charging times	8.0	7.4	8.8

According to the distribution of average monthly charging times of new energy private cars, the proportion of new energy private cars with an average monthly charging time of more than 5 was 61.3%, with an increase of 14.7% compared with 2020 (Fig. 5.19). It is mainly due to the increase in the proportion of vehicles with high-frequency average monthly charging compared with 2020. BEV private cars' average monthly charging times were mainly concentrated within 5 times, accounting for 57.9%. However, the proportion of BEV private cars with an average monthly charging time of 5–15 was significantly increased (Fig. 5.20); the proportion of PHEV private cars with an average monthly charging time of less than 5 times increased compared with 2020 (Fig. 5.21).

From the changes in vehicle charging methods over the years, the proportion of slow charging for new energy private cars has remained mostly stable in the past three years. In 2021, the proportion of slow charging in the average monthly charging times of new energy private cars was 85.2%, which is mostly the same as that in 2020 (Fig. 5.22).

In 2021, the average monthly fast charging times of new energy private cars were 1.3 times, with a slight increase from previous years.

In 2021, the average monthly fast charging times of new energy private cars were 1.3 times, slightly increasing from previous years (Table 5.5). The new energy private cars with an average monthly fast charging time of less than 5 still accounted for the main proportion, reaching 89.5% in 2021 (Fig. 5.23). The proportion of vehicles with an average monthly fast charging time of more than 5 increased, from 3.4% in 2019 to 10.6% in 2021, mainly due to the rapid growth of public fast charging facilities and the increasing trend of fast charging times for new energy private cars.

In 2021, the average monthly slow charging times of new energy private cars were 6.9 times, with an increase from 2020 (Table 5.6).

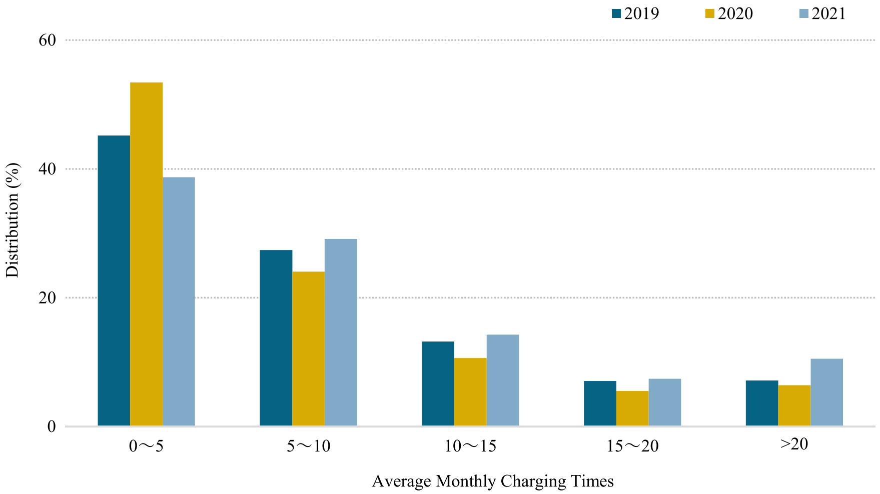


Fig. 5.19 Distribution of average monthly charging times of new energy private cars—by year

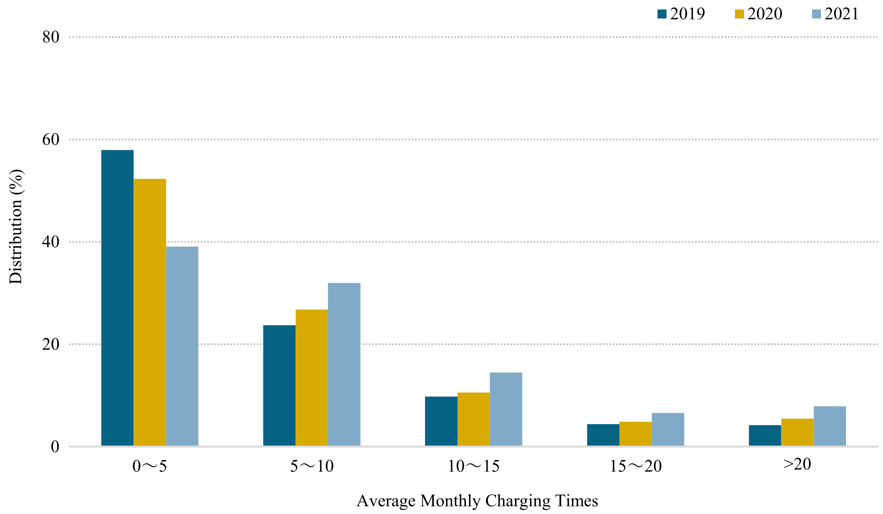


Fig. 5.20 Distribution of average monthly charging times of BEV private cars—by year

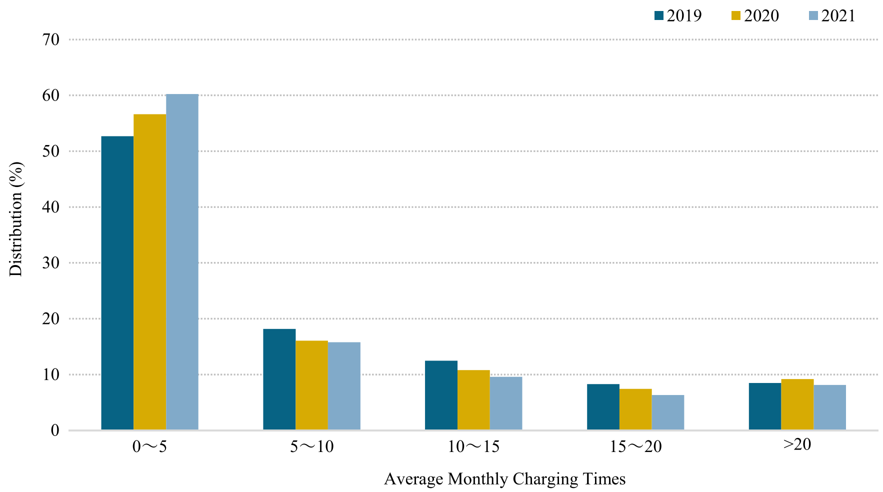


Fig. 5.21 Distribution of average monthly charging times of PHEV private cars—by year

Slow charging is still the primary method for new energy private cars, accounting for 85.2% of the monthly average charging times. From the distribution of times (Fig. 5.24), the proportion of vehicles with an average monthly slow charging time of 5 or more increased from 39.6% in 2020 to 54.1% in 2021, with a higher charging frequency of slow charging for private cars in 2021.

The slow charging frequency of private cars with different driving modes is increasing. The proportion of BEV private cars with an average monthly slow

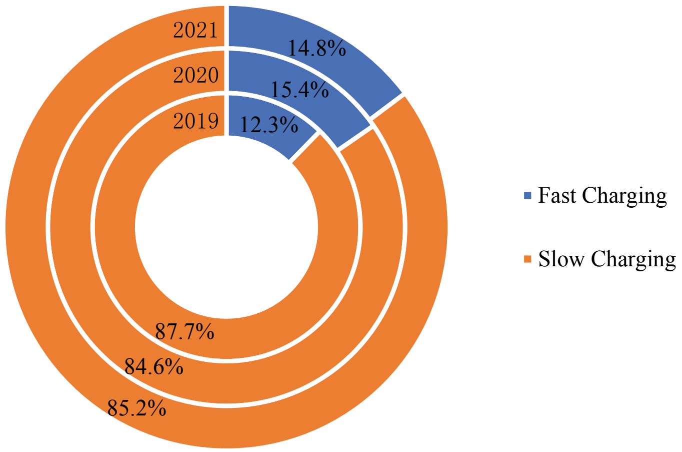


Fig. 5.22 Distribution of average monthly charging times of new energy private cars over the years—by fast charging and slow charging

Table 5.5 Average monthly fast charging times of new energy private cars over the years

Year	2019	2020	2021
Average monthly fast charging times	0.8	1.2	1.3

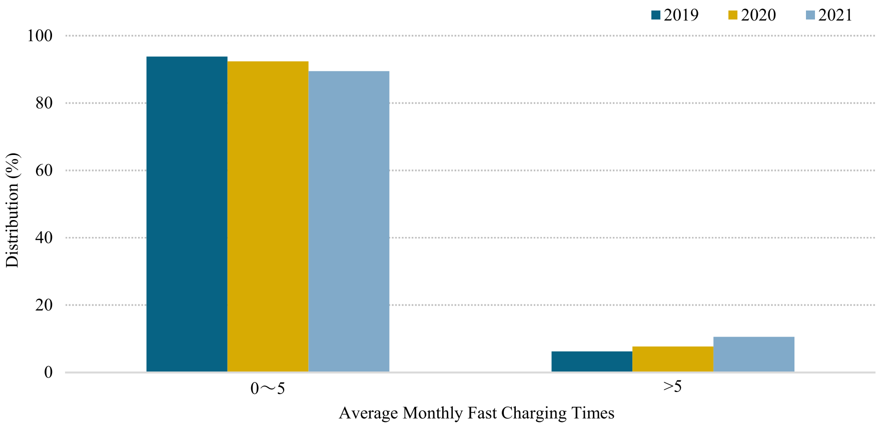


Fig. 5.23 Distribution of average monthly charging times of new energy private cars—by year for fast charging

Table 5.6 Average monthly slow charging times of new energy private cars over the years

Year	2019	2020	2021
Average monthly slow charging times	7.4	6.5	6.9

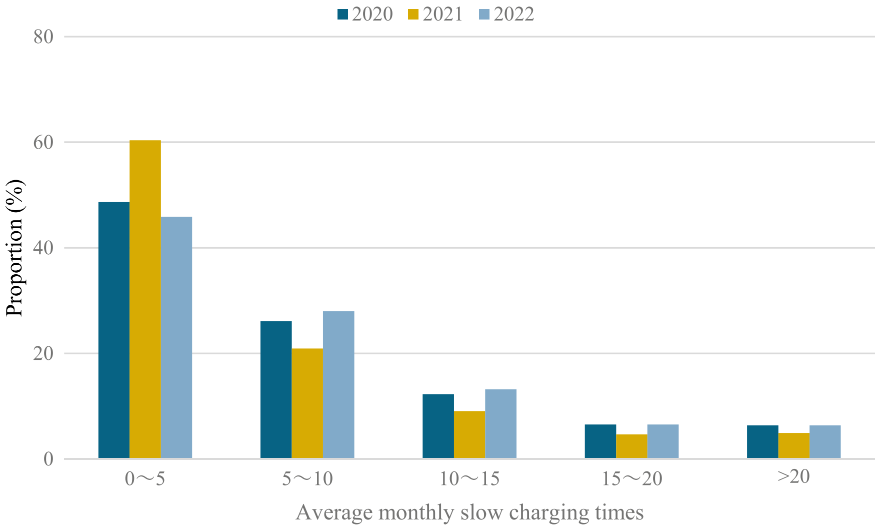


Fig. 5.24 Distribution of average monthly slow charging times of new energy private cars—by year

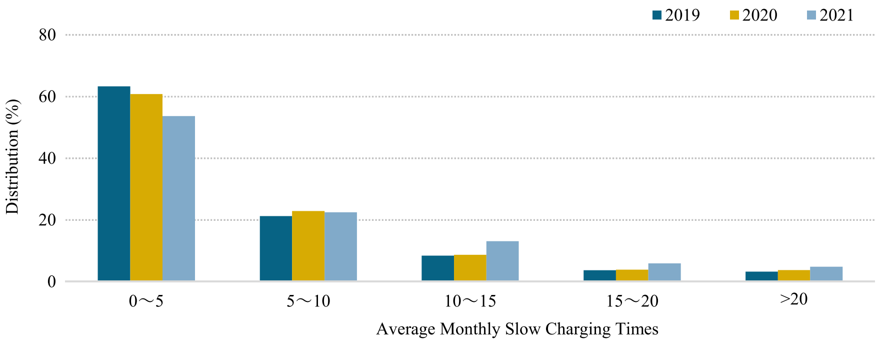


Fig. 5.25 Distribution of average monthly slow charging times of BEV private cars—by year

charging time of over 5 increased from 39.2% in 2019 to 46.3% in 2021 (Fig. 5.25); the proportion of PHEV private cars with an average monthly slow charging time of over 5 increased from 40.8% in 2020 to 47.4% in 2021 (Fig. 5.26).

The average monthly charge of new energy private cars in 2021 was 105.5 kWh, with an increase of 25.3% compared with that in 2020 (Table 5.7).

The new energy private cars with an average monthly charge of less than 100 kWh in 2021 controlled a large proportion of 44.3%. Regarding the trend of changes over the years (Fig. 5.27), the proportion of vehicles with an average monthly charge of more than 50 kWh showed a significant upward trend, increasing from 49.4% in 2019 to 55.7% in 2021. There are multiple reasons for the increase in average monthly charge, mainly due to the increase in mileage and vehicle upsizing.

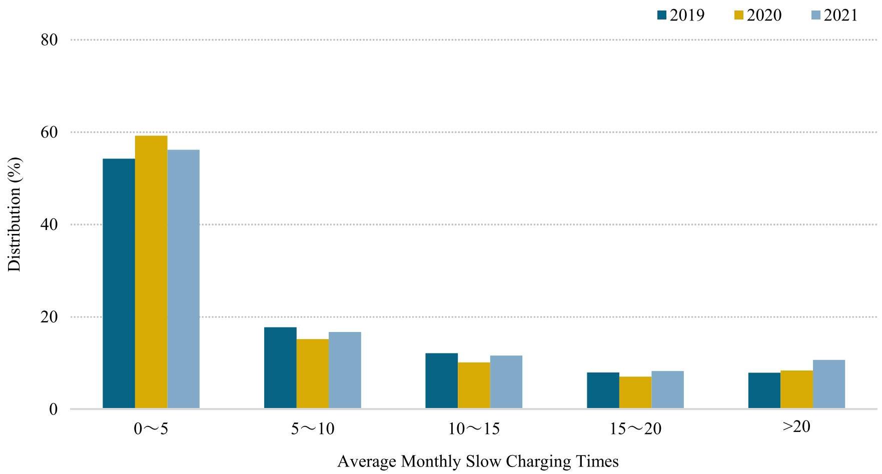


Fig. 5.26 Distribution of average monthly slow charging times of PHEV private cars—by year

Table 5.7 Average monthly charge of new energy private cars over the years

Year	2019	2020	2021
Average monthly charge (kWh)	86	84.2	105.5

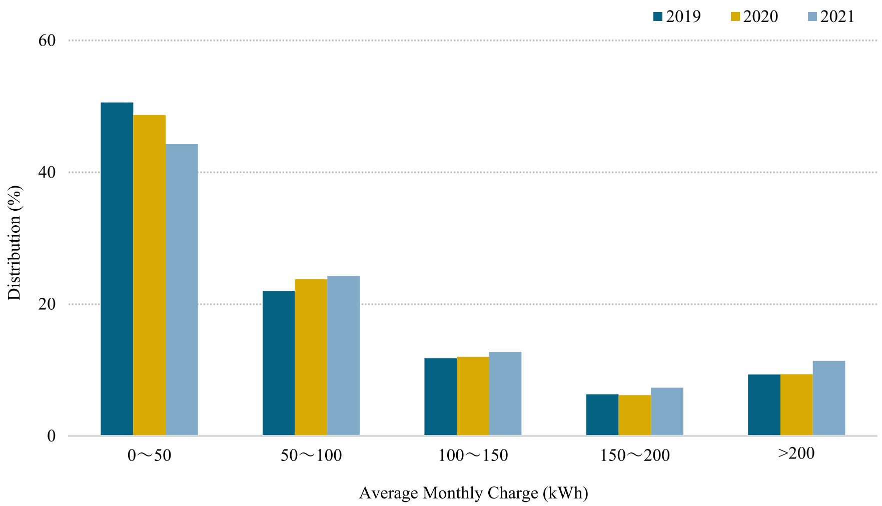


Fig. 5.27 Distribution of average monthly charge of new energy private cars—by year

5.2.2 Charging Characteristics of BEV E-taxis

(1) Average single-time charging characteristics of BEV e-taxis

The average single-time charging duration of BEV e-taxis was 1.6 h in 202, which is mostly the same as that in 2020.

As shown in Table 5.8, the average single-time charging duration of BEV e-taxis was 1.6 h in 202, which is mostly the same as in 2020. According to the distribution of average single-time charging duration (Fig. 5.28), the proportion of BEV e-taxis with an average single-time charging duration of more than 2 h increased from 26.1% in 2020 to 32.9% in 2021, which to some extent indicates that the proportion of BEV e-taxis using slow charging is increasing.

Regarding the charging methods, the fast charging of BEV e-taxis is mainly concentrated within 1 h, with the number of vehicles accounting for 84.2%. The average single-time charging durations of e-taxis using slow charging are relatively dispersed (Fig. 5.29). For operation purposes, the average single-time charging durations of BEV e-taxis are more concentrated in 4–5 h, which is longer than 2–3 h of BEV private cars.

The average single-time charging initial SOC of BEV e-taxis was 42.5% in 2021, which is mostly the same as that in previous years.

Table 5.8 Average single-time charging duration of BEV e-taxis over the years

Year	2019	2020	2021
Average single-time charging duration (h)	1.8	1.5	1.6

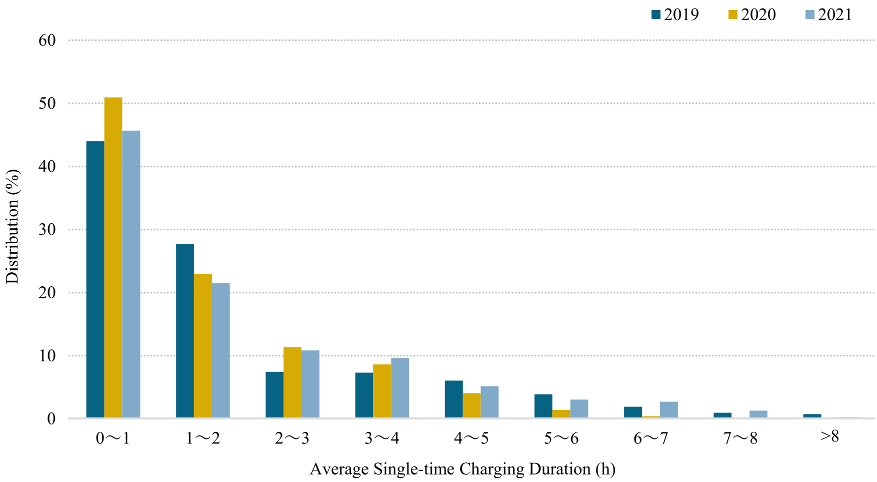


Fig. 5.28 Distribution of average single-time charging duration of BEV e-taxis—by year

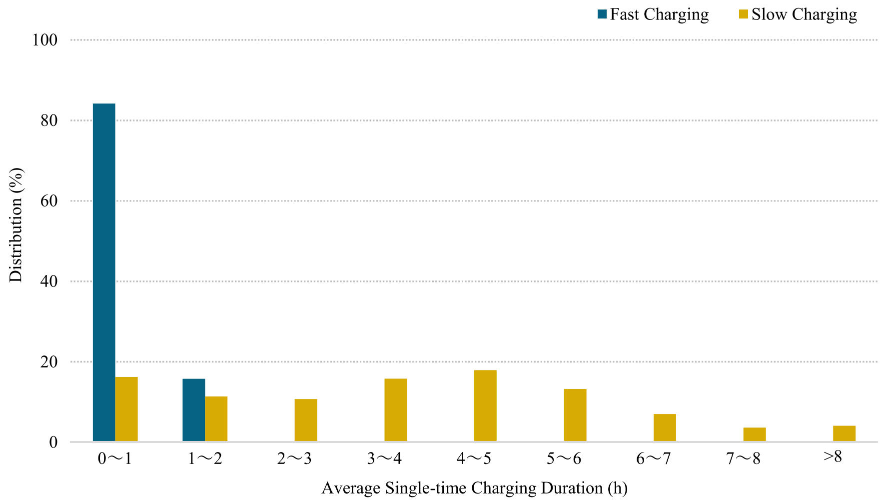


Fig. 5.29 Distribution of average single-time charging duration of BEV e-taxis in 2021—by fast charging and slow charging

The average single-time charging initial SOC of BEV e-taxis was 42.5% in 2021 (Table 5.9), which is mostly the same as in previous years. As the distribution shows (Fig. 5.30), the average single-time charging initial SOC of BEV e-taxis concentrated at 30–50%, and the proportion of vehicles in this range over the years is more than 75%.

Regarding charging methods, the average single-time charging initial SOC of BEV e-taxis using fast charging is concentrated at 20–50%, and that using slow charging is relatively dispersed (Fig. 5.31).

(2) **Average daily charging characteristics of BEV e-taxis**

In 2021, the overall charging time of BEV e-taxis was mainly distributed at noon and night, which is higher than that of the same period of the previous two years.

In 2021, the charging time of BEV e-taxis was mainly distributed at noon and night, of which the proportion of vehicles charged from 19:00 to 0:00 the next day increased from 30.9% in 2019 to 41% in 2020 (Fig. 5.32). During the charging peak period from 11:00 am to 12:00 am in 2021, the proportion of vehicles increased compared with previous years.

Regarding the charging methods, the slow charging period of BEV e-taxis is mainly concentrated at night, with 55.3% of vehicles charged from 19:00 to 0:00 the

Table 5.9 Average single-time charging initial SOC of BEV e-taxis over the years

Year	2019	2020	2021
Average single-time charging initial SOC (%)	43.2	43.4	42.5

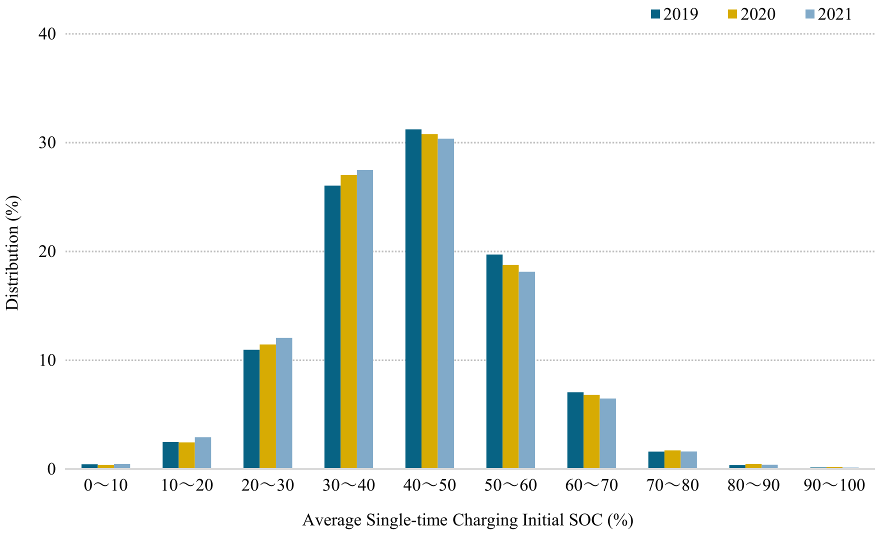


Fig. 5.30 Distribution of average single-time charging initial SOC of BEV e-taxis-by year

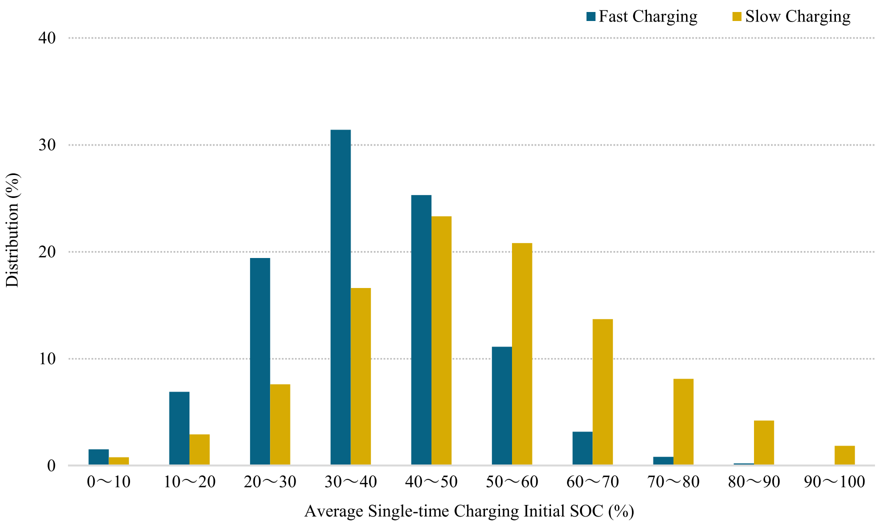


Fig. 5.31 Distribution of average single-time charging initial SOC of BEV e-taxis in 2021—by fast charging and slow charging

next day; the charging time of vehicles using fast charging is mainly concentrated from 11:00 to 16:00 and 22:00 to 0:00 the next day, which is mainly related to the operation attribute of e-taxis. Some e-taxis operate at night, so there will be a high demand for fast charging after 22:00 (Fig. 5.33).

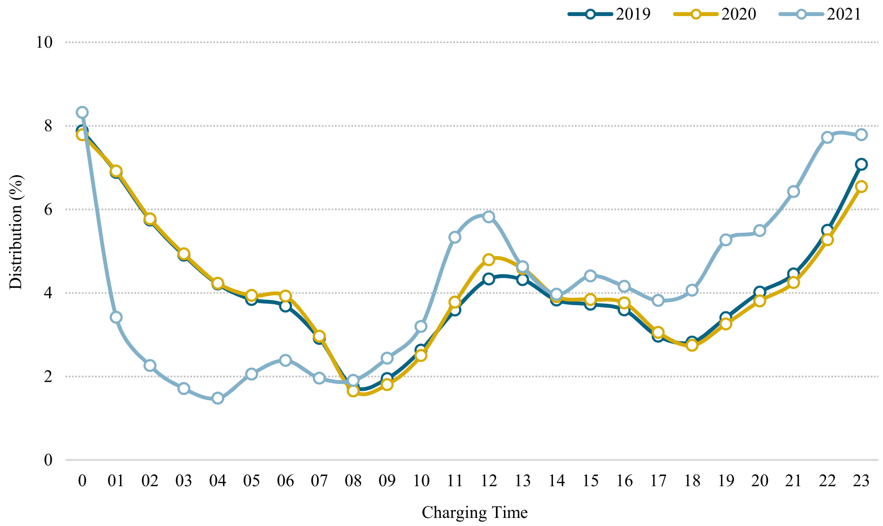


Fig. 5.32 Distribution of charging time of BEV e-taxis—by year

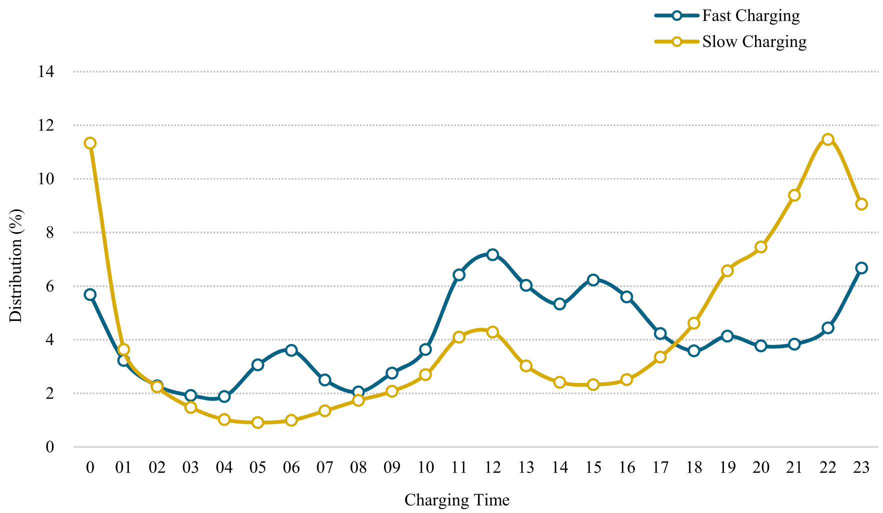


Fig. 5.33 Distribution of charging time of BEV e-taxis in 2021—by fast charging and slow charging

(3) Average monthly charging characteristics of BEV e-taxis

The average monthly charging times of BEV e-taxis were 28.9 times, and the proportion of vehicles with high charging times increased.

The average monthly charging times of BEV e-taxis reached 28.9 times in 2021, which increased significantly compared with the previous two years (Table 5.10).

Regarding the average monthly charging times (Fig. 5.34), the proportion of BEV e-taxis with average monthly charging times of more than 30 increased from 28.8% in 2020 to 43.9% in 2021, with an increase of 15.1%. Regarding the charging methods, the proportion of BEV e-taxis using fast charging was slightly higher (Fig. 5.35).

In 2021, the average monthly fast charging times of BEV e-taxis were 21.7 times, and the overall fast charging times increased.

Table 5.10 Average monthly charging times of BEV e-taxis over the years

Year	2019	2020	2021
Average monthly charging times	26.6	25.0	28.9

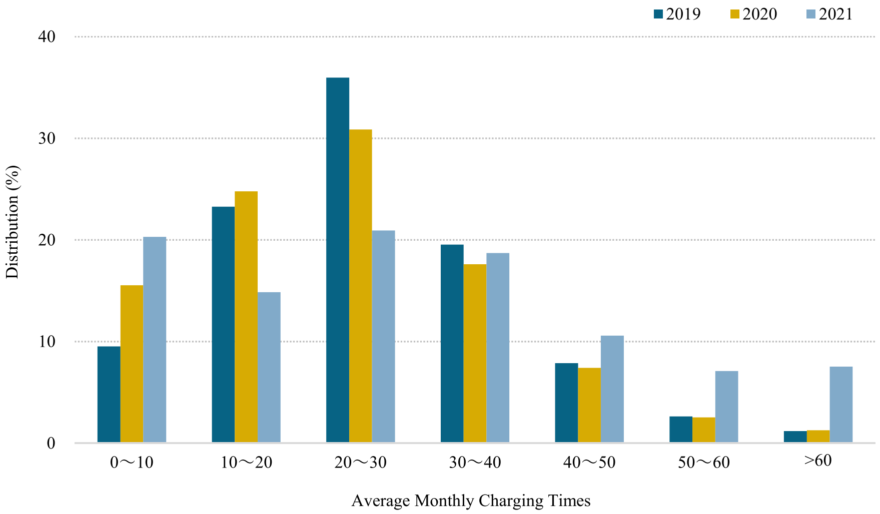
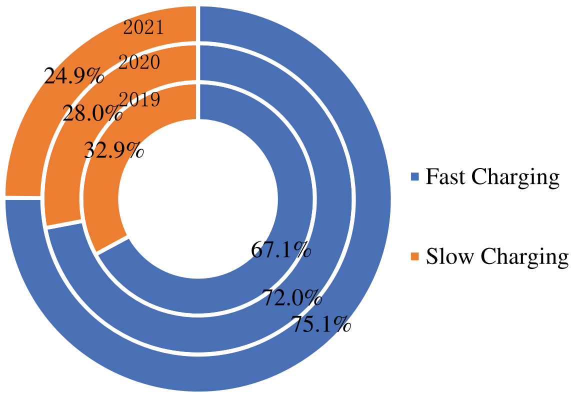


Fig. 5.34 Distribution of average monthly charging times of BEV e-taxis—by year

Fig. 5.35 Distribution of average monthly charging times of BEV e-taxis over the years—by fast charging and slow charging



The average monthly fast-charging times of BEV e-taxis in 2021 were 21.7 times higher than that in the previous two years (Table 5.11). As the distribution shows (Fig. 5.36), the proportion of BEV e-taxis with an average monthly fast charging time of more than 30 was 26.3%, with an increase of 7.9% and 9.3%, respectively, compared to the previous two years. In general, more and more vehicles are choosing fast charging to replenish their battery quickly.

The monthly average slow charging times of BEV e-taxis are mainly within 10 times.

The average monthly slow charging times of BEV e-taxis in 2021 were 7.2 times, mostly consistent with that in 2019 and 2021 (Table 5.12). From the distribution of average monthly slow charging times (Fig. 5.37), the BEV e-taxis with an average monthly slow charging time of less than 10 accounts for the main proportion, with the proportion in the recent three years of more than 70%.

Table 5.11 Average monthly fast charging times of BEV e-taxis over the years

Year	2019	2020	2021
Average monthly fast charging times	19.2	18.0	21.7

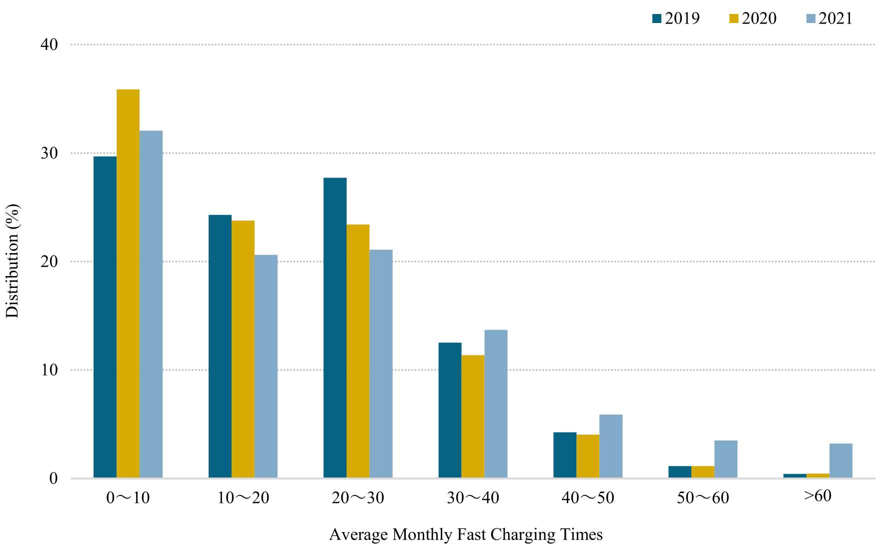


Fig. 5.36 Distribution of average monthly fast charging times of BEV e-taxis-by year

Table 5.12 Average monthly slow charging times of BEV e-taxis over the years

Year	2019	2020	2021
Average monthly slow charging times	7.5	7.0	7.2

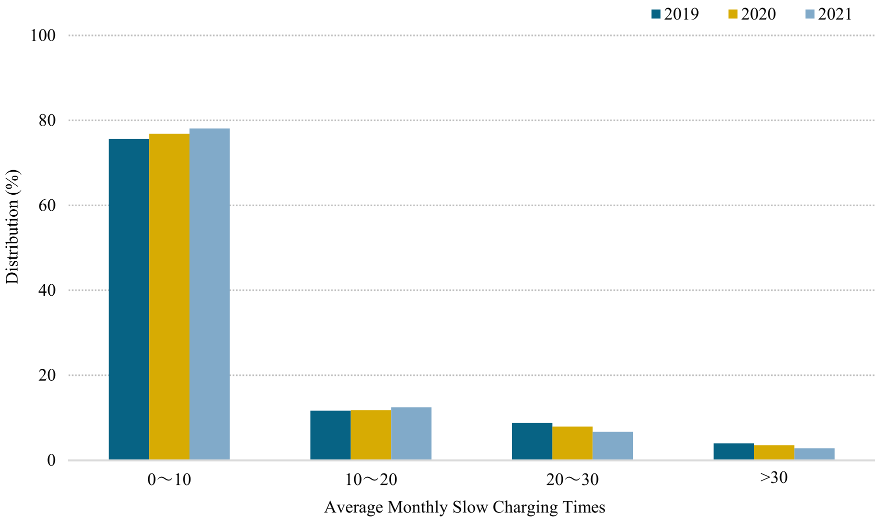


Fig. 5.37 Distribution of average monthly slow charging times of BEV e-taxis—by year

Table 5.13 Average monthly charge of BEV e-taxis over the years

Year	2019	2020	2021
Average monthly charge (kWh)	640.4	548.4	652.8

The average monthly charge of BEV e-taxis in 2021 was 652.8 kWh, with an increase of 19.0% compared with that in 2020 (Table 5.13).

As the distribution shows (Fig. 5.38), the proportion of BEV e-taxis using fast charging with an average monthly charge of more than 1000 kWh increased from 4.9% in 2020 to 12.5% in 2021, with the highest growth rate, indicating that BEV e-taxis tends to use fast charging during high mileage travel. In 2021, the proportion of BEV e-taxis using slow charging with an average monthly charge of more than 500 kWh increased significantly (Fig. 5.39).

5.2.3 Charging Characteristics of BEV Taxis

(1) **Average single-time charging characteristics of BEV taxis**

The distribution of BEV taxis' annual average single-time charging duration is mainly concentrated within 1 h.

The average single-time charging duration of BEV taxis in 2021 was 1.1 h, the same as in 2020 (Table 5.14). As the distribution shows (Fig. 5.40), the distribution of average single-time charging duration of BEV taxis was mainly concentrated within 1 h, and the proportion of vehicles with an average charging single-time charging

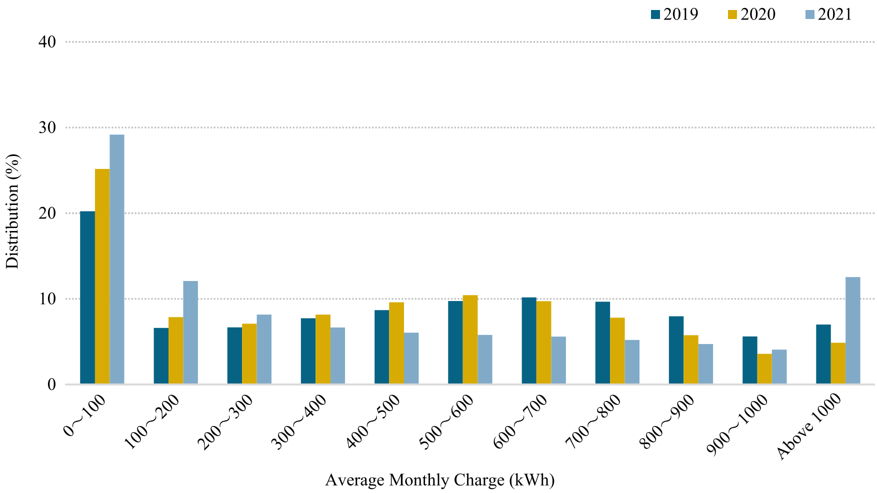


Fig. 5.38 Distribution of average monthly charge of BEV e-taxis—by year for fast charging

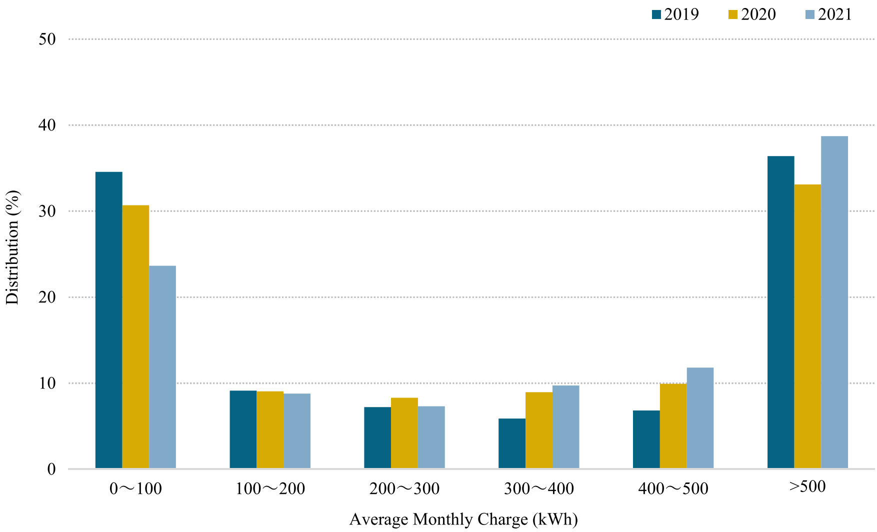


Fig. 5.39 Distribution of average monthly charge of BEV e-taxis—by year for slow charging

duration of less than 1 h increased from 52.2% in 2019 to 68.9% in 2021, which is related mainly to the continuous increase of average power of public DC charging piles.

Regarding charging methods, BEV taxis with shorter average single-time charging duration are dominant, with those using fast charging with an average single-time charging duration of less than 1 h accounting for 86.6% and those using slow charging

Table 5.14 Average single-time charging duration of BEV taxis-average

Year	2019	2020	2021
Average single-time charging duration (h)	1.5	1.2	1.1

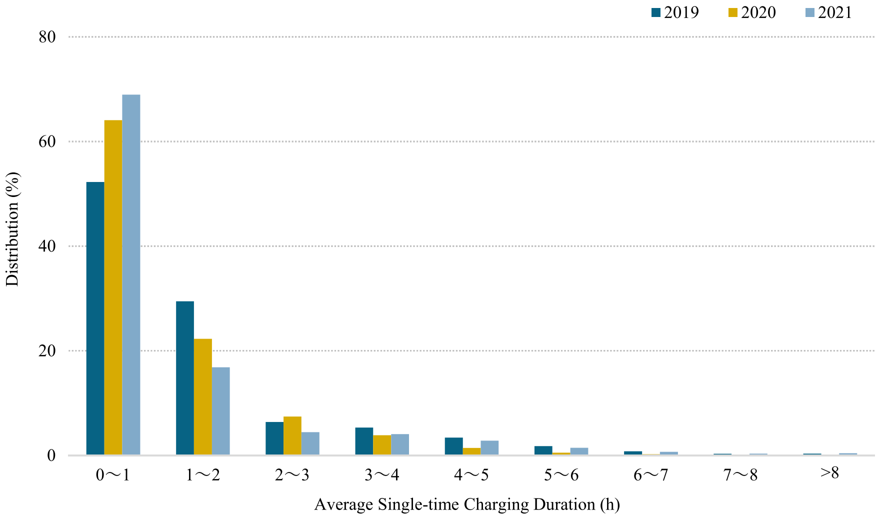


Fig. 5.40 Distribution of average single-time charging duration of BEV taxis—by year

with an average single-time charging duration of less than 2 h accounting for 61% (Fig. 5.41). Regardless of fast or slow charging, it is a practical requirement for BEV taxis to have a charging duration of less than 2 h as much as possible.

The average single-time charging initial SOC of BEV taxis was mainly the same as in previous years.

In 2021, the average single-time charging initial SOC of BEV taxis was 42.2%, which showed little change compared with 2020 (Table 5.15). As the distribution shows (Fig. 5.42), the average single-time charging initial SOC of BEV taxis was mainly distributed in the range of 30–50%, but the proportion of vehicles increased from 58.7% in 2020 to 61.6% in 2021.

Regarding charging methods, the average single-time charging initial SOC of BEV taxis using fast charging was mainly concentrated at 30–50%, and that using slow charging was relatively dispersed (Fig. 5.43).

(2) **Average daily charging characteristics of BEV taxis**

The proportion of BEV taxis charged between 11:00 and 17:00 during the day in 2021 was significantly higher than that in previous years.

According to the distribution of charging time (Fig. 5.44), in 2021, BEV taxis charged more intensively during the noon, afternoon, and night periods, with a higher peak than that in the previous two years. With the acceleration of the electrification

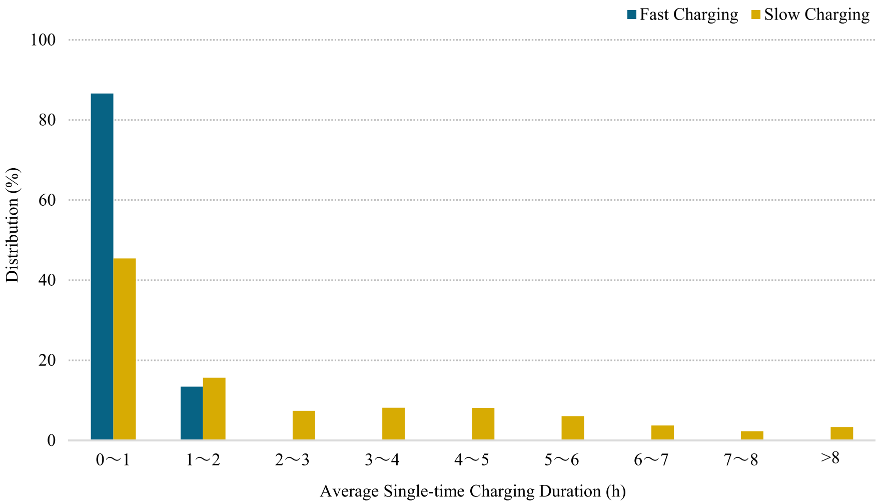


Fig. 5.41 Distribution of average single-time charging duration of BEV taxis in 2021—by fast charging and slow charging

Table 5.15 Average single-time charging initial SOC of BEV taxis over the years

Year	2019	2020	2021
Average single-time charging initial SOC (%)	44.2	43.3	42.2

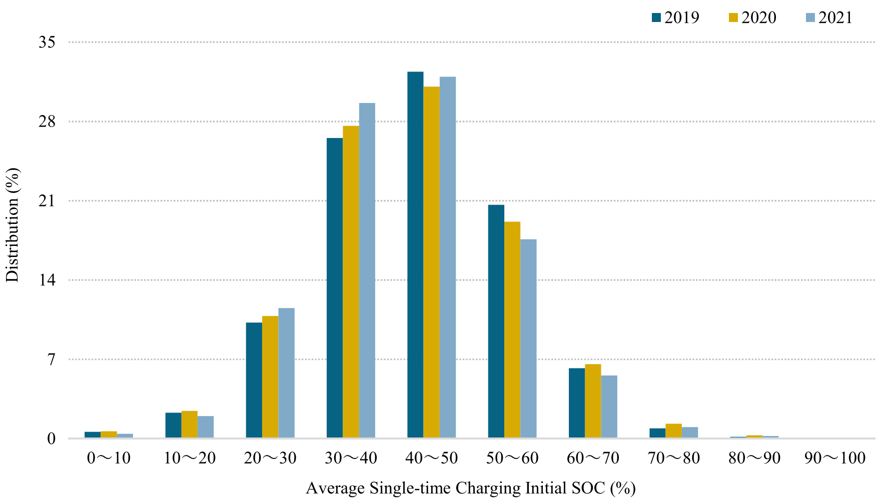


Fig. 5.42 Distribution of average single-time charging initial SOC of BEV taxis—by year

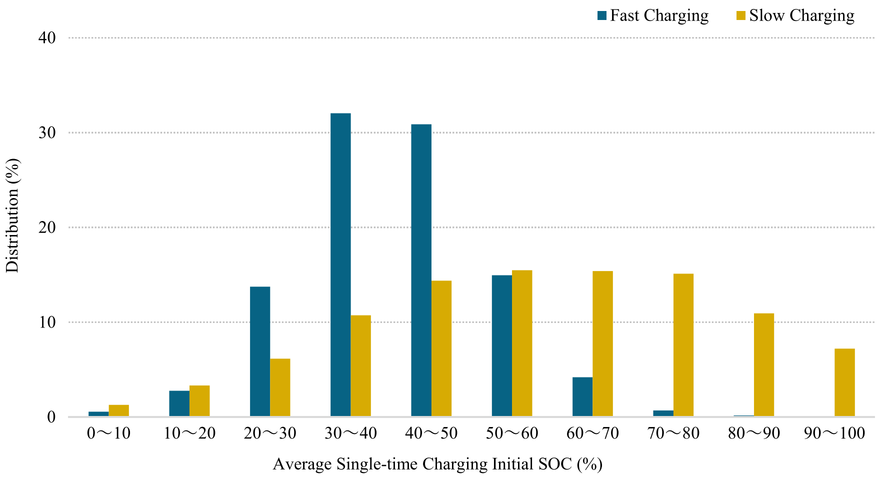


Fig. 5.43 Distribution of average single-time charging initial SOC of BEV taxis in 2021—by fast charging and slow charging

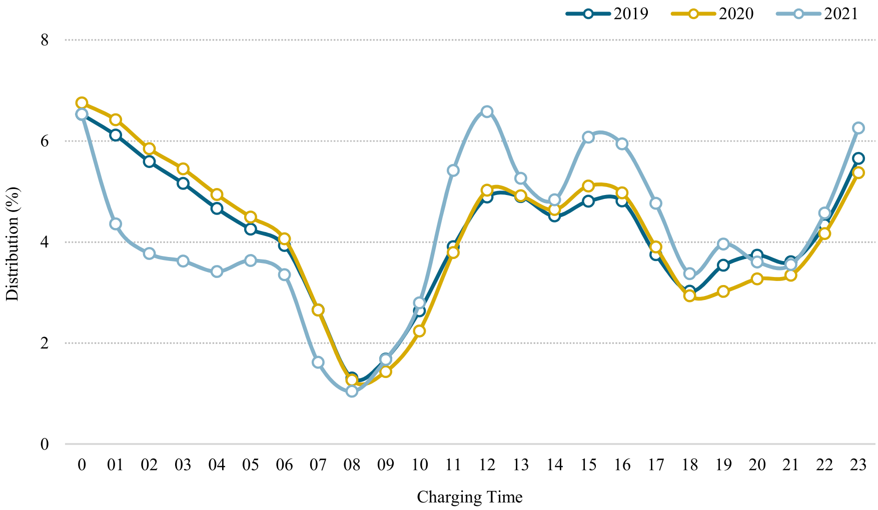


Fig. 5.44 Distribution of charging time of BEV taxis—by year

process of taxis, if the concentration of charging periods continues to increase, especially when taxis choose high-rate fast charging, attention should be paid to the power grid load.

Considering the charging method, the fast charging of BEV taxis was mainly concentrated from 11:00 to 17:00, 23:00 to 0:00 the next day; the slow charging was mainly concentrated from 21:00 to 1:00 the next day (Fig. 5.45), which is in line with the operation characteristics of taxis charging during peak travel demand periods.

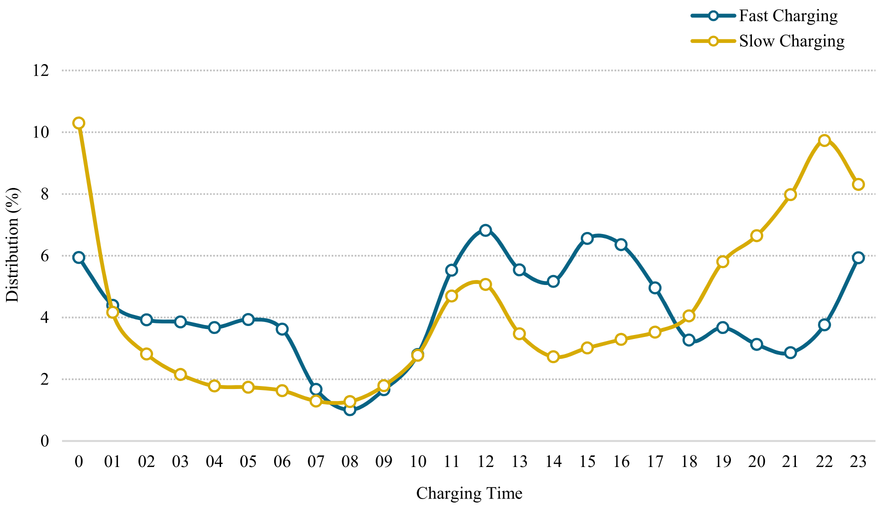


Fig. 5.45 Distribution of charging time of BEV taxis in 2021—by fast charging and slow charging

Table 5.16 Average monthly charging times of BEV taxis over the years

Year	2019	2020	2021
Average monthly charging times	31.2	28.6	41.0

(3) **Average monthly charging characteristics of BEV taxis**

The average monthly charging times of BEV taxis in 2021 were 41 times, with an increase compared with the previous two years.

Regarding the average monthly charging times (Table 5.16), the proportion of BEV taxis with average monthly charging times of more than 30 increased from 42.1% in 2019 to 66.8% in 2021 (Fig. 5.46). It indicates that in 2021, nearly 70% of BEV taxis charge more than once a day.

Considering the charging methods, BEV taxis mainly choose fast charging to supplement their electricity, with 80.2% of them using fast charging in 2021 (Fig. 5.47).

In 2021, the average monthly fast charging times of BEV taxis was 32.9 times, with a YoY increase of 44.9% (Table 5.17).

As the distribution shows (Fig. 5.48), the proportion of BEV taxis with average monthly fast charging times of more than 30 showed an upward trend, increasing from 27.5% in 2019 to 59% in 2021. Among them, the proportion of BEV taxis with average monthly fast charging times of more than 60 had increased 8.6 times compared with 2019. It can be seen that the demand for fast recharging of BEV taxis is very high, and the increase in fast charging behavior has put forward higher requirements for vehicle battery safety management and vehicle safety monitoring.

The average monthly slow charging times of BEV taxis in 2021 were 8.1 times, with an increase compared with that in 2020.

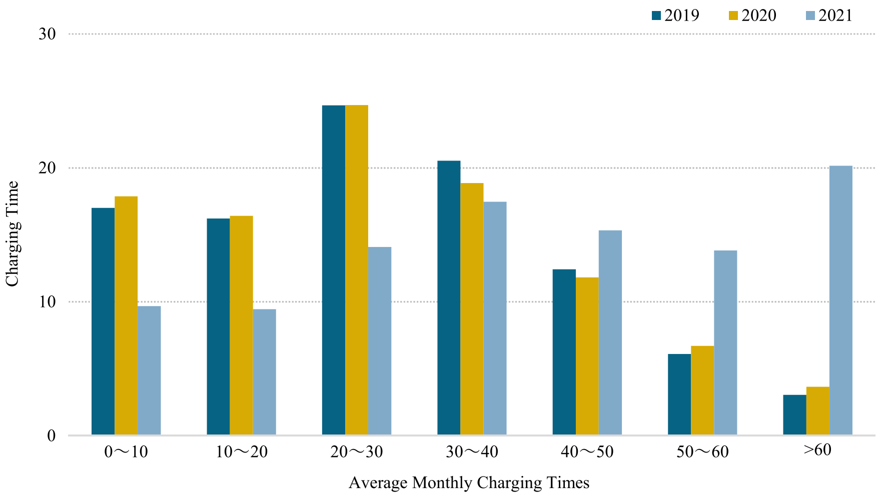


Fig. 5.46 Distribution of average monthly charging times of BEV taxis—by year

Fig. 5.47 Distribution of average monthly charging times of BEV taxis over the years—by fast charging and slow charging

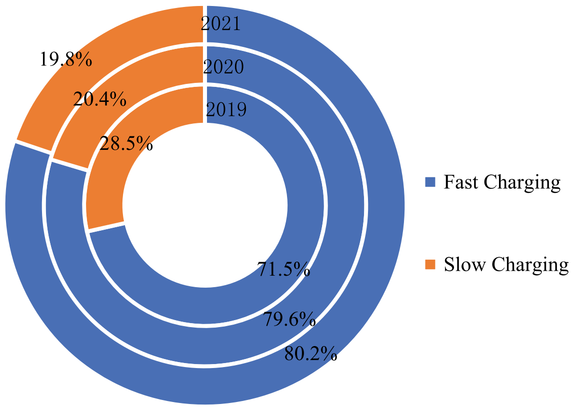


Table 5.17 Average monthly fast charging times of BEV taxis over the years

Year	2019	2020	2021
Average monthly fast charging times	22.6	22.7	32.9

The average monthly slow charging times of BEV taxis in 2021 were 8.1 times, with an increase compared with 2020 (Table 5.18). As the distribution shows (Fig. 5.49), it was mainly concentrated within the average monthly slow charging times of 10. In 2021, the proportion of vehicles with average monthly slow charging times of more than 10 increased.

The average monthly charge of BEV taxis was 944.5 kWh in 2021, with a YoY increase of 43.9%.

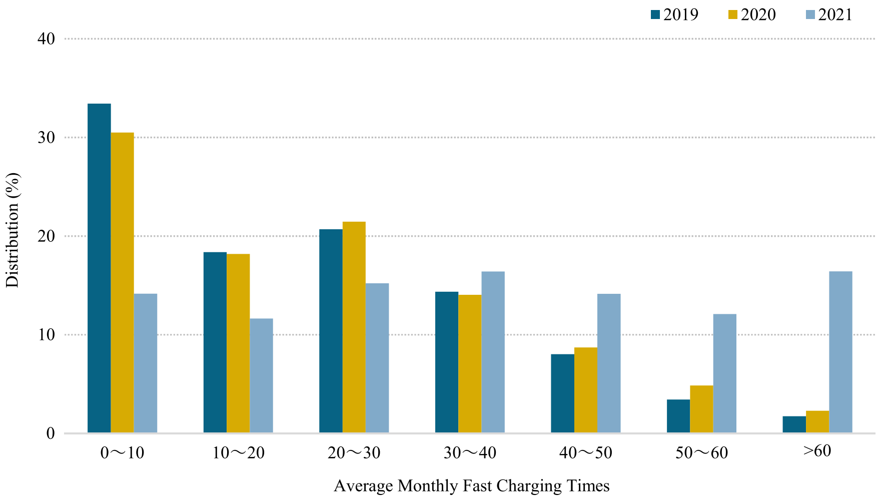


Fig. 5.48 Distribution of average monthly fast charging times of BEV taxis—by year

Table 5.18 Average monthly slow charging times of BEV taxis over the years

Year	2019	2020	2021
Average monthly slow charging times	8.5	5.8	8.1

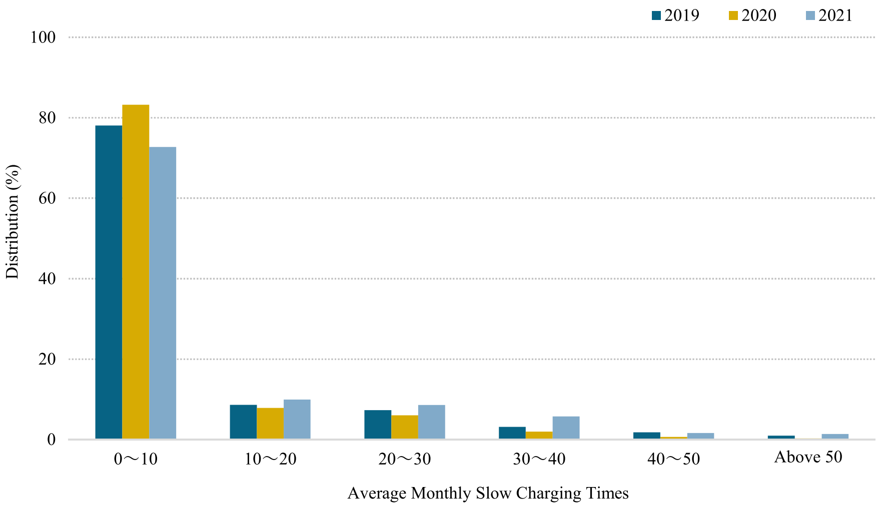


Fig. 5.49 Distribution of average monthly slow charging times of BEV taxis—by year

Table 5.19 Average monthly charge of BEV taxis over the years

Year	2019	2020	2021
Average monthly charge (kWh)	742.8	656.5	944.5

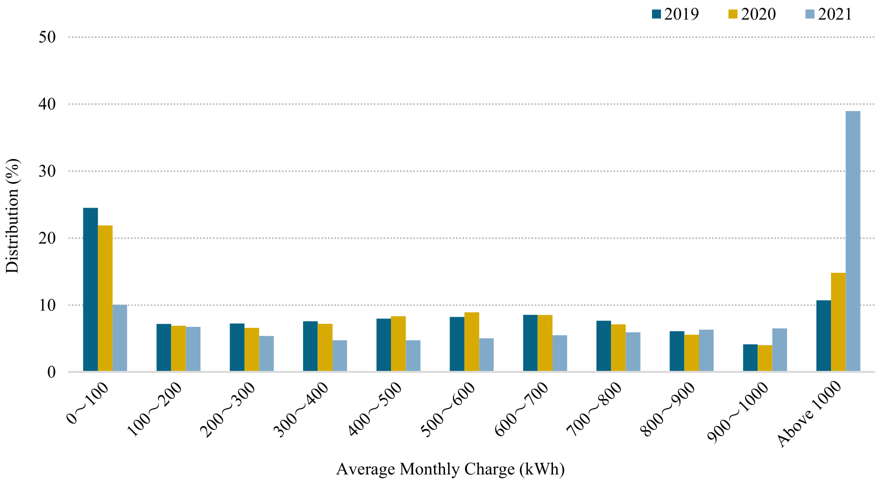


Fig. 5.50 Distribution of average monthly charge of BEV taxis—by year for fast charging

The average monthly charge of BEV taxis was 944.5 kWh in 2021, with an increase compared with the previous two years (Table 5.19). From the distribution of average monthly charge (Fig. 5.50), the proportion of BEV taxis using fast charging with an average monthly charge of more than 1000 kWh increased from 10.7% in 2019 to 39% in 2021; the proportion of BEV taxis using slow charging with an average monthly charge of more than 1000 kWh increased from 20.5% in 2020 to 32% in 2021 (Fig. 5.51).

5.2.4 Charging Characteristics of BEV Cars for Sharing

(1) **Average single-time charging characteristics of BEV cars for sharing**

The average single-time charging duration of BEV cars for sharing is mainly concentrated within 1 h.

The average single-time charging duration of BEV cars for sharing in 2021 was 1.4 h, with a decrease of 0.3 h compared with that in 2020 (Table 5.20). As the distribution shows (Fig. 5.52), the proportion of BEV cars for sharing with an average single-time charging duration of less than 1 h in 2021 reached 51%, with a significant increase compared with that in 2019 and 2020.

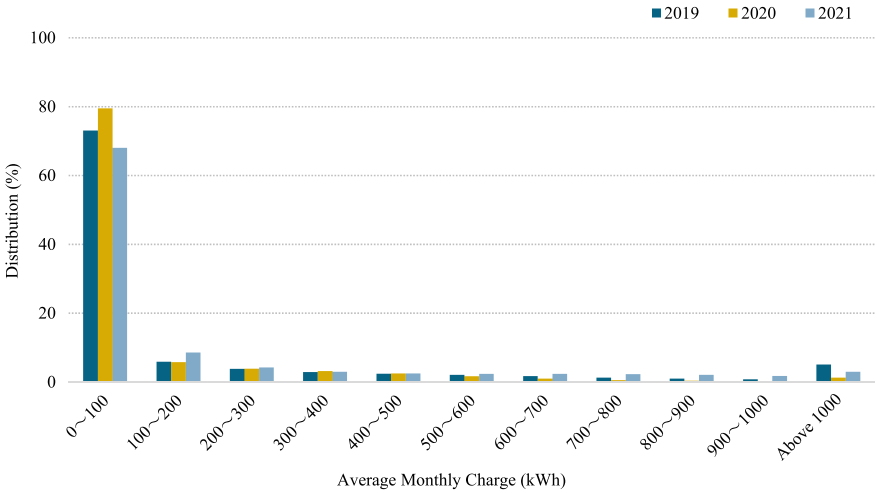


Fig. 5.51 Distribution of average monthly charge of BEV taxis—by year for slow charging

Table 5.20 Average single-time charging duration of BEV cars for sharing over the years

Year	2019	2020	2021
Average single-time charging duration (h)	2.2	1.7	1.4

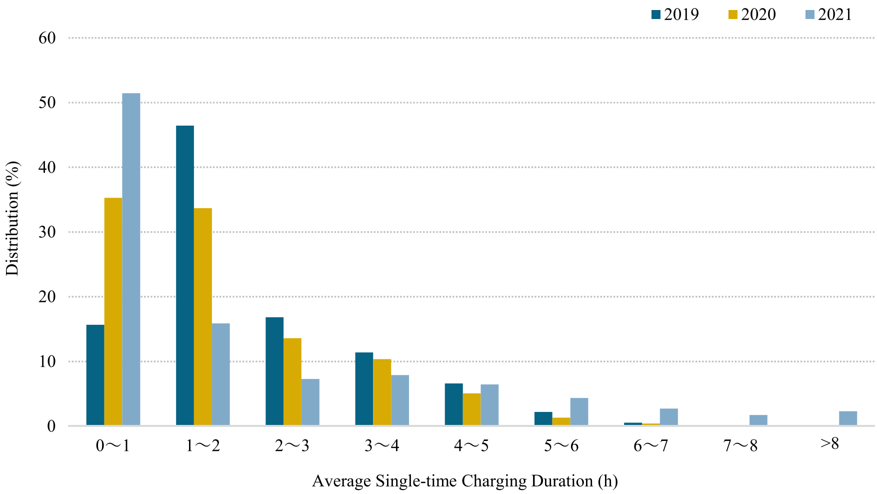


Fig. 5.52 Distribution of average single-time charging duration of BEV cars for sharing—by year

Considering the charging duration on weekdays and weekends, the proportion of BEV cars for sharing with an average single-time charging duration of less than 2 h during weekdays is lower than that during weekends (Fig. 5.53).

Regarding the charging methods, the average single-time charging duration of over 80% of BEV cars for sharing using fast charging is mainly concentrated within 1 h; the average single-time charging duration of BEV cars for sharing using slow charging is relatively dispersed (Fig. 5.54).

The average single-time charging initial SOC of BEV cars for sharing was mainly concentrated at 30–50%, which is mostly the same as the previous year.

The average single-time charging initial SOC of BEV cars for sharing was 42.5% in 2021, which is mostly the same as in 2020 (Table 5.21). As the distribution shows (Fig. 5.55), the average single-time charging initial SOC of BEV cars for sharing was mainly concentrated at 30–50%, and the proportion of vehicles within this range over the years was more than 50%.

From the distribution of average single-time charging initial SOC of vehicles on weekdays and weekends, the proportion of BEV cars for sharing with an average single-time charging initial SOC of more than 40% during weekdays was higher than that during weekends (Fig. 5.56), indicating that the proportion of vehicles charging during high SOC periods on weekdays is higher.

Regarding charging methods, the average single-time charging initial SOC of BEV cars for sharing using fast charging was mainly concentrated at 30–50%, with the proportion of vehicles accounting for 61.9%, and that using slow charging was relatively dispersed (Fig. 5.57).

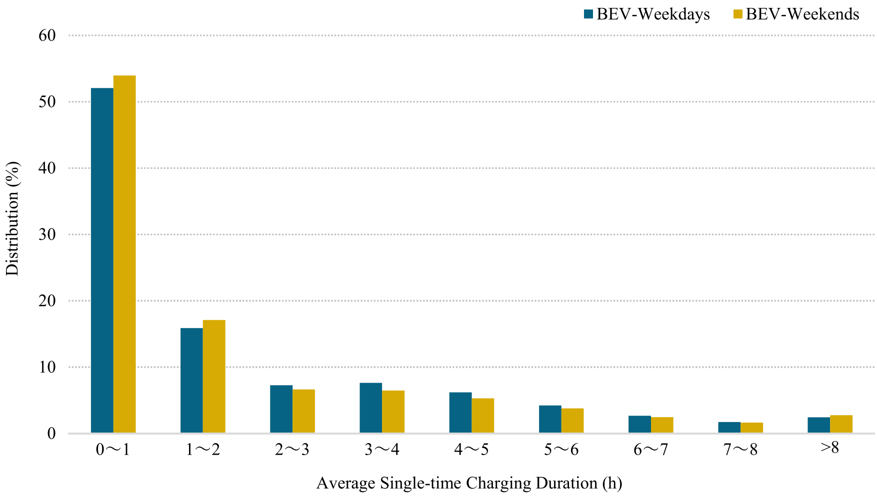


Fig. 5.53 Distribution of average single-time charging duration of BEV cars for sharing in 2021—by weekday and weekend

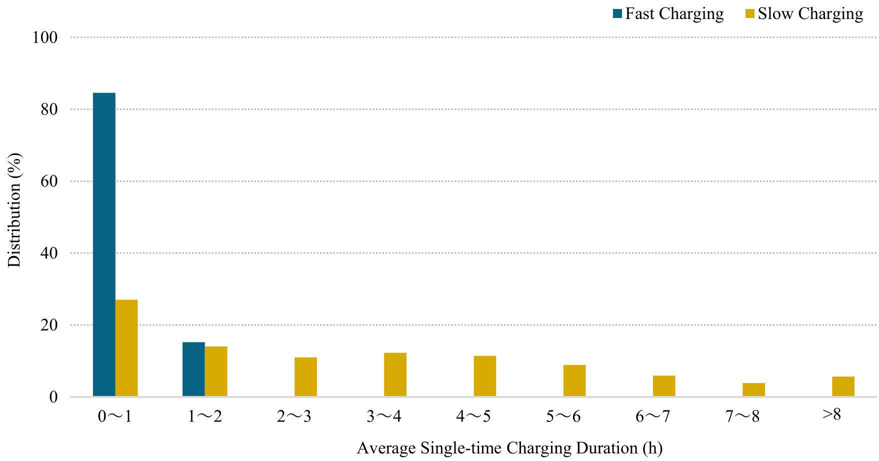


Fig. 5.54 Distribution of average single-time charging duration of BEV cars for sharing in 2021—by fast charging and slow charging

Table 5.21 Average single-time charging initial SOC of BEV cars for sharing over the years

Year	2019	2020	2021
Average single-time charging initial SOC (%)	44.0	42.6	42.5

(2) Average daily charging characteristics of BEV cars for sharing

The proportion of BEV cars for sharing charged between 11:00 and 16:00 during the day in 2021 was significantly higher than that in previous years.

Regarding the charging time (Fig. 5.58), the proportion of BEV cars for sharing charged from 11:00 to 16:00 in 2021 significantly increased compared with the previous two years, with more pronounced peaks.

According to the daily charging characteristics of vehicles on weekdays and weekends, the charging distribution curve of vehicles at different times is mainly consistent, but the proportion of BEV cars for sharing charged from 11:00 to 12:00 on weekdays is higher than that on weekends (Fig. 5.59).

Considering the charging methods, the charging time of BEV cars for sharing using fast charging is concentrated at two time periods: 11:00–16:00 and 23:00–01:00 the next day; the charging time of BEV cars for sharing using slow charging is more distributed at night (Fig. 5.60).

(3) Average monthly charging characteristics of BEV cars for sharing

The average monthly charging times of BEV cars for sharing in 2021 were 27.2 times, with an increase of 68.9% compared with 2020.

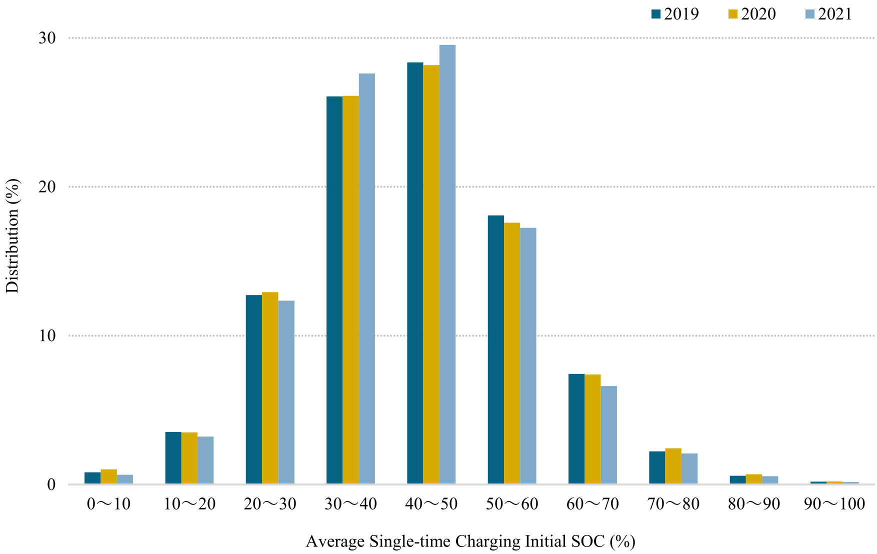


Fig. 5.55 Distribution of average single-time charging initial SOC of BEV cars for sharing—by year

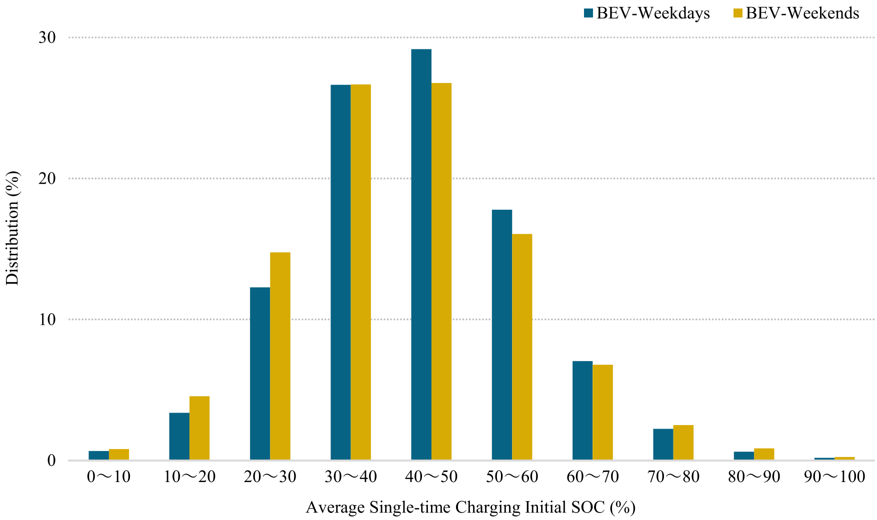


Fig. 5.56 Distribution of average single-time charging initial SOC of BEV cars for sharing in 2021—by weekday and weekend

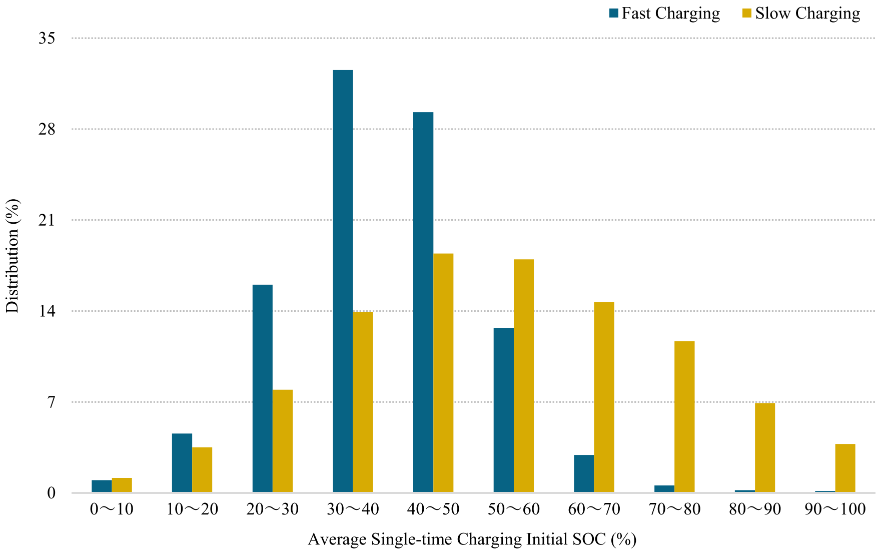


Fig. 5.57 Distribution of average single-time charging initial SOC of BEV cars for sharing in 2021—by fast charging and slow charging

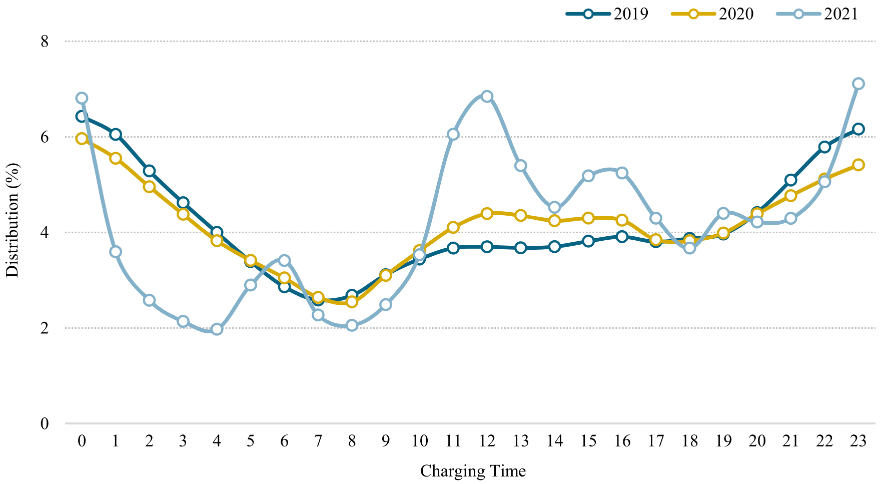


Fig. 5.58 Distribution of charging time of BEV cars for sharing—by year

The average monthly charging times of BEV cars for sharing in 2021 were 27.2 times, with an increase compared with the previous two years (Table 5.22). As the distribution shows (Fig. 5.61), the proportion of BEV cars for sharing with average monthly charging times of more than 30 increased from 24.1% in 2019 to 41.4% in 2021, indicating an increase in usage frequency. Considering the charging methods,

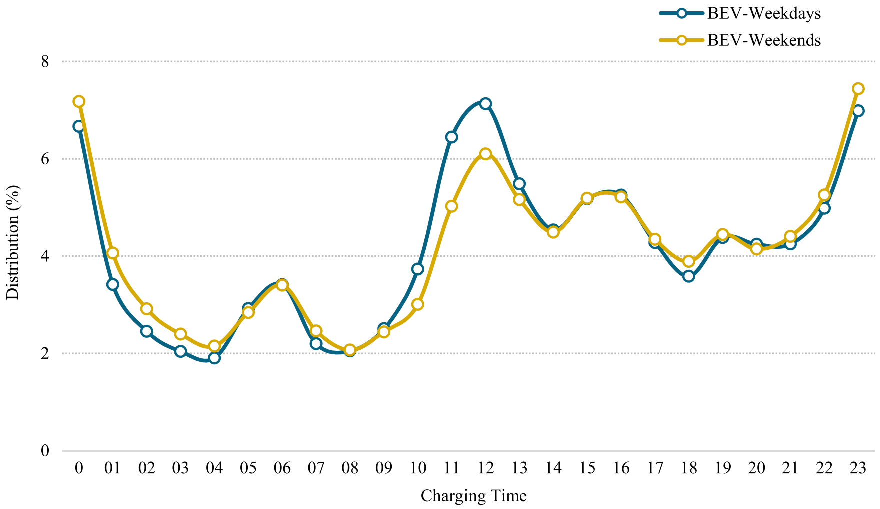


Fig. 5.59 Distribution of charging time of BEV cars for sharing in 2021—by weekday and weekend

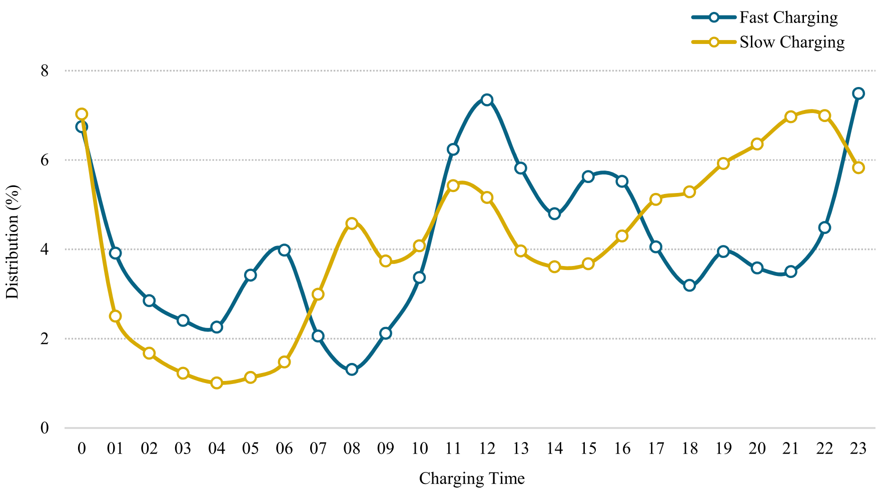


Fig. 5.60 Distribution of charging time of BEV cars for sharing in 2021—by fast charging and slow charging

in the past two years, fast charging has been the primary charging method for BEV cars for sharing, with 75.7% of them adopting fast charging in 2021 (Fig. 5.62).

The average monthly fast charging times of BEV cars for sharing show an increasing trend yearly.

The average monthly fast charging times of BEV cars for sharing were 15.4 times, with an increase of 4.5 times compared with 2020 (Table 5.23). As the distribution

Table 5.22 Average monthly charging times of BEV cars for sharing over the years

Year	2019	2020	2021
Average monthly charging times	16.7	16.1	27.2

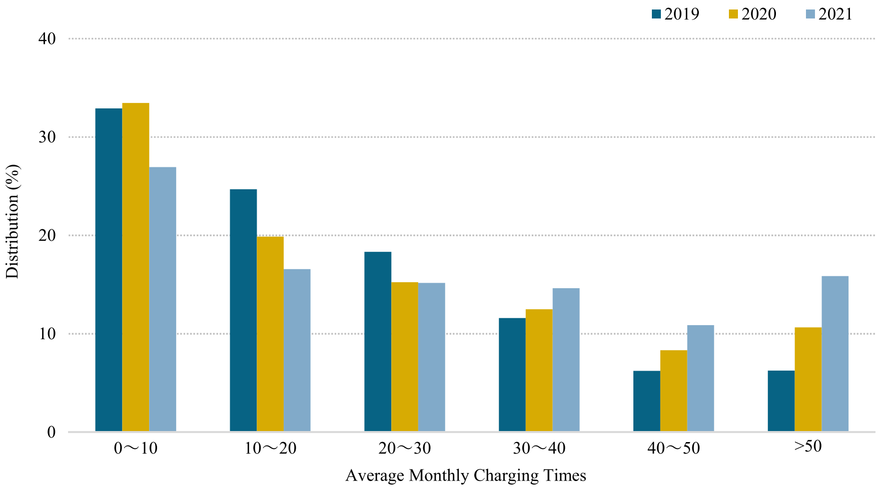
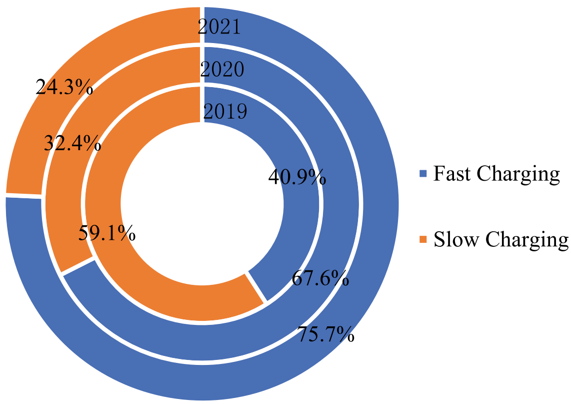


Fig. 5.61 Distribution of average monthly charging times of BEV cars for sharing—by year

Fig. 5.62 Distribution of average monthly charging times of BEV cars for sharing over the years—by fast charging and slow charging



shows (Fig. 5.63), the proportion of BEV cars for sharing with average monthly fast charging times of 20 or more has shown an increasing trend yearly, from 21.5% in 2019 to 39.9% in 2020.

The average monthly slow charging times of BEV cars for sharing in 2021 were 11.8 times, 2.27 times higher than 2020.

The average monthly slow charging times of BEV cars for sharing in 2021 were 11.8 times, with a significant increase compared with 2020 (Table 5.24). As the

Table 5.23 Average monthly fast charging times of BEV cars for sharing over the years

Year	2019	2020	2021
Average monthly fast charging times	6.9	10.9	15.4

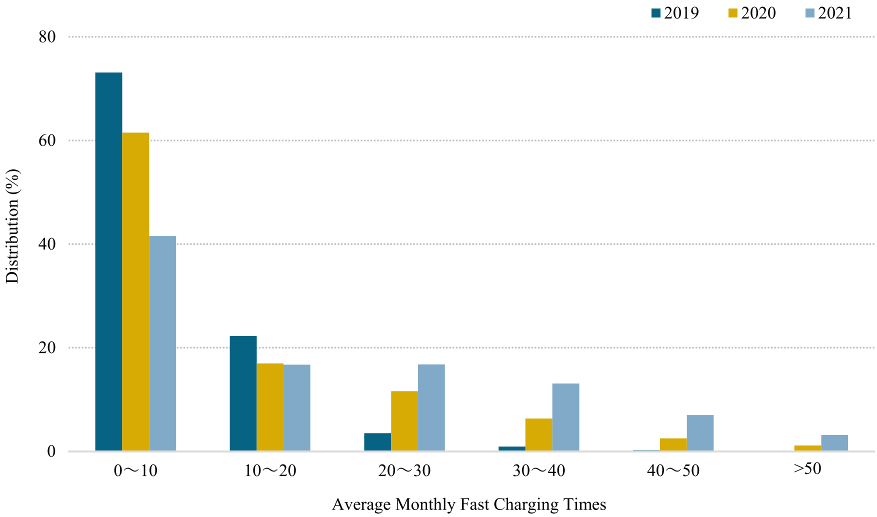


Fig. 5.63 Distribution of average monthly fast charging times of BEV cars for sharing—by year

Table 5.24 Average monthly slow charging times of BEV cars for sharing over the years

Year	2019	2020	2021
Average monthly slow charging times	9.7	5.2	11.8

distribution shows (Fig. 5.64), in the past three years, the average monthly slow charging times of BEV cars for sharing were mainly concentrated within 10 times. In 2021, this indicator accounted for 61.0%, but the proportion of BEV cars for sharing with average monthly slow charging times of more than 10 increased significantly compared with 2020, in a scattered distribution compared with 2020.

The monthly average charge of BEV cars for sharing is 463.4 kWh, with a significant YoY increase.

In 2021, the average monthly charge of BEV cars for sharing was 463.4 kWh, with a significant YoY increase (Table 5.25). From the distribution of average monthly charge (Fig. 5.65), the proportion of BEV cars for sharing using fast charging with an average monthly charge of more than 400 kWh increased from 21.8% in 2019 to 39.5% in 2021; the proportion of BEV cars for sharing using fast charging with an average monthly charge of more than 1000 kWh was 12.0%, much higher than the previous two years.

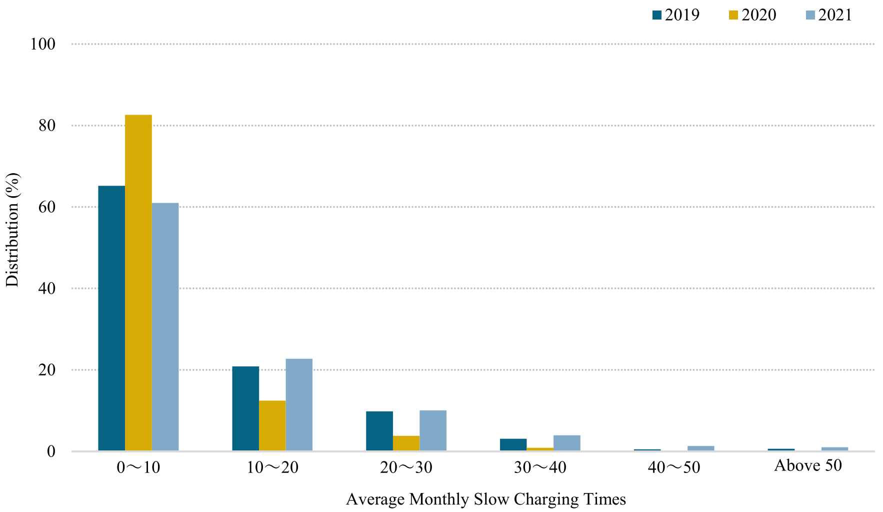


Fig. 5.64 Distribution of average monthly slow charging times of BEV cars for sharing—by year

Table 5.25 Average monthly charge of BEV cars for sharing over the years

Year	2019	2020	2021
Average monthly charge (kWh)	220.6	293.9	463.4

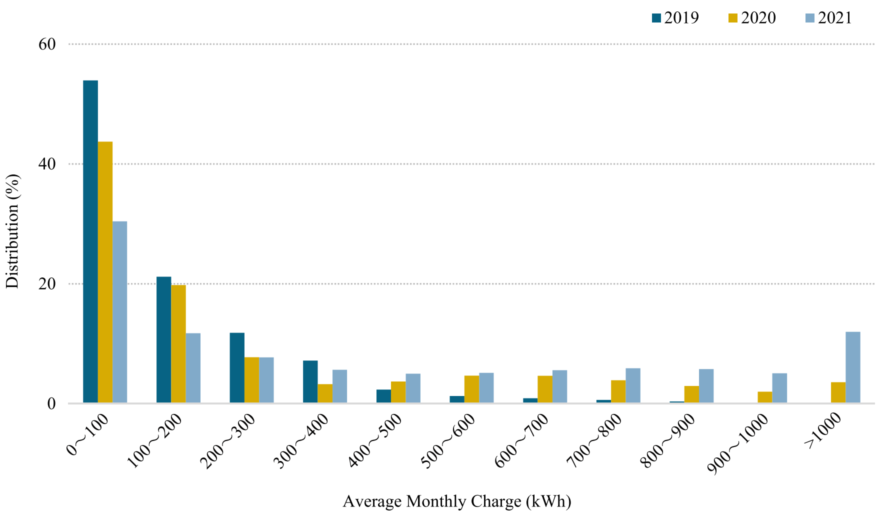


Fig. 5.65 Distribution of average monthly charge of BEV cars for sharing—by year for fast charging

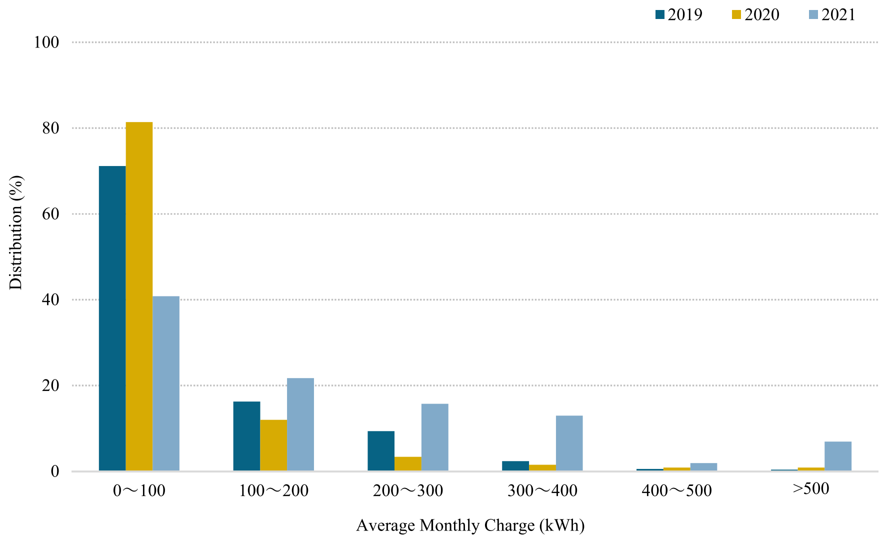


Fig. 5.66 Distribution of average monthly charge of BEV cars for sharing—by year for slow charging

Compared to 2020, in 2021, the average monthly charge of BEV cars for sharing using slow charging shifted to higher levels (Fig. 5.66), with vehicles with an average monthly charge of more than 500 kWh accounting for 6.9%, showing a significant breakthrough.

5.2.5 Charging Characteristics of BEV Logistics Vehicles

(1) **Average single-time charging characteristics of BEV logistics vehicles**

The average single-time charging duration of BEV logistics vehicles in 2021 has increased compared with that in 2020.

The average single-time charging duration of BEV logistics vehicles in 2021 was 2.1 h, which is mostly consistent with that in 2020 (Table 5.26). From the distribution of average single-time charging duration (Fig. 5.67), the proportion of vehicles with an average single-time charging duration of less than 1 h and more than 8 h increased compared with the previous two years.

Table 5.26 Average single-time charging duration of BEV logistics vehicles over the years

Year	2019	2020	2021
Average single-time charging duration (h)	2.9	2.0	2.1

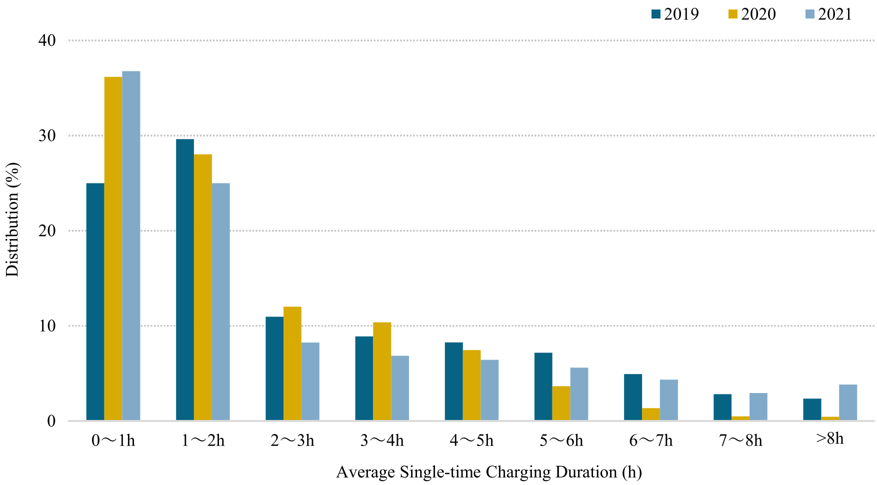


Fig. 5.67 Distribution of average single-time charging duration of BEV logistics vehicles—by year

The distribution pattern of the number of vehicles with an average single-time charging duration of less than 2 h during weekdays and weekends is mostly consistent. The proportion of vehicles with an average single-time charging duration of less than 2 h during weekdays and weekends is 62%, but the proportion of vehicles with an average single-time charging duration of more than 8 h during weekends is higher (Fig. 5.68). This phenomenon is related to the working nature of BEV logistics vehicles. There is little change in the working intensity of BEV logistics vehicles seven days a week.

The average single-time charging initial SOC of BEV logistics vehicles was 48.4%, mostly the same as that in previous years.

The average single-time charging initial SOC of BEV logistics vehicles was 48.4% in 2021, which is mostly the same as in previous years (Table 5.27). As the distribution shows (Fig. 5.69), the average single-time charging initial SOC of BEV logistics vehicles is concentrated at 40–60%, and the proportion of vehicles in this range over the years is more than 50%. During weekdays and weekends, the distribution of vehicles in each charging initial SOC segment is mainly consistent (Fig. 5.70).

(2) **Average daily charging characteristics of BEV logistics vehicles**

The proportion of BEV logistics vehicles with charging time distributed during the day in 2021 is significantly higher than that in previous years.

The charging time of BEV logistics vehicles in 2021 concentrated at three periods, namely around 0:00 in the morning, around 12:00 in the noon, and 17:00 to 18:00 peak (Fig. 5.71); there is no significant difference in the distribution of BEV logistics vehicles at different charging times on weekdays and weekends (Fig. 5.72).

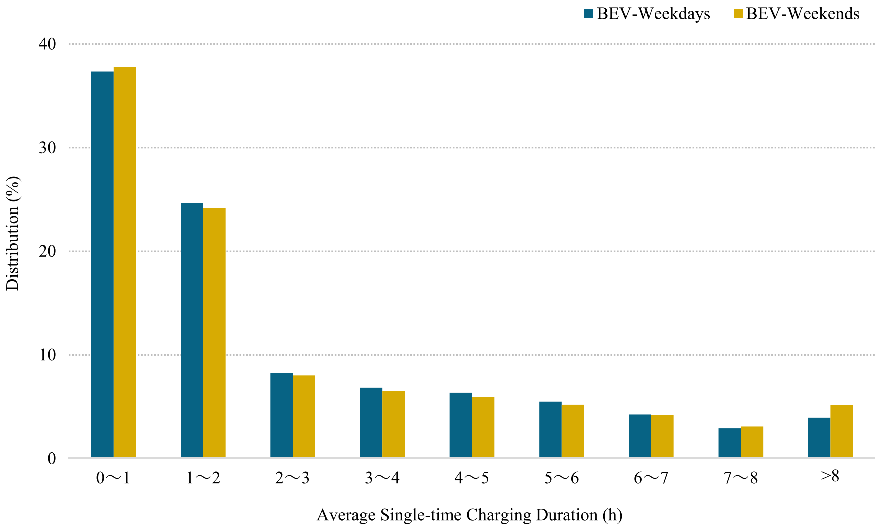


Fig. 5.68 Distribution of average single-time charging duration of BEV logistics vehicles in 2021—by weekday and weekend

Table 5.27 Average single-time charging initial SOC of BEV logistics vehicles over the years

Year	2019	2020	2021
Average single-time charging initial SOC (%)	49.3	49.0	48.4

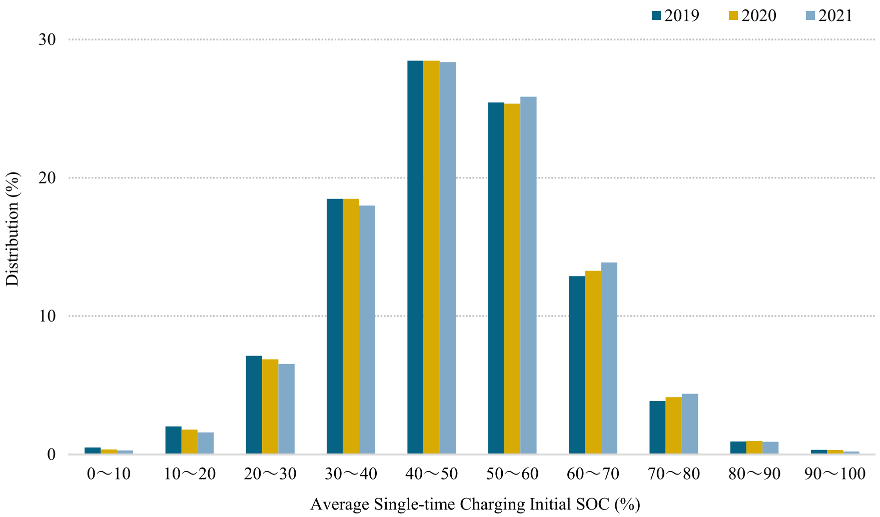


Fig. 5.69 Distribution of average single-time charging initial SOC of BEV logistics vehicles—by year

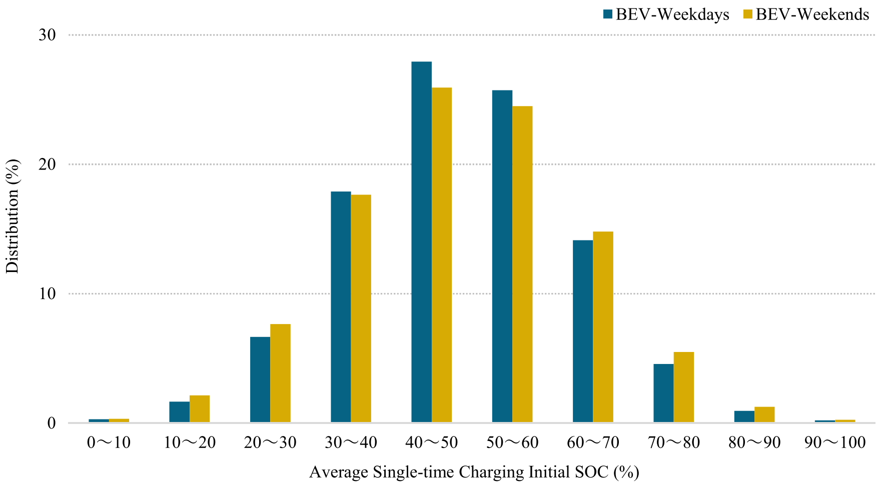


Fig. 5.70 Distribution of average single-time charging initial SOC of BEV logistics vehicles in 2021—by weekday and weekend

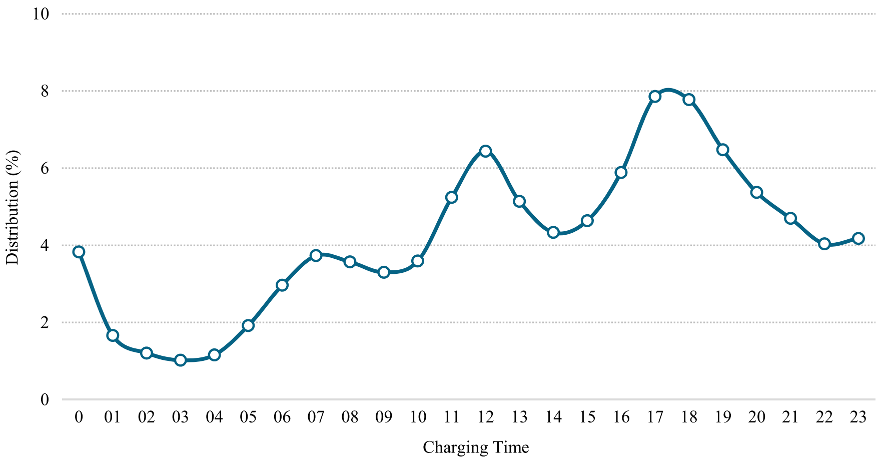


Fig. 5.71 Distribution of charging time of BEV logistics vehicles in 2021

(3) Average monthly charging characteristics of BEV logistics vehicles

The average monthly charging times of BEV logistics vehicles show an increasing trend yearly.

The average monthly charging times of BEV logistics vehicles were 25.7 times in 2021, showing a YoY growth trend compared with the previous two years

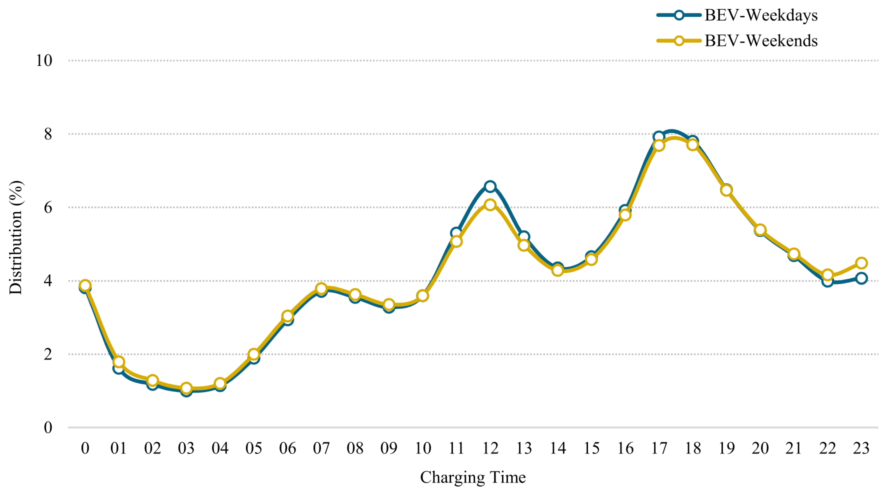


Fig. 5.72 Distribution of charging time of BEV logistics vehicles in 2021—by weekday and weekend

(Table 5.28). As the distribution shows (Fig. 5.73), the proportion of BEV logistics vehicles with average monthly charging times of more than 30 increased from 11.2% in 2019 to 35.2% in 2021. This phenomenon is related to the gradual improvement of fast charging pile facilities, and the increase in fast charging times has driven a rapid increase in the overall charging times.

Considering the charging methods (Fig. 5.74), BEV logistics vehicles tend to choose fast charging to supplement their electricity, with their proportion reaching 58.9%.

The average monthly fast charging times of BEV logistics vehicles have significantly increased.

In 2021, the average monthly fast charging times of BEV logistics vehicles were 15.4 times, with a rapid increase in fast charging times (Table 5.29). As the distribution shows (Fig. 5.75), the proportion of BEV logistics vehicles with average monthly charging times of more than 10 increased from 18.1% in 2019 to 63.2% in 2021. The overall distribution in 2021 was relatively scattered, with fast charging moving towards high frequency.

The average monthly slow charging times of BEV logistics vehicles in 2021 were 10.2 times, with a slight decrease compared with the previous two years.

The average monthly slow charging times of BEV logistics vehicles in 2021 were 10.2 times (Table 5.30), with a slight decrease compared with the previous two

Table 5.28 Average monthly charging times of BEV logistics vehicles over the years

Year	2019	2020	2021
Average monthly charging times	17.7	20.6	25.7

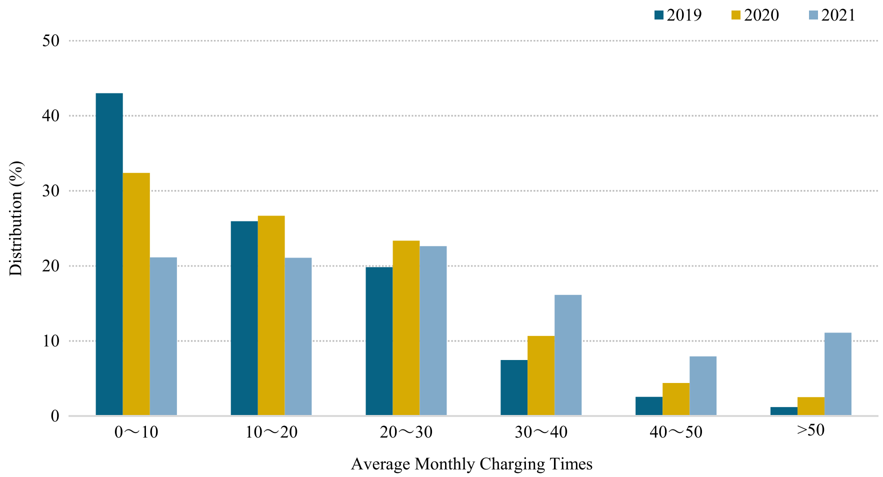


Fig. 5.73 Distribution of average monthly charging times of BEV logistics vehicles—by year

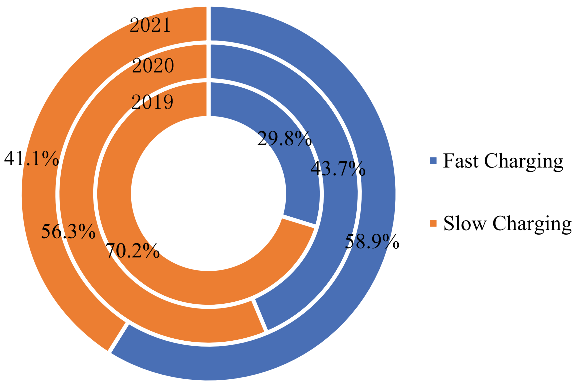


Fig. 5.74 Distribution of average monthly charging times of BEV logistics vehicles over the years—by fast charging and slow charging

Table 5.29 Average monthly fast charging times of BEV logistics vehicles over the years

Year	2019	2020	2021
Average monthly fast charging times	5.3	9.0	15.4

years. Specifically, the proportion of BEV logistics vehicles with average monthly slow charging times of less than 10 was 67.55% (Fig. 5.76), and the number of BEV logistics vehicles using slow charging has decreased. Under the premise of multiple charging methods coexisting, BEV logistics vehicles tend to choose fast charging, mainly for time costs.

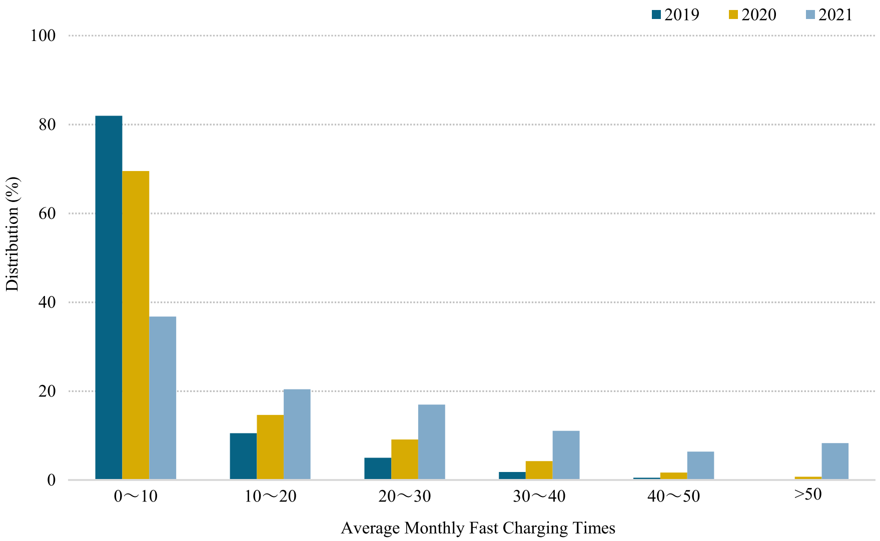


Fig. 5.75 Distribution of average monthly fast charging times of BEV logistics vehicles—by year

Table 5.30 Average monthly slow charging times of BEV logistics vehicles over the years

Year	2019	2020	2021
Average monthly slow charging times	12.5	11.6	10.2

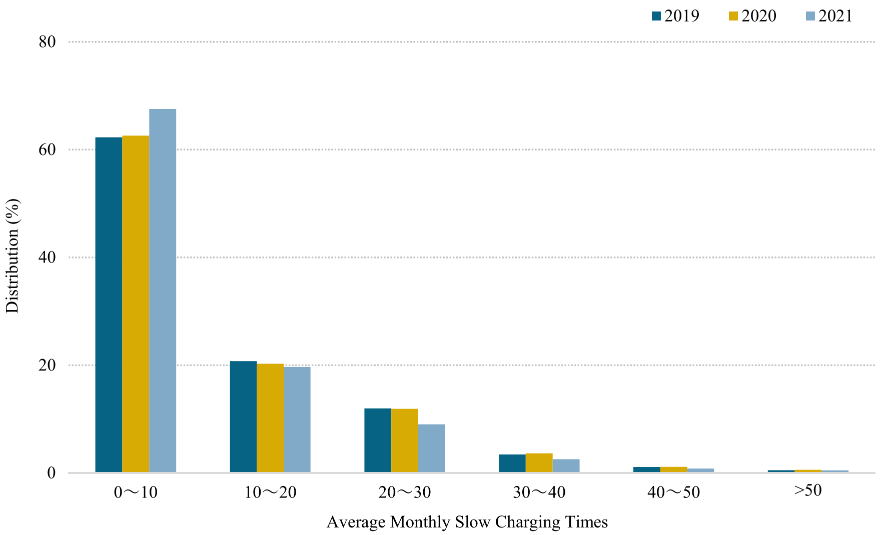


Fig. 5.76 Distribution of average monthly slow charging times of BEV logistics vehicles—by year

Table 5.31 Average monthly charge of BEV logistics vehicles over the years

Year	2019	2020	2021
Average monthly charge (kWh)	396.1	435.6	552.5

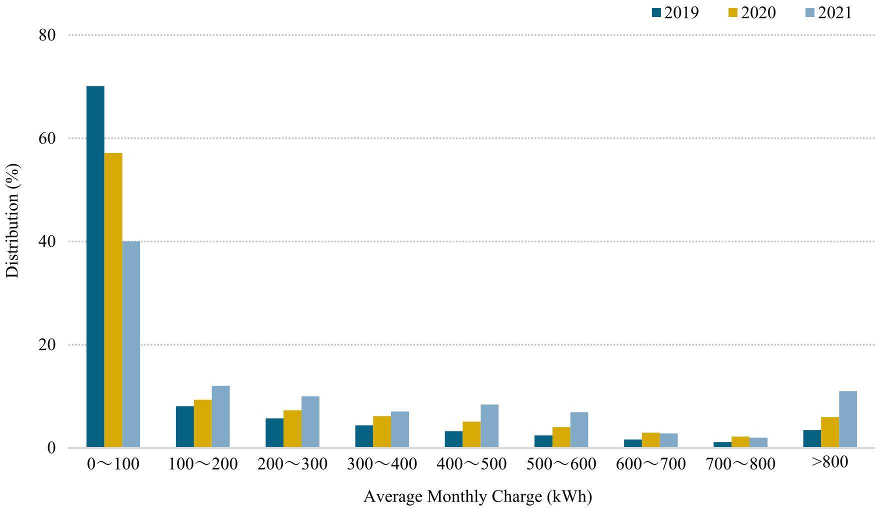


Fig. 5.77 Distribution of average monthly charge of BEV logistics vehicles—by year for fast charging

The average monthly charge of BEV logistics vehicles shows an increasing trend yearly.

The average monthly charge of BEV logistics vehicles was 552.5 kWh, showing a YoY growth trend compared with the previous two years (Table 5.31). As the distribution shows (Fig. 5.77), the proportion of BEV logistics vehicles using fast charging with an average monthly charge of more than 800 kWh increased from 3.4% in 2019 to 11.0% in 2021.

The average monthly charge of BEV logistics vehicles using slow charging is mainly concentrated within 100 kWh, which has increased from 50.2% in 2019 to 58.2% in 2021 (Fig. 5.78).

5.2.6 Charging Characteristics of BEV Buses

(1) **Average single-time charging characteristics of BEV buses**

The average single-time charging duration of BEV buses is mainly concentrated around 1 h, which is mostly consistent with previous years.

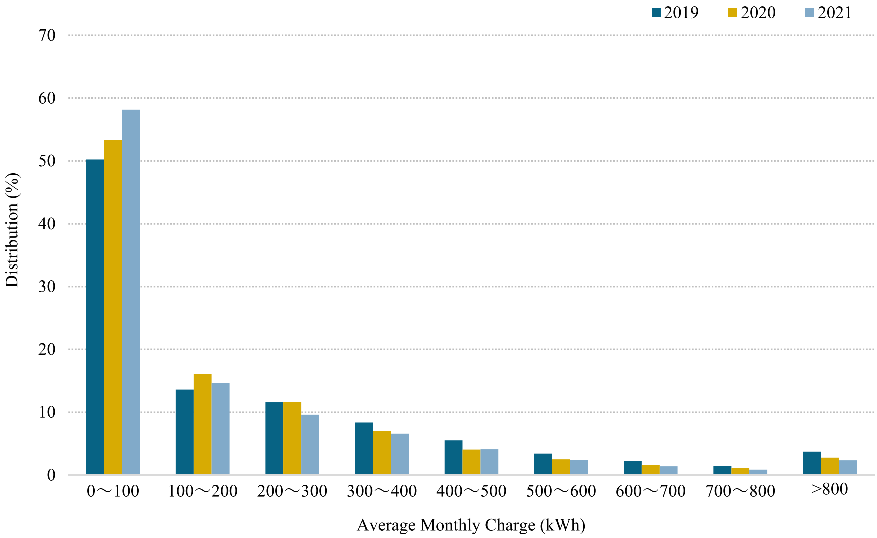


Fig. 5.78 Distribution of average monthly charge of BEV logistics vehicles—by year for slow charging

BEV buses' average single-time charging duration was 1.1 h in 2021, mostly consistent with previous years (Table 5.32). The proportion of BEV buses with an average single-time charging duration of less than 2 h in 2021 was the highest, with the proportion of vehicles over the years of more than 70% (Fig. 5.79).

The distribution of charging initial SOC has remained mostly above 50% over the years, and the average single-time charging initial SOC of BEV buses in 2021 was 54.6%.

In 2021, the average single-time charging initial SOC of BEV buses was 54.6%, which decreased compared with the previous two years (Table 5.33). As the distribution shows (Fig. 5.80), the average single-time charging initial SOC of BEV buses concentrated at 40–70%, and the proportion of vehicles within this range in 2021 was 74.2%. Regarding the annual distribution trend, the proportion of vehicles with an average single-time charging initial SOC of more than 60% increased from 27.9% in 2019 to 33.4% in 2021. The improvement of public charging pile construction makes charging more convenient and improves the single-time charging initial SOC to a certain extent. At the same time, the high charging initial SOC is related to the regular charging operation mechanism of buses.

The charging rate of BEV buses shows an increasing trend yearly.

Table 5.32 Average single-time charging duration of BEV buses over the years

Year	2019	2020	2021
Average single-time charging duration (h)	1.1	1.0	1.1

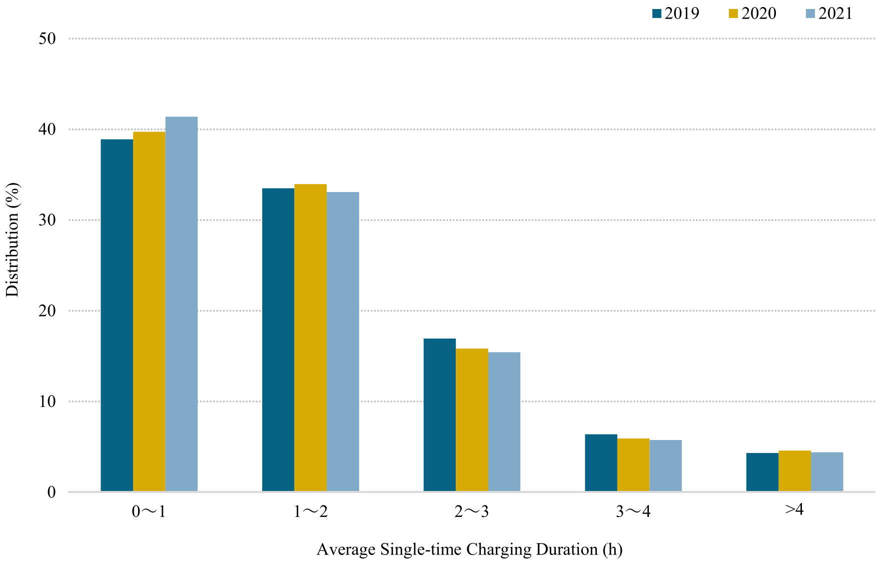


Fig. 5.79 Distribution of average single-time charging duration of BEV buses—by year

Table 5.33 Average single-time charging initial SOC of BEV buses over the years

Year	2019	2020	2021
Average single-time charging initial SOC (%)	57.7	58.0	54.6

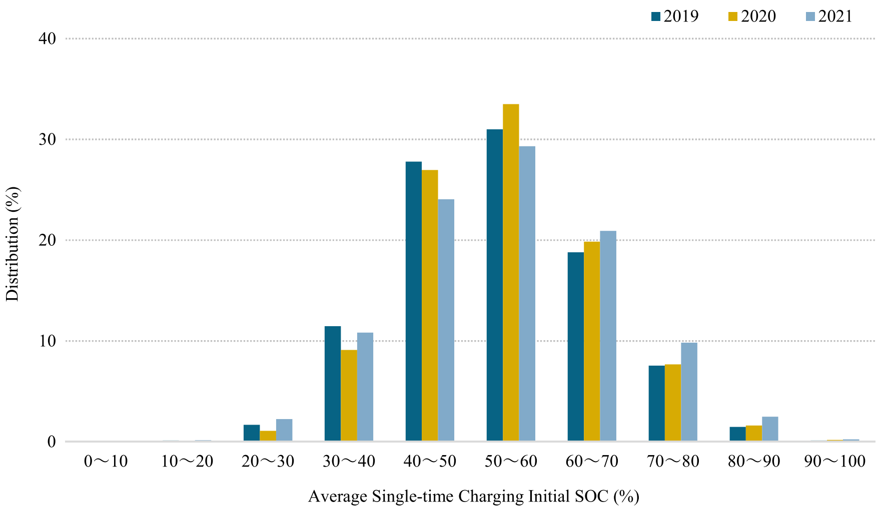


Fig. 5.80 Distribution of average single-time charging initial SOC of BEV buses—by year

From changes in the average charging rate of BEV buses over the years (Table 5.34), the charging rate of BEV buses has shown an increasing trend yearly. The average charging rate of BEV buses in 2021 was 0.81 C, an increase of 3.85% compared with 2020.

The proportion of BEV buses with a charging rate ranging from 0.2 to 0.6 C is relatively high (Fig. 5.81); from the development trend of charging rate of BEV buses over the years, the proportion of BEV buses with a charging rate ranging from 1 to 2 C has been increasing yearly, while the proportion of BEV buses with a charging rate of 2 C and above has been little change from year to year.

(2) **Average daily charging characteristics of BEV buses**

The proportion of BEV buses charged during the day in 2021 is significantly higher than that in previous years.

As the distribution shows (Fig. 5.82), the charging time presents a "W"-shaped distribution. BEV buses form a small charging peak at 12:00, with valleys around 5:00–6:00 and 17:00, but relatively shallow valleys at 17:00. After 6:00 in the morning, the number of buses in operation begins to increase rapidly, welcoming the

Table 5.34 Average charging rate of BEV buses over the years

Year	2019	2020	2021
Average charging rate of BEV buses (C)	0.77	0.78	0.81

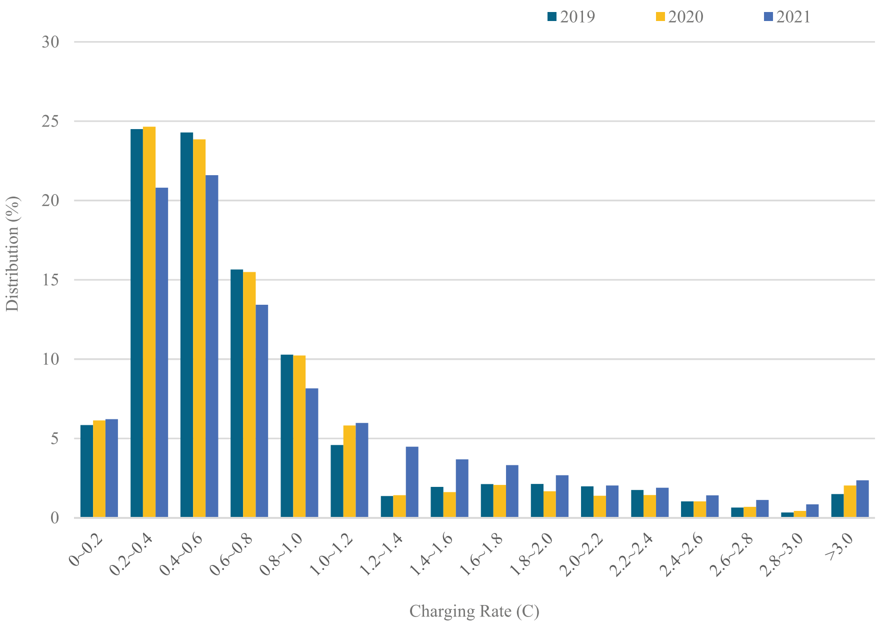


Fig. 5.81 Distribution of charging rate of BEV buses over the years

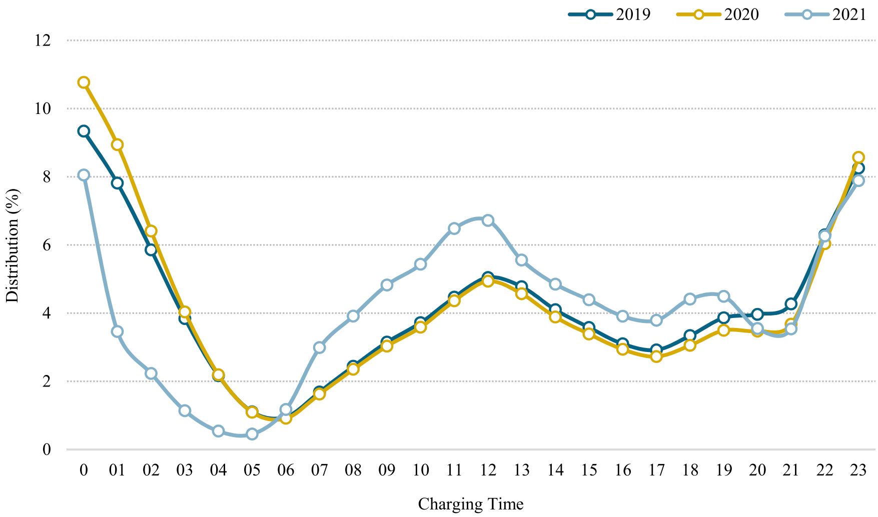


Fig. 5.82 Distribution of charging time of BEV buses—by year

morning rush hour; at about 17:00, some vehicles need to be charged after daytime operation, so the valley of buses is shallow at 17:00, and the proportion of vehicles charged between 7:00 and 19:00 is higher than that in 2019 and 2020.

(3) **Average monthly charging characteristics of BEV buses**

The average monthly charging times of BEV buses in 2021 were 44.7 times, higher than that in previous years.

The average monthly charging times of BEV buses in 2021 were 44.7 times, with an increase compared with the previous two years (Table 5.35). As the distribution shows (Fig. 5.83), the proportion of BEV buses with average monthly charging times of more than 30 increased from 38% in 2019 to 60.7% in 2021.

The average monthly charge of BEV buses was 2607.7 kWh in 2021, with a YoY increase of 36.3%.

In 2021, the average monthly charge of BEV buses was 2607.7 kWh, which increased compared with the previous two years (Table 5.36). As the distribution shows (Fig. 5.84), the proportion of BEV buses with an average monthly charge of over 2400 kWh was 50.8%, with an increase of 22.6% compared with 2020, with the overall trend towards high charge.

Table 5.35 Average monthly charging times of BEV buses over the years

Year	2019	2020	2021
Average monthly charging times	34.6	32.3	44.7

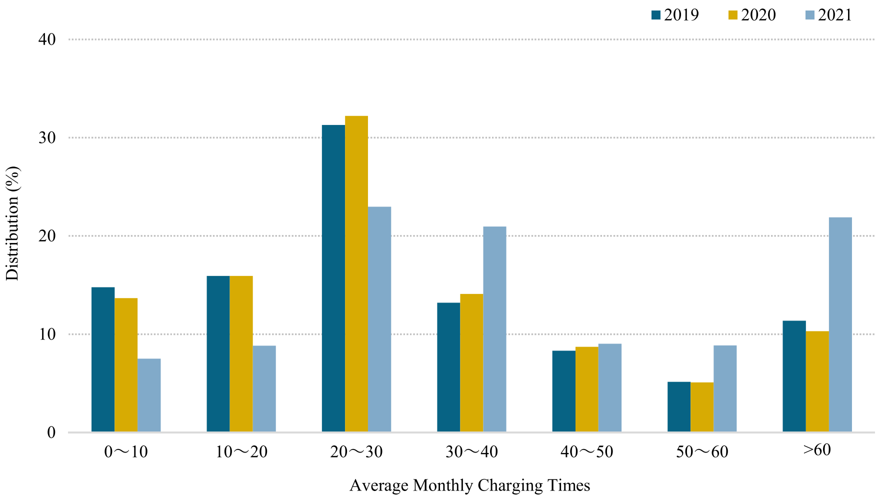


Fig. 5.83 Distribution of average monthly charging times of BEV buses—by year

Table 5.36 Average monthly charge of BEV buses over the years

Year	2019	2020	2021
Average monthly charge (kWh)	2242.5	1913.1	2607.7

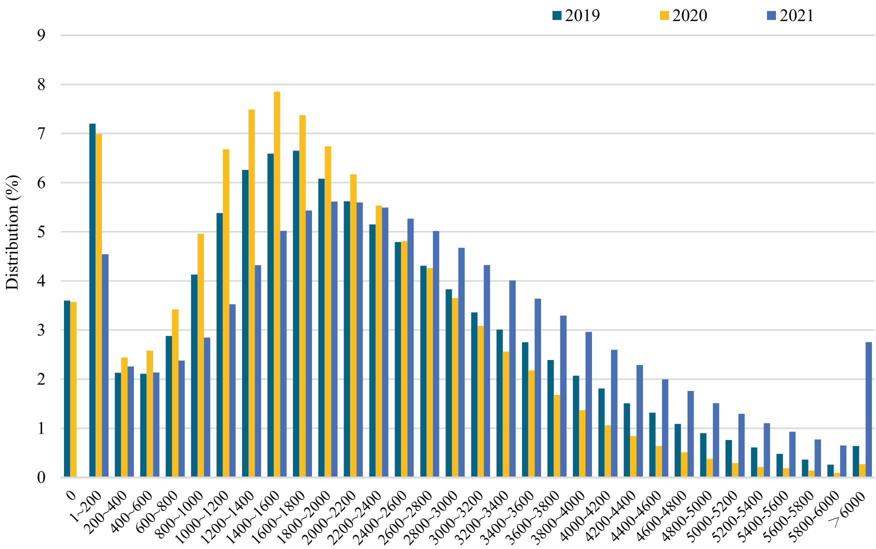


Fig. 5.84 Distribution of average monthly charge of BEV buses—by year

5.2.7 Charging Characteristics of BEV Heavy-Duty Trucks

(1) **Average single-time charging characteristics of BEV heavy-duty trucks**

The average single-time charging duration of BEV heavy-duty trucks shows a decreasing trend yearly.

The average single-time charging duration of BEV heavy-duty trucks in 2021 was 1.5 h, which is mostly consistent with that in 2020 (Table 5.37). As the distribution shows (Fig. 5.85), the proportion of vehicles with a single-time charging duration of less than 2 h increased from 53.1% in 2019 to 83.8% in 2021. The improvement of charging facilities has increased the proportion of fast charging, and the charging power of fast charging piles has gradually increased, resulting in a trend of shortened charging time.

The average single-time charging initial SOC of BEV heavy-duty trucks was 49.5%, mostly the same as that in previous years.

The average single-time charging initial SOC of BEV heavy-duty trucks was 49.5% in 2021, which is mostly the same as in previous years (Table 5.38). As the distribution shows (Fig. 5.86), the average single-time charging initial SOC of BEV is 49.5%, concentrated at 40–60%. The proportion of vehicles with an average single-time charging initial SOC of more than 40% increased from 77.9% in 2020 to

Table 5.37 Average single-time charging duration of BEV heavy-duty trucks over the years

Year	2019	2020	2021
Average single-time charging duration (h)	2.1	1.5	1.5

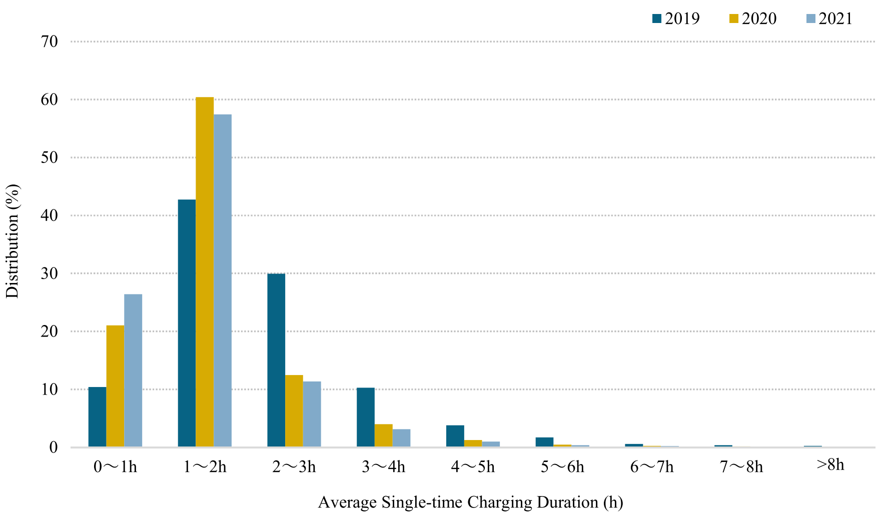


Fig. 5.85 Distribution of average single-time charging duration of BEV heavy-duty trucks—by year

80.4% in 2021. The improvement of charging pile construction makes charging more convenient and improves the average single-time charging initial SOC to a certain extent.

(2) Average monthly charging characteristics of BEV heavy-duty trucks

The average monthly charging times of BEV heavy-duty trucks show an increasing trend yearly.

The average monthly charging times of BEV heavy-duty trucks were 28.7 times in 2021, showing a YoY growth trend compared with the previous two years (Table 5.39). As the distribution shows (Fig. 5.87), the proportion of BEV heavy-duty trucks with average monthly charging times of more than 20 increased from 47.8% in 2019 to 66.8% in 2021, which is related to the increase in average monthly mileage and the improvement of public charging facilities.

Considering the charging methods, BEV heavy-duty trucks mainly choose fast charging to supplement their electricity. As shown in Fig. 5.88, in 2021, the proportion of fast charging times for BEV heavy-duty trucks was relatively high, reaching 72.8%.

Table 5.38 Average single-time charging initial SOC of BEV heavy-duty trucks over the years

Year	2019	2020	2021
Average single-time charging initial SOC (%)	49.9	48.6	49.5

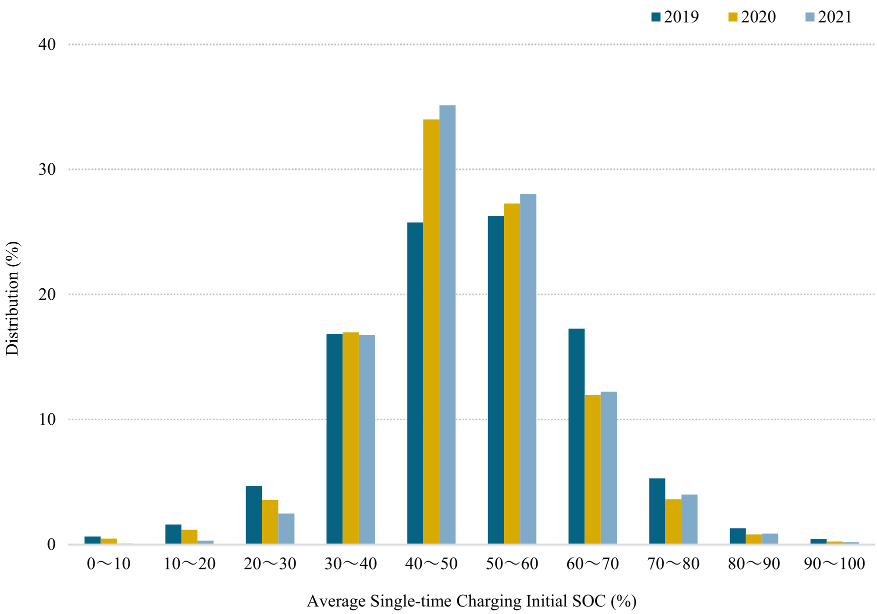


Fig. 5.86 Distribution of average single-time charging initial SOC of BEV heavy-duty trucks—by year

Table 5.39 Average monthly charging times of BEV heavy-duty trucks over the years

Year	2019	2020	2021
Average monthly charging times	21.1	25.7	28.7

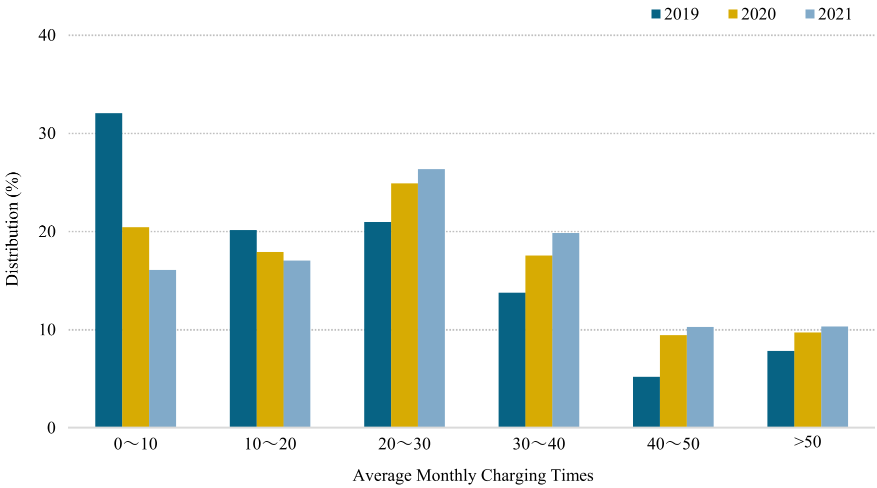
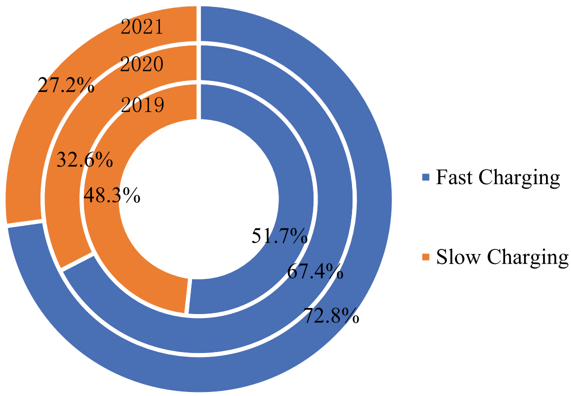


Fig. 5.87 Distribution of average monthly charging times of BEV heavy-duty trucks—by year

Fig. 5.88 Distribution of average monthly charging times of BEV heavy-duty trucks over the years—by fast charging and slow charging



Commercial vehicles are more likely to choose fast charging due to time costs. Additionally, due to the high charging capacity of BEV heavy-duty trucks, it is more appropriate for them to choose fast charging.

The average monthly fast charging times of BEV heavy-duty trucks show an increasing trend yearly.

The average monthly charging times of BEV heavy-duty trucks were 20.9 times in 2021, showing a YoY growth trend compared with the previous two years

(Table 5.40). As the distribution shows (Fig. 5.89), the proportion of BEV heavy-duty trucks with average monthly fast charging times of more than 20 increased from 34.4% in 2019 to 48.1% in 2021, and more BEV heavy-duty trucks tend to use the high-frequency fast charging method during operation.

The monthly average slow charging times of BEV heavy-duty trucks show an overall downward trend.

The average monthly slow charging times of BEV heavy-duty trucks in 2021 were 7.8 times, with a slight decrease compared with 2020 (Table 5.41). As the distribution shows (Fig. 5.90), the monthly average slow charging times of BEV heavy-duty trucks are mainly concentrated within 10 times, with the proportion of vehicles accounting for 67.3%.

The average monthly charge of BEV heavy-duty trucks increases yearly.

In 2021, the average monthly charge of BEV heavy-duty trucks was 4516.1 kWh, with a YoY increase of 4.7% (Table 5.42), 2.18 times that of 2019. As the distribution shows, BEV heavy-duty trucks with an average monthly charge of more than 1000 kWh account for the absolute majority, and the proportion of BEV heavy-duty trucks using fast charging with an average monthly charge of more than 1000 kWh increased from 65.8% in 2019 to 77.2% in 2021 (Fig. 5.91).

Table 5.40 Average monthly fast charging times of BEV heavy-duty trucks over the years

Year	2019	2020	2021
Average monthly fast charging times	10.9	17.3	20.9

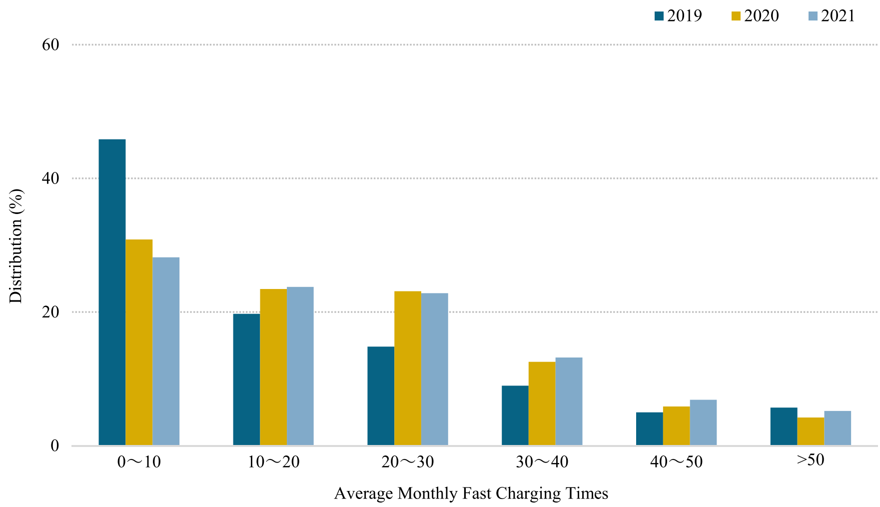


Fig. 5.89 Distribution of average monthly charging times of BEV heavy-duty trucks—by year for fast charging

Table 5.41 Average monthly slow charging times of BEV heavy-duty trucks over the years

Year	2019	2020	2021
Average monthly slow charging times	10.2	8.4	7.8

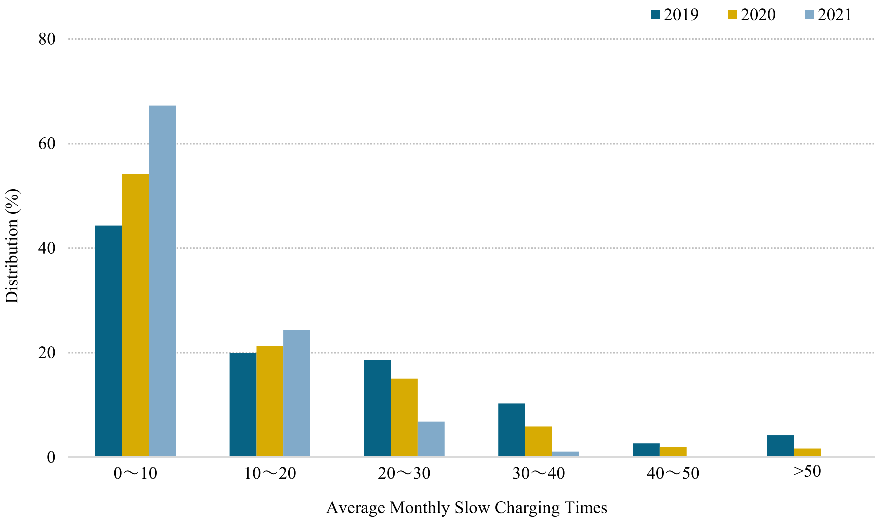


Fig. 5.90 Distribution of average monthly charging times of BEV heavy-duty trucks—by year for slow charging

Table 5.42 Average monthly charge of BEV heavy-duty trucks over the years

Year	2019	2020	2021
Average monthly charge (kWh)	2073.4	4314.7	4516.1

5.3 Analysis of User Charging Behavior in Different Charging Scenarios

Considering that under different charging scenarios, there may be great differences in the type of charged vehicle, the distribution of charging start time, and the charging duration, this section, based on the three different charging scenarios including an urban public charging station, community charging station, and expressway charging station, analyzes the user's charging behavior characteristics.

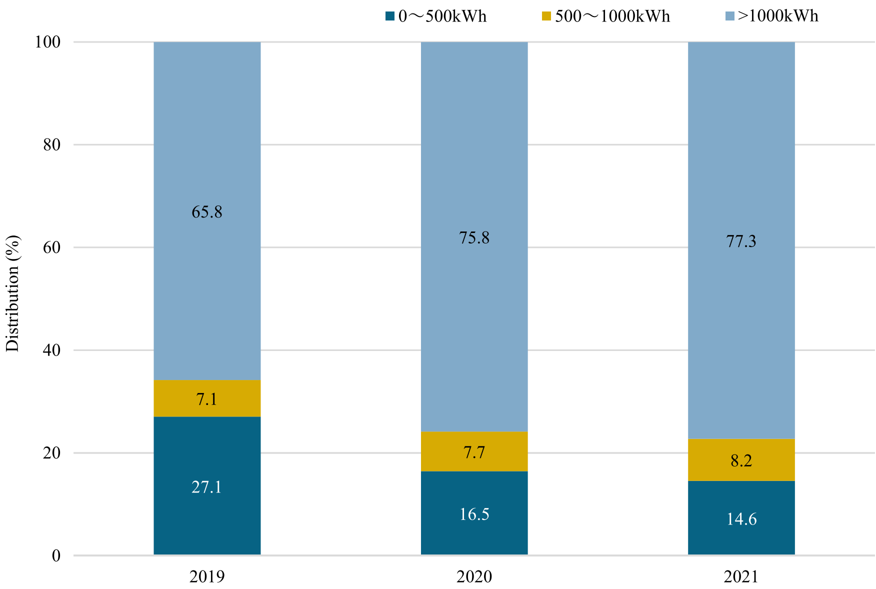


Fig. 5.91 Distribution of average monthly charge of BEV heavy-duty trucks—by year for fast charging

5.3.1 Analysis of Charging Behavior of Users in Public Charging Stations

Most vehicles charge for less than 1 h in public charging stations, and the number of fast-charging vehicles in public charging stations increases rapidly during the day.

This section is intended for the charging stations open to the whole society in urban public places, and by fitting the vehicle charging data of a city with the location data of the charging station, the public charging stations are identified. As shown in Fig. 5.92, the service targets of public charging stations are mainly private cars and taxis/e-taxis, which are mainly due to large scale of UIO of private cars and the high operation intensity of taxis/e-taxis; from the distribution of vehicles in key segments of public charging stations, the proportion of private cars and public buses charged in public charging stations has decreased; the proportion of taxis/e-taxis, logistics vehicles and other types of vehicles charged at public charging stations has increased significantly, and the types of vehicles charged in public charging stations are diversified.

As shown in Fig. 5.93, The charging time of NEVs in public charging stations is mainly concentrated during the day, with a relatively high proportion of vehicles charged from 8:00 to 17:00. The period of 15:00–16:00 is the charging peak. According to the distribution of vehicles charged at different times in public charging

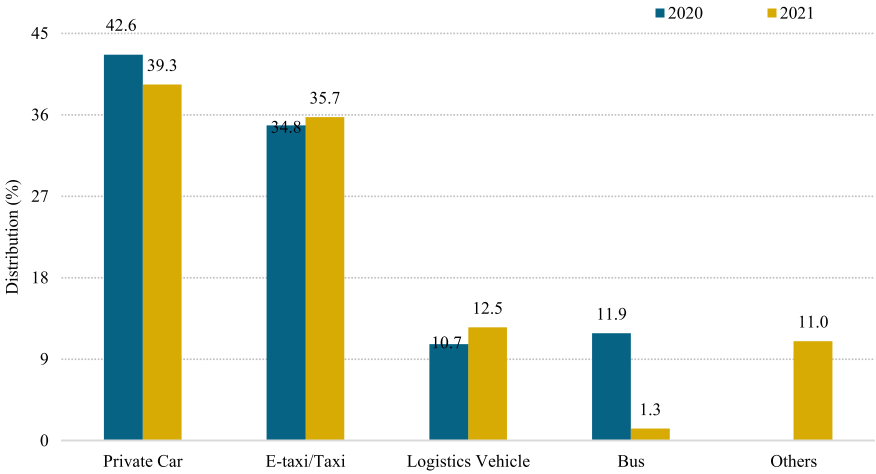


Fig. 5.92 Difference in distribution of vehicles charged in public charging stations—by key segments

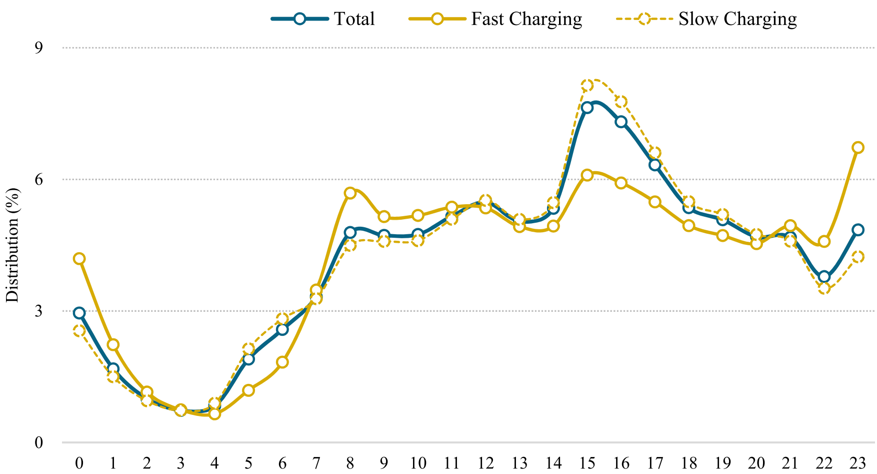


Fig. 5.93 Distribution of vehicle charging time in public charging stations in 2021—by fast charging and slow charging

stations over the years (Fig. 5.94), the proportion of vehicles using fast charging during the day has significantly increased.

As shown in Fig. 5.95, the staying duration of most vehicles in public charging stations is less than 1 h. Specifically, the proportion of private cars, taxis/e-taxis, logistics vehicles, and buses staying in public charging places for less than 1 h accounts for 52.3%, 71.6%, 53.6%, and 57.1%, respectively.

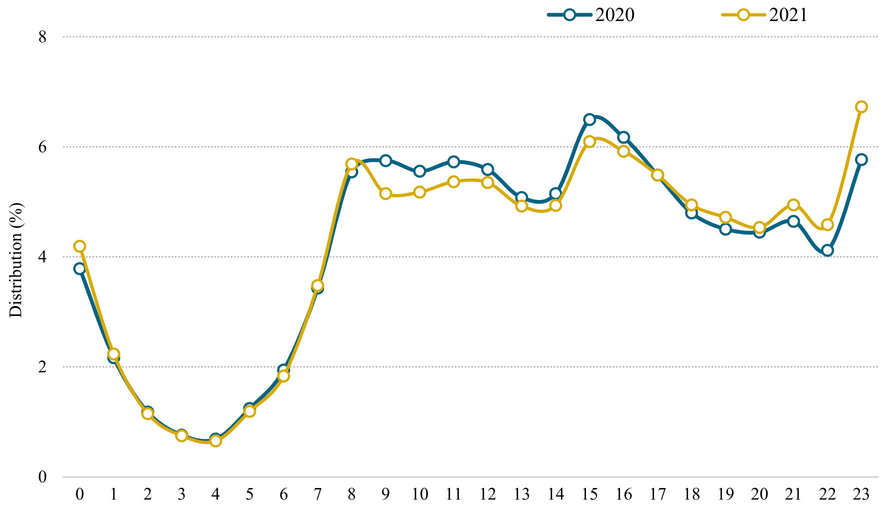


Fig. 5.94 Proportion of fast charging vehicles at different charging times in public charging stations over the years in 2021

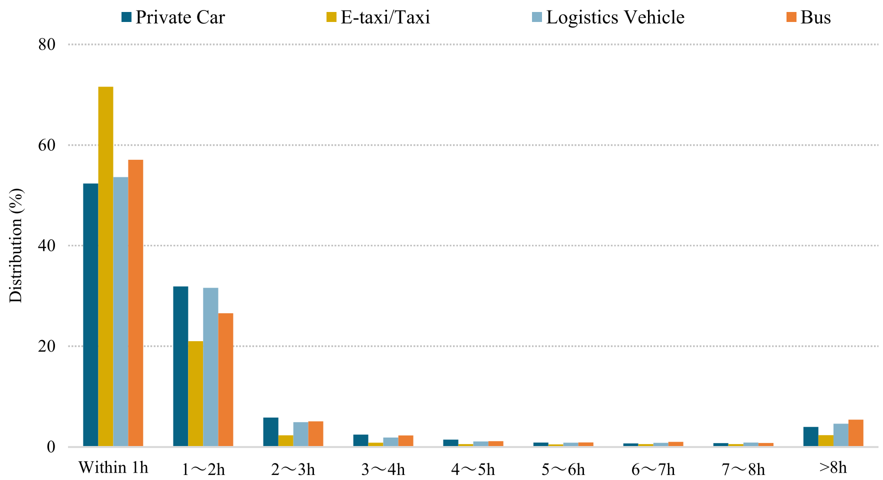


Fig. 5.95 Distribution of single-time charging staying duration of vehicles in public charging stations—by key segments

5.3.2 Analysis of Charging Behavior of Users in Community Charging Stations

The charging in the community charging stations mainly takes place from 15:00 to 24:00, and the proportion of taxis/e-taxis staying for less than 1 h in community charging stations is up to 63.6%.

This section is intended for the charging stations constructed in urban communities for public service, and by fitting the vehicle charging data of a city with the location data of the charging station, the community charging stations will be identified. As shown in Fig. 5.96, the community charging stations mainly serve private cars and taxis/e-taxis, with private cars taking the lead with a charging proportion of up to 77.1% in 2021; Regarding annual changes, the proportion of other types of vehicles charged in community charging stations other than private cars increased. In 2021, the proportion of taxis/e-taxis and other vehicles charged in community charging stations increased significantly, while the proportion of private passenger cars declined.

As shown in Fig. 5.97, the users of community charging stations are mainly private cars, the charging time in community charging stations is mainly 15:00–24:00, and the staying duration of vehicles in community charging stations is more than 8 h. Considering the proportion of vehicles charged at different charging times in the past two years (Fig. 5.98), the proportion of vehicles using fast charging has increased in the two time periods of around 10:00 and 15:00–16:00 in 2021, while the proportion of vehicles using fast charging during the day has increased.

As shown in Fig. 5.99, the vehicles charged in community charging stations are mainly private cars and taxis/e-taxis, and the staying duration of most vehicles in community charging stations is less than 1 h. The proportion of private cars and taxis/e-taxis with a staying duration of less than 1 h after charging is 45.45% and 63.47%, respectively.

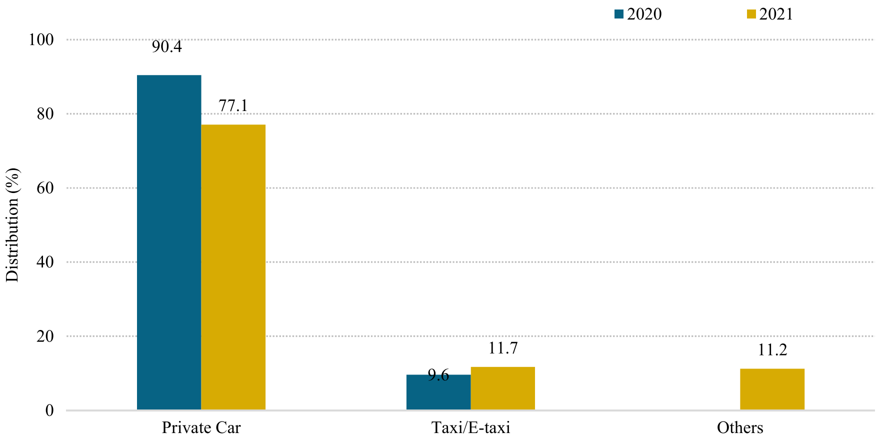


Fig. 5.96 Distribution of vehicles in community charging stations over the years—by key segments

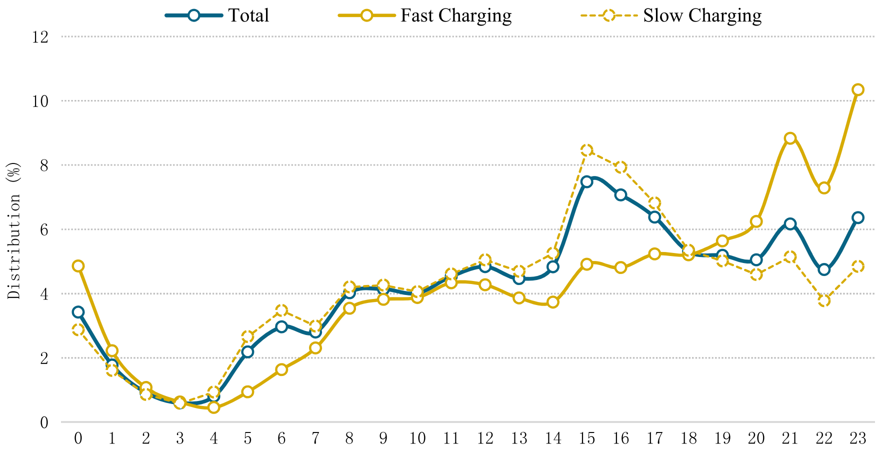


Fig. 5.97 Distribution of vehicle charging time in community charging stations over the years

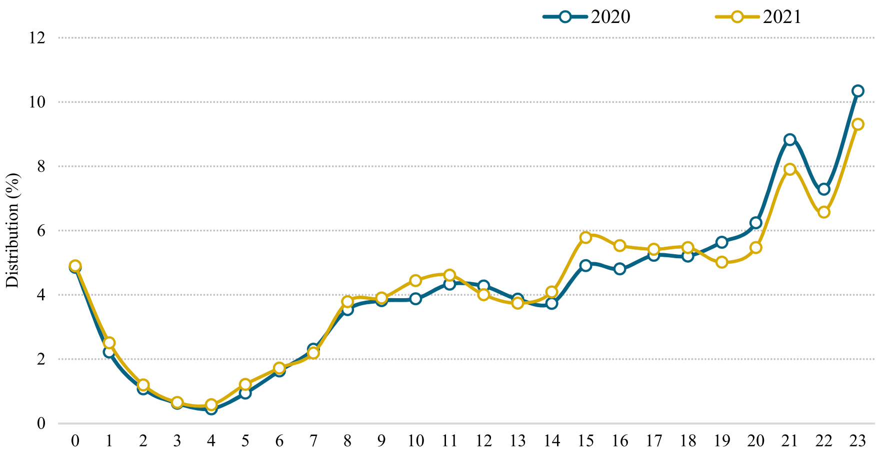


Fig. 5.98 Proportion of fast charging vehicles at different charging times in community charging stations over the years

5.3.3 Analysis of Charging Behavior of Users in Expressway Charging Stations

1. **Analysis of Charging Behavior of Users in Expressway Charging Stations**

The charging time in expressway charging stations is mainly concentrated from 9:00 to 17:00, and the staying duration of most vehicles in expressway charging stations is less than 1 h.

This section is intended for the charging stations constructed along expressways for public service, and by fitting the vehicle charging data of a city with the location

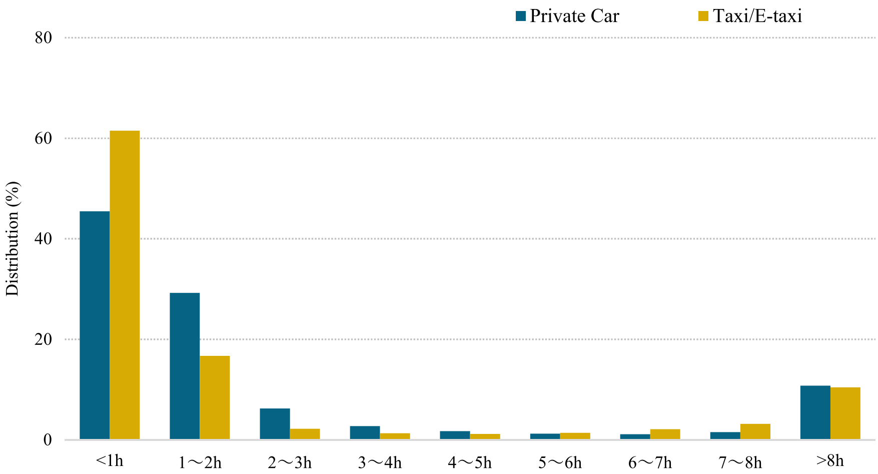


Fig. 5.99 Distribution of single-time charging staying duration of vehicles in community charging stations—by key segments

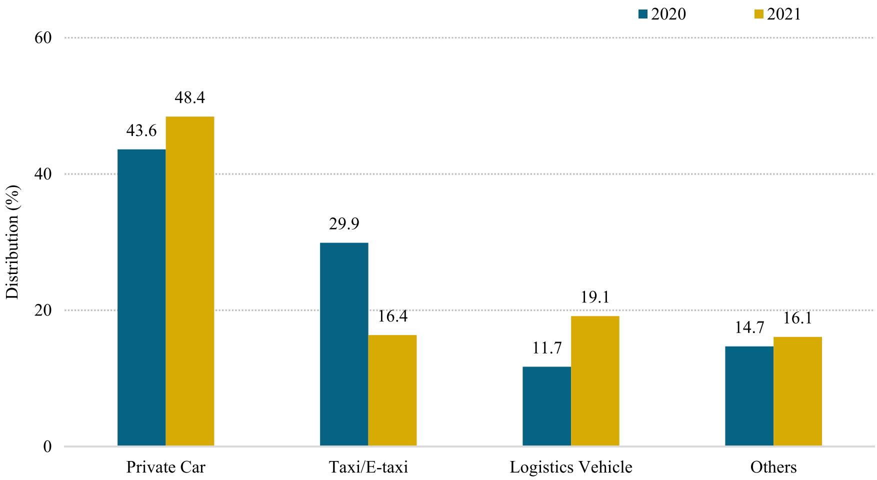


Fig. 5.100 Distribution of vehicles charged in expressway charging stations—by key segments

data of the charging station, the expressway charging stations will be identified. As shown in Fig. 5.100, private cars take the largest proportion among all vehicles charged in expressway charging stations, up to 48.4% in 2021. According to the changes in the proportion of vehicle structure over the years, the proportion of private cars, logistics vehicles, and other types of vehicles charged in expressway charging stations has significantly increased.

As shown in Fig. 5.101, The charging time in expressway charging stations is mainly concentrated during the day. Compared with 2020, in 2021, the proportion

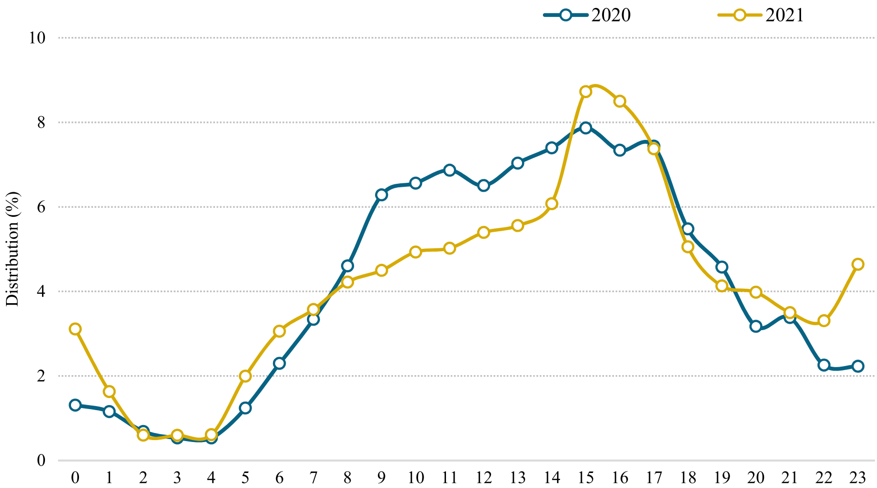


Fig. 5.101 Proportion of fast charging vehicles at different charging times in expressway charging stations over the years

of vehicles charged in expressway charging stations has significantly increased from 15:00 to 16:00 and from 22:00 to 01:00 the next day. The fluctuation of expressway charging capacity can be an important reference for power grid companies to regulate grid loads.

As shown in Fig. 5.102, the staying duration of most vehicles in expressway charging stations is less than 1 h. Specifically, the proportion of private cars, taxis/e-taxis, and logistics vehicles staying in expressway charging stations for less than 1 h accounts for 86.2%, 90.2%, and 67.0%, respectively. Regarding different types of vehicles, the proportion of logistics vehicles with a charging duration of 1–2 h in expressway charging stations is significantly higher than that of other vehicles.

2. **Analysis of Charging Behavior of Users in Expressway Charging Stations Before and After Holidays**

Charging stations along expressways exhibit typical holiday peak characteristics.

Taking the National Day of 2021 as an example, 66 charging stations along the Shanghai-Suzhou-Wuxi-Changzhou intercity expressway in the Yangtze River Delta were selected as the research objects to analyze the charging and waiting characteristics of vehicles in expressway charging stations in order to provide a relevant reference for further optimizing the layout of expressway charging stations.

According to the research results of the 2022 Monitoring Report on Charging Infrastructures in China's Major Cities jointly prepared by the China Academy of Urban Planning & Design and the National Big Data Alliance of New Energy Vehicles (Fig. 5.103), the average daily turnover rate of a single pile of 66 charging stations along the Shanghai-Suzhou-Wuxi-Changzhou intercity expressway in the Yangtze

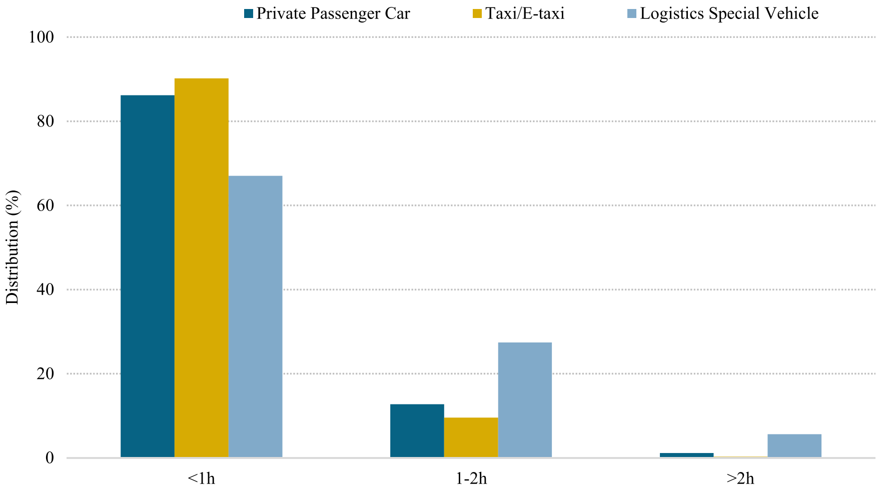


Fig. 5.102 Distribution of single-time charging staying duration of vehicles in expressway charging stations-by key segments

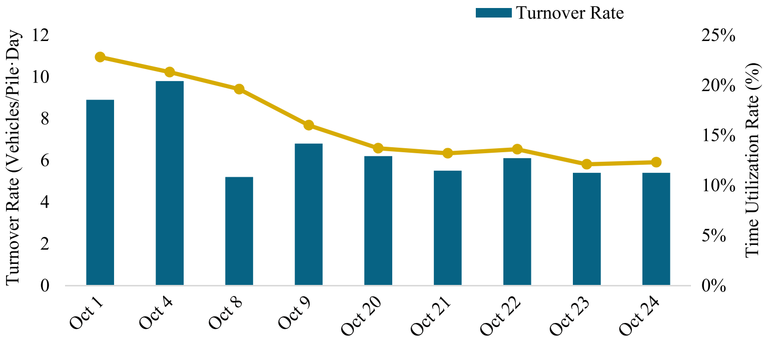


Fig. 5.103 Comparison of daily turnover rate and time utilization rate of charging stations along the intercity expressway in the Yangtze River Delta. *Source* 2022 Monitoring Report on Charging Infrastructures in China's Major Cities. *Note* The average time utilization rate is the ratio of the charging working hours of all public piles in the charging station to the total service hours available in a day; the average turnover rate is the ratio of the total number of vehicles served by the charging station throughout the day to the total number of public piles

River Delta is 6.5 vehicles/pile·day. Specifically, 94% of charging stations have a higher turnover rate during the National Day holiday than on normal days. The average turnover rate during the National Day holiday is 9.2 vehicles/pile·day, higher than the 5.7 vehicles/pile·day during normal days. The time utilization index of the sample stations along the line also shows holiday characteristics, with the time utilization rate during the National Day holiday being higher than that during normal days.

The service targets of expressway charging stations are mainly private cars.

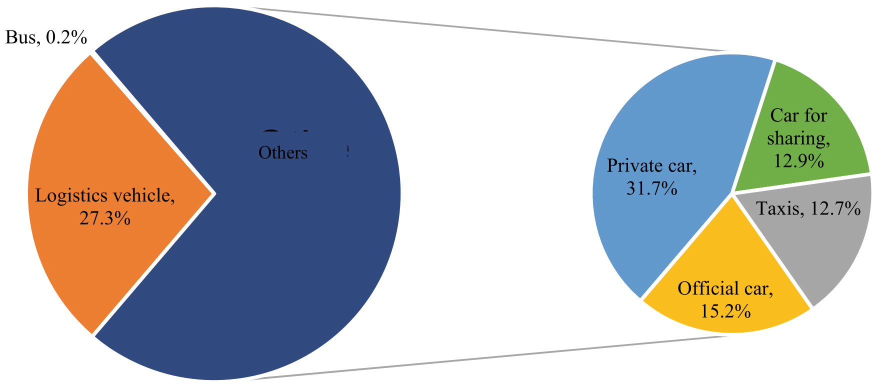


Fig. 5.104 Distribution of main vehicle types served by charging stations along the Shanghai-Suzhou-Wuxi-Changzhou intercity expressway

According to the calculation results of the matching of vehicle piles at expressway charging stations (Fig. 5.104), the main types of vehicles served by charging stations along the Shanghai-Suzhou-Wuxi-Changzhou intercity expressway are passenger cars and logistics vehicles, accounting for 72.5% and 27.3% of the total number of vehicles charged. Further dividing electric passenger cars into private cars, taxis, official cars (including business cars), and cars for sharing, it can be found that private cars account for the highest proportion at 31.7%. In contrast, official cars, cars for sharing, and taxis (including business cars) account for 15.2%, 12.9%, and 12.7% respectively with little difference in proportion.

During the National Day holiday, the increase in passenger cars is the highest, while the decrease in logistics vehicles is significant.

The demand for long-distance travel across cities during the National Day holiday in October 2021 was relatively strong. Regarding the types of vehicles served by charging stations along the Shanghai-Suzhou-Wuxi-Changzhou Intercity Expressway (Fig. 5.105), the number of passenger cars charged in such stations has increased significantly, reaching 69.4%. However, the charging behavior of vehicles for operational purposes has significantly decreased, and the number of logistics vehicles charged in such stations has significantly decreased by 46.8% compared with normal days.

The number of passenger cars charged during the National Day holiday has increased by 33% compared with normal days, with rental cars experiencing the highest growth rate.

Although private passenger cars are still the main model of vehicles charged among various types of passenger cars (Fig. 5.106), accounting for 43% of the total number of vehicles charged, the highest increase during the National Day holiday compared with normal days is in cars for sharing, reaching 153%; followed by taxi, with the number of charged taxi increased by 110.8%. The number of private cars charged has increased by 66.3%. The high growth rate of cars for sharing reflects users' confidence in new energy passenger cars for long-distance travel and their affirmation of the economic advantages of new energy passenger cars for travel.

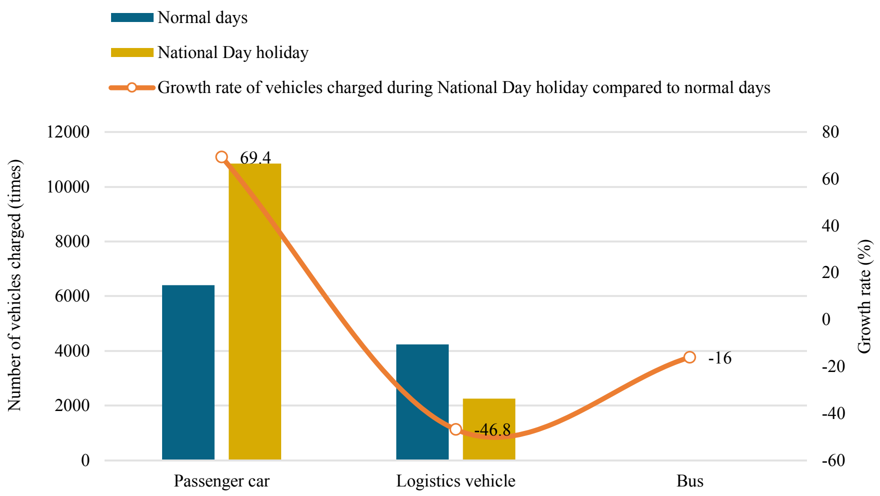


Fig. 5.105 Charging of vehicles along the expressway in the Yangtze River Delta during the 2021 National Day holiday and normal days

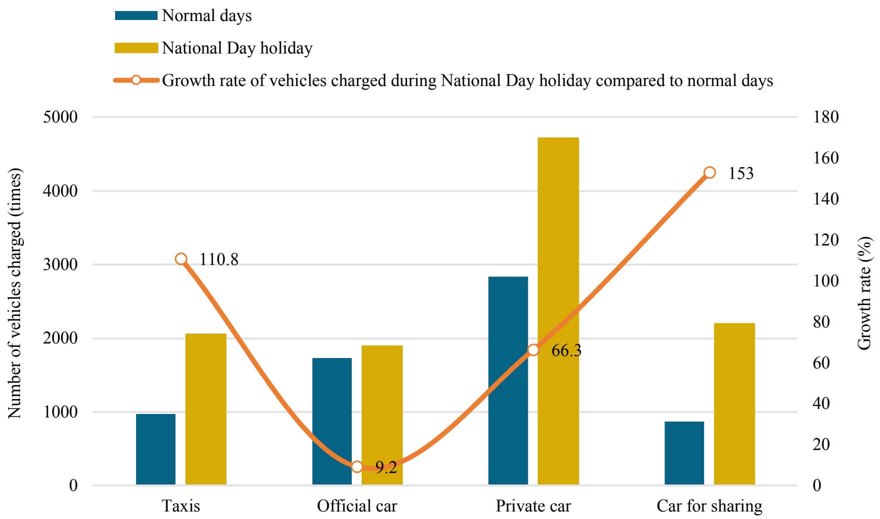


Fig. 5.106 Charging of passenger cars along the expressway in the Yangtze River Delta during the 2021 National Day holiday and normal days

Comprehensively improving the service efficiency of charging piles along expressways during holidays should be based on potential tapping, supplemented by densification and new construction. On the one hand, through measures such as improving the power of DC charging piles, getting through the network of charging operators, and unifying the intelligent charging platform, users are guided to reasonably select charging stations and charging periods, thus reducing users' waiting time and improve the charging experience on holidays; on the other hand, in combination with the assessment results, additional measures shall be considered, such as densification of new charging stations and introduction of battery swapping facilities, to resolve the range anxiety of intercity travelers further and promote the healthy development of the electric vehicle industry. Besides, in guiding users' charging behavior, time-sharing and classified differences can guide the charging behavior of expressway vehicles, creating a compatible and orderly charging service environment with passengers and goods separated.

5.3.4 Analysis of Charging Behavior of Users in Township Charging Stations

The charging in the township charging stations mainly takes place from 17:00 to 24:00, and the proportion of private cars staying for more than 8 h in township charging stations is up to 37.2%.

This section is intended for the charging stations constructed in township areas for public service, and by fitting the vehicle charging data of a city with the location data of the charging station, the township charging stations will be identified. As shown in Fig. 5.107, township charging stations mainly serve private cars and taxis/e-taxis, mainly private cars, with a proportion up to 63.6%. Township charging piles are mainly private charging piles.

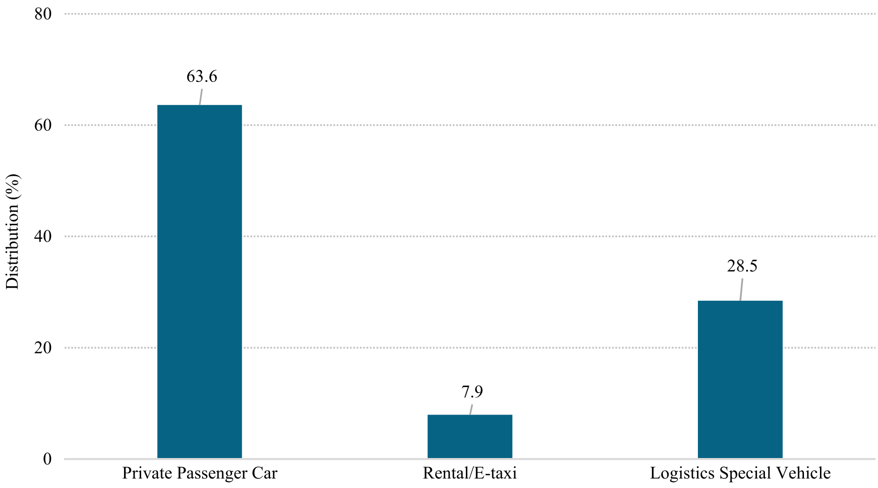


Fig. 5.107 Difference in distribution of vehicles charged in township charging stations in 2021—by key segments

As shown in Fig. 5.108, the users of township charging stations are mainly private passenger cars. The charging time in township charging stations is mainly 13:00–17:00.

As shown in Fig. 5.109, the vehicles charged in township charging stations are mainly private cars, taxis/e-taxis, and logistics vehicles. The proportion of taxis/e-taxis with a charging staying duration of less than 1 h at township charging stations is the highest, reaching 84.2%; followed by private cars and logistics vehicles with a charging staying duration of less than 1 h, accounting for 62.7% and 47.1%, respectively.

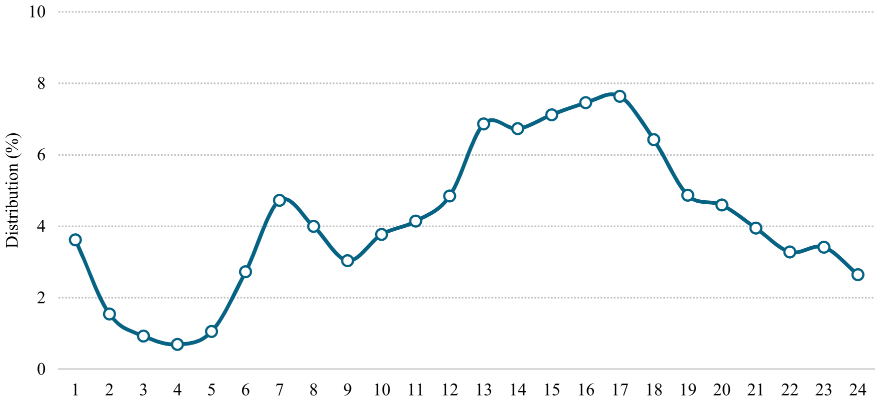


Fig. 5.108 Distribution of vehicle charging time in township charging stations

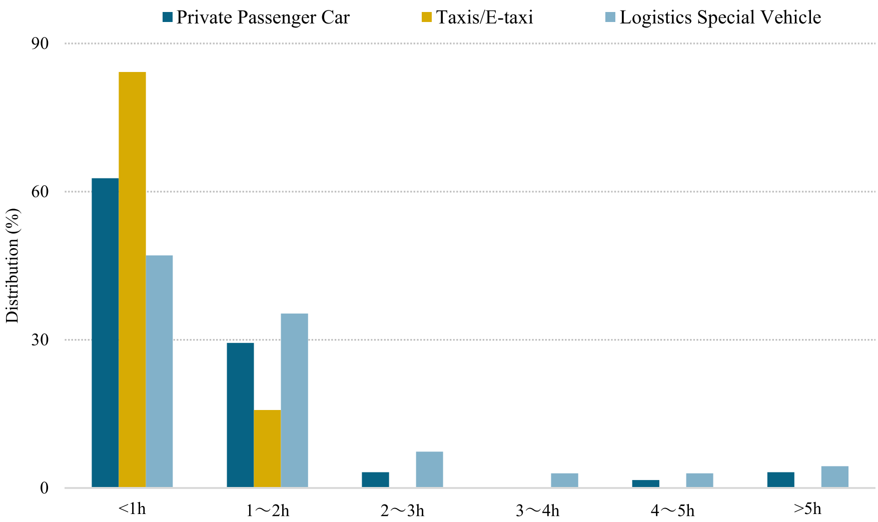


Fig. 5.109 Distribution of single-time charging staying duration of vehicles in township charging stations—by key segments

5.4 Summary

Through the analysis of charging characteristics of new energy vehicles on the National Monitoring and Management Platform, this chapter draws the following conclusions for the charging characteristics of vehicles in key segments:

The scale of charging infrastructures continues to grow rapidly, and the charging technology has made significant progress. By the end of 2021, the UIO of charging infrastructures in China has reached 2.617 million, and the number of new charging piles has increased significantly. The vehicle-to-pile increment ratio is 3.7:1, and the construction of charging infrastructures can mostly meet the rapid development of NEVs; the charging technology has continued to improve, and the average charging power of public DC charging piles has steadily increased. The number of new public DC charging piles with an average power of 120 kW and above has proliferated over the years, and the trend of high power in the field of public charging facilities has gradually emerged.

Regarding charging methods, new energy private cars mainly rely on slow charging, supplemented by fast charging; other operating vehicles mainly rely on fast charging, supplemented by slow charging. The average monthly charging times of private cars in 2021 has increased compared with 2020, with an average of 8.8 charging times per month and about 2 charging times per week; private cars mainly rely on slow charging, and the proportion of new energy private cars using slow charging in 2021 was 85.2% in the average monthly charging times. According to the distribution of charging time for private cars, the average daily charging time for new energy private cars in 2021 was concentrated during the morning rush hours and at night, with charging at the destination work units in the morning rush hours and charging mainly in the residential areas at night. In the field of operating vehicles, e-taxis, taxis, cars for sharing, logistics vehicles, buses, and heavy-duty trucks rely on fast charging. Operating vehicles have relatively high time costs, and the proportion of vehicles choosing to recharge electricity quickly during the day is increasing yearly.

Diversified charging venues meet the charging needs of vehicles in different application scenarios. Community charging stations, expressway charging stations, and township charging stations mainly serve private cars, accounting for 77.1%, 48.4%, and 63.6%, respectively. With the policy of promoting NEVs to the countryside, vehicle promotion and application in township charging scenarios tend to be diversified. In addition to private cars, cars for sharing, e-taxis, and logistics vehicles also account for a certain proportion; with the rapid growth of the NEV industry, rapidly increased charging orders of expressway charging stations during the holiday period, prolonged waiting time for charging and poor user charging experience have become important propositions for improving the charging service experience in the next stage.

Chapter 6
Battery Swapping of New Energy Vehicles

The battery swapping mode is one of the important ways of energy supply for new energy vehicles, which can effectively solve the pain points of slow and fast charging methods, alleviate the impact from the grid, improve battery safety, and have a positive promoting effect on improving the convenience and safety of NEVs. With the deepening development of China's NEV industry, many automobile enterprises and operators have successively launched the battery-swapping-type mode and battery-swapping infrastructure, accumulating rich practical experience in the field of battery swapping. Since 2021, the support policies based on the battery swapping mode at the national level have been accelerated, and the pilot work for battery swapping has been officially launched. The development of universal national and group standards in battery swapping is accelerating. This section sorts out the current status of policies and standard systems related to the battery-swapping mode of BEVs. Based on the promotion of battery-swapping-type vehicle enterprises and battery-swapping-type vehicles on the National Monitoring and Management Platform, an analysis is conducted on the battery-swapping behavior and economic efficiency of battery-swapping-type vehicles, which provides some experience and reference for promoting the application of battery swapping mode of BEVs and the healthy and sustainable development of battery swapping infrastructure in China.

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2022)*,
https://doi.org/10.1007/978-981-99-6411-6_6

6.1 Current Status of Industrial Policies and Standards for Battery Swapping Mode

6.1.1 Accelerated Implementation of Battery Swapping Mode Support Policy and Officially Launched Pilot Work

The battery swapping mode has certain advantages in reducing the cost of the first-time car purchase, eliminating range anxiety, improving the safety level. It can effectively address the demand for energy supplement efficiency of operating vehicles, commercial vehicles, and other subdivision segments. The Government Work Report in 2020 and 2021 mentioned "increasing facilities such as charging piles and battery swapping stations," the battery swapping stations will be developed together with charging piles as supporting facilities in the future (Table 6.1).

As the first stage of promoting the battery-swapping model nationwide, pilot cities for battery-swapping will accelerate the formation of replicable and promotable experiences in the battery-swapping industry. On October 28, 2021, the Ministry of Industry and Information Technology issued the *Notice on Launching the Pilot Work of Application of Battery Swapping Mode for New Energy Vehicles* (hereinafter referred to as the "Notice"), deciding to launch the pilot work of application of battery swapping mode for new energy vehicles. There are a total of 11 cities included in the pilot scope, including 8 cities of comprehensive application category (Beijing, Nanjing, Wuhan, Sanya, Chongqing, Changchun, Hefei, Jinan), and 3 heavy-duty trucks featured cities (Yibin, Tangshan, Baotou). The goal is to promote over 100,000 battery-swapping-type vehicles and construct over 1000 new battery-swapping stations.

On January 10, 2022, the Implementation Opinions of the National Development and Reform Commission and other departments on Further Improving the Service Guarantee Capacity of Electric Vehicle Charging Infrastructure (FGNYG [2022] No. 53) (referred to as the "Implementation Opinions") were released. The Implementation Opinions respectively mention the battery swapping mode in optimizing urban public charging networks, strengthening innovation and standard support of charging and swapping technology, and accelerating the promotion and application of battery swapping modes, with an aim to arrange battery swapping stations according to local conditions, promote the formation of unified battery swapping standards in main application fields, and improve the safety, reliability, and economy of the battery swapping mode; propose to accelerate the promotion and application of the battery swapping mode to support the construction and layout of dedicated battery swapping stations around scenarios such as mines, ports, and urban transportation; accelerate the exploration and promotion of the separation mode of vehicle and battery, and promote the electrification transformation of heavy-duty trucks and container trucks in ports; explore shared battery swapping mode in rental, logistics and transportation fields, and optimize and enhance the shared battery swapping service.

Table 6.1 Summary of relevant policies on battery swapping at the national level since 2021

Time	Released by	Name	Content
March 5, 2021	The Fourth Session of the 13th National People's Congress	2021 Government Work Report	Steadily increase mass consumption of automobiles and household appliances, increase parking lots, charging piles, battery swapping stations, and other facilities, and accelerate the construction of power battery recycling systems
October 21, 2021	General Office of the Chinese Communist Party, General Office of the State Council	Opinions on Promoting Green Development in Urban and Rural Construction	Reasonably arrange and construct electric vehicle charging and swapping stations, accelerate the development of intelligent connected vehicles, new energy vehicles, smart parking, and accessible infrastructure
October 28, 2021	Ministry of Industry and Information Technology	Notice on Launching the Pilot Work of Application of Battery Swapping Mode for New Energy Vehicles	Decided to launch pilot work on the application of battery swapping mode for new energy vehicles. There are a total of 11 cities included in the pilot scope, including 8 cities of comprehensive application category (Beijing, Nanjing, Wuhan, Sanya, Chongqing, Changchun, Hefei, Jinan), and 3 heavy-duty trucks featured cities (Yibin, Tangshan, Baotou)
January 10, 2022	National Development and Reform Commission	Implementation Opinions of the National Development and Reform Commission and other departments on Further Improving the Service Guarantee Capacity of Electric Vehicle Charging Infrastructure	Optimize the layout of urban public charging network construction. Arrange the battery swapping stations according to local conditions to enhance the guaranteed capacity of public charging service; Strengthen the innovation and standard support of charging and swapping technology. Promote the formation of unified battery swapping standards in major application fields, and improve the safety, reliability, and economy of the battery swapping mode; Accelerate the promotion and application of the battery-swapping mode. Support the construction and layout of dedicated battery swapping stations around scenarios such as mines, ports, and urban transportation; accelerate the exploration and promotion of the separation mode of vehicle and battery. Moreover, promote the electrification transformation of heavy-duty trucks and container trucks in ports. Explore shared battery swapping mode in rental, logistics, and transportation fields, and optimize and enhance the shared battery swapping service

Source Official websites of the General Office of the State Council, the Ministry of Finance, the Ministry of Industry and Information Technology, and www.gov.cn

Local governments provide different levels of financial subsidies for the construction and operation of battery-swapping stations. In order to speed up the construction of battery-swapping stations, Hainan, Guangzhou, Chongqing, Dalian, Chengdu, Guangxi, and other provinces or cities have successively issued subsidy standards for the construction of battery-swapping stations. For example, on May 13, 2021, Chongqing Municipal Finance Bureau and Chongqing Economic and Information Commission jointly issued the Notice of Chongqing on the Financial Subsidy Policies for Promotion and Application of New Energy Vehicles in 2021, which provides a one-time construction subsidy of 400 yuan/kW according to the rated charging power of the charging module of the battery swapping equipment or the rated output power of the transformer (whichever is smaller) for the battery swapping stations in the public service field that has been completed, accepted and put into use, with a maximum subsidy for a single station not exceeding 500,000 yuan; on July 30, 2021, Hainan Provincial Development and Reform Commission issued the "Guiding Opinions on Supporting the Construction of Electric Vehicle Battery Swapping Stations in Hainan Province (Trial)", which provides a one-time construction subsidy of 15% of the project equipment investment for battery swapping stations that have been completed and put into operation before December 31, 2022 and serve the key application fields of the battery swapping mode; on October 9, 2021, Dalian Development and Reform Commission, Dalian Industry and Information Technology Bureau, Dalian Science and Technology Bureau, and Dalian Finance Bureau jointly issued the "Management Measures of Dalian for New Energy Vehicle Charging Infrastructure Construction Rewards and Subsidies", which provides a one-time subsidy of no more than 30% of the battery swapping facility investment for new energy vehicle battery swapping stations that meet the conditions, with a maximum subsidy not exceeding 2 million yuan.

Regarding operating subsidies for battery-swapping facilities, Shanghai, Guangxi, Guangzhou, and other provinces or cities have provided different levels of operating subsidies for battery-swapping infrastructure. On April 1, 2020, Shanghai Municipal Development & Reform Commission and four other departments jointly issued the Interim Measures of Shanghai Municipality for Promoting the Orderly Development of the Interconnection of Electric Vehicle Charging (Swapping) Facilities (HFGZ [2020] No. 4), proposing that charging facilities should shift from construction to operation. The support direction should shift from equipment subsidies to KWH subsidies, and for special charging piles and battery swapping facilities, subsidy standards should be determined according to the star level of the stations. The basic KWH subsidy for a "One Star" station is 0.1 yuan/kWh, 0.2 yuan/kWh for a "Two Star" station, and 0.3 yuan/kWh for a "Three Star" station, with a maximum subsidy of 2000 kWh/kW-year. The subsidy standards for 2021 and beyond will adopt a two-year mechanism based on factors such as the overall operational efficiency of charging facilities. The specific calculation plan will be proposed by the municipal platforms and approved by the municipal development and reform commissions before implementation.

With the rapid growth of battery swapping stations in the future, various provinces and cities may gradually introduce subsidy standards. At present, the battery-swapping industry is still in the early stage of development. With the gradual unification of the standards of the battery-swapping industry in the future and the gradual improvement of the subsidy policies of various provinces and cities, the growth rate of the battery-swapping station will also be further improved, consistent with the development history of the charging pile.

6.1.2 Gradually Unified Standards for Battery Swapping

Regarding formulating specific standards in the field of battery swapping, the formulation of national and group standards based on the field of battery swapping has been gradually accelerated. On March 16, 2021, the Ministry of Industry and Information Technology announced the Key Points of Industry and Information Technology Standards in 2021, proposing to promote the development of standards for new technologies, new industries, and new infrastructures and vigorously carrying out the research and development of standards for electric vehicles, charging and swapping systems, FCEVs.

On April 30, 2021, the recommended national standard GB/T 40032-2021, Safety Requirements of Battery Swap for Electric Vehicles, proposed by the Ministry of Industry and Information Technology and under the jurisdiction of the National Technical Committee of Automotive Standardization, was approved for release by the State Administration for Market Regulation and the National Standardization Administration Committee, it has been officially implemented since November 1, 2021 (Fig. 6.1). The Safety Requirements of Battery Swap for Electric Vehicles applies to BEVs of category M1 whose batteries can be swapped. It specifies the safety requirements, test methods, and rules for electric vehicles with swappable batteries. This standard is the first basic universal national standard developed by the automotive industry in the field of battery swapping, which solves the problem of no standard for the battery swapping mode, helps guide enterprises in product research and development, and ensures the safety of battery-swapping-type vehicles.

In commercial vehicles, heavy-duty trucks, and mining trucks, it is relatively easy to unify battery pack standards. Currently, the battery capacity of heavy-duty trucks in the market is mostly concentrated at 282 and 350 kWh. In the Global Intelligent Mobility Conference held in June 2021, 11 of the 13 battery-swapping-type heavy-duty trucks participating in the exhibition are equipped with 282 kWh CATL LFP batteries; in addition, unlike in the field of passenger cars, commercial vehicles place more emphasis on actual operational efficiency rather than appearance and driving experience, and the demand for personalized customization of batteries is not high, which provides favorable conditions for unified battery swapping standards.

Regarding passenger cars, the China Association of Automobile Manufacturers announced in October 2021 that the group standard *Construction Requirements for EV Shared Swap Station* (hereinafter referred to as "Construction Requirements") has

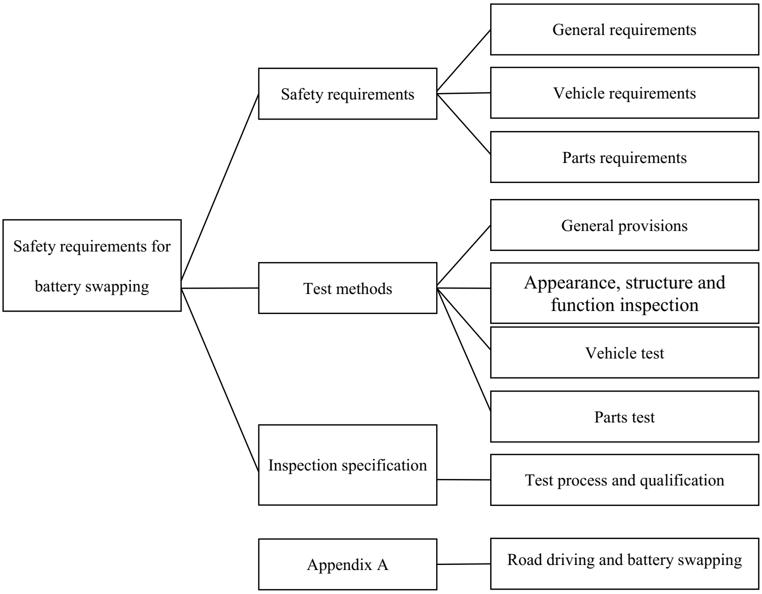


Fig. 6.1 Framework of the safety requirements of battery swap for electric vehicles. *Source* Safety requirements of battery swap for electric vehicles (GB/T 40032-2021)

been reviewed and officially released on December 22 of the same year (Table 6.2). The standard was jointly formulated by battery suppliers (CATL, Sunwoda, GAC, NIO, BAIC BJEV) and third-party operators (including Botan, GCL-ET, Aulton New Energy), and provides for battery swapping stations in 12 aspects, including battery pack, battery swapping mechanism, and layout planning of battery swapping stations, aiming to ultimately achieve the sharing of the battery pack platform and battery modules for the battery swapping station with the "three-step" approach.

6.2 Current Development Status of Battery Swapping Infrastructure

The construction of battery swapping stations is gradually advancing, and as of the end of 2021, the total number of battery swapping stations in China has reached 1298.

Regarding mainstream battery-swapping operators, the current battery-swapping infrastructure market is on a relatively small scale and is facing a good opportunity for development. Aulton New Energy, Botan, and Nio are the main operators of battery-swapping facilities. Aulton New Energy and Botan are oriented to the public sector (including public transport, taxis), while Nio is oriented to private battery swapping stations (private users). As shown in Fig. 6.2, as of the end of 2021, the total number

Table 6.2 Relevant standards in the field of battery swapping in 2021

Time	Released by	Name	Content
March 16, 2021	Ministry of Industry and Information Technology	Key Points of Industry and Information Technology Standards	Promote the development of standards for new technologies, new industries, and new infrastructures. Vigorously research and develop standards for electric vehicles, charging and swapping systems, FCEVs
April 30, 2021	State Administration for Market Regulation, National Standardization Administration Committee	GB/T 40032-2021, Safety Requirements of Battery Swap for Electric Vehicles	Specify the safety requirements, test methods, and test rules for electric vehicles with swappable batteries;
October 2021	China Association of Automobile Manufacturers	T/CAAMTB 55, Construction Requirements for EV Shared Swap Station	Part 1: General provisions; Part 2: Technical requirements for change platform and equipment; Part 3: Technical requirements for changing battery communication protocol; Part 4: Technical requirements for vehicle identification system; Part 5: Requirement of swappable battery pack; Part 6: Technical requirements for lock mechanism and unlock mechanism; Part 7: Technical requirements for the electrical connector; Part 8: Technical requirements for the liquid cooling connector; Part 9: Requirements for charging equipment, handling equipment, and battery storage system; Part 10: Technical requirements for data security and data warning analysis; Part 11: Requirements for safety protection emergency; Part 12: Requirements for planning and layout of a change station; Part 13: Requirements for identification, safe operation, equipment transportation, and installation;

of battery swapping stations in China was 1298, with an increase of 743 compared with 2020, indicating a rapid growth rate in the construction of battery swapping stations. Among the three major battery swapping operators, Nio's battery swapping station ranks first regarding the growth in construction quantity. As of the end of 2021, the total number of Nio's battery swapping stations has reached 789, with an

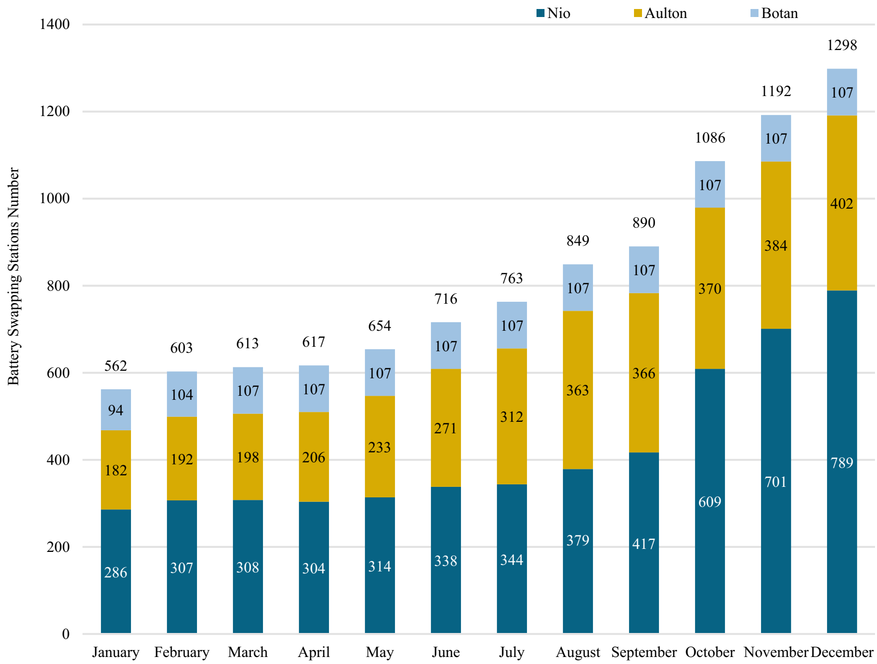


Fig. 6.2 Number of battery swapping stations owned by major battery swapping operators in China in 2021. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance

annual increase of 503; the total number of Aulton's battery swapping stations was 402, with an increase of 227 in 2021.

The number of battery swapping stations in Beijing ranks first in China, accounting for nearly 1/5 of the total number in the country.

Regarding the number of battery swapping stations in various provinces (Fig. 6.3), Beijing ranks first. As of the end of 2021, its number of battery swapping stations reached 255, accounting for nearly 1/5 of the total number in China, followed by Guangdong, Zhejiang, Shanghai, and Jiangsu, with over 90 battery swapping stations, accounting for over 7% of the total number in China.

National policy support and investment in the battery-swapping industry.

With the gradual launch of battery-swapping-type models, the speed of construction of battery-swapping stations in the industry has significantly accelerated, and various operators of battery-swapping stations have announced plans to construct battery-swapping stations in the next five years. Aulton New Energy and Changan New Energy said that by 2025, they would invest and build more than 10,000 battery swapping stations. Sinopec, Geely, and GCL-ET plan to build 5000 battery-swapping stations. Nio and SPIC respectively, plan to add 4000 battery-swapping stations. According to enterprise planning, the number of battery-swapping stations is expected to reach more than 20,000 by 2025.

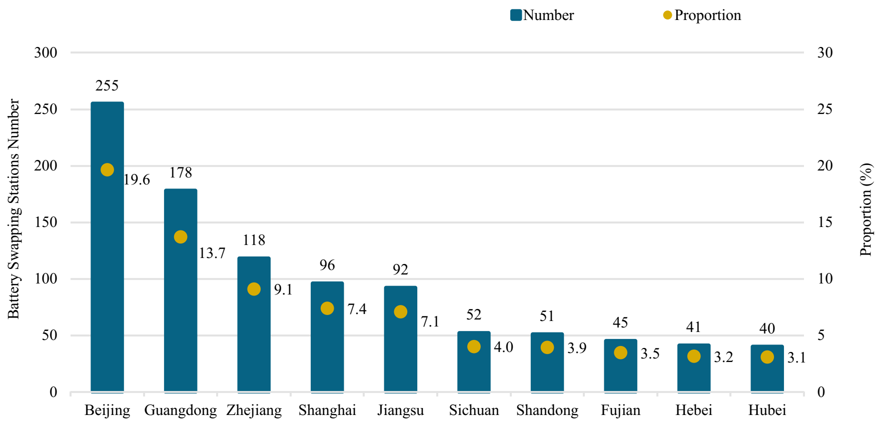


Fig. 6.3 Number of battery swapping stations in major provinces in China in 2021 (units, %). *Source* China electric vehicle charging infrastructure promotion alliance

Regarding vertical and horizontal collaboration in the battery swapping industry, operators of battery swapping stations such as Aulton and Botan have accelerated the construction of battery swapping stations, actively cooperated with vehicle manufacturers, and energy enterprises such as Sinopec have carried out strategic cooperation with Nio to carry out the construction and operation of battery swapping stations. Huawei, SoftBank, and other capitals invest in the battery-swapping mode, and companies such as CATL have also entered the battery-swapping industry. On the one hand, they can improve battery sales through charging and swapping. On the other hand, they have set up battery asset management companies with Nio, to leap from production to energy service, and the battery swapping market is expected to usher in rapid development.

6.3 Promotion of Battery-Swapping-Type BEVs

6.3.1 National Promotion of Battery-Swapping-Type BEVs

As of the end of 2021, China has promoted over 140,000 battery-swapping-type BEVs, with battery-swapping-type BEV private passenger cars in the majority.

According to data from the National Monitoring and Management Platform, as of the end of 2021, over 140,000 battery-swapping-type BEVs have been accessed in China. In 2021, the access volume of battery-swapping-type vehicles increased rapidly, reaching 97,000 annually, with an increase of 4.8 times compared to 2020. Regarding vehicle usage, the promotion of battery-swapping-type BEV private passenger cars is dominant, with a total of 88,000 ones accessed, accounting for

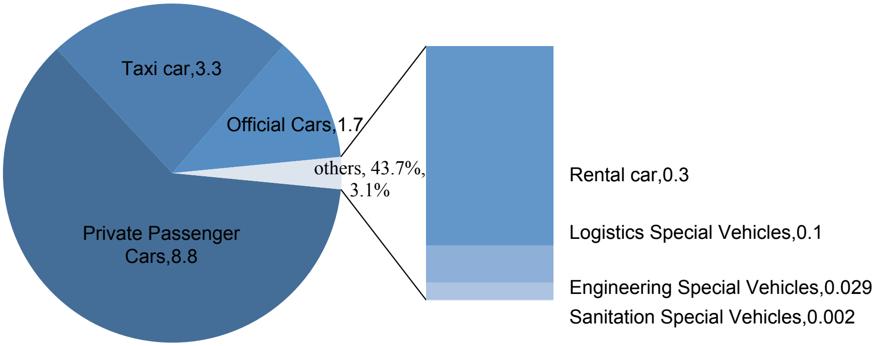


Fig. 6.4 Cumulative access and proportion of battery-swapping-type BEVs—by class (10,000 units)

62.0%, followed by taxi cars and official cars, with a total of 33,000 and 17,000 accessed, accounting for 23.2% and 12.0% respectively (Fig. 6.4).

The battery-swapping-type BEVs have a relatively high market concentration (Fig. 6.5). Nio mainly focuses on private passenger cars. By the end of 2021, Nio had 95,000 battery-swapping-type BEVs accessed, accounting for 66.4% in China. BAIC and BAIC BJEV are mainly engaged in the taxi, official car, and rental car markets. The two enterprises have 26,000 and 14,000 battery-swapping-type BEVs accessed, respectively, accounting for 18.5 and 9.5% in China.

According to the promotion of battery-swapping-type BEVs in the TOP10 provinces (Fig. 6.6), Beijing has a cumulative access volume of 31,000 battery-swapping-type BEVs, accounting for 21.7% in China, followed by Shanghai, Guangdong, and Zhejiang, all with a cumulative access volume of over 15,000 battery-swapping-type BEVs, accounting for over 10% in China.

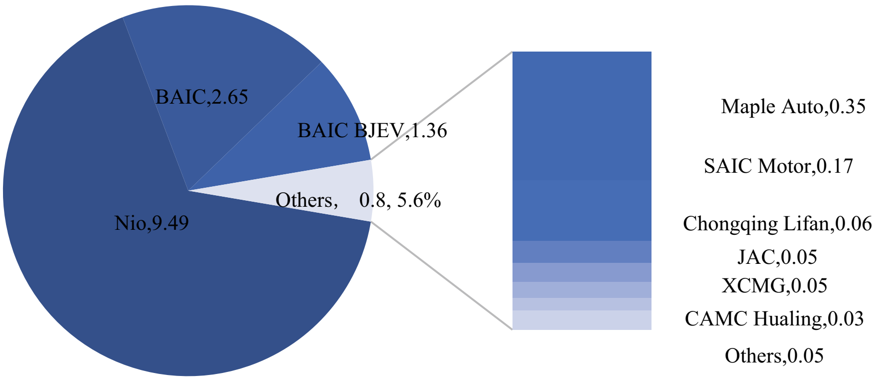


Fig. 6.5 Cumulative access and proportion of battery-swapping-type BEVs—by vehicle enterprise (10,000 units)

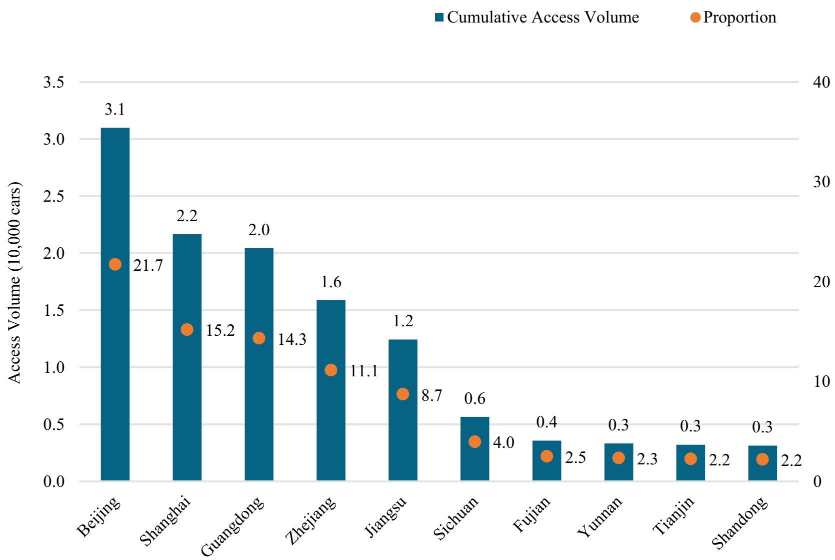


Fig. 6.6 Cumulative access and proportion of battery-swapping-type BEVs in the TOP 10 provinces

The concentration of urban promotion of battery-swapping-type BEVs is relatively high (Fig. 6.7), and Beijing ranks first in the cumulative access volume of battery-swapping-type BEVs in various cities in China; followed by Shanghai and Guangzhou, with a cumulative access volume of over 10,000 battery-swapping-type BEVs.

6.3.2 Promotion of Battery-Swapping-Type Heavy-Duty Trunks

As the core carrier of logistics transportation and engineering construction, heavy-duty trucks have high sensitivity to operation efficiency. According to data from the Ministry of Transport, the road freight transportation volume in China in 2021 was 39.14 billion tons, accounting for 75.1% of the total freight transportation volume in China. Heavy-duty trucks, with their advantages of long-haul distance, large volume, and high transportation efficiency, are commonly used in logistics transportation, engineering construction, and specialized fields and are important production materials for economy and life.

The field of battery-swapping-type heavy-duty trucks is still in the demonstration operation stage, and with policy support, mainstream commercial vehicle companies are gradually accelerating the pace of launching battery-swapping-type heavy-duty trucks. Judging from the mainstream commercial vehicles and new energy heavy-duty truck models launched by enterprises in 2021 (Table 6.3), such enterprises

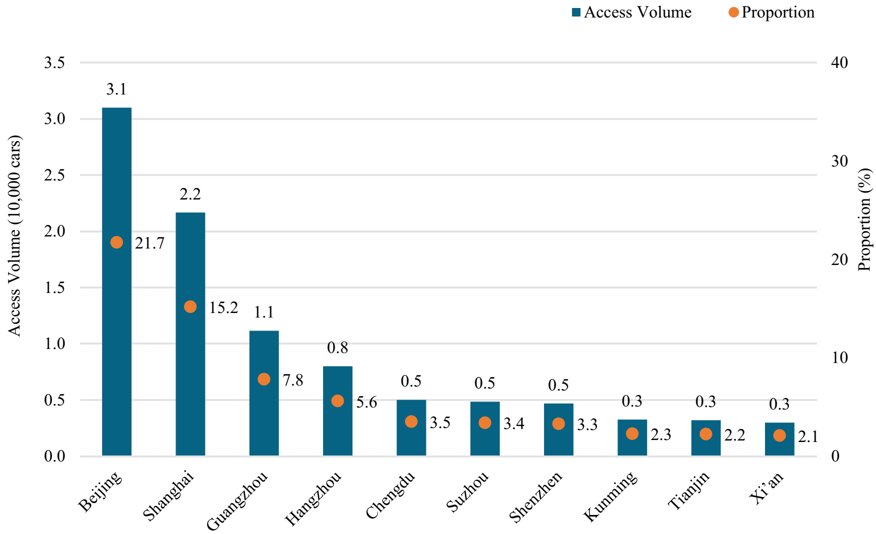


Fig. 6.7 Cumulative access and proportion of battery-swapping-type BEVs in the TOP10 cities

as Maxus, Dongfeng Motor, CAMC, Chufeng, and Dayun Motor have all started their layout in the field of battery-swapping-type heavy-duty trucks. The new energy heavy-duty trucks are mainly equipped with LFP batteries, which use the integrated charging and swapping mode to recharge. The motor suppliers like CRRC EV and Top Gear account for a relatively high proportion of supporting facilities. The endurance mileage of battery-swapping-type heavy-duty trucks is generally between 150 and 200 km.

As of the end of 2021, nearly 1,000 battery-swapping-type BEV heavy-duty trucks has been cumulatively accessed to the National Monitoring and Management Platform, with traction heavy-duty truck as the main promotion vehicle type.

According to the statistical results on the National Monitoring and Management Platform (Fig. 6.8), as of the end of 2021, 941 battery-swapping-type BEV heavy-duty trucks have been accessed nationwide. Regarding specific purposes, the main promoted models are the battery-swapping-type BEV semi-trailer tractor and tractor, with cumulative access volume of 300 and 247 units, accounting for 31.9 and 26.2% of the battery-swapping-type BEV heavy-duty trucks in China.

The promotion area of the battery-swapping-type BEV heavy-duty trucks has a high distribution concentration. Tangshan, Hebei Province, takes the lead in the access volume of battery-swapping-type heavy-duty trucks, and other heavy industrial cities have achieved remarkable promotion results.

The promotion area of battery-swapping-type heavy-duty trucks has a relatively high concentration. As of the end of 2021, Hebei Province has cumulative access volume of 590 battery-swapping-type BEV heavy-duty trucks, accounting for 62.7% in China (Fig. 6.9). Tangshan, as an important bulk material (steel) and cargo transport

Table 6.3 Parameter configuration of new energy heavy-duty trucks exhibited at the 2021 Global Intelligent Mobility Conference

Enterprise name	Model	Battery type	Charging mode	Motor brand	Peak power	Endurance mileage (km)
FAW Jiefang Automotive Co., Ltd	J6P6 * 4 tractor with integrated charging and swapping device	LFP	Integrated charging and swapping	CRRC	360	150–200
FAW Jiefang Automotive Co., Ltd	J6P slag car with integrated charging and swapping device	LFP	Integrated charging and swapping	CRRC	360	200
Dongfeng Trunks Co., Ltd	Dongfeng Tianlong battery-swapping-type tractor	LFP	Integrated charging and swapping	SNC	360	/
BAIC Foton Motor Co., Ltd	Zhilan heavy-duty truck	LFP	Integrated charging and swapping	Top Gear	360	200
SAIC Hongyan Truck Co., Ltd	Jieshi H6 6 * 4 BEV tractor	LFP	Integrated charging and swapping	CRRC/ Top Gear	360	/
SAIC Hongyan Truck Co., Ltd	Jieshi H6 4 * 2 BEV tractor	LFP	Integrated charging and swapping	CRRC/ Top Gear	360	/
Chengdu Dayun Automobile Group Co., Ltd	E8 battery-swapping-type tractor	LFP	Integrated charging and swapping	Inovance/ Top Gear/ IVKON	/	120
Hanma Technology Group Co., Ltd	Battery-swapping-type tractor	LFP	Integrated charging and swapping	Top Gear	360	200
Hanma Technology Group Co., Ltd	Battery-swapping-type dumper	LFP	Integrated charging and swapping	/	360	130–150
Hanma Technology Group Co., Ltd	Battery-swapping-type mixer	LFP	Integrated charging and swapping	/	360	100

(continued)

Table 6.3 (continued)

Enterprise name	Model	Battery type	Charging mode	Motor brand	Peak power	Endurance mileage (km)
Chtc KINWIN (Nanjing) AUTOMOBILE Co., Ltd	Battery-swapping-type dumper	LFP	Integrated charging and swapping	CVCT	240	160
Xuzhou XCMG Automobile Manufacturing Co., Ltd	E700 6 * 4 battery-swapping-type tractor	LFP	Integrated charging and swapping	Jiangsu Weiteli	360	200

Source https://www.cvworld.cn/, 2021 Global Intelligent Mobility Conference

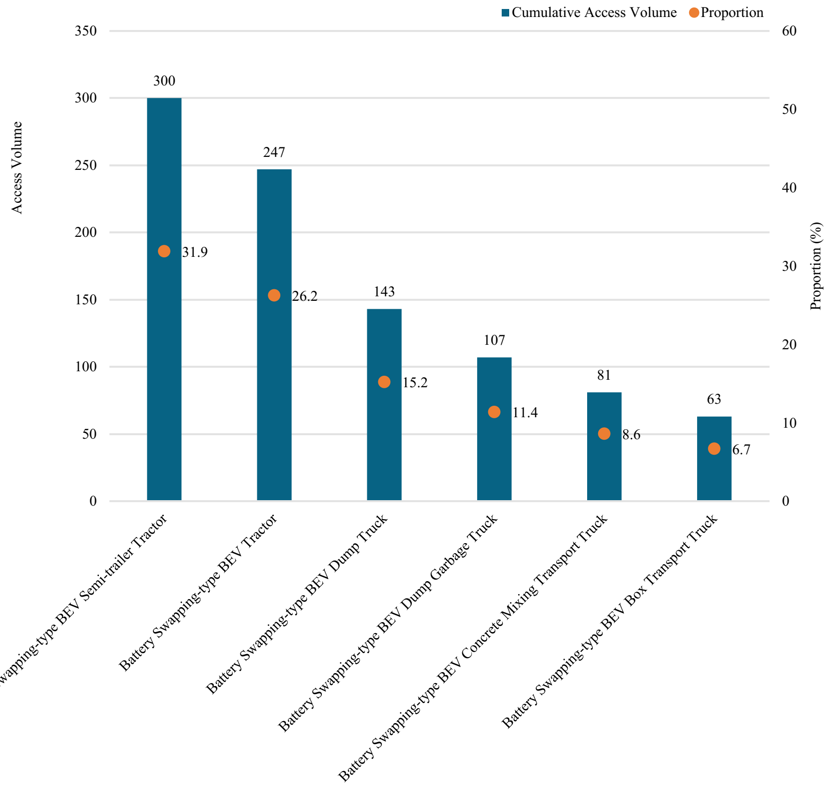


Fig. 6.8 Cumulative access and proportion of battery-swapping-type BEV heavy-duty trucks

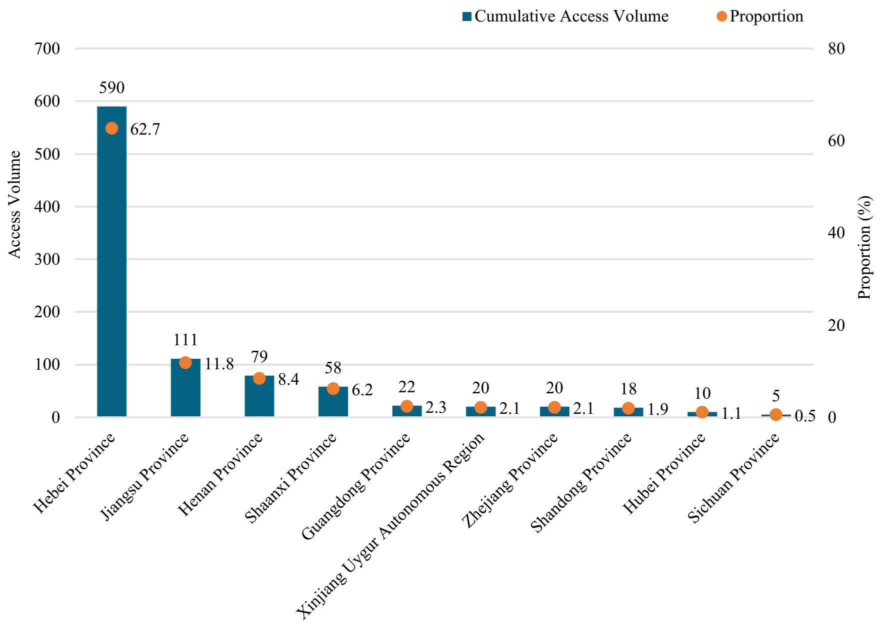


Fig. 6.9 Cumulative access and proportion of battery-swapping-type BEV heavy-duty trucks in the TOP10 provinces

port city and a powerful industrial city in the Circum-Bohai Sea Region, as well as a national pilot city of battery-swapping-type heavy-duty trucks, has realized the batch replacement of battery-swapping-type BEV heavy-duty trucks in 2021. By the end of 2021, Tangshan has achieved a cumulative access volume of 378 battery-swapping-type BEV heavy-duty trucks, accounting for 40.2% of cumulative access in cities across China (Fig. 6.10).

According to the promotion of battery-swapping-type BEV heavy-duty trucks in other cities, the cumulative accessed volumes in Handan, Xuzhou, Zhengzhou, Yulin, and other heavy industrial cities in central and western China reached 136, 90, 60, and 50 units, respectively, all accounting for more than 5% in China.

The promotion market of the battery-swapping-type BEV heavy-duty trucks has a high distribution concentration, and the access proportion of XCMG and CAMC exceeds 4/5 of the national market.

According to the promotion of the vehicle enterprises of battery-swapping-type BEV heavy-duty trucks (Fig. 6.11), XCMG and CAMC have cumulative access volume of 451 and 336 battery-swapping-type BEV heavy-duty trucks, accounting for 47.9% and 35.7% respectively in China. In addition, other commercial vehicle enterprises, such as BEIBEN Trucks, Dayun Motor, Foton Motors, JAC, SANY, are respectively making a layout of the market of battery-swapping-type BEV heavy-duty trucks.

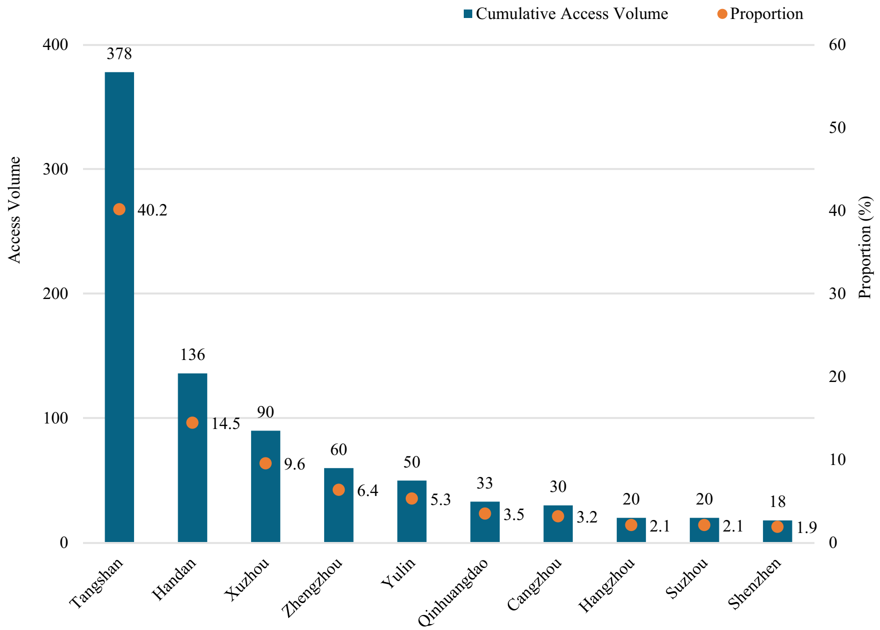


Fig. 6.10 Cumulative access and proportion of battery-swapping-type BEV heavy-duty trucks in the TOP10 cities

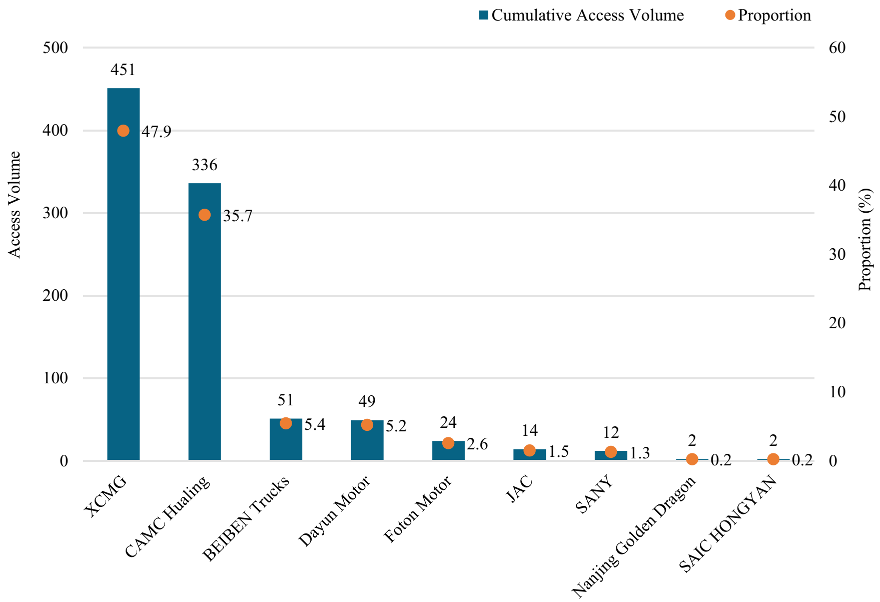


Fig. 6.11 Cumulative access and proportion of battery-swapping-type BEV heavy-duty trucks—by vehicle enterprise

6.4 Operation Characteristics of Battery-Swapping-Type Vehicles

By selecting battery-swapping-type BEVs with battery-swapping behavior on the National Monitoring and Management Platform, this section compares and analyzes the battery-swapping characteristics of various types of vehicles and their charging characteristics with BEVs, summarizes the battery-swapping characteristics of vehicles and the progress of battery swapping pilot work, and evaluate the progress of China's pilot work of battery-swapping-type BEVs, which provides some experience and reference for the wider operation of battery-swapping-type vehicles.[1]

6.4.1 Operation Characteristics of Battery-Swapping-Type BEV Passenger Cars

The average mileage traveled by private cars during a single battery swapping is higher than that of operating passenger cars during a single battery swapping.

In 2021, the average mileage traveled by private cars during a single battery swapping was significantly higher than the average monthly mileage traveled by taxis and cars for sharing during a single battery swapping (Fig. 6.12). Nio mainly aims at private cars, with an average mileage of 213.7 km during a single battery swapping. The average monthly mileage traveled by taxis and cars for sharing during a single battery swapping is mostly the same, maintaining around 170 km.

There is a relatively significant seasonal difference in the average monthly mileage traveled by battery-swapping-type passenger cars during a single battery swapping.

According to the monthly mileage during a single battery swapping (Figs. 6.13 and 6.14), the mileage of taxis, cars for sharing, and private cars during a single battery swapping in winter is significantly affected and significantly lower. The low temperature in winter, the low-temperature charging and discharging characteristics of the power battery, and the use of the air conditioning in the vehicles affect the mileage during a single battery swapping; in the spring and autumn seasons, vehicles can travel a longer mileage during a single battery swapping.

[1] Description of battery swapping behavior: There is no charging behavior between vehicle shutdown and restart; the time interval between vehicle shutdown and restart is not more than 15 min; SOC when the vehicle is restarted—SOC when the vehicle is shutdown $\geq$ 40%. The shutdown interval with the above three characteristics is marked as a one-time battery swapping.

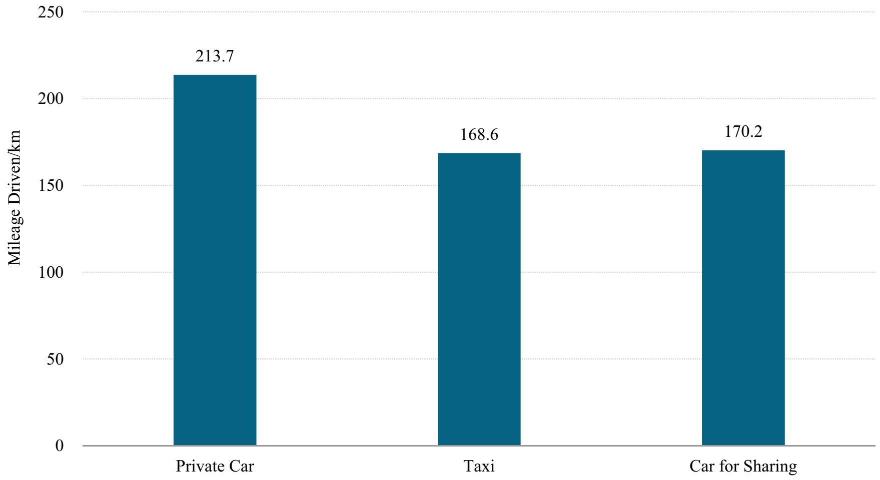


Fig. 6.12 Average mileage traveled by battery-swapping-type BEV passenger cars during a single battery swapping in 2021—by type

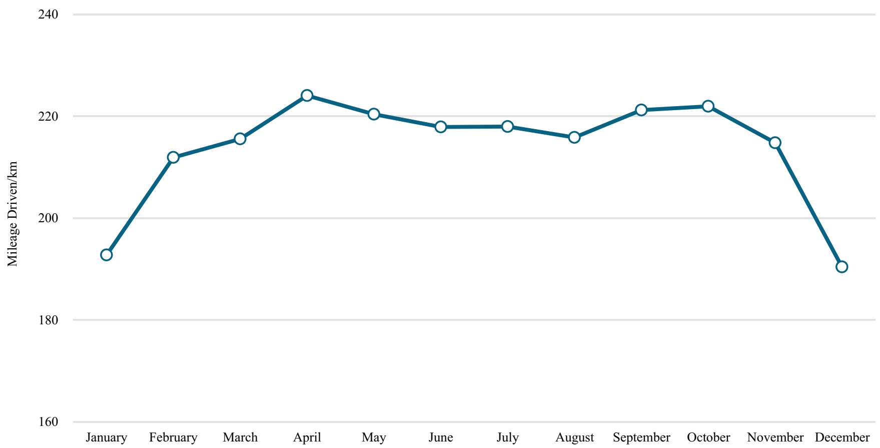


Fig. 6.13 Comparison of monthly mileage of private cars during a single battery swapping in 2021

6.4.2 Operation Characteristics of Battery-Swapping-Type BEV Commercial Vehicles

Compared with passenger cars, the mileage during a single battery swapping of BEV logistics vehicles and heavy-duty trucks in the commercial vehicle field is shorter, at 101.6 km and 149.6 km, respectively (Fig. 6.15). Some cities have demonstrated good results in battery-swapping-type logistics vehicles and heavy-duty trucks, with relatively high battery-swapping rates. This section selects enterprises with more

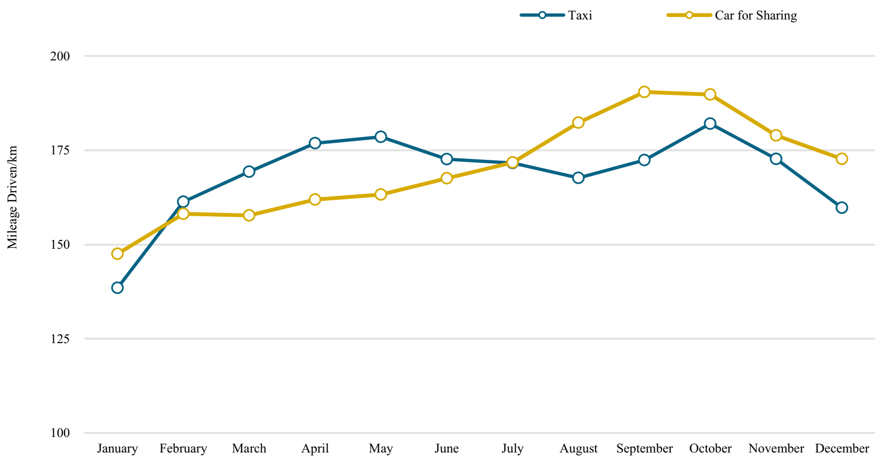


Fig. 6.14 Comparison of average monthly mileage of operating passenger cars during a single battery swapping in 2021

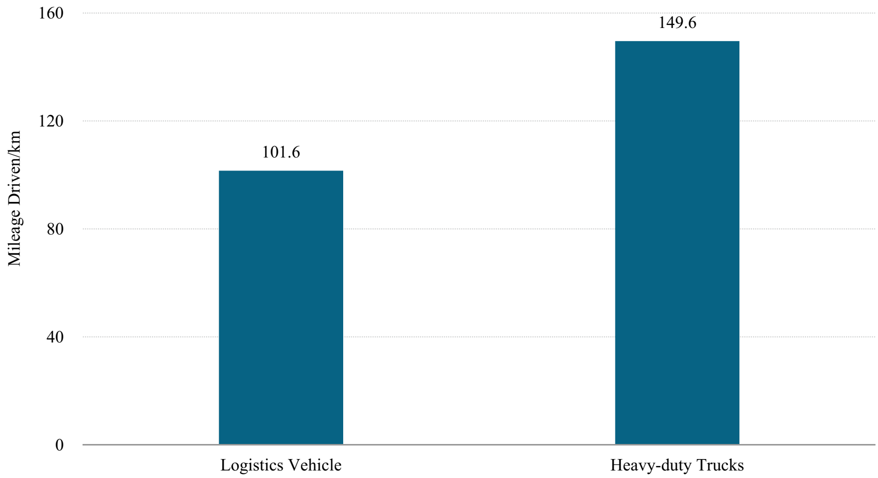


Fig. 6.15 Average mileage traveled by battery-swapping-type BEV commercial vehicles during a single battery swapping in 2021—by type

than 10 battery-swapping-type logistics vehicles and heavy-duty trucks accessed in some typical cities, with the actual battery-swapping rate as shown in Table 6.4. In 2021, the actual battery swapping rate of battery-swapping-type BEV cargo trucks promoted by JAC in Haikou has reached 66.67%, and that promoted by Dayun in Shenzhen and Suzhou has reached 33.33% and 50%, respectively. In addition, the actual battery swapping rate of battery-swapping-type BEV semi-trailer tractors promoted by XCMG in Tangshan has reached 30%.

Table 6.4 Actual battery swapping rates of typical battery swapping enterprises in some cities in 2021

City name	Enterprise name	Vehicle use	Actual battery swapping rate (%)
Shenzhen	Chengdu Dayun Automobile Group Co., Ltd	Battery-swapping-type BEV cargo truck	33.33
Suzhou	Chengdu Dayun Automobile Group Co., Ltd	Battery-swapping-type BEV cargo truck	50.00
Haikou	Anhui Jianghuai Automobile Group Crop., Ltd	Battery-swapping-type BEV cargo truck	66.67
Tangshan	Anhui Hualing Automobile Co., Ltd	Battery-swapping-type BEV tractor	9.72
	Xuzhou XCMG Automobile Manufacturing Co., Ltd	Battery-swapping-type BEV semi-trailer tractor	30.00
Yulin	Anhui Hualing Automobile Co., Ltd	Battery-swapping-type BEV tractor	14.00
Zhengzhou	Anhui Hualing Automobile Co., Ltd	Battery-swapping-type BEV concrete mixer	20.51
	Xuzhou XCMG Automobile Manufacturing Co., Ltd	Battery-swapping-type BEV concrete mixer	15.00
Xuzhou	Xuzhou XCMG Automobile Manufacturing Co., Ltd	Battery-swapping-type BEV garbage dump truck	17.65

The monthly mileage of commercial vehicles during a single battery swapping is within 150 km.

The mileage of commercial vehicles during a single battery swapping is mostly stable (Fig. 6.16). Regarding different types of vehicles, the monthly mileage during a single battery swapping of heavy-duty trucks is significantly higher than that of logistics vehicles. From the average monthly mileage of vehicles during a single battery swapping, it can be seen that heavy-duty trucks have a shorter mileage from January to February, which is closely related to construction progress factors.

Regarding the operation characteristics of battery-swapping-type heavy-duty trucks (Fig. 6.17), the mileage during a single battery swapping concentrated at 120–160 km range. The proportion of vehicles with a mileage of 120–160 km during a single battery swapping in 2021 was 78.56%, which is mostly consistent with the distribution of vehicles with a mileage of 120–160 km in 2020. From the changes in vehicle distribution in the past two years, the proportion of heavy-duty trucks with a mileage of over 140 km during a single battery swapping in 2021 was significantly higher than that in 2020.

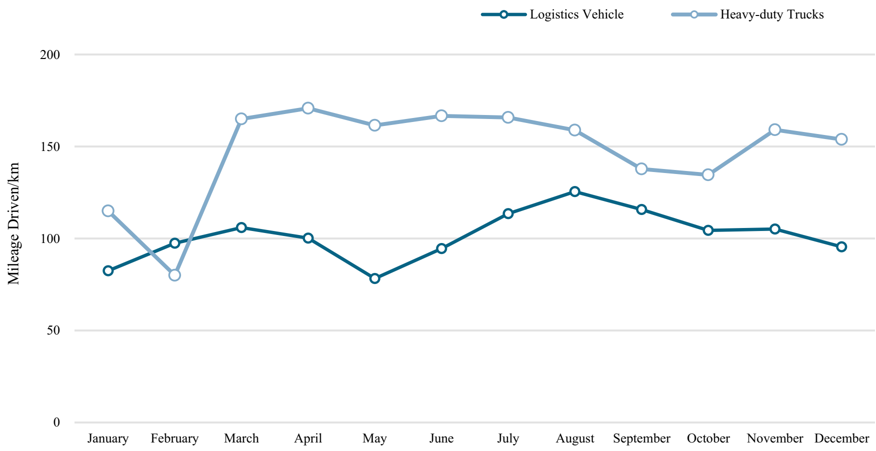


Fig. 6.16 Comparison of average monthly mileage of commercial vehicles during a single battery swapping in 2021

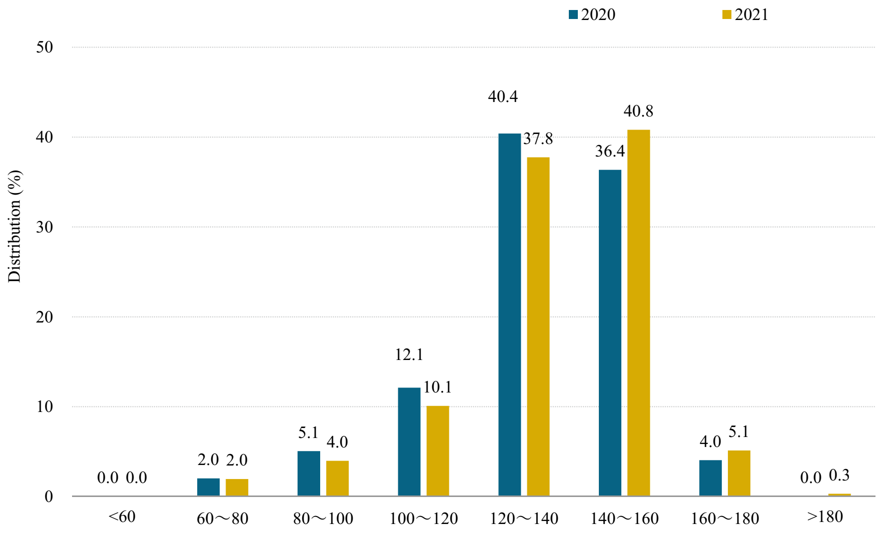


Fig. 6.17 Distribution of heavy-duty trucks in different mileage segments during a single battery swapping—by year

6.5 Battery Swapping Characteristics

6.5.1 Characteristics of Battery-Swapping-Type Vehicles Across China

The initial SOC of monthly battery swapping for various types of vehicles is generally lower than the initial SOC of charging.

From the comparison of the initial SOC of charging and swapping for different types of BEVs (Fig. 6.18), it can be seen that the initial SOC of swapping for different types of BEVs is generally lower than the average monthly initial SOC of charging. Among them, the difference in initial SOC of swapping for commercial vehicles, buses, and heavy-duty trucks is relatively large compared with the average monthly initial SOC of charging; the average monthly initial SOC of swapping for private cars is relatively low, at 26.3%, which is 13.5% lower than the initial SOC of charging at 9.8%.

The distribution of initial SOCs of charging and swapping of private cars, represented by private cars and taxis, is shown in Fig. 6.19. The initial SOC of swapping for private cars is mainly distributed in 0–30%, with vehicles accounting for 69.78%; the initial SOC of charging is concentrated at 30–50%. The distribution of the initial SOC of swapping for taxis is relatively scattered, and the initial SOC of charging is mainly concentrated at 30–50% (Fig. 6.20).

From the comparison of SOCs at the end of charging and swapping for different types of BEVs (Fig. 6.21), there is a significant difference in SOCs at the end of

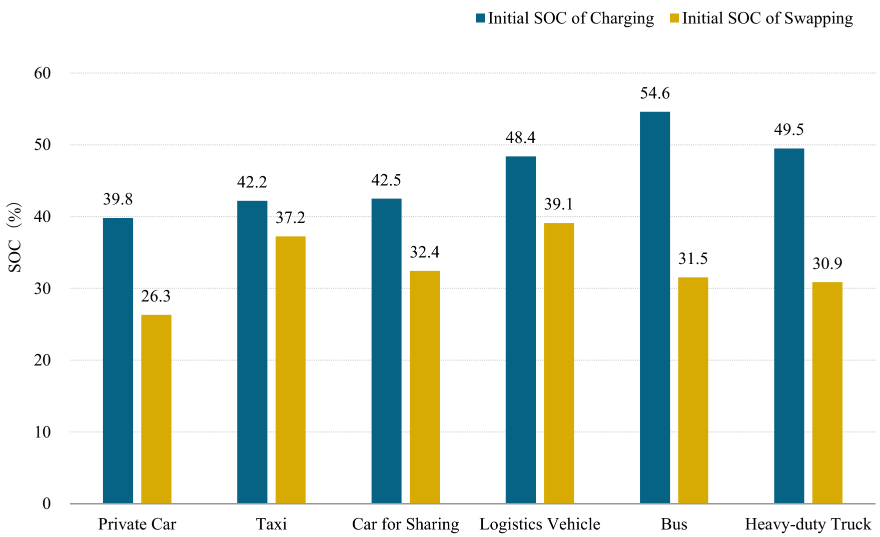


Fig. 6.18 Comparison between initial SOC of charging and initial SOC of swapping for battery-swapping-type vehicles and BEVs of the same type in 2021

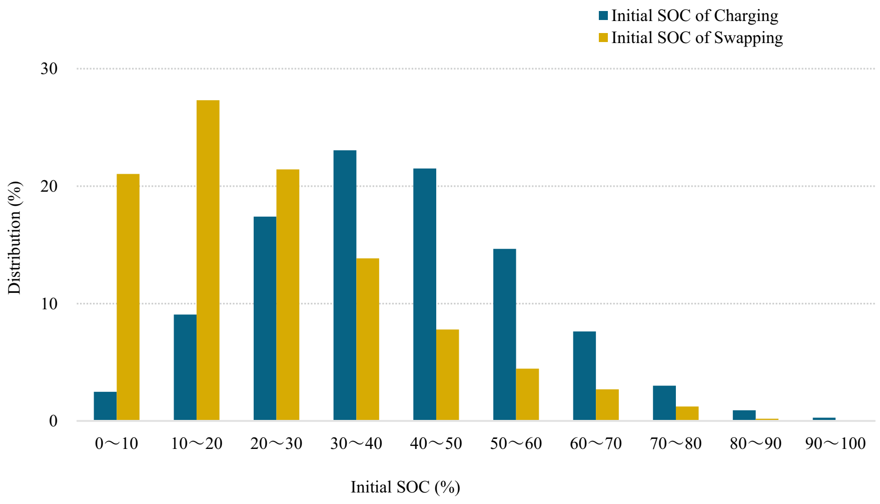


Fig. 6.19 Distribution of SOCs of charging and swapping for battery-swapping-type private cars and rechargeable private cars in 2021

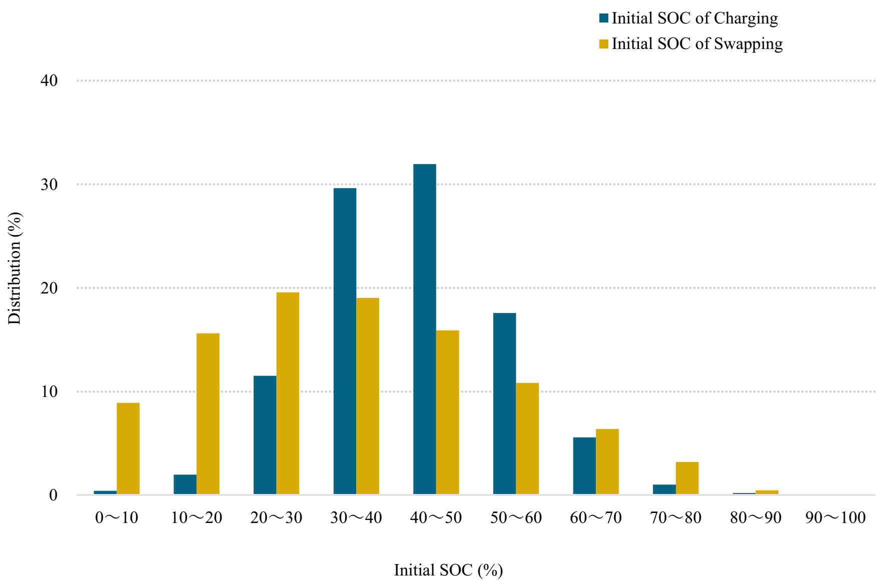


Fig. 6.20 Distribution of SOCs of charging and swapping for battery-swapping-type taxis and rechargeable taxis in 2021

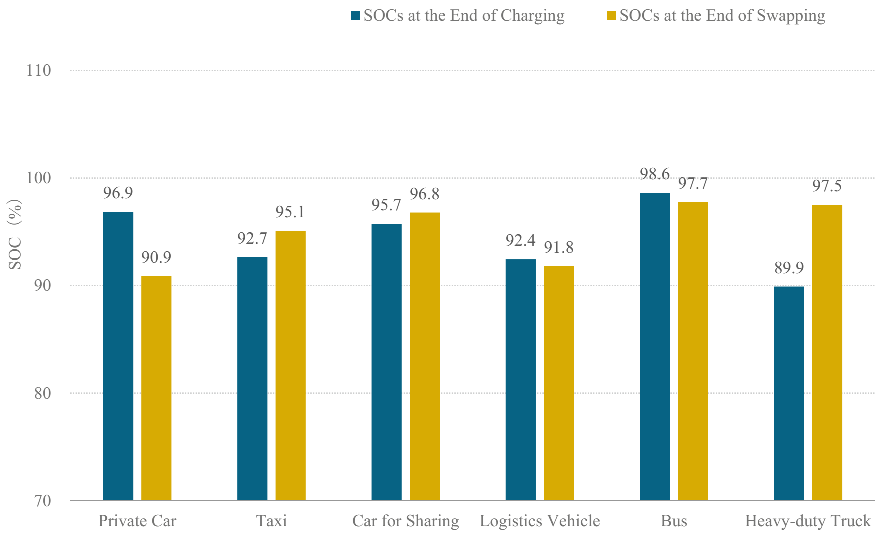


Fig. 6.21 Comparison of average monthly SOCs at the end of charging and swapping between battery-swapping vehicles and rechargeable BEVs in 2021

charging and swapping for vehicles. The SOC of heavy-duty trucks, taxis, and cars for sharing at the end of battery swapping is higher than that of charging. Among them, the SOC of heavy-duty trucks at the end of charging is significantly lower than that of battery swapping, i.e., 4.6% lower than the latter. The SOC of private cars at the end of battery swapping is relatively low, and with the rapid growth of the scale of battery-swapping-type private cars, if there is a waiting or urgent situation at the battery-swapping stations, the battery-swapping-type vehicles may be loaded with not fully-charged battery packs for travel.

From the distribution of heavy-duty trucks with SOCs at the end of charging and swapping (Fig. 6.22), the SOCs at the end of charging and swapping for heavy-duty trucks are both mainly concentrated in 90%–100%, with vehicles accounting for 66.51% and 81.57%, respectively.

6.5.2 *Battery Swapping Characteristics of Vehicles in Pilot Cities for Battery Swapping*

This section focuses on the 11 pilot cities for battery swapping included in the pilot scope of battery swapping based on the "Notice on Launching the Pilot Work of Application of Battery Swapping Mode for New Energy Vehicles" issued by the Ministry of Industry and Information Technology of China in 2021. Starting from cities of comprehensive application category and heavy-duty trucks featured cities, this section analyzes the operation and electricity consumption characteristics of

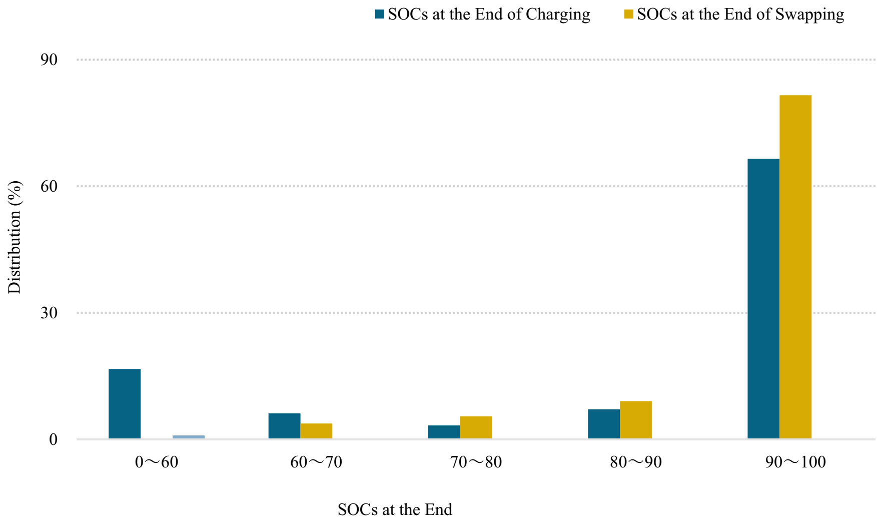


Fig. 6.22 Distribution of heavy-duty trucks with SOCs at the end of charging and swapping in 2021

battery-swapping-type vehicles in the two types of cities, and promptly summarizes successful experiences, committed to providing experience and reference for large-scale market-oriented operation of battery swapping.

1. **Cities of comprehensive application category**

Pilot cities for battery swapping have accumulated certain experiences in promoting battery-swapping BEVs. As of the end of 2021, a total of 40,000 battery-swapping-type BEVs have been accessed in 8 comprehensive application pilot cities nationwide, with Beijing accounting for the main proportion of access, mainly consisting of private passenger cars and taxi cars; other comprehensive application pilot cities for battery swapping mainly promote the battery-swapping-type passenger cars (Figs. 6.23 and 6.24).

The average monthly mileage of battery-swapping-type vehicles in comprehensive application pilot cities during a single battery swapping is shown in Fig. 6.25. The mileage of battery-swapping-type vehicles during a single battery swapping shows obvious seasonal characteristics, and the average mileage between swapping in winter is significantly lower than that in other seasons.

From the comparison of specific cities in the comprehensive application category (Fig. 6.26), the average monthly mileage of battery-swapping-type vehicles in Beijing, Changchun, and Jinan in the northern region shows obvious seasonal characteristics, with relatively shorter mileage in winter; the battery-swapping-type vehicles in Wuhan, Chongqing, and Nanjing operate well. The mileage of battery-swapping-type vehicles in Sanya is good in the first half of the year but is affected in the second half.

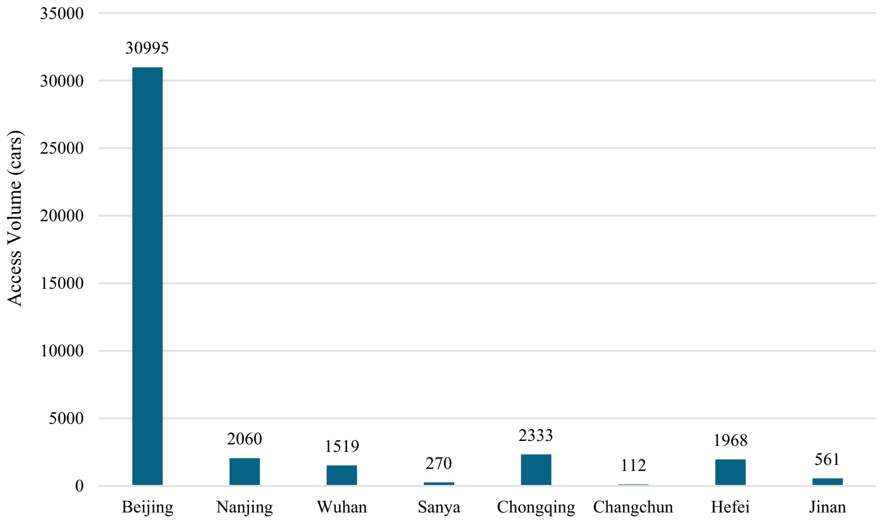


Fig. 6.23 Cumulative access volume of battery-swapping-type BEVs in comprehensive application pilot cities

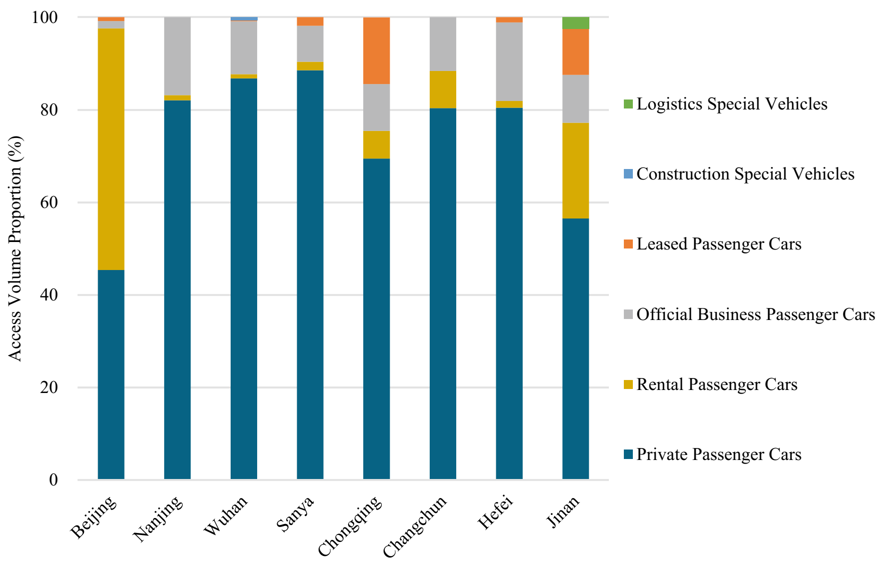


Fig. 6.24 Distribution of battery-swapping-type BEVs in comprehensive application pilot cities in 2021

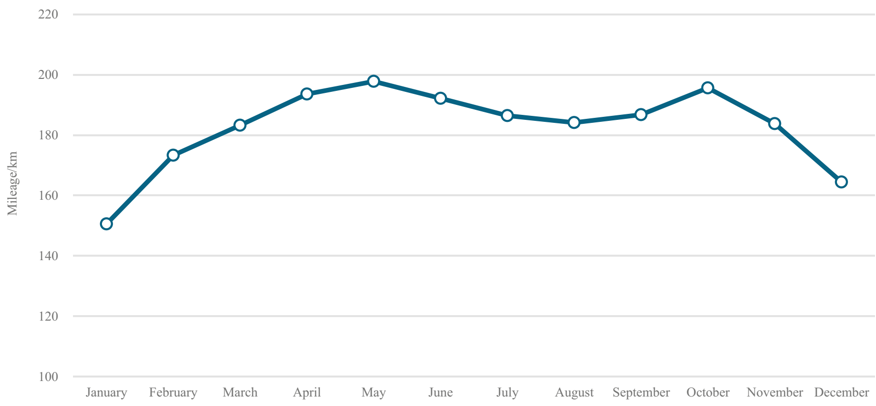


Fig. 6.25 Average monthly mileage of battery-swapping-type vehicles in cities of comprehensive application category during a single battery swapping

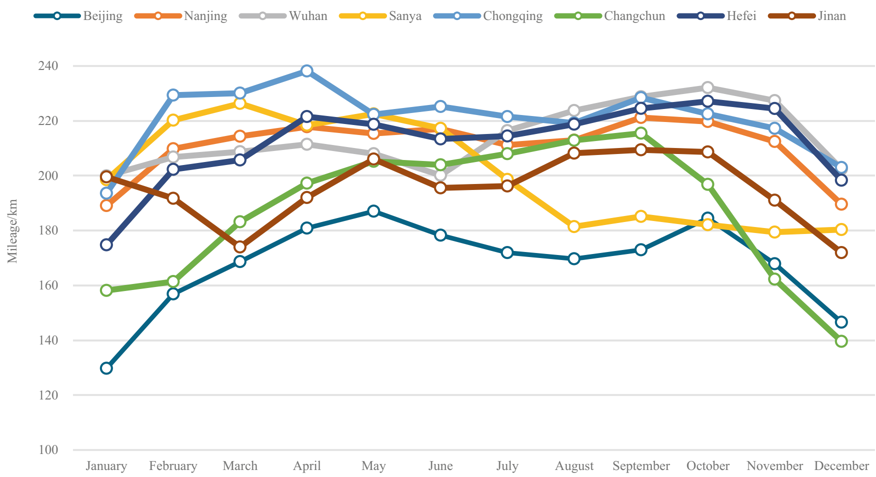


Fig. 6.26 Comparison of average monthly mileage of battery-swapping-type vehicles in cities of comprehensive application category during a single battery swapping

Regarding the specific practice of cities of comprehensive application category, taking the typical urban cases of Nanjing and Sanya as an example, the development achievements of the urban battery swapping industry are summarized in combination with local industrial development characteristics.

- **Nanjing**

As of November 2021, State Grid Nanjing Power Supply Company has successfully built 5 bus battery charging stations in Nanjing, serving 170 battery-swapping-type buses, with a total of over 500,000 swapping times and a mileage of approximately 22.48 million km. According to the pilot work plan, Nanjing will expand the battery swapping mode to five major application scenarios, including municipal engineering, industrial ports, logistics transportation, taxis, and private cars. It is planned that by the end of 2023, the city will strive to promote the application of more than 20,000 battery-swapping-type vehicles, build no less than 260 battery-swapping stations of all types, and explore and form experiences that can be replicated nationwide. Nearly 100 battery swapping stations are mainly used for municipal engineering slag cars.

- **Sanya**

Since 2019, Sanya has promoted battery swapping mode for NEVs in many cities and counties. By the end of December 2021, Sanya has built and used 12 battery swapping stations, with more than 300 power batteries equipped. Among them, Aulton New Energy has built 8 battery swapping stations, mainly serving battery-swapping-type cruising taxis; Hainan Huapu has built 2 battery swapping stations, mainly serving battery-swapping-type cars for sharing; Nio has built 2 battery swapping stations, mainly providing battery-swapping service for private cars. A citywide BEV battery swapping service network has been preliminarily established.

By the end of December 2021, Sanya has promoted more than 1600 battery-swapping-type vehicles, accounting for 6.2% of the city's new energy vehicle population. Among them are about 800 battery-swapping-type cruising taxis, about 400 battery-swapping-type cars for sharing, and about 400 private cars.

2. **Heavy-duty trucks featured cities**

The environmental policies of carbon peaking and carbon neutrality jointly promote the transformation from fuel vehicles to BEV heavy-duty trucks from supply and demand sides. Rechargeable heavy-duty trucks face problems such as short range, slow charging, and high one-time purchase costs. However, battery-swapping-type heavy-duty trucks adopting the "separation of vehicle and battery" mode can effectively solve the pain points of rechargeable heavy-duty trucks, improve the vehicle operation efficiency and reduce purchase costs.

Some heavy-duty trucks have simpler application scenarios than passenger cars, and those used for short-distance transportation account for a larger proportion. They carry out point-to-point transportation according to established routes, including dedicated line transportation, straight short haul, port, and trunk transportation. Among them, the transportation distances for dedicated line transportation, straight short-haul, and port transportation are relatively short, with the one-way distance mainly concentrated within 150 km (Table 6.5). According to the distribution of battery-swapping-type heavy-duty trucks with an average daily mileage on the National Monitoring and Management Platform (Table 6.5), heavy-duty trucks with an average daily mileage of less than 150 km account for the main proportion, reaching 76.1% (Fig. 6.27).

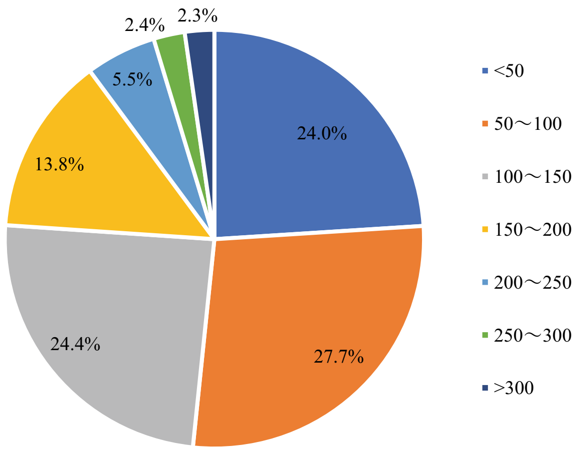
In the battery-swapping industry, suppliers of key components such as batteries, motors, and electronic control systems are in the upstream of the industry chain (Fig. 6.28), while enterprises that design, develop, and produce battery-swapping-type unpowered vehicle bodies, battery leasing/operating companies that provide battery leasing services, and auto financial service companies are in the midstream.

Table 6.5 Relatively simple application scenarios for heavy-duty trucks

Transportation scenario	Transportation route	One-way distance
Dedicated line transportation	Dedicated line for fixed freight transportation, coal washery to the railway, engineering material transportation, etc	$\leq$ 100 km
Straight short haul	Straight short haul from centralized stations to surrounding cities, such as railway/port container transportation	$\leq$ 150 km
Port transportation	Repeated short-haul transportation within closed scenarios, such as cargo transportation within ports, container transportation, etc	Short distance
Trunk transportation	Inter-cities highway transportation, such as auto parts, department store goods, etc	Longer distance

Source www.21-sun.com, CICC Securities

Fig. 6.27 Distribution of new energy heavy-duty trucks with an average daily mileage in 2021



Downstream customers are operating enterprises and logistics enterprises with transportation needs. It is necessary to connect various links in the upstream, midstream, and downstream of the industrial chain, including purchasing batteries from upstream battery suppliers, negotiating unified battery standards with vehicle manufacturers, and establishing infrastructure such as battery swapping stations based on user needs.

Currently, the mainstream battery swapping stations for BEV heavy-duty trucks in China mainly adopt the top-lifting battery swapping mode. A battery swapping station covers an area of less than 200 m^2 and is suitable for models covering tractors, dump trucks, slag cars, and other heavy-duty truck models (Table 6.6). Regarding the operational efficiency of the battery swapping station, a single-channel 8 $\times$ 7 heavy-duty truck battery swapping station is equipped with 8 battery workstations, including 7 with batteries at full capacity and 1 with a buffer battery. The battery swapping station adopts a double-layer container structure, which is easy to install, disassemble, and displace. The upper layer is equipped with batteries and a battery-swapping mechanism, while the lower layer consists of a charging compartment, a control compartment, and a monitoring room. The charging rate is 1C, which is determined based on the battery capacity. The duration of battery swapping for a single vehicle at the power station is $\leq$ 5 min. If a vehicle flow rate is 10 min/vehicle, the battery swapping station can achieve 24-h uninterrupted battery swapping and serve no less than 50 battery-swapping-type heavy-duty trucks.

In 2021, among the pilot cities launched by the Ministry of Industry and Information Technology of China to apply battery swapping mode for NEVs, there are three heavy-duty trucks featured pilot cities: Yibin, Tangshan, and Baotou. Each pilot city relies on local vehicle enterprises and unique application scenarios to comprehensively promote the construction of pilot work around various links such as technological innovation and vehicle supply, battery swapping facility construction, application scenario expansion, and policy support, in combination with battery swapping operators and power battery supporting enterprises. The content below will analyze the battery-swapping-type heavy-duty truck industry chain system by combining the local characteristics of Yibin, Tangshan, and Baotou.

- **Yibin**

As a heavy-duty trucks featured pilot city for battery swapping, it is planned to build 60 or more battery-swapping stations by the end of 2025 and promote 3000 or more battery-swapping-type heavy-duty trucks. Regarding the ecological construction of the battery-swapping industry cluster, Yibin has a complete battery-swapping industry chain for new energy heavy-duty trucks. Relying on Chery Commercial Vehicles, CATL Sichuan Company, Yibin KeyPower, Fuxi power station, Yibin Port Group, Baichuan Logistics, Yibin Sanjiang Investment and Construction Group, and other enterprises, Yibin has established a demonstration operation consortium of battery swapping for new energy heavy-duty trucks. Regarding the construction of the battery-swapping infrastructure network, Yibin has integrated the needs of the application scenarios, conducted overall planning for the layout of the battery-swapping network, and established the operation supervision platform for the charging and

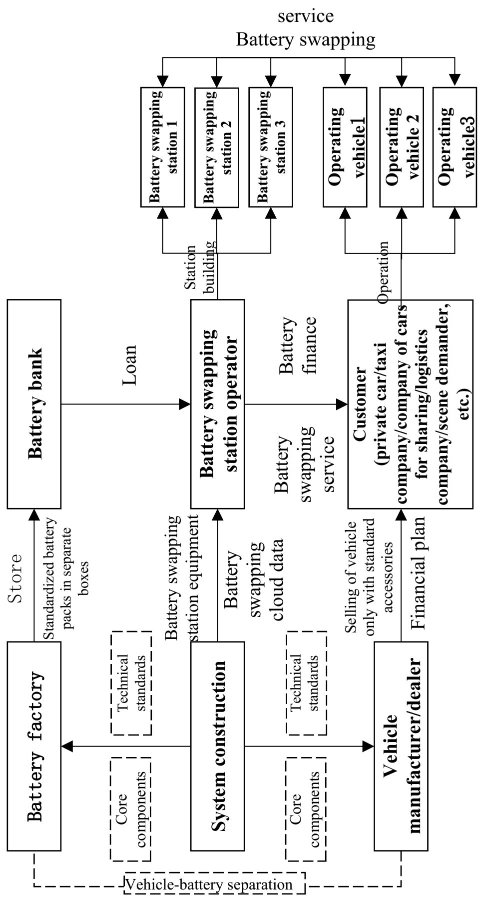


Fig. 6.28 Business chain system of participants in battery swapping mode

Table 6.6 Solution of a battery swapping operator's battery swapping station for BEV heavy-duty trucks

Product series	8 workstations—automatic battery swapping station for heavy-duty trucks	10 workstations—automatic battery swapping station for heavy-duty trucks
Overall dimension (mm)	25,000(L) * 7000(W) * 7000(H)	27,000(L) * 7000(W) * 7000(H)
Floor area (m^2)	150	170
Battery swapping time (min)	4 ~ 5	4 ~ 5
Battery swapping success rate (%)	99	99
Battery swapping working time (h)	7 * 24	7 * 24
Charging power (kW)	2560(8 * 320 kW)	3200(10 * 320 kW)
Single-compartment charging capacity (A)	Dual-charger 400 A	Dual-charger 400 A
Number of spare batteries (Nrs)	7	9
Service capability (time/24 h)	240	240
Battery swapping mode	Top lifting battery swapping	Top lifting battery swapping
Suitable models	Tractor, dump truck, slag car	Tractor, dump truck, slag car
Suitable battery capacity	282 kW/321 kW/350 kW	321 kW/350 kW
Vehicle positioning system	Laser guidance system	Laser guidance system
Vehicle identification system	Identification by RFID + VIN code	Identification by RFID + VIN code
Software platform	Main control system + cloud platform operation system	Main control system + cloud platform operation system

Source Official website of a battery swapping operator

swapping facilities. A wide range of application scenarios suitable for promoting and demonstrating pilot projects of battery swapping for heavy-duty trucks are covered, including large-scale urban construction, industrial parks, mines, ports, power plants, etc.

Regarding policy support and guarantee, Yibin has currently introduced policies that provide for a purchase subsidy of 300 yuan/kWh for battery-swapping-type heavy-duty trucks, and give priority to land indicators for the construction of battery swapping stations; and has established the first 6 billion yuan industrial development fund to provide capital support for high-quality battery swapping projects.

- **Tangshan**

As an important port city for bulk materials (steel) and cargo transportation and a powerful industrial city in the Circum-Bohai Sea Region, Tangshan, Hebei Province, has built into a heavy-duty trucks featured pilot city to meet the needs of current transformation and development. Tangshan's battery-swapping market for heavy-duty trucks has ushered in new opportunities. Most iron and steel enterprises in Tangshan are located in Tangshan and some surrounding areas. In addition to the demand for high-frequency short-haul in the factories, the trunk transportation generated by the outward transportation of finished crude steel is also part of enterprises' urgent desire to achieve green upgrading. By 2021, Tangshan had more than 100,000 heavy-duty trucks. With the increasing pressure on air pollution control, accelerating the electrification transformation of freight vehicles has become a top priority for Tangshan's industrial transformation. In 2021, Tangshan was listed as one of the heavy-duty trucks featured pilot cities for battery swapping. According to the development needs of Tangshan's industrial chain, Tangshan plans to operate 2600 battery-swapping-type heavy-duty trucks, build and put into operation at least 60 battery swapping stations, set up at least one battery asset management company and 2–4 demonstration enterprises for battery swapping in the pilot period. Regarding the battery swapping infrastructure construction, Tangshan has designed a "three vertical and one horizontal" trunk battery swapping network layout to meet the needs of large steel enterprises to transport finished products to Jingtang Port and Caofeidian Port (Table 6.7). By the end of November 2021, Tangshan has built 7 battery swapping stations, of which 5 are in the steel enterprise plant, 2 are trunk battery swapping stations, and another 5 are under construction.

Table 6.7 Construction planning of battery swapping station in Tangshan

Planning for battery swapping station	Laying route for battery swapping station	Steel enterprises passed by
Line 1: Qian'an—Jingtang Port	Laying along the Pingquan-Qinglong-Laoting Line (with a trunk of 100 km)	Passing by steel mills such as Yanshan Iron and Steel, Xinda, Jiujiang, Shougang Qian'an, etc
Line 2: Qianxi—Caofeidian	Laying along the Qian'an-Caofeidian Line (with a trunk of 170 km)	Passing by steel mills such as Jinxi, Chunxing, Guoyi, Jing'an, and Donghai
Line 3: Zunhua—Caofeidian	Laying along Tangshan-Fengrun Expressway (with a trunk of 175 km)	Passing by steel mills such as Ganglu, Jinzhou, Zhengfeng, Tianzhu, Ruifeng, and Donghua
Line 4: Fengnan—Jingtang Port	Trunk of 175 km	Passing by Zongheng, Wenfeng

Regarding the policy guarantee for pilot work, Tangshan will give policy support in planning land use, power expansion, facility construction, and other aspects in combination with the actual operation demand of vehicles. For battery-swapping infrastructure projects built on newly requisitioned land, the nature of land planning is determined according to the land for public facilities, and priority is given to land supply; free power expansion support is provided for the power demand for the construction of battery-swapping infrastructure. At the same time, green transportation convenience support is provided for new energy heavy-duty trucks and green transportation permits are issued, with no restrictions on travel in urban areas.

- **Baotou**

With the goal of integrated development of "enterprise, vehicle, station, and battery," Baotou has continued to make efforts in various links such as technological innovation and vehicle production, battery swapping infrastructure construction, application scenario expansion, and strengthening policy support in the construction of the battery swapping industry ecosystem, to comprehensively promote the pilot work. Relying on the new energy heavy-duty truck models of BEIBEN Trucks as the main force, the vehicle enterprises have successively launched the battery-swapping-type heavy-duty truck models in the fields of battery-swapping-type tractors, dump trucks, and special vehicles; Regarding the construction of supporting battery swapping infrastructure, Baotou has successively carried out technical research and development on battery swapping station with Aulton New Energy, GCL-ET and UNEX, and plan to arrange more than 60 battery swapping stations; Regarding vehicle application scenarios, in combination with the mine transportation scenarios of Baotou and based on increasing the proportion of battery-swapping-type heavy-duty trucks in mining areas, thermal power plants, and steel plants, Baotou has actively expanded the transport scenarios such as waste handling, slag removal, logistics parks, and municipal sanitation to form a diversified demonstration effect.

Regarding strengthening policy guarantee, Baotou has formulated appropriate management measures for battery charging and swapping stations, built standardized standard systems such as review service and operation management for battery swapping stations, worked hard to provide a package solution for pilot work, and actively guided the participation of social capital, finance and insurance, to build a guarantee system in all fields.

6.6 Summary

By sorting out the national policy and standard system of the battery-swapping industry, the status quo of battery-swapping-type vehicles and battery swapping infrastructure industry, and the operation of battery-swapping-type vehicles, this paper mainly draws the following conclusions:

1. **The acceleration of implementing the battery-swapping industry policy has driven the rapid development of the industry**. On the one hand, the battery-swapping infrastructure is proliferating. According to data from the China Electric Vehicle Charging Infrastructure Promotion Alliance, as of the end of 2021, the total number of battery swapping stations in China was 1298, with an increase of 743 compared with 2020. NIO, Aulton, and Botan are the three major battery-swapping operators. In the field of passenger cars, Nio and BAIC BJEV have implemented the layout in the fields of private passenger cars and taxis in succession, and domestic mainstream commercial vehicle enterprises such as CAMC, SAIC Hongyan, BAIC Foton, etc. have implemented the layout in the field of battery-swapping-type heavy-duty trucks in succession. As of December 31, 2021, the National Monitoring and Management Platform has a cumulative access volume of over 100,000 battery-swapping-type BEVs, with passenger cars occupying the leading position in battery swapping and commercial vehicles occupying a relatively small proportion but showing a rapid growth trend. With the gradual implementation of policies, more and more enterprises will implement the layout in the battery-swapping market.
2. **The battery-swapping-type vehicles have a high power supplement efficiency and have been rapidly promoted in public operation fields such as taxis, cars for sharing, and heavy-duty trucks**. The battery-swapping-type vehicles have significant advantages Regarding power supplement efficiency. The initial SOC of swapping for battery-swapping-type vehicles is generally lower than the initial SOC of charging, and battery swapping can be completed in 3–5 min. For public operating vehicles such as taxis, cars for sharing, and heavy-duty trucks, on the one hand, it solves the problem of high battery purchase cost, and on the other hand, high-frequency and fast power supplement demand is more applicable than the charging mode. Regarding the total cost of ownership of battery-swapping-type heavy-duty trucks within five years, the total cost of battery-swapping-type heavy-duty trucks is significantly lower than that of fuel-powered heavy-duty trucks. Driven by environmental benefits and innovative business models, the scale of battery-swapping-type heavy-duty trucks will rapidly increase.
3. **The electrification of heavy-duty trucks significantly affects "energy conservation and carbon reduction," and local governments need to make comprehensive planning and design at the levels of ROW, subsidies, and supporting facilities**. Currently, the governance efforts of the national and local governments towards fuel-powered heavy-duty trucks are still increasing. The battery-swapping-type BEV heavy-duty trucks effectively solve the problems of high purchase cost and long charging time in the practical application process while greatly reducing user purchase costs and achieving high user acceptance. Currently, although some cities have already promoted the application of some battery-swapping-type BEV heavy-duty trucks, some battery-swapping-type heavy-duty truck fleets often choose fast charging methods, resulting in lower actual battery swapping rates due to the problems such as low load operation of some vehicles, lagging construction of battery swapping stations, and low operational efficiency. The scale and layout of infrastructure construction

and the quality and maintenance of charging facilities will all affect the driving behavior of owners of battery-swapping-type BEV heavy-duty trucks. Therefore, government departments shall conduct in-depth research and analysis, coordinate planning and design, and address the experience of cities with better promotion of battery-swapping-type heavy-duty trucks Regarding ROW, subsidies, supporting facilities, etc., in order to improve the utilization rate of battery-swapping-type heavy-duty trucks.

4. **The construction of a battery swapping station requires a high investment amount, so it is necessary to collaborate with financial institutions in the battery swapping industry chain, battery swapping service providers, and upstream and downstream industry chains of vehicle enterprises for coordinated development**. According to research results, the investment required for a single battery swapping station (including land) for passenger cars is about 5.072 million yuan, of which 2.6072 million yuan is for the equipment, accounting for about 52%. In addition, investment in lines, batteries, etc., is also required. A single battery swapping station for heavy-duty trucks requires more investment, of about 4.2014 million yuan, about twice the total investment for passenger cars. In addition, the battery-swapping mode also requires enterprises to invest a significant amount of research and development costs to design the battery-swapping-type vehicle models. Automobile enterprises need to make targeted modifications to the vehicle chassis, power batteries, and body structure. With the implementation of national policies and the promotion of pilot cities for battery swapping, the market space for the battery swapping mode is gradually emerging. Battery-swapping operators can lead the development of the industry by integrating multiple forces to participate together.

Chapter 7
Fuel Cell Electric Vehicles (FCEVs)

As clean and efficient secondary energy, hydrogen energy brings new opportunities for developing FCEVs. In recent years, China has attached great importance to developing the hydrogen energy industry and included hydrogen energy in the national "14th Five-Year Plan" and the 2035 Long-Range Objectives. In 2021, China's Ministry of Finance and four other ministries and commissions have successively approved the first and second batches of FCEV demonstration urban agglomerations, aiming to effectively create a green energy community and drive the sustainable development of the entire hydrogen energy industry chain through the collaboration of the FCEV industry chain and the demonstration and promotion of cross-regional scenarios. From the perspective of FCEVs, this section sorts out the current national and local fuel cell industry policies, demonstration and promotion status, and vehicle operation, evaluates the promotion and application status of FCEV demonstration urban agglomerations, analyzes the current characteristics of local FCEV industry promotion, helps the demonstration urban agglomerations continuously improve the demonstration and application level, and explores replicable and scalable advanced experiences for large-scale promotion and application.

7.1 Development Status of FCEV Industry

7.1.1 Continuously Increasing Industrial Policies

1. **National top-level design accelerates the transformation of clean energy, and the hydrogen energy industry is listed as a forward-looking industry**

Hydrogen energy is an important development direction of the global energy technology revolution. Accelerating the development of the hydrogen energy industry is a strategic choice to address global climate change, ensure national energy supply security, and achieve sustainable development. As an important direction for China's

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2022)*,
https://doi.org/10.1007/978-981-99-6411-6_7

energy transformation, hydrogen energy will play an important role in synergy with other energy sources to achieve China's goal of "Carbon Peaking and Carbon Neutrality".

According to the development of China's FCEV industry, the overall FCEV industry is still in the policy-driven stage. In the series of policy documents on carbon peaking and carbon neutrality released at the national level, the hydrogen energy and the fuel cell industry have been gradually incorporated into the green and low-carbon transformation, achieving one of the goals of carbon peaking and carbon neutrality. On March 11, 2021, the 4th Session of the 2021 National People's Congress adopted the Resolution of the 4th Session of the 2021 National People's Congress on the 14th Five-Year Plan for National Economic and Social Development and the Outline of the 2035 Long-Range Objectives, which included hydrogen energy as a frontier technology and industrial transformation field in the document, "Organize the implementation of future industry incubation and acceleration plans in frontier technologies and industrial transformation fields including hydrogen energy and energy storage, and plan to lay out a batch of future industries"; the *Opinions of the CPC Central Committee and State Council on the Complete, Accurate and Comprehensive Implementation of the New Development Concept to Do a Good Job in Carbon Peaking and Carbon Neutrality* (hereinafter referred to as the "Opinions"), was released on October 24, 2021, and pointed out that carbon peaking and carbon neutrality should be included in the overall economic and social development, led by the comprehensive green transformation of economic and social development, and green and low-carbon development as the key. Actively developing non-petrochemical energy and coordinating the full chain development of hydrogen energy production, storage, transportation, and utilization: on October 26, 2021, the *Notice of the State Council on Issuing the Action Plan for Carbon Peak before 2030* (GF [2021] No. 23) (referred to as the "Notice") was officially released. The Notice clearly stated that China would actively expand the application of new and clean energies such as hydrogen and natural gas in the transportation field, vigorously promote new energy vehicles, and gradually reduce the proportion of traditional fuel vehicles in the production, sales, and holdings of new vehicles, promote the electrified substitution of urban public service vehicles, and promote FCEVs and other electric heavy-duty freight vehicles.

A series of supporting policies for the development of the NEV industry have been issued at the national level, clearly accelerating the demonstration, promotion, and commercial application of FCEVs and comprehensively promoting the development of the whole chain of hydrogen energy "production, storage, transportation and use." The industry has shown a clear acceleration signal. On November 2, 2020, the State Council issued the *Notice of the General Office of the State Council on Issuing the Development Plan for the New Energy Vehicle Industry (2021–2035)* (GBF [2020] No. 39), which established the medium and long-term development goals of the fuel cell industry. The policy stated that "after 15 years of sustained efforts, China's core technology of new energy vehicles will reach the international advanced level, and the quality brands will have strong international competitiveness. The commercial application of FCEVs will be realized. The construction of hydrogen fuel supply systems will be steadily promoted". Regarding industrial development goals, according to the "Technology Roadmap for Energy-Saving and New Energy Vehicles (2.0)", by 2025, the number of FCEVs will reach about 100,000, and the number of hydrogen refueling stations will reach 1000; by 2035, the number of FCEVs will reach about 1 million, and the number of Hydrogen refueling stations will reach 5000.

In fuel cell technology innovation and standardization, the fuel cell common technologies, engineering applications, and key component technology innovation have been successively laid out around the entire hydrogen energy industry chain at the national level. On May 11, 2021, the *Notice of the Ministry of Science and Technology on Issuing the 2021 Project Guidelines for the National Key R&D Program "Information Photonics Technology" and Other Key Special Projects of the 14th Five-Year Plan* (GKFZ [2021] No. 133) was officially released. The 2021 project guidelines for key hydrogen energy technology projects point out that the overall goal of key projects is to be guided by major needs such as the energy revolution and a country with strong transportation network, systematically lay out the green production, safe and dense storage and transportation and efficient utilization technologies of the hydrogen energy, connect the links of foundation and foresight, common and key technology, engineering application and evaluation standard, and achieve China's hydrogen energy technology research and development level entering the international advanced ranks by 2025. The 2021 guidelines revolve around four technical directions: green hydrogen production and large-scale transfer storage system, safe hydrogen storage and rapid transmission and distribution system, convenient hydrogen upgrading and efficient power system, and comprehensive demonstration of "hydrogen entering thousands of households." Based on basic frontier technologies, common and key technologies, and demonstration applications, 18 projects will be launched, with a planned national allocation of 795 million yuan. On December 4, 2021, the Ministry of Science and Technology of China released the formula list of key proposed projects of the national key R&D program in 2021, including 35 hydrogen energy and fuel cell technologies in five categories of key projects, including hydrogen technology (17), new energy vehicle (2), catalytic science (12), high-end function and smart material (3), and frontier research on large-scale scientific facility (1), mostly covering common and key technologies in the entire industry chain of hydrogen energy and FCEV.

On June 28, 2021, the First Department of Equipment Industry of the Ministry of Industry and Information Technology of China released the "Key Points for Automotive Standardization in 2021". Among them, in the field of FCEVs, the Key Points proposed to focus on the use of FCEVs, promote the standard formulation and revision for FCEV energy consumption and driving range, low-temperature cold start, power performance, on-board hydrogen system, and hydrogen refueling nozzle, etc., accelerate innovation and breakthroughs in key components, and carry out standard formulation and revision for power batteries, supercapacitors, drive motor systems, and insulated gate bipolar transistor (IGBT) modules.

2. **The pilot scope of demonstration urban agglomerations is gradually expanding, with a focus on supporting industrial chain technology breakthroughs and strengthening regional synergy and complementarity**

Regarding accelerating the construction of the FCEV industry chain and the promotion and application of FCEVs, the national level is committed to fully mobilizing the comparative advantages of each city, giving play to the radiation and driving role of leading cities, focusing on cultivating distinctive industrial clusters, and rewarding the owners of FCEVs to replace fiscal and tax policies, and promote the coordinated development of the fuel cell industry within and between urban agglomerations, and strive to drive the complementary, interactive, mutually beneficial and win–win development of cities.

In August 2021, the Ministry of Finance and four other ministries and commissions issued the *Notice of the Ministry of Finance, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, the National Development and Reform Commission, and the National Energy Administration on Starting the Demonstration and Application of Fuel Cell Electric Vehicles* (CJ [2001] No. 266), marking the first batch of FCEV demonstration urban agglomerations including Beijing-Tianjin-Hebei Urban Agglomeration, Shanghai Urban Agglomeration led by Shanghai and Guangdong Urban Agglomeration led by Foshan City have officially landed, further clarifying the determination to accelerate the development of the FCEV industry (Table 7.1).

In August 2021, the Ministry of Finance and four other ministries and commissions issued the Notice of the Ministry of Finance, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, the National Development and Reform Commission, and the National Energy Administration

Table 7.1 List of the first batch of FCEV demonstration and application urban agglomerations in 2021

Urban agglomeration	Beijing-Tianjin-Hebei urban agglomeration	Shanghai urban agglomeration	Guangdong urban agglomeration
Led by	Beijing Municipal Bureau of Finance, Daxing District, Beijing	Shanghai	Foshan
Component	**Beijing**: Six districts, including Haidian District, Changping District **Tianjin**: Binhai New Area **Hebei**: Baoding, Tangshan **Shandong**: Binzhou, Zibo	**Jiangsu**: Suzhou, Nantong **Zhejiang**: Jiaxing **Shandong**: Zibo **Ningxia**: Ningdong Energy and Chemical Industry Base **Inner Mongolia**: Ordos	**Guangdong**: Guangzhou, Shenzhen, Zhuhai, Dongguan, Zhongshan, Yangjiang, Yunfu **Fujian**: Fuzhou **Shandong**: Zibo **Inner Mongolia**: Baotou **Anhui**: Lu'an

Source Planning data of various provinces and cities on Starting A New Round of Demonstration and Application of Fuel Cell Electric Vehicles (CJ [2001] No. 437). It listed Hebei Urban Agglomeration, led by Zhangjiakou, and Henan Urban Agglomeration, led by Zhengzhou, as the second batch of FCEV demonstration urban agglomerations. The formal establishment of the five major demonstration urban agglomerations is expected to fully leverage each city's resource endowment and technological industry advantages, committed to creating a leading model for the development of the hydrogen energy industry (Table 7.2).

3. **Intensive introduction of policies for demonstration urban agglomerations, with a total number of vehicles in demonstration and application exceeding 33,000**

As of the end of 2021, the national "3 + 2" FCEV demonstration urban agglomeration pattern has been formed, and industrial policies are gradually being implemented. The first batch of demonstration urban agglomerations, Beijing-Tianjin-Hebei Urban Agglomeration, Shanghai Urban Agglomeration, and Guangdong Urban Agglomeration, have obvious advantages in the promotion and application of fuel cell key technologies and are the pioneer areas in the promotion and application of FCEVs in China strong economic strength. Hebei Urban Agglomeration and Henan Urban Agglomeration take the opportunity of vehicle demonstration and application and combine their advantages to continue forming local promotion characteristics, which are expected to drive the development of local industries. According to the 4-year demonstration period (2022–2025), the five major demonstration urban agglomerations are expected to promote 33,000 FCEVs of various types. With the continuous growth of vehicles in demonstration and application, various technological breakthroughs, large-scale product promotion, and hydrogen refueling infrastructure in the upstream and downstream of the fuel cell industry chain will also have good development opportunities.

Table 7.2 List of the second batch of FCEV demonstration and application urban agglomerations in 2021

Urban agglomeration	Hebei urban agglomeration	Henan urban agglomeration
Led by	Zhangjiakou, Hebei	Zhengzhou
Component	**Hebei**: Tangshan, Baoding City, Handan City, Qinhuangdao City, Dingzhou City, Xinji, Xiong'an New Area **Inner Mongolia**: Wuhai **Xinjiang**: Bazhou, Korla **Shanghai**: Fengxian District **Henan**: Zhengzhou **Shandong**: Liaocheng, Zibo	**Henan**: Xinxiang, Luoyang, Kaifeng, Anyang, Jiaozuo **Shanghai**: Jiading District, Fengxian District, Lin-gang Special Area of China (Shanghai) Pilot Free Trade Zone **Hebei**: Zhangjiakou, Baoding, Xinji **Shandong**: Yantai, Zibo, Weifang **Guangdong**: Foshan **Ningxia**: Ningdong Town

Source Planning data of various provinces and cities

The Beijing-Tianjin-Hebei Urban Agglomeration is committed to building an ecotope with independent technological innovation, closed-loop sustainable development of the entire industry chain, and regional integration and coordination.

Beijing, Tianjin, and Hebei are geographically connected, with integrated industries, creating an inherent advantage of jointly conducting FCEV demonstrations. The Beijing-Tianjin-Hebei Urban Agglomeration, led by Daxing District, Beijing, was established in conjunction with six districts, including Haidian and Changping, and the Economic and Technological Development Zone in Beijing, as well as 12 cities (districts) including Tianjin Binhai New Area, Baoding and Tangshan in Hebei, Binzhou and Zibo in Shandong Province. On December 25, 2021, the construction of the Beijing-Tianjin-Hebei FCEV Demonstration Urban Agglomeration was officially launched. The demonstration of urban agglomeration will be led by Beijing's technological innovation and commitment to building a green energy community. According to the Implementation Plan for the Beijing-Tianjin-Hebei FCEV Demonstration Urban Agglomeration, the Beijing-Tianjin-Hebei Demonstration Urban Agglomeration has set a "1 + 4 + 5" goal task system, which aims to complete an overall goal of building an ecotope with independent technological innovation, closed-loop sustainable development of the entire industry chain, and regional integration and coordination; also achieve 4 sub-goals: 100% localization of key technologies, construction of high-quality industrial clusters, vehicle promotion and application, and creation of a friendly demonstration environment, with supporting key tasks covering 5 major fields; and establish the division of labor and positioning of "one core, two chains, and four districts" based on the location conditions and resource endowments of each city (Table 7.3).

Table 7.3 Positioning and division of labor in the Beijing-Tianjin-Hebei demonstration urban agglomeration

Key indicators	Specific contents
One core	• Beijing—To play a leading role in technological innovation, key component and vehicle R&D, and manufacturing
Two chains	• Beijing-Tianjin-Baoding-Zibo industrial development chain • Beijing-Baoding-Binzhou hydrogen energy supply chain
Four districts	• Yanqing District, Beijing—winter Olympics scenario distinctive demonstration zone • Tianjin Binhai New Area—port scenario distinctive demonstration zone • Baoding, Hebei—building materials transportation scenario distinctive demonstration zone • Tangshan, Hebei—ore and steel heavy load scenario distinctive demonstration zone

Source Data for the Beijing-Tianjin-Hebei FCEV demonstration urban agglomeration kickoff meeting

The Shanghai Urban Agglomeration is committed to building a fuel cell industry cluster with the largest industrial scale, the best ecological environment, and the strongest overall competitiveness in China.

The Shanghai Urban Agglomeration, led by Shanghai, is jointly established by six cities (districts), including Suzhou and Nantong in Jiangsu, Jiaxing in Zhejiang, Zibo in Shandong, Ningdong Energy and Chemical Base in Ningxia, and Ordos in Inner Mongolia. On November 11, 2021, the first joint meeting on the demonstration and application of FCEVs in Shanghai Urban Agglomeration was held, marking the official launch of the demonstration work in Shanghai Urban Agglomeration. The Shanghai Urban Agglomeration has strengthened organizational support and established a joint meeting system. The joint meeting will be held twice a year, and each city will establish a dedicated team for FCEV demonstration and application work.

Regarding financial support, on November 3, 2021, Shanghai issued Several Policies on Supporting the Development of the City's Fuel Cell Vehicle Industry ("Several Policies") (HFGZ [2021] No. 10), involving incentives for supporting the purchase of complete vehicles, incentives for key parts, incentives for vehicle operation, subsidies for supporting bus operations, subsidies for the construction of hydrogen refueling stations, and subsidies for hydrogen retail prices. The "Several Policies" clearly propose that by 2025, the municipal finance department of Shanghai will contribute following the 1:1 ratio of the national fuel cell vehicle demonstration central financial incentive fund, and give 200,000 yuan/point incentives in support of the vehicle product demonstration and application.

The Guangdong Urban Agglomeration is committed to creating a vehicle demonstration and application and technological innovation highland with a sound industry chain, advanced technologies, and leading scale.

On December 8, 2021, the Guangdong FCEV Demonstration and Application Urban Agglomeration was officially launched. The Guangdong Urban Agglomeration, led by Foshan City, jointly established by cities such as Guangzhou, Shenzhen, Zhuhai, Dongguan, Zhongshan, Yangjiang, Yunfu, Fuzhou, Zibo, Baotou, and Lu'an, aiming to build a technological innovation highland with global competitiveness for the FCEV industry by 2025 by taking the opportunity of FCEV demonstration and application. According to the Action Plan of Guangdong Province to Accelerate the Construction of Fuel Cell Vehicle Demonstration Urban Agglomeration (2021–2025) (the "Draft for Comments") released by the Guangdong Provincial Development and Reform Commission in December 2021, by the end of the demonstration period, the Guangdong Demonstration Urban Agglomeration will realize the independent and controllable technology of eight key parts including cell stack, membrane electrode, bipolar plate, proton exchange membrane, catalyst, carbon paper, air compressor, and hydrogen circulation system, have products with independent intellectual property rights supporting applications, promote more than 10,000 FCEVs, form more than 460,000 tons of hydrogen supply system, build more than 200 hydrogen refueling stations, reduce the price of hydrogen to 35 yuan/kg below (30 yuan/kg below in the province), and build a sound FCEV policy system.

In the field of financial support, the "Draft for Comments" proposes to provide financial incentives to enterprises that have obtained the "Key Component R&D Industrialization" bonus points for Guangdong in the national demonstration urban agglomeration assessment, to be specifically, the provincial financial department will provide supporting funds in accordance with the 1:1 ratio of national reward and subsidy standard, and local financial department of demonstration cities in the province will provide supporting subsidies in accordance with the 1:1 ratio of national and provincial reward and subsidy standard; Regarding the subsidy standard for the construction of hydrogen refueling stations, the provincial financial department will subsidize hydrogen refueling stations that have been built and put into use during the "14th Five-Year Plan" period and have a daily hydrogen refueling capacity of 500 kg or more, and an energy supply station that integrates fuel, hydrogen, and gas will be provided with a subsidy of 2.5 million yuan per station; an independent fixed hydrogen refueling station will be provided with a subsidy of 2 million yuan per station; a skid-mounted hydrogen refueling station will be provided with a subsidy of 1.5 million yuan per station. The local financial department will provide supporting subsidies following the 1:1 ratio of provincial subsidy amount, with a total subsidy of no more than 5 million yuan at each financial level. If a hydrogen refueling station receiving the provincial financial subsidy stops the hydrogen refueling service within 5 years after the first subsidy is in place, it shall refund the subsidy issued.

The Hebei Urban Agglomeration fully leverages the advantages of "green hydrogen" and takes the Winter Olympics as an opportunity to actively explore multiple application scenarios for demonstration.

The Hebei FCEV Demonstration Urban Agglomeration (hereinafter referred to as "Hebei Urban Agglomeration"), led by Zhangjiakou, is composed of 13 cities, including Tangshan, Baoding, Handan, Qinhuangdao, Dingzhou, Xinji and Xiong'an New Area in Hebei, Wuhai in Inner Mongolia, Fengxian District in Shanghai, Zhengzhou in Henan, Zibo and Liaocheng in Shandong and Xiamen in Fujian. Hebei Urban Agglomeration plans to promote 7710 FCEVs of various types during the four-year demonstration period. Among them, Zhangjiakou, the leading city, will promote 1130 FCEVs of various types. Hebei Urban Agglomeration will give full play to hydrogen production from renewable energy to achieve the goal of producing "green hydrogen" with "green electricity" and achieve zero emission in the whole process of hydrogen energy utilization. During the 2022 Winter Olympic Games, all Winter Olympic support vehicles in the core area of Zhangjiakou were FVEV buses. In addition, Hebei Urban Agglomeration will actively enrich the promotion and application scenarios of FVEVs in cities within Hebei.

The Henan Urban Agglomeration drives the development of the fuel cell industry with advantageous enterprises to help the transformation and upgrading of local automobile and energy industries.

The Henan FCEV Demonstration Urban Agglomeration (hereinafter referred to as "Henan Urban Agglomeration") takes Zhengzhou as the leading city and Yutong as the advantageous enterprise, unites with the most powerful integration enterprises of fuel cell system and cities in China, including five cities in Henan, namely Xinxiang, Luoyang, Kaifeng, Anyang, Jiaozuo, and three districts of Shanghai (Jiading, Lin-gang, Fengxian), and other 11 advantageous cities or districts in the industrial chain like Zhangjiakou, Weifang and Foshan. Regarding the working mechanism of demonstration operation, Henan Urban Agglomeration will establish and improve the overall coordination mechanism of demonstration and application, promote the leading cities to continuously improve the level of demonstration and application, and accelerate the formation of advanced experience that can be replicated and promoted in the development of FCEVs. It is expected that during the 4-year demonstration period, the total investment of various types of funds from provincial and municipal government departments, enterprises, and society in Henan will be approximately 28.5 billion yuan.

7.1.2 Significant Demonstration and Promotion Effects

The recommended catalog of FCEVs is mainly in the field of commercial vehicles, and the application scenarios are gradually expanded to multiple fields.

Hydrogen fuel cell technology is important for commercial vehicles to achieve carbon peaking. In recent years, China has actively promoted the application, demonstration, and supporting infrastructure construction of new technologies and new models in FCEV commercial vehicles. Local governments also actively introduced policies to follow up and fully support the promotion and application of FCEV commercial vehicles. From the 1st batch to the 12th batch of Recommended Models Catalogue for New Energy Vehicle Applications (Fig. 7.1) published by the Ministry of Industry and Information Technology of China in 2021, 47 FCEV enterprises and 239 product models were involved, including 1 passenger car, 25 buses, and 214 special vehicles. From the number of recommended models throughout the year, the recommended models of special vehicles are significantly higher than those of buses. With the gradual increase in the scale of demonstration and promotion of FCEVs, FCEVs are gradually expanding from the field of buses to multiple application scenarios of buses and special vehicles. Each demonstration urban agglomeration relies on diversified application scenarios to gradually explore effective commercial operation models.

The demonstration and promotion of FCEVs have gradually increased, and the cumulative sales volume has exceeded 8900 by 2021.

Since 2016, the sales of FCEVs in China have shown a rapid growth trend. In 2019, the sales of FCEVs exceeded 2737 vehicles, with a YoY increase of 79.2%. Since 2020, the sales of FCEVs affected by COVID-19 has declined compared with 2019. Driven by the top-level goal of "carbon peaking and carbon neutrality" and the effect of demonstration urban agglomerations, the development of the FCEV industry in various regions has significantly accelerated. By 2021, the cumulative sales volume has exceeded 8900 vehicles (Fig. 7.2). It is expected that by the end of the 14th Five-Year Plan period, with the promotion of fuel cell multi-scenario application models

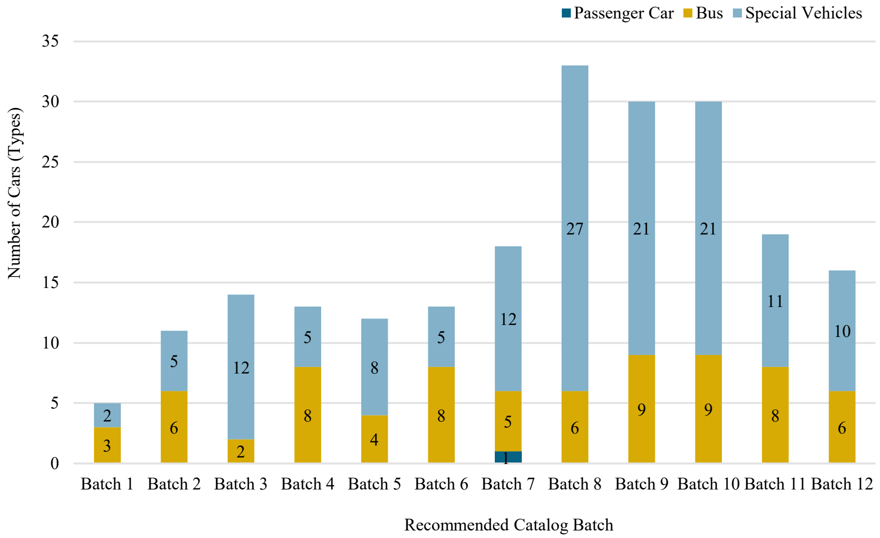


Fig. 7.1 Number of FCEV models in the 1st to 12th batch recommended models catalog in 2021. *Source* Batches 1–12 of recommended models catalogue for new energy vehicle applications in 2021

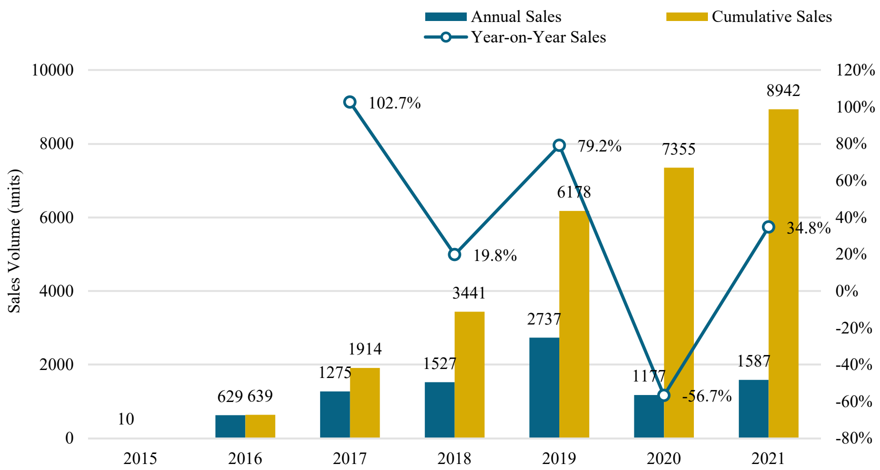


Fig. 7.2 Sales growth of FCEVs in China over the years. *Source* China Association of Automobile Manufacturers

and the gradual improvement of policy and regulatory environments, the scale of demonstration and promotion of FCEVs is expected to gradually achieve industrial development.

As of the end of 2021, more than 255 hydrogen refueling infrastructures have been built in China.

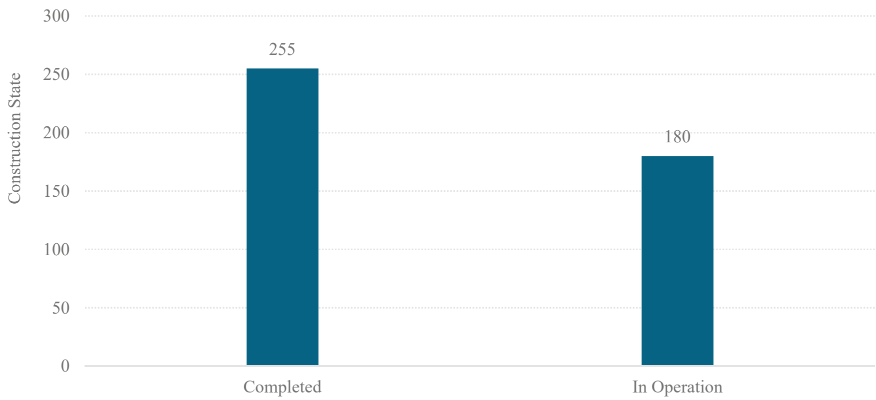


Fig. 7.3 Construction and operation of hydrogen refueling stations in China. *Source* China Society of Automotive Engineers (China SAE). International Hydrogen Fuel Cell Association (Preparatory), China Hydrogen Industry Technology Innovation and Application Alliance

The large-scale demonstration and promotion of FCEVs have led to remarkable achievements in constructing hydrogen refueling infrastructure. By December 31, 2021, 255 hydrogen refueling stations have been built, and 180 hydrogen refueling stations have been put into operation in China (Fig. 7.3). Regarding the construction of new hydrogen refueling stations, the new hydrogen refueling stations in 2021 mainly were energy service stations integrating hydrogen, fuel, electricity, and gas; Regarding the construction layout of domestic hydrogen refueling stations, the construction layout of China's hydrogen refueling stations is regional, mainly distributed in Beijing-Hebei region, Shandong Peninsula region, Yangtze River Delta region, Pearl River Delta region, and other economic development regions.

7.2 Operation Characteristics of FCEVs in China

The National Monitoring and Management Platform can monitor the access and operation of FCEVs in real-time across the country. This section summarizes and analyzes the operation characteristics of FCEVs across the country by selecting data on the access, online rate, travel characteristics, and hydrogen refueling characteristics of FCEVs from the National Monitoring and Management Platform in 2021 to provide experience for the commercialized promotion of FCEVs.

7.2.1 Access Characteristics

1. **Overall access**

The cumulative access volume of FCEVs has exceeded 7737 vehicles, which are mainly operating vehicles.

By December 31, 2021, a total 7737 FCEVs have been accessed to the National Monitoring and Management Platform, including 4071 buses, accounting for 52.63% of the total access; special vehicles include logistics special vehicles, engineering special vehicles, and environmental sanitation special vehicles, with 3663 vehicles accessed, accounting for 47.34% of the total access; 3 passenger cars accessed, accounting for 0.04% of the total access, as shown in Fig. 7.4.

2. **Concentration of vehicle access in various provinces**

The regional distribution of FCEVs concentrated at the demonstration urban agglomerations, and the promotion proportion of the TOP3 provinces reached 62.5%.

As of December 31, 2021, the TOP10 provinces had cumulative access volume of 7289 FCEVs, accounting for 94.2% of the total access in China (Fig. 7.5). According to the promotion of FCEVs in various provinces, the promotion areas of FCEVs are mainly concentrated in Guangdong Urban Agglomeration, Shanghai Urban Agglomeration, and Beijing-Tianjin-Hebei Urban Agglomeration. Guangdong, Shanghai, and Beijing have a cumulative access volume of 4832 FCEVs, accounting for 62.5% of the total access in China. Among them, Guangdong ranks first, with 2536 FCEVs accessed, accounting for 32.8% of total access in China.

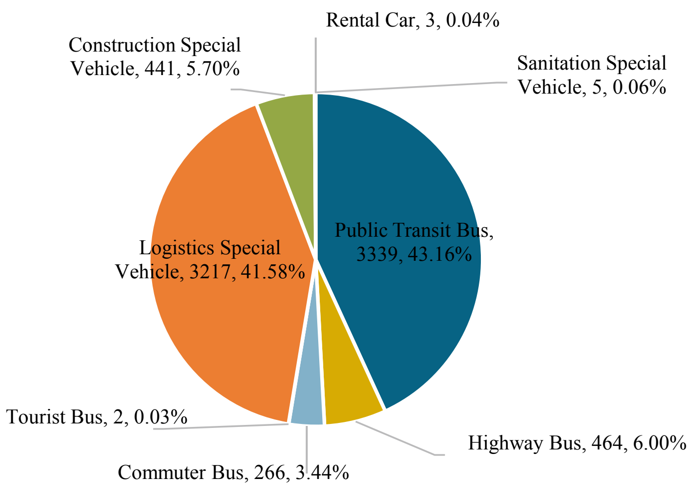


Fig. 7.4 Cumulative access and proportion of FCEVs in China

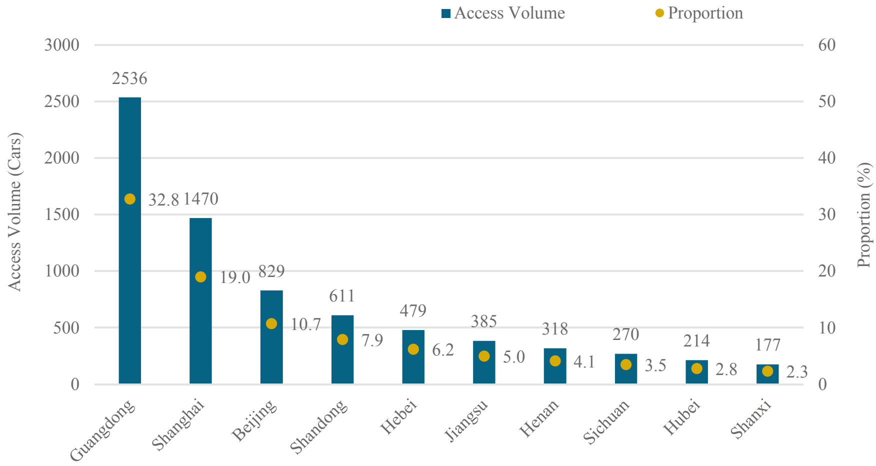


Fig. 7.5 Access and proportion of FCEVs in the TOP10 provinces in 2021

The regional concentration of the promotion and application of FCEVs generally shows a downward trend. According to the change of regional concentration of FCEV promotion and application in provinces over the years (Fig. 7.6), in 2021, the promotion of FCEVs in the TOP3 provinces accounted for 62.5% in China, with a decrease of 6.8% compared with 2020; the promotion proportion of FCEVs in the TOP5 provinces and TOP10 provinces decreased by 3.8% and 1.5% respectively on a YoY basis. With the heating up of the domestic hydrogen energy and fuel cell industry and the continuous maturity of fuel cell technology, multiple provinces in China have released development plans for the hydrogen energy and fuel cell industry to accelerate the promotion and application of vehicles and drive the accelerated development of the hydrogen energy industry chain.

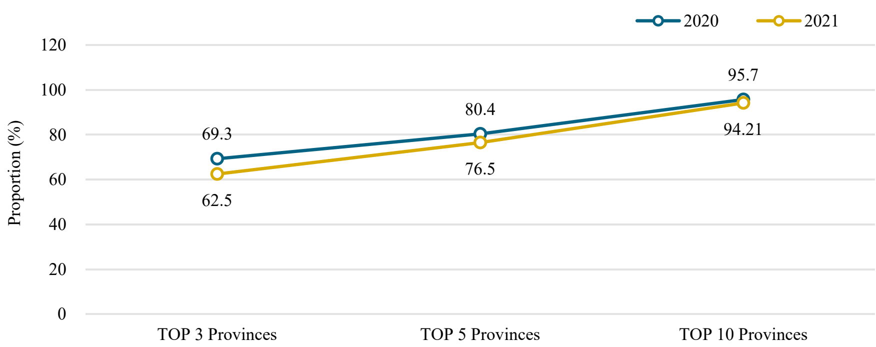


Fig. 7.6 Changes in the regional concentration of FCEVs over the years

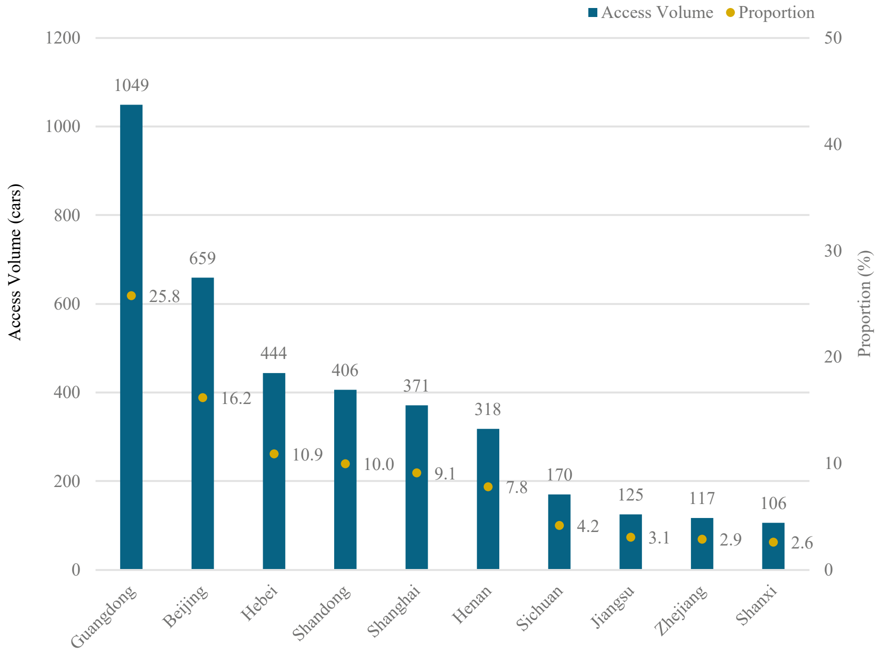


Fig. 7.7 Cumulative access and proportion of FCEV buses in the TOP10 provinces and cities

A total of 4071 FCEV buses have been accessed nationwide, and the promotion proportion in the TOP10 provinces reaches 95.0%.

In the field of FCEV buses, as of December 31, 2021, 4071 FCEV buses have been accessed, accounting for 52.6% of the access volume of FCEVs on the National Monitoring and Management Platform (Fig. 7.7). The TOP10 provinces have a cumulative access volume of 3765 FCEV buses, accounting for 92.5% of the total access volume of FCEV buses in China. Guangdong has the maximum access volume of FCEV buses from the distribution by province. As of December 31, 2021, the access volume of FCEV buses in Guangdong was 1049, accounting for 25.8% of the access volume of FCEV buses in China, followed by Beijing, Hebei, Shandong, Shanghai, and Henan, all with access characteristic of more than 300 FCEV buses.

A total of 3663 FCEV special vehicles have been accessed nationwide, and the promotion proportion in the TOP10 provinces reaches 98.9%.

In the field of FCEV special vehicles, as of December 31, 2021, 3663 FCEV special vehicles have been accessed, accounting for 47.3% of the access volume of FCEVs on the National Monitoring and Management Platform (Fig. 7.8). The TOP10 provinces have a cumulative access volume of 3624 FCEV special vehicles, accounting for 98.9% of the total access volume of FCEV special vehicles in China. Among them, the TOP2 provinces are Guangdong Province and Shanghai City, with

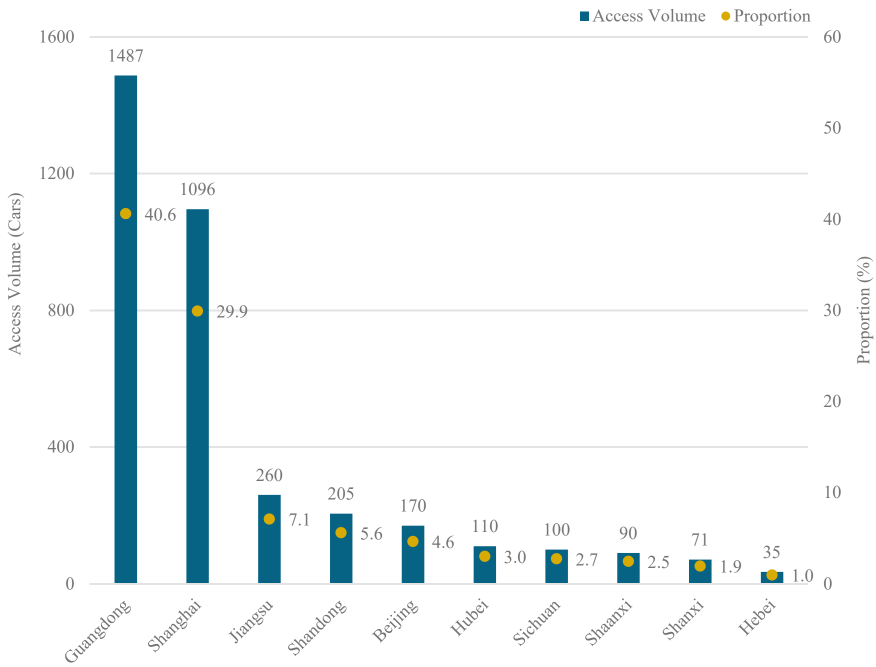


Fig. 7.8 Cumulative access and proportion of FCEV special vehicles in the TOP10 provinces

an access volume of 1487 and 1096 FCEV special vehicles, accounting for 40.6% and 29.9% of the access volume of FCEV special vehicles in China, showing a remarkable promotion effect.

3. **Concentration of vehicle access in various cities**

Totally 6158 FCEVs have been accessed in the TOP10 cities in China, and the proportion of national promotion has reached 79.64%.

The promotion of FCEVs in cities is shown in Fig. 7.9. As of December 31, 2021, 6158 FCEVs have been accessed in the TOP10 cities, accounting for 79.6% of the national promotion. Among them, the promotion scale of FCEVs in Shanghai and Foshan ranked the top two in China, with cumulative access volumes of 1484 and 1470 FCEVs, accounting for 19.2% and 19.0%, respectively, in China.

According to the annual vehicle promotion structure of the TOP10 cities (Fig. 7.10), in Foshan, Beijing, Zhangjiakou, and Zhengzhou, FCEV buses are the main type of vehicles promoted; in Shanghai, Shenzhen, Suzhou, Qingdao, and Wuhan, FCEV special vehicles are the main type of vehicles promoted.

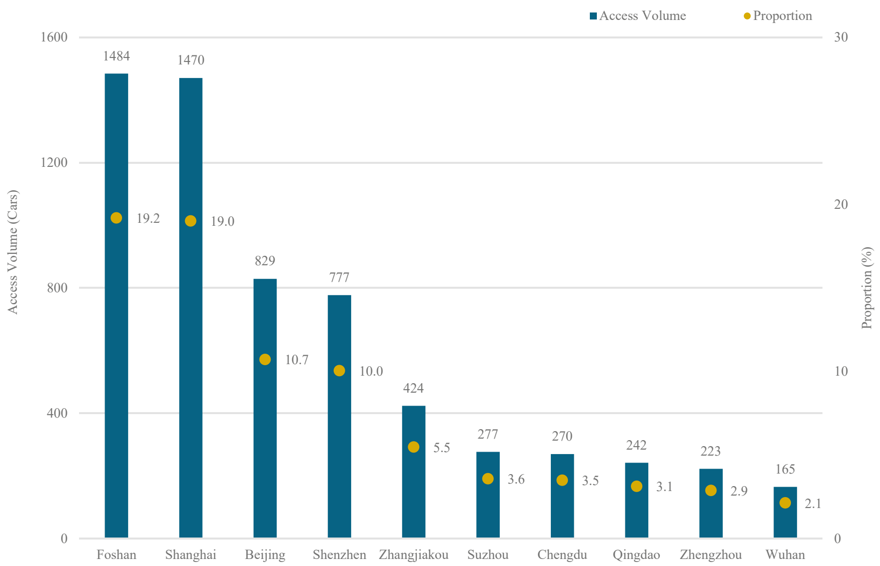


Fig. 7.9 Cumulative access and proportion of FCEVs in the TOP10 cities

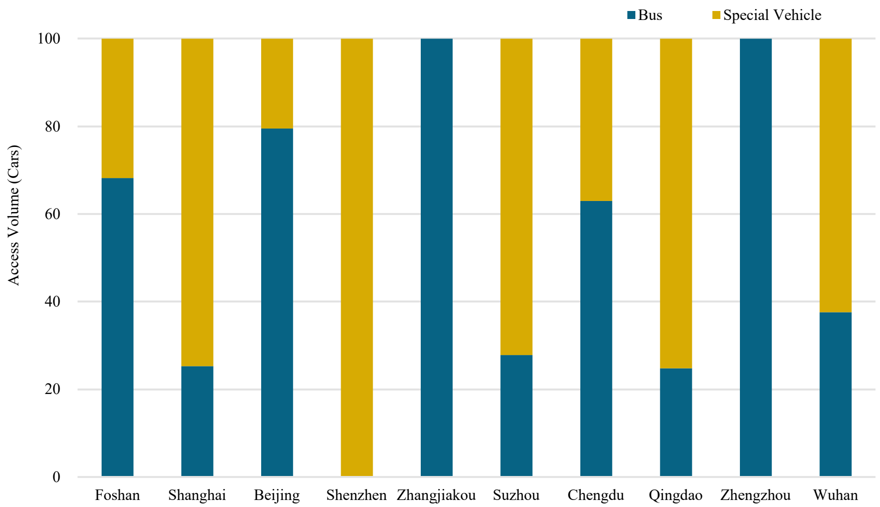


Fig. 7.10 Cumulative access structure of FCEVs in the TOP10 cities

4. **Market Concentration of FCEVs**

The FCEVs have a high market concentration. Top10 enterprises have an access volume of 6501 FCEVs in total, accounting for 84.0%.

At present, the industry has a large number of enterprises participating in the promotion of FCEVs. By 2021, FCEVs from 42 enterprises have been accessed to the National Monitoring and Management Platform. Regarding the industry market concentration, FECV production is dominated by traditional bus enterprises. As of December 31, 2021, 6501 FECVs have been accessed in the TOP10 FECV enterprises nationwide, accounting for 84.0% of the access volume of FECVs nationwide (Fig. 7.11). Among them, Zhongtong Bus had a cumulative access volume of 1620 FCEVs, accounting for 20.9% nationwide; Shanghai Shenlong, Foshan Feichi, BAIC Foton, and Dongfeng Motor had a cumulative access volume of more than 500 FCEVs, that is 933, 906, 693 and 620 FCEVs, accounting for 12.1%, 11.7%, 9.0%, and 8.0% respectively. Benefiting from the 2022 Winter Olympics, the access volume of BAIC Foton FCEVs in 2021 nearly tripled on a YoY basis, reaching 190.0%.

According to the promotion and application scenarios of FCEVs of the TOP10 enterprises (Fig. 7.12), Foshan Feichi, BAIC Foton, Zhengzhou Yutong Bus, Xiamen Golden Dragon, and Yunnan Wulong mainly promote and apply FCEVs in the field of buses; Zhongtong Bus, Sunlong Bus, and Dongfeng Motor mainly promote and apply FCEVs in the field of special vehicles. Besides, in 2021, Foshan Feichi and Nanjing Golden Dragon accelerated the product layout in the field of FCEV engineering special vehicles. They successively launched announcements on FCEV trucks, truck

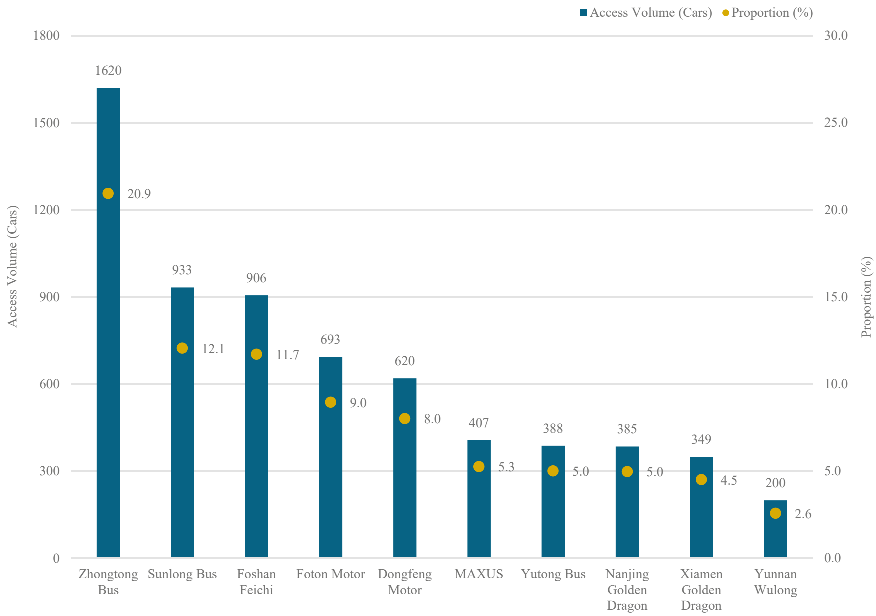


Fig. 7.11 Cumulative access and proportion of FCEVs in the TOP10 enterprises

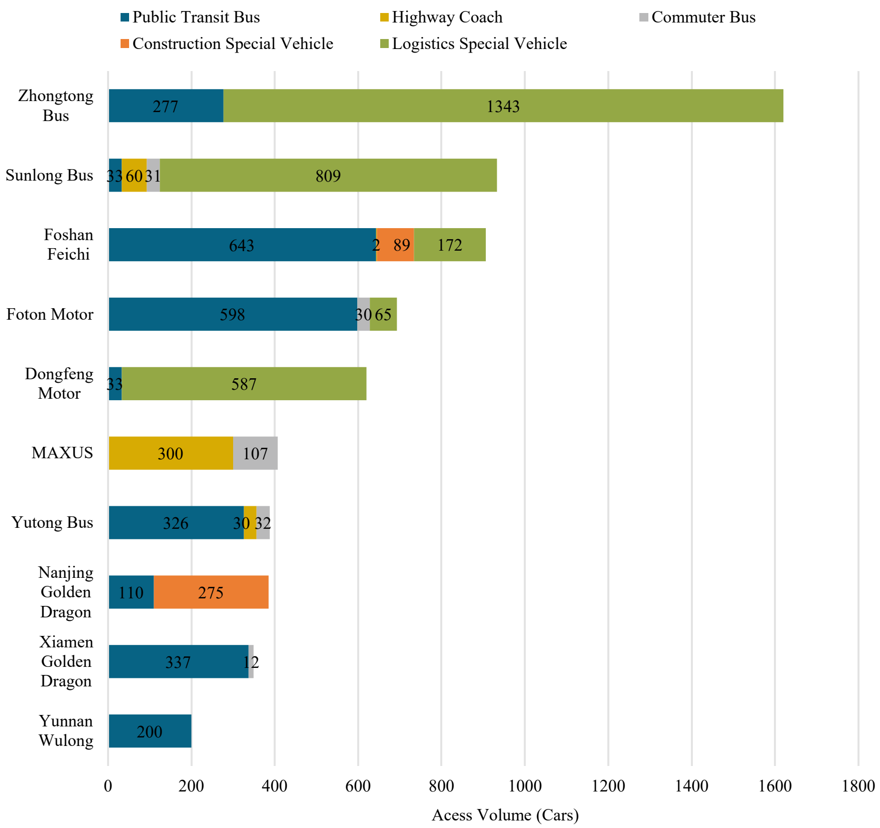


Fig. 7.12 Cumulative access volume of FCEVs of the TOP10 enterprises in different application scenarios

chassis, and other models, with the focus on promoting the demonstration and application in the field of medium-and-long distance and medium-and-heavy commercial vehicles.

Top10 enterprises have a cumulative access volume of 3322 FCEV buses in total, accounting for 81.6% of promotion.

In the field of FCEV buses, the TOP10 enterprises have a cumulative access volume of 3322 vehicles, accounting for 81.6% of the FCEV buses on the National Monitoring and Management Platform (Fig. 7.13). Among them, Foshan Feichi has a cumulative access volume of 645 FCEV buses, accounting for 15.8% of the access volume of FCEV buses. BAIC Foton, Maxus, Yutong Bus, Xiamen Golden Dragon, and Zhongtong Bus have a cumulative access volume of more than 200 FCEV buses.

Top10 enterprises have a cumulative access volume of 3605 FCEV special vehicles in total, accounting for 98.4% of promotion.

In the field of FCEV special vehicles, the TOP5 enterprises have a cumulative access volume of 3605 vehicles, accounting for 98.4% of the access volume of FCEV

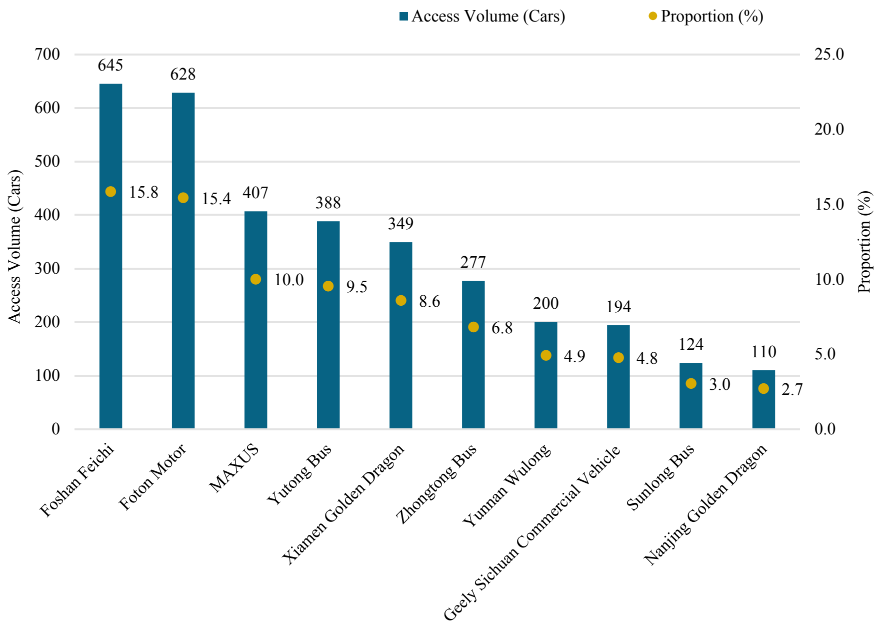


Fig. 7.13 Cumulative access and proportion of FCEV buses in the TOP10 enterprises

special vehicles (Fig. 7.14). Among them, Zhongtong Bus has an access volume of 1343 FCEV special vehicles, accounting for 36.7%. The enterprises of FCEV special vehicles have a relatively high promotion concentration.

7.2.2 Online Rate Characteristics

The average monthly online rate of FCEVs over the years has gradually stabilized, and the average monthly online rate in the past two years has been more than 70%.

As shown in Fig. 7.15, since 2018, the annual average monthly online rate of FCEVs has shown a trend of first rising and then stabilizing. In 2020, the average monthly online rate of FCEVs grew faster than that in 2018 and 2019, and the utilization rate of vehicles was significantly improved. In 2021, the average monthly online rate of FCEVs was 71.3%, mainly accompanied by the acceleration of the FCEV demonstration and promotion process and the further expansion of the vehicle promotion scale in China. The annual average monthly online rate of FCEVs gradually stabilizes.

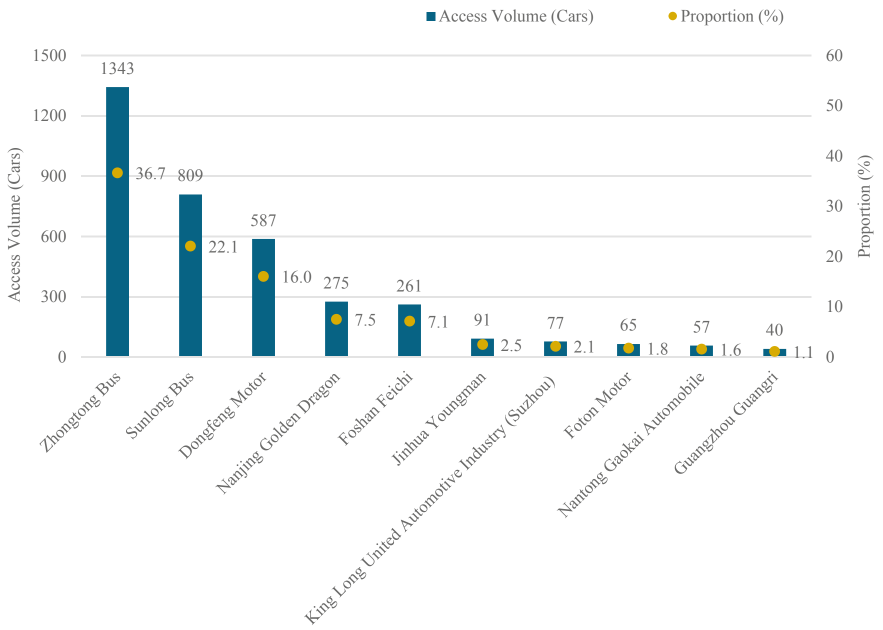


Fig. 7.14 Cumulative access and proportion of FCEV special vehicles in the TOP10 enterprises

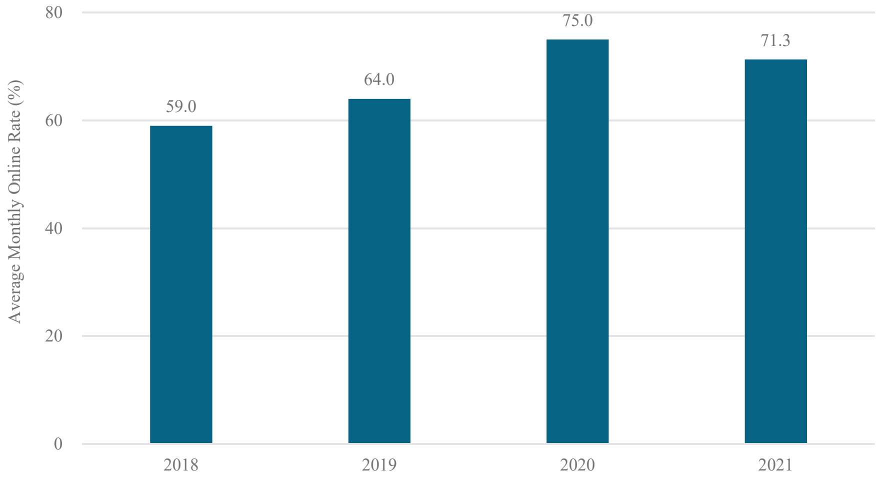


Fig. 7.15 Average monthly online rate of FCEVs over the years

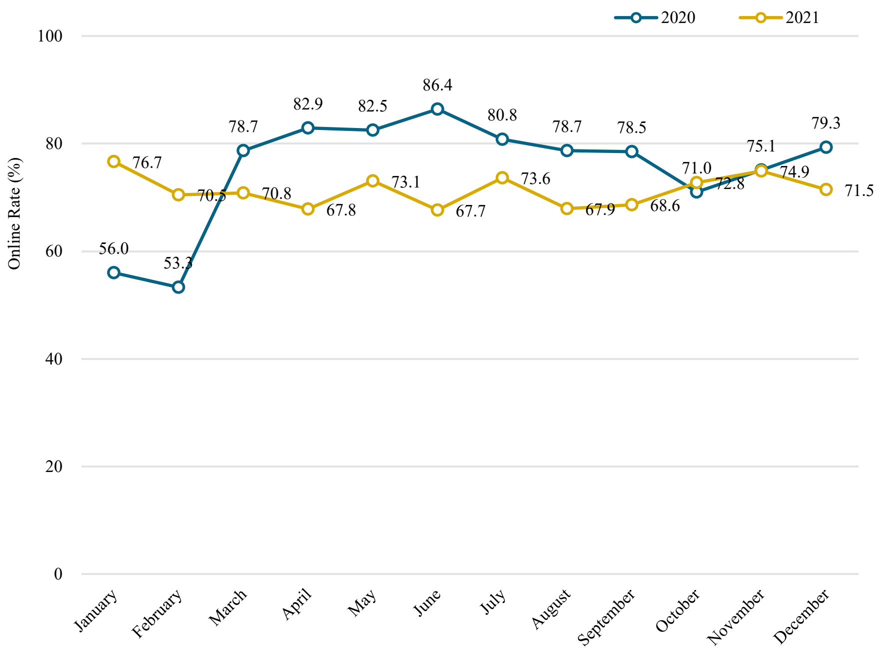


Fig. 7.16 Monthly online rate of FCEVs over the years

According to the curve of the monthly online rate of FCEVs (Fig. 7.16), the monthly online rate of FCEVs in 2021 showed a relatively stable trend, and the online rate in each month fluctuated around 70%.

In 2021, the monthly average daily online vehicles generally maintained an upward trend, and the number of online vehicles increased rapidly in the fourth quarter. Regarding the monthly average daily online FCEVs nationwide in 2021 (Fig. 7.17), except that the number of online vehicles in February 2021 was 1967, the number of online vehicles in other months remained above 2000. The number of online vehicles in the fourth quarter of 2021 steadily increased, reaching the highest average daily number of online vehicles in each month of the year in December, with 2790 vehicles.

The online rate of FCEV buses is higher than that of FCEV special vehicles. Regarding application scenarios, the FCEV buses have a good operation effect. According to the monthly average online rate by vehicle type over the years (Fig. 7.18), the online rate of FCEV buses has remained above 80% in the past three years, with a high online rate and good operation effect; the average monthly online rate of FCEV special vehicles reached 69% in 2020, and that declined in 2021. The fuel cell industry needs to further summarize experience through pilot demonstration in core equipment and key parts development and hydrogen refueling infrastructure construction to promote the rapid development of hydrogen and fuel cell industries.

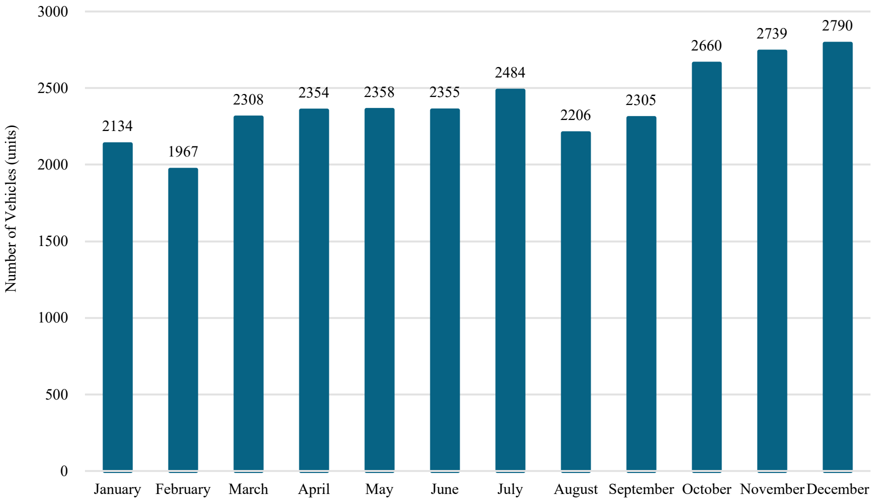


Fig. 7.17 Number of monthly average daily online FCEVs in 2021

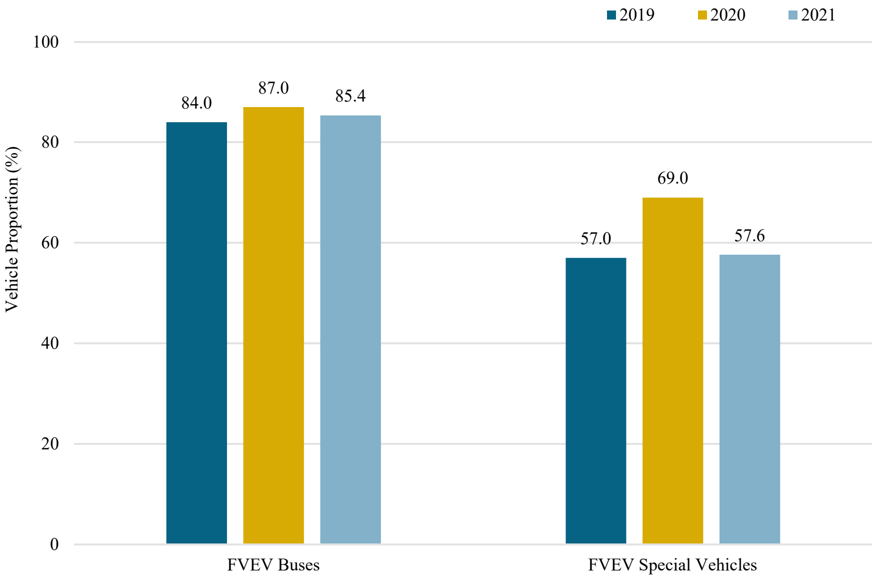


Fig. 7.18 Average monthly online rate of FCEV buses and special vehicles over the years

7.2.3 Operation Characteristics

1. **Cumulative mileage and travel duration**

As of December 31, 2021, the cumulative mileage of FCEVs in China was nearly 200 million km, and the travel duration exceeded 7.42 million h.

As of December 31, 2021, the cumulative mileage of FCEVs was 194.417 million km (Fig. 7.19), and the cumulative travel duration was up to 7.42 million h (Fig. 7.20). In 2021, FCEVs traveled 110,096,000 km and 4,482,000 h, accounting for 56.6% and 60.4% of the cumulative mileage and travel duration of fuel cell electric vehicles, respectively.

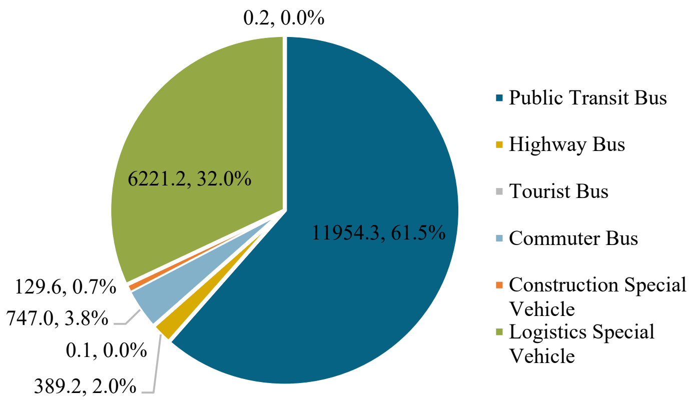


Fig. 7.19 Distribution of cumulative mileage of FCEVs in different application scenarios (10,000 km, %)

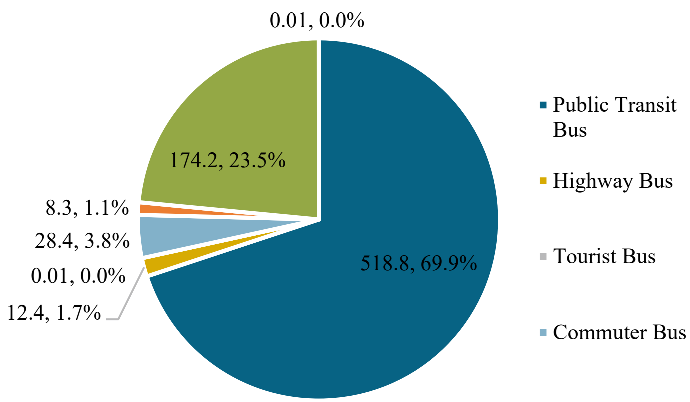


Fig. 7.20 Distribution of cumulative travel duration of FCEVs in different application scenarios

Regarding application scenarios, FCEV buses and logistics special vehicles dominate. FCEV buses have traveled 119.543 million km cumulatively, with a travel duration of 5.188 million h; FCEV logistics special vehicles have traveled 62.212 million km cumulatively, with a travel duration of 1.742 million h.

The promotion scale of fuel cell electric vehicles in Guangdong ranks first in China, with good vehicle operation effect.

According to the ranking of cumulative mileage and cumulative travel duration of fuel cell electric vehicles in all provinces of China (Fig. 7.21), by the end of 2021, the cumulative mileage of FCEVs in the TOP10 provinces was 187.219 million km, and the cumulative travel duration was 7.169 million h, accounting for 96.3% and 96.6% of the total cumulative mileage and cumulative travel duration of FCEVs in China, respectively. Among them, the operation effect of Guangdong ranks first. By the end of 2021, the cumulative mileage of FCEVs in Guangdong was 76.069 million km, and the cumulative travel duration was 2.584 million h, followed by Shanghai, Henan, Hebei, Shandong, and Beijing. The demonstration operation of FCEVs has achieved good results.

2. **Characteristics of Daily Mileage and Travel Duration of a Single Vehicle**

In 2021, the daily mileage of a single vehicle for FCEVs was concentrated at 120 ~ 240 km, and the "migration" trend of vehicles to high mileage was significant.

As the distribution shows, in 2019 and 2020, the daily mileage of a single vehicle for FCEVs was mainly 0 ~ 40 km (Fig. 7.22). In 2021, the proportion of FCEVs with a daily mileage of a single vehicle in the high mileage section increased significantly. The proportion of FCEVs with a single-vehicle mileage of 120 ~ 240 km was 56.2%, significantly higher than that in the last two years. With the continuous strengthening of policy support for the hydrogen and fuel cell industries, the technical performance of onboard devices and the layout of hydrogen refueling infrastructure are gradually optimized, and the operational effectiveness of vehicles is significantly improved.

The mileage of FCEV buses is concentrated within 120–240 km; the distribution of special vehicles in each mileage segment is relatively balanced, with a high proportion of vehicles in high mileage segments.

Regarding application scenarios, in 2021, the daily mileage of a single vehicle for FCEV buses was mainly less than 120 ~ 240 km, with vehicles accounting for 62.6% (Fig. 7.23). The distribution of daily mileage of a single vehicle for FCEV special vehicles is relatively uniform. Compared with FCEV buses, the share of FCEV special vehicles in high mileage segments above 200 km is significantly higher, accounting for 44.2%. Among them, the proportion of vehicles with a daily mileage of over 480 km is 9.9%, indicating that the role of FCEV special vehicles in trans-city transportation is gradually emerging.

The distribution of daily travel duration of a single vehicle for FCEVs gradually transits to long duration segments, with their use intensity gradually increased.

The daily travel durations of a single vehicle for FCEVs are distributed dispersedly in all duration segments. Compared to 2019 and 2020, the distribution proportion

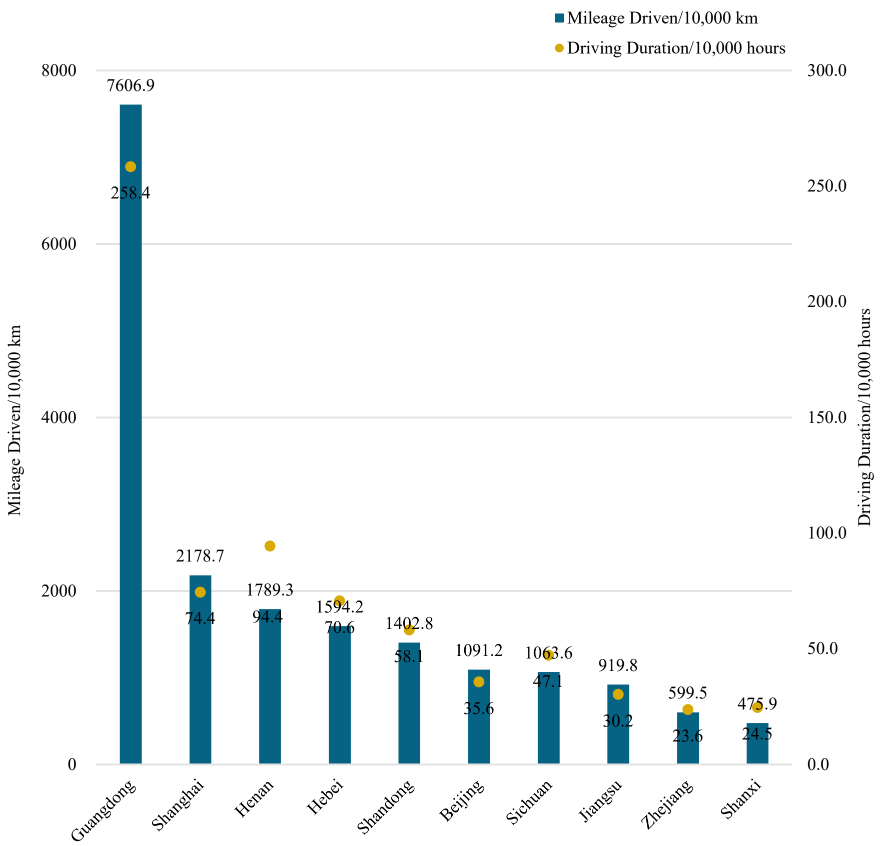


Fig. 7.21 Cumulative mileage and travel duration of FCEVs in the TOP10 provinces

of FCEVs in long travel duration segments gradually increased in 2021 (Fig. 7.24). The proportion of FCEVs with a daily travel duration of more than 6 h accounted for 61.34%, and the proportion of vehicles with a daily travel duration of more than 10 h accounted for 18.5%, indicating that the use intensity of vehicles gradually increased.

The proportion of FCEV buses in long travel duration segments is generally higher than that of FCEV special vehicles.

Generally, the proportion of FCEV buses in long travel duration segments is higher than that of FCEV special vehicles (Fig. 7.25). Regarding the application scenarios, the daily travel duration of a single vehicle for FCEV buses is mainly more than 5 h, and the proportion of vehicles reaches 72.6% (higher than 62.1% of special vehicles), mainly for urban transport; the daily travel duration of a single vehicle for FCEV special vehicles has been differentiated to a certain extent. On the one hand, FCEV special vehicles with a travel duration of less than 2 h account for a large proportion, mainly for short-distance logistics distribution in the city; some FCEV special vehicles with a travel duration of more than 10 h account for 19.0%, and they transport across cities.

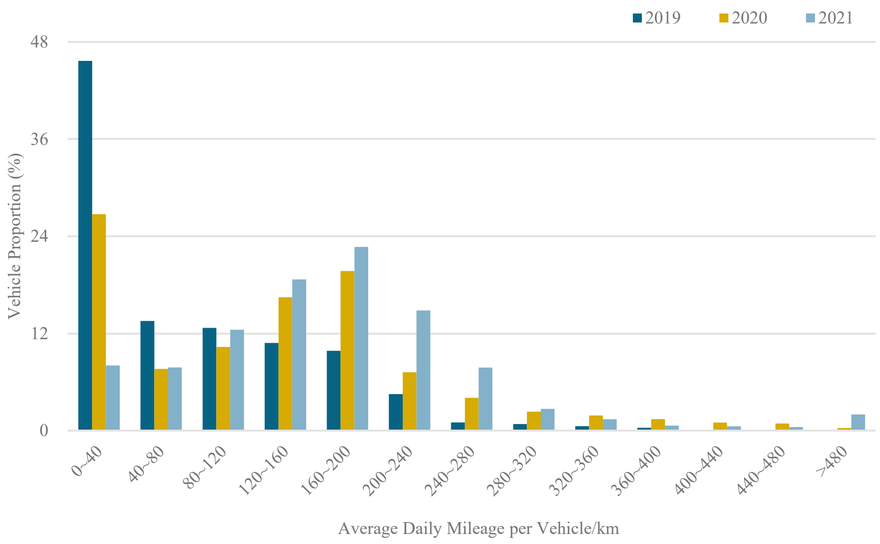


Fig. 7.22 Distribution of daily mileage of a single vehicle for FCEVs

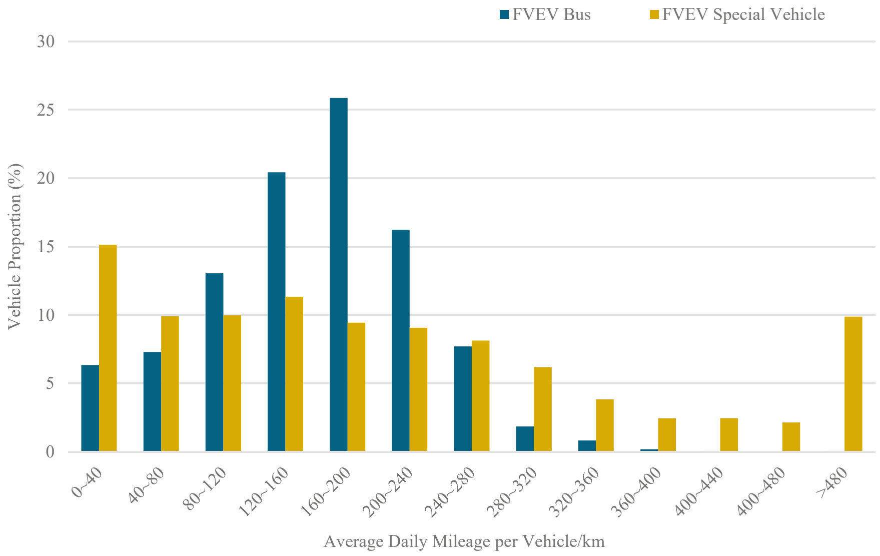


Fig. 7.23 Distribution of daily mileage of a single vehicle for FCEV buses and special vehicles in 2021

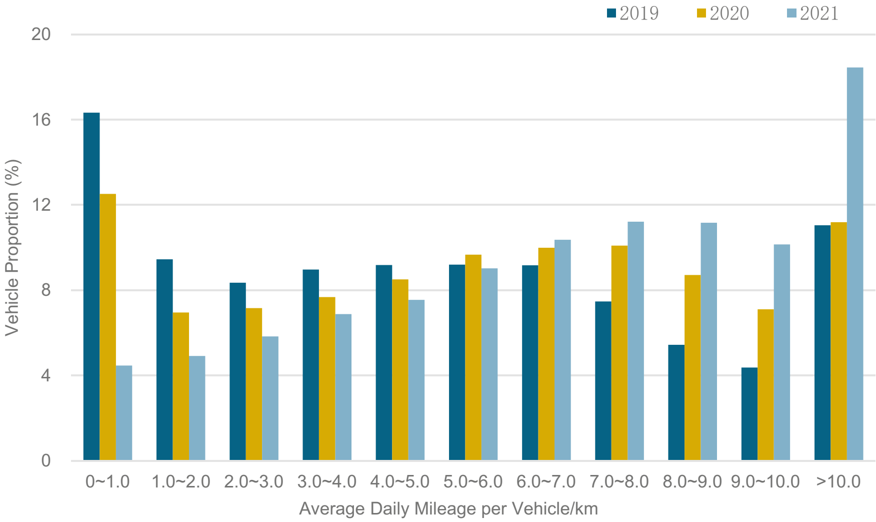


Fig. 7.24 Distribution of daily travel duration of a single vehicle for FCEVs in 2018–2021

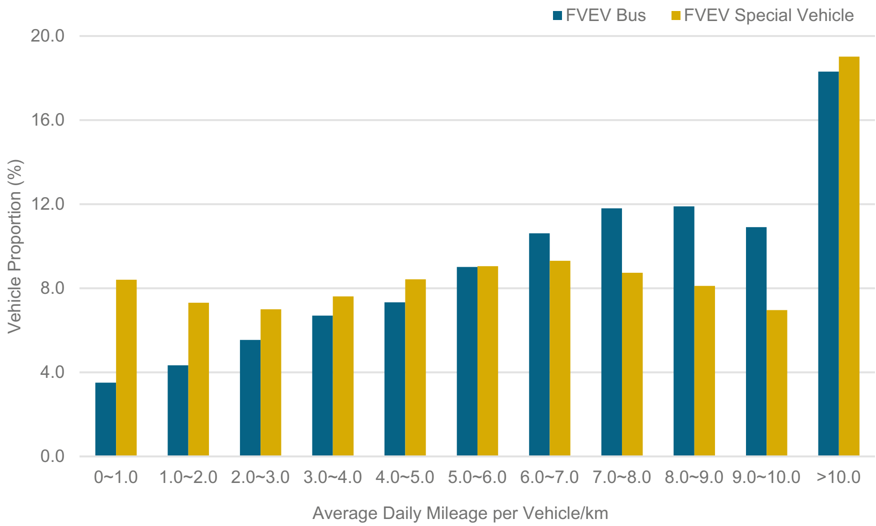


Fig. 7.25 Distribution of daily travel duration of a single vehicle for FCEV buses and special vehicles in 2021

3. **Characteristics of Mileage and Travel Duration for Vehicle Enterprises**

In the field of buses, there is a positive correlation between the average daily mileage and the average daily travel duration of vehicles.

Compared with the average daily mileage and travel duration of all bus enterprises, there is a significant positive correlation between the mileage and travel duration of different bus enterprises (Fig. 7.26). Among them, Ankai Automobile has the highest average daily mileage, reaching 233.0 km, and an average daily travel duration of 6.9 h. In addition, the average daily mileage of Asiastar Bus and FAW Bus (Dalian) is 201.7 km and 197.0 km, respectively, and the average daily travel duration is 6.4 h and 5.2 h, respectively, with good operation effect.

There are significant operation differences in the field of special vehicles, with typical enterprises achieving outstanding operation results.

The average daily mileage and daily travel duration of typical FCEV enterprises are longer. According to the travel characteristics of vehicles of typical enterprises (Fig. 7.27), Foshan Feichi has the longest average daily mileage of 290.6 km and an average daily travel duration of 8.5 h. In addition, the daily mileage of Foshan Feichi and Zhongtong Bus is longer, 266.9 km and 254.1 km, respectively, with the daily travel duration of 6.0 h and 7.5 h.

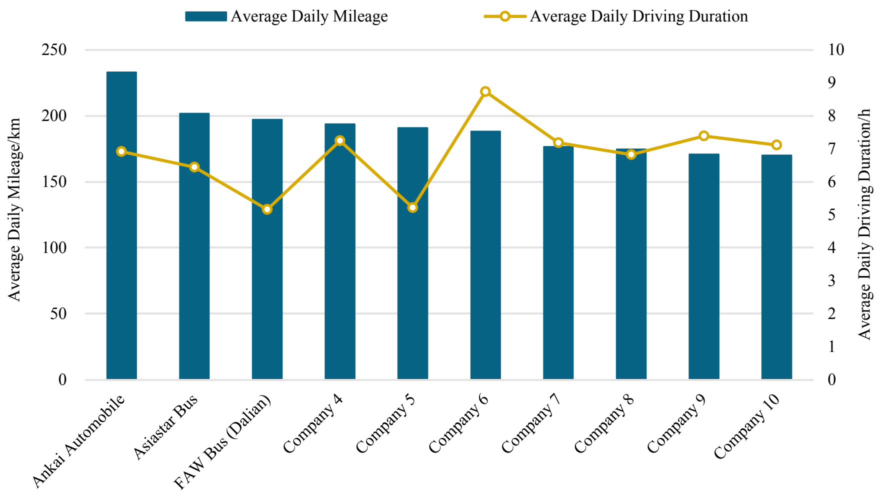


Fig. 7.26 Distribution of average daily mileage and travel duration of FCEVs of typical bus enterprises in 2021

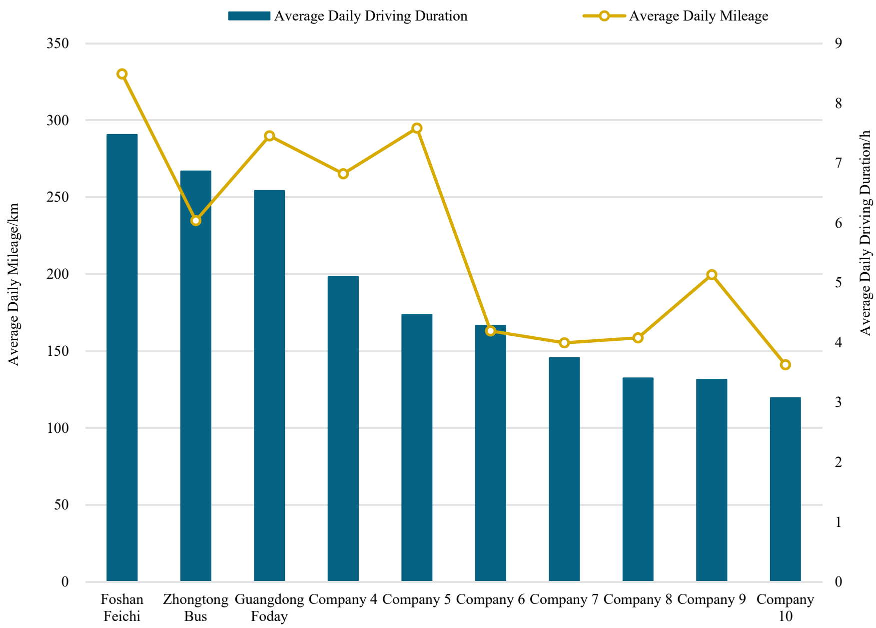


Fig. 7.27 Distribution of average daily mileage and travel duration of FCEVs of typical special vehicle enterprises in 2021

7.3 Operation Characteristics of FCEVs in Demonstration Urban Agglomerations

China is accelerating the launch of FCEV application and promotion project driven by the "demonstration urban agglomerations." The FCEV demonstration urban agglomerations, led by typical cities, will give full play to the characteristics of the industries and application scenarios of each demonstration urban agglomeration to drive the rapid iterative development of hydrogen energy and product technologies of fuel cell industry chain, promote the commercialization of products, and accelerate the formation of industrial competitiveness. This section selects Beijing-Tianjin-Hebei Urban Agglomeration, Shanghai Urban Agglomeration, Guangdong Urban Agglomeration, Hebei Urban Agglomeration, and Henan Urban Agglomeration as the research objects. It compares and evaluates the promotion, application, operation characteristics and hydrogen refueling characteristics of FCEVs in five demonstration urban agglomerations.

7.3.1 Promotion and Application Characteristics

The data in this study adopts the real-time operation data of FCEVs on the National Monitoring and Management Platform. The specific statistical scope of FCEVs in each demonstration urban agglomeration is as follows: for the Beijing-Tianjin-Hebei Urban Agglomeration, the demonstration and application of FCEVs in Beijing were mainly counted; for Shanghai Urban Agglomeration, the demonstration, and application of FCEVs represented by Shanghai were mainly counted; for Guangdong Urban Agglomeration, the demonstration, and application of FCEVs represented by Guangdong were mainly counted; for Hebei Urban Agglomeration, the demonstration, and application of FCEVs represented by Hebei were mainly counted; for Henan Urban Agglomeration, the demonstration, and application of FCEVs represented by Henan were mainly counted.

From the comparison of the cumulative access characteristics of each demonstration urban agglomeration (Fig. 7.28), as of December 31, 2021, the five demonstration urban agglomerations had a cumulative access volume of 5629 FCEVs, accounting for 72.8% of the cumulative access volume of FCEVs in China. Among them, the cumulative access volume of FCEVs in Guangdong Urban Agglomeration was the highest, reaching 2536 vehicles, including 1049 buses and 1487 special vehicles, followed by Shanghai Urban Agglomeration, with a cumulative access volume of 1470 FCEVs, including 371 buses and 1096 special vehicles, and 3 passenger cars; the cumulative access volume of FCEVs in Beijing-Tianjin-Hebei Urban Agglomeration reached 829 vehicles, including 659 buses and 170 special vehicles; the cumulative access volume of FCEVs in Hebei Urban Agglomeration and Henan Urban Agglomeration was 479 and 318 vehicles respectively, mainly buses.

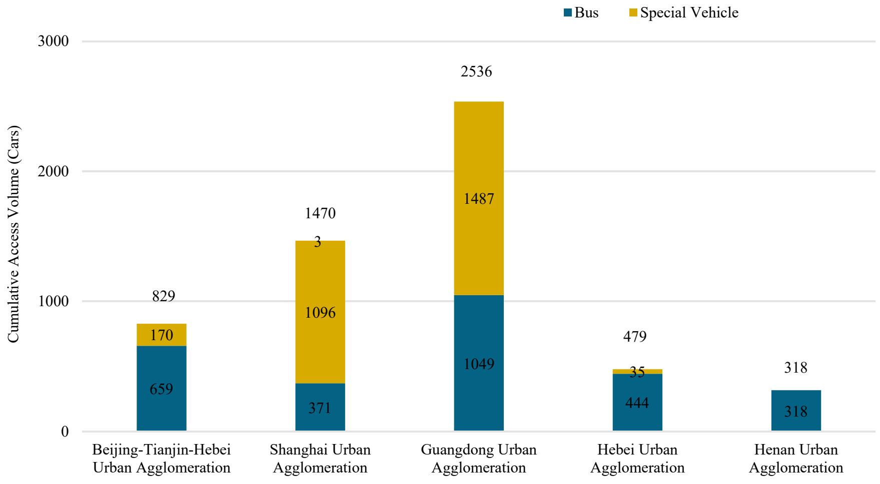


Fig. 7.28 Cumulative access volume of FCEVs in each demonstration urban agglomeration-by type

Regarding the cumulative access characteristics of different types of vehicles in various demonstration urban agglomerations, the cumulative access volume of FCEV special vehicles in the Guangdong and Shanghai Urban Agglomerations is higher than that of buses; the cumulative access volume of FCEV buses in Beijing-Tianjin-Hebei, Hebei, and Henan Urban Agglomerations is significantly higher than that of special vehicles.

Regarding vehicle promotion and application in different fields, the cumulative access characteristics of FCEV buses in the demonstration urban agglomerations (TOP5) are shown in Table 7.4. As of December 31, 2021, the TOP5 enterprises in the FCEV bus demonstration application scale in Beijing-Tianjin-Hebei Urban Agglomeration include BAIC Foton, Sunlong Bus, SFTM, Zhongzhi New Energy Vehicle (Chun'an) and Yutong Bus, with a cumulative access volume of 659 FCEV buses. A total of 4 enterprises, Maxus, Wanxiang Auto, SUNWIN Bus, and Sunlong Bus, have vehicles accessed and operated in the demonstration and application of FCEV buses in Shanghai Urban Agglomeration. Among them, Maxus has 347 buses accessed in total, ranking first, accounting for 93.5% of the promotion of FCEV buses in Shanghai Urban Agglomeration. Many enterprises are promoting and applying FCEV buses in Guangdong Urban Agglomeration, and the cumulative access volume of the TOP5 enterprises has reached 1036 vehicles, accounting for 98.8% of the cumulative FCEVs in Guangdong Urban Agglomeration. The number of FCEV buses promoted and applied by Foshan Feichi is the highest, i.e., 589, accounting for 56.1% of the promotion of FCEV buses in Guangdong Urban Agglomeration. Thanks to the 2022 Beijing Winter Olympic Games, the promotion scale of vehicles in Hebei Urban Agglomeration has proliferated, including 209 vehicles of BAIC Foton, accounting for 47.1% of the promotion scale of Hebei Urban Agglomeration. The main promotion enterprises in Henan Urban Agglomeration are Zhengzhou Yutong Bus and Jinhua Youngman, with an access volume of 224 and 94 vehicles, respectively.

In special vehicles, the cumulative access characteristics of vehicle enterprises in the demonstration urban agglomerations (TOP5) are shown in Table 7.5. As of December 31, 2021, a total of three enterprises in Beijing-Tianjin-Hebei Urban Agglomeration, namely Sunlong Bus, BAIC Foton, and Foshan Feichi, have vehicles accessed and operated in the demonstration and application of FCEV special vehicles, with a total access volume of 170 FCEV special vehicles, accounting for 100% of the access volume of FCEV special vehicles in Beijing-Tianjin-Hebei Urban Agglomeration. A total of 4 enterprises in Shanghai Urban Agglomeration, namely Sunlong Bus, Dongfeng Motor, King Long United Automotive Industry (Suzhou), and JMC Heavy Duty Vehicle, have vehicles accessed and operated in the demonstration and application of FCEV special vehicles. Among them, Sunlong Bus has 509 buses accessed in total, ranking first, accounting for 46.4% of the promotion of FCEV special vehicles in Shanghai Urban Agglomeration. Many enterprises are promoting and applying FCEV special vehicles in Guangdong Urban Agglomeration,

Table 7.4 Cumulative access volume of FCEVs in the TOP5 enterprises in each demonstration urban agglomeration-bus field

Name of urban agglomeration	Ranking of cumulative access and proportion of each enterprise (vehicle, %)					
	TOP1	TOP2	TOP3	TOP4	TOP5	
Beijing-Tianjin-Hebei urban agglomeration	BAIC Foton	Sunlong Bus	Sichuan FAW Toyota	Zhongzhi New Energy Vehicle (Chun'an)	Zhengzhou Yutong Bus	Subtotal
	416	90	72	50	31	659
	63.2%	13.7%	10.9%	7.6%	4.7%	100%
Shanghai urban agglomeration	MAXUS	Wanxiang Auto	SUNWIN Bus	Sunlong Bus	–	Subtotal
	347	16	6	2	–	371
	93.5%	4.3%	1.6%	0.6%	–	100%
Guangdong urban agglomeration	Foshan Feichi	Yunnan Wulong	Xiamen Golden Dragon	Nanjing Golden Dragon	Zhongtong Bus	Subtotal
	589	200	186	41	20	1036
	56.1%	19.1%	17.7%	3.9%	1.9%	98.8%
Hebei urban agglomeration	BAIC Foton	Zhengzhou Yutong Bus	Geely Sichuan Commercial Vehicle	Zhongtong Bus	Shanghai Shenlong	Subtotal
	209	85	80	40	30	444
	47.1%	19.1%	18.0%	9.0%	6.8%	100%
Henan urban agglomeration	Zhengzhou Yutong Bus	Jinhua Youngman	–	–	–	
	224	94	–	–	–	318
	70.4%	29.6%	–	–	–	100%

and the cumulative access volume of the TOP5 enterprises has reached 1459 vehicles, accounting for 98.1% of the cumulative access volume of FCEVs in Guangdong Urban Agglomeration. The special vehicle enterprises in Hebei Urban Agglomeration are mainly Foshan Feichi and Nanjing Golden Dragon, with an access volume of 20 and 15 vehicles, respectively.

Table 7.5 Cumulative access characteristics of FCEVs in the TOP5 enterprises in each demonstration urban agglomeration-special vehicle field

Name of urban agglomeration	Ranking of cumulative access and proportion of each enterprise (vehicle, %)					
	TOP1	TOP2	TOP3	TOP4	TOP5	
Beijing-Tianjin-Hebei urban agglomeration	Sunlong Bus	BAIC Foton	Foshan Feichi	–	–	Subtotal
	100	65	5	–	–	170
	58.8%	38.2%	3.0%	–	–	100%
Shanghai urban agglomeration	Sunlong Bus	Dongfeng Motor	King Long United Automotive Industry (Suzhou)	JMC Heavy Duty Vehicle	–	Subtotal
	509	500	77	10	–	1069
	46.4%	45.6%	7.0%	0.9%	–	100%
Guangdong urban agglomeration	Zhongtong Bus	Foshan Feichi	Dongfeng Motor	Nanjing Golden Dragon	Guangzhou Guangri	Subtotal
	1110	171	75	63	40	1416
	74.6%	11.5%	5.0%	4.2%	2.7%	95.2%
Hebei urban agglomeration	Foshan Feichi	Nanjing Golden Dragon	–	–	–	Subtotal
	20	15	–	–	–	35
	57.1%	42.9%	–	–	–	100%

7.3.2 Operation Characteristics

1. **FCEV Online Rate**

The average monthly online rate of FCEV buses in each demonstration urban agglomeration (Table 7.6) shows that the monthly online rates of FCEV buses in Henan Urban Agglomeration and Guangdong Urban Agglomeration were 93.9% and 91.9%, respectively, with an average exceeding 90%; The average monthly online rate of FCEV buses in Shanghai Urban Agglomeration was low, i.e., 61.4%.

The change in the monthly online rate of FCEV buses (Fig. 7.29) shows that the average monthly online rates of FCEV buses in Beijing-Tianjin-Hebei Urban Agglomeration, Guangdong Urban Agglomeration, Hebei Urban Agglomeration, and Henan Urban Agglomeration were distributed steadily, and the number of online vehicles in Shanghai Urban Agglomeration in September and October was relatively low, which has reduced the overall online rate throughout the year.

The average monthly online rate of FCEV special vehicles in each demonstration urban agglomeration (Table 7.7) shows that the overall average online rate

Table 7.6 Average monthly online rate of FCEV buses in each demonstration urban agglomeration in 2021

	Beijing-Tianjin-Hebei urban agglomeration	Shanghai urban agglomeration	Guangdong urban agglomeration	Hebei urban agglomeration	Henan urban agglomeration
Average monthly online rate (%)	74.8	61.4	91.9	79.4	93.9

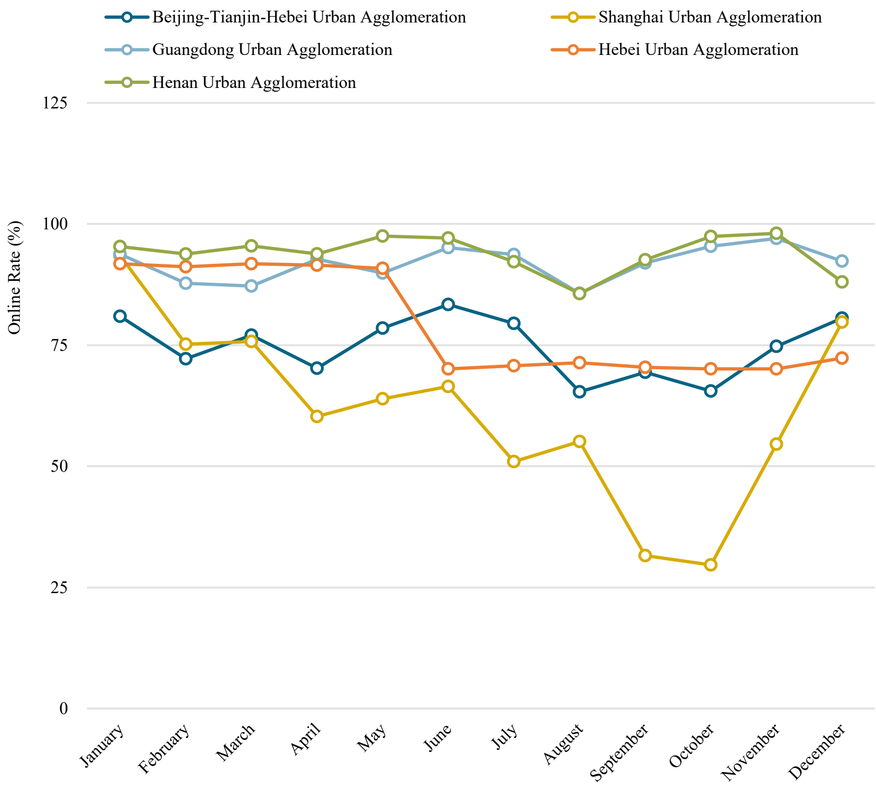


Fig. 7.29 Monthly online rate of FCEV buses in each demonstration urban agglomeration in 2021

of specialized vehicles was slightly lower than that of buses. From the perspective of specific demonstration urban agglomerations, since new FCEVs were introduced in Hebei in 2021, the vehicle operation effect was good, and the average monthly online rate of FCEVs was 93.7%. The average monthly online rates of the Beijing-Tianjin-Hebei Urban Agglomeration, Shanghai Urban Agglomeration, and Guangdong Urban Agglomeration were 67.6%, 60.0%, and 59.1%, respectively (Fig. 7.30).

Table 7.7 Average monthly online rate of FCEV special vehicles in each demonstration urban agglomeration in 2021

	Beijing-Tianjin-Hebei urban agglomeration	Shanghai urban agglomeration	Guangdong urban agglomeration	Hebei urban agglomeration
Average monthly online rate (%)	67.6	60.0	59.1	93.7

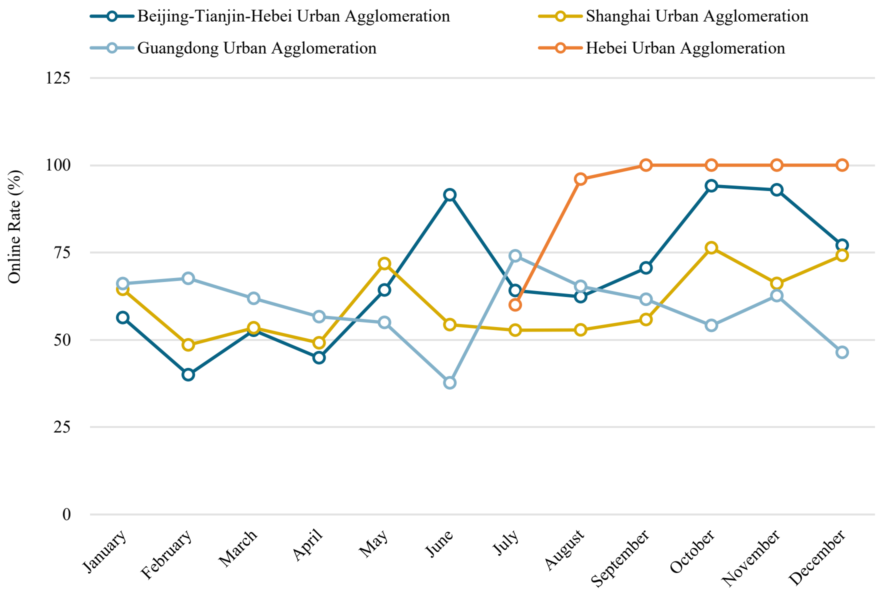


Fig. 7.30 Monthly online rate of FCEV special vehicles in each demonstration urban agglomeration in 2021

2. **Cumulative mileage and cumulative travel duration**

As of December 31, 2021, the cumulative mileage of FCEVs in each demonstration urban agglomeration totaled 142.602 million km, of which the cumulative mileage of FCEVs in Guangdong Urban Agglomeration was the maximum, i.e., 76.069 million km; The cumulative mileage of Beijing-Tianjin-Hebei Urban Agglomeration and Shanghai Urban Agglomeration was 10.912 million km and 21.785 million km respectively (Fig. 7.31).

From the cumulative mileage of classified vehicles in different demonstration urban agglomerations, it can be seen that due to differences in vehicle promotion structures and online rates, there were significant differences in the cumulative mileage of classified vehicles in different demonstration urban agglomerations, among which, the cumulative mileage of FCEV buses in Beijing-Tianjin-Hebei

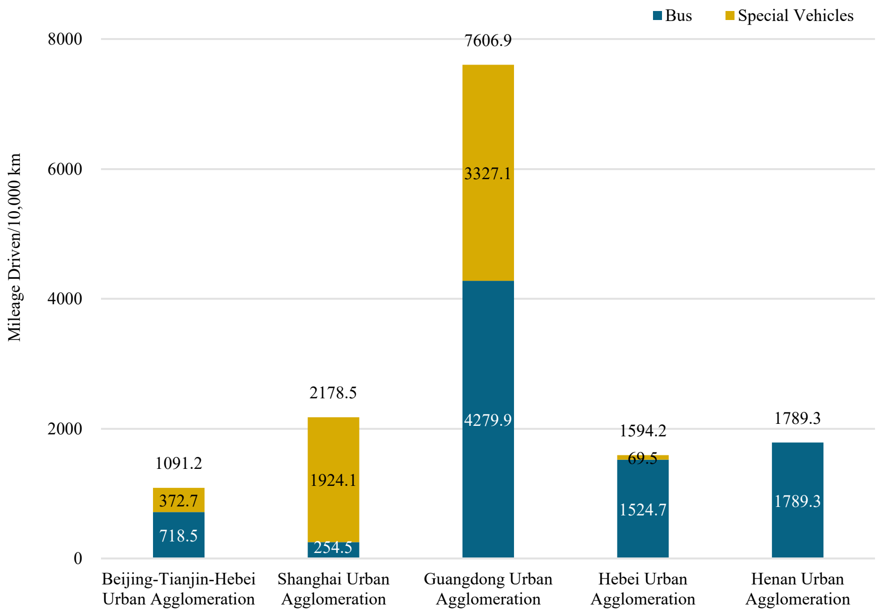


Fig. 7.31 Cumulative mileage of FCEVs in each demonstration urban agglomeration

Urban Agglomeration, Guangdong Urban Agglomeration, Hebei Urban Agglomeration, and Henan Urban Agglomeration was higher than that of special vehicles. In comparison, the cumulative mileage of specialized vehicles in Shanghai Urban Agglomeration was higher than that of buses.

As of December 31, 2021, the cumulative travel duration of FCEVs in each demonstration urban agglomeration totaled 5.333 million h, of which the cumulative travel duration of FCEVs in Guangdong Urban Agglomeration was the maximum, i.e., 2.584 million h, and the cumulative travel durations of Beijing-Tianjin-Hebei Urban Agglomeration and Shanghai Urban Agglomeration were 356,000 h and 744,000 h respectively (Fig. 7.32).

From the cumulative travel duration of classified vehicles in different demonstration urban agglomerations, the cumulative travel duration of FCEV buses in Beijing-Tianjin-Hebei Urban Agglomeration, Guangdong Urban Agglomeration, Hebei Urban Agglomeration, and Henan Urban Agglomeration was higher than that of special vehicles. In comparison, the cumulative travel duration of FCEV specialized vehicles in Shanghai Urban Agglomeration was higher than that of buses.

3. **Daily mileage and travel duration**

- **Daily mileage and travel duration**

The average daily single-trip mileage and average daily single-trip travel duration of FCEV buses in different urban agglomerations in 2021 are shown in Table 7.8. The

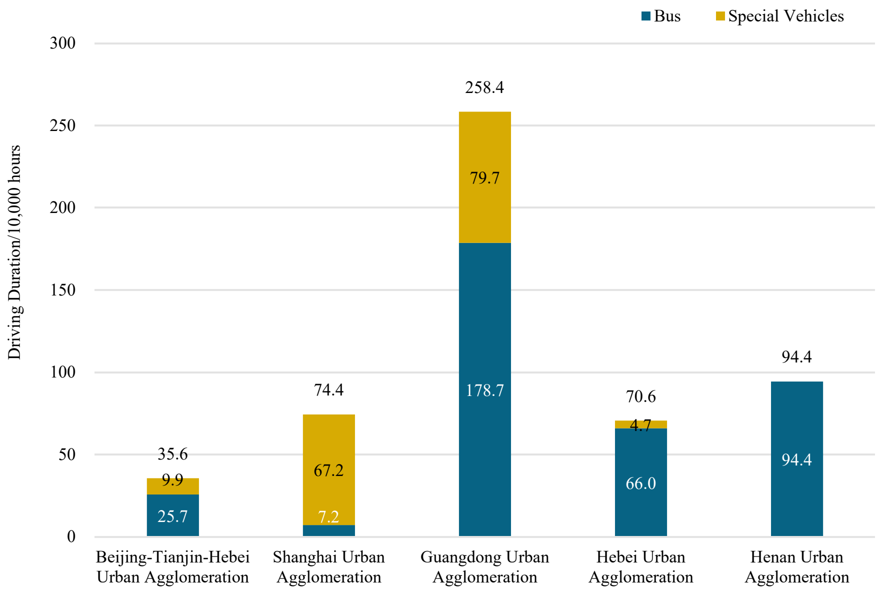


Fig. 7.32 Cumulative travel duration of FCEVs in each demonstration urban agglomeration

operating efficiency of FCEV buses in Shanghai demonstration urban agglomeration was the maximum, and the average daily mileage of FCEV buses in Guangdong Urban Agglomeration was the maximum, i.e., 184.2 km; The FCEV special vehicles (Table 7.9) in Guangdong demonstration urban agglomeration have the maximum operating efficiency and the maximum average daily mileage of 277.8 km.

The average daily single-trip mileage of FCEV special vehicles in each demonstration urban agglomeration was higher than that of EV special vehicles, and FCEV special vehicles have obvious advantages of long mileage.

- **Daily mileage distribution**

The distribution of daily single-trip mileage of vehicles in each demonstration urban agglomeration in 2021 is shown in Fig. 7.33. The daily mileage of FCEV buses in Beijing-Tianjin-Hebei Urban Agglomeration and Shanghai Urban Agglomeration was within 120 km; The average daily mileage of Guangdong Urban Agglomeration, Hebei Urban Agglomeration, and Henan Urban Agglomeration was high, of which the daily mileage of FCEV buses in Guangdong Urban Agglomeration was 160 ~ 280 km, while that in Hebei Urban Agglomeration was 120 ~ 200 km.

The distribution of the daily mileage of FCEV special vehicles in each demonstration urban agglomeration in 2021 is shown in Fig. 7.34. The daily mileage of FCEV special vehicles in Beijing-Tianjin-Hebei Urban Agglomeration was short; The daily mileage of FCEV special vehicles in Hebei Urban Agglomeration was 80 ~ 200 km, accounting for 66.6%. Compared with Beijing-Tianjin-Hebei Urban Agglomeration, the daily mileage of vehicles in Hebei Urban Agglomeration shows

Table 7.8 Comparison of the daily operation of FCEV buses and EV buses in demonstration cities

Vehicle type	Specific parameter	Beijing-Tianjin-Hebei urban agglomeration	Shanghai urban agglomeration	Guangdong urban agglomeration	Henan urban agglomeration	Hebei urban agglomeration
FCEV bus	Average daily single-trip mileage/km	112.1	113.4	184.2	139.8	155.0
	Average daily single-trip travel duration/h	4.2	2.5	7.4	7.3	9.2
EV bus	Average daily single-trip mileage/km	135.2	159.8	176.3	150.6	156.3
	Average daily single-trip travel duration/h	7.0	9.3	9.6	7.6	8.8

Table 7.9 Comparison of the daily operation of FCEV special vehicles and EV special vehicles in demonstration cities

Vehicle type	Specific parameter	Beijing-Tianjin-Hebei urban agglomeration	Shanghai urban agglomeration	Guangdong urban agglomeration	Henan urban agglomeration
FCEV special vehicle	Average daily single-trip mileage/km	185.5	175.2	277.8	146.5
	Average daily single-trip travel duration/h	5.2	6.9	6.1	9.8
EV special vehicle	Average daily single-trip mileage/km	97.0	113.1	121.5	85.2
	Average daily single-trip travel duration/h	6.3	7.0	7.2	5.5

a trend of high mileage; The distribution of vehicles with a mileage range of over 400 km in Guangdong Urban Agglomeration was relatively high, accounting for 28.8%.

- **Daily travel duration distribution**

The distribution of daily single-trip travel duration of FCEV buses in each demonstration urban agglomeration is shown in Fig. 7.35. The distribution of daily travel duration of FCEV buses in Shanghai Urban Agglomeration was 0–2 h, accounting for 56.9%; The operation effect of FCEV buses in Henan Urban Agglomeration was good, but the travel duration was more than 10 h, accounting for 42.6%.

The distribution of daily single-trip travel duration of FCEV special vehicles in each demonstration urban agglomeration is shown in Fig. 7.36. The distribution of daily single-trip travel duration of FCEV special vehicles in Hebei Urban Agglomeration was concentrated in the high travel duration segment, accounting for 46.9%; The distribution of vehicles with different daily single-trip travel durations in other demonstration urban agglomerations was relatively uniform.

3. **Average mileage between two hydrogen refueling cycles**

The average mileage between two energy supplement cycles of FCEV buses and special vehicles in the demonstration urban agglomerations in 2021 is shown in

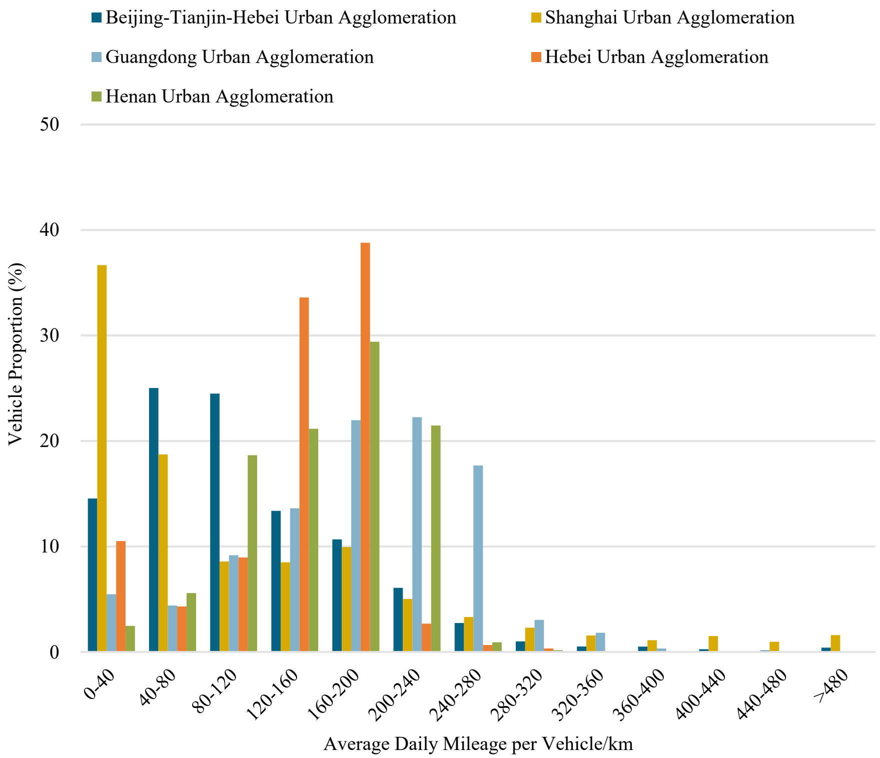


Fig. 7.33 Distribution of daily mileage of FCEV buses in each demonstration urban agglomeration in 2021

Figs. 7.37 and 7.38. The mileage between two hydrogen refueling cycles of FCEVs in each demonstration urban agglomeration was significantly higher than that of EVs. The mileage between two hydrogen refueling cycles of FCEV buses in Henan Urban Agglomeration was the maximum, i.e., 423.1 km, while the mileage between two hydrogen refueling cycles of FCEV buses in other demonstration urban agglomerations exceeded 220 km. The mileage between two hydrogen refueling cycles of FCEV special vehicles in Beijing-Tianjin-Hebei Urban Agglomeration and Guangdong Urban Agglomeration exceeded 260 km. The mileages between two hydrogen refueling cycles of FCEV special vehicles in Shanghai Urban Agglomeration and Hebei Urban Agglomeration were 194.6 and 171.3 km, significantly higher than the mileage between two hydrogen refueling cycles of EVs in the same demonstration urban agglomeration.

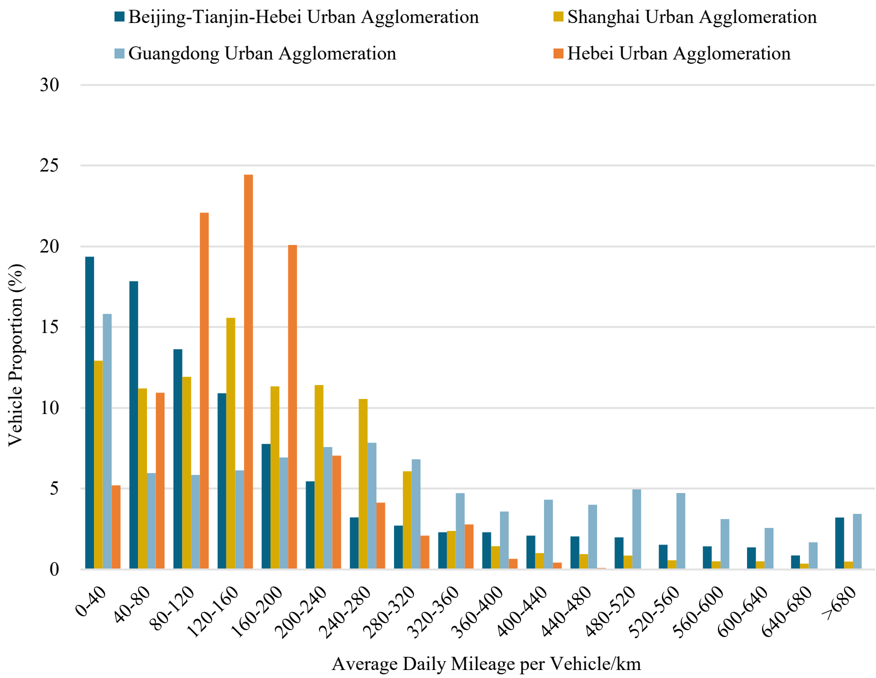


Fig. 7.34 Distribution of daily mileage of FCEV special vehicles in each demonstration urban agglomeration in 2021

7.3.3 Hydrogen Refueling Characteristics

1. **Daily single-trip hydrogen refueling frequency distribution**

In 2021, the FCEV buses in Beijing-Tianjin-Hebei Urban Agglomeration, Guangdong Urban Agglomeration, Hebei Urban Agglomeration, and Henan Urban Agglomeration with their daily hydrogen refueling times $\leq$ 1 accounted for more than 50%, of which those with their daily hydrogen refueling times $\leq$ 1 accounted for 85.6%; The proportion of FCEV buses in Shanghai Urban Agglomeration and Guangdong Urban Agglomeration with their daily hydrogen refueling times > 1 was significantly higher than that of FCEV buses in other demonstration urban agglomerations due to the following factors. On the one hand, due to the high cost of the on-board hydrogen storage system, or the poor hydrogen storage density and heavy-weight hydrogen cylinder, the single-trip hydrogen capacity is limited; On the other hand, the number of hydrogen charging stations under construction and operation is relatively small, and some vehicles, such as those in Guangdong Urban Agglomeration, have a long daily mileage. In order to alleviate mileage anxiety, hydrogen should be charged for vehicles (Fig. 7.39).

Figure 7.40 shows that the proportion of FCEV special vehicles in Guangdong Urban Agglomeration with daily hydrogen refueling times more than 1 was relatively

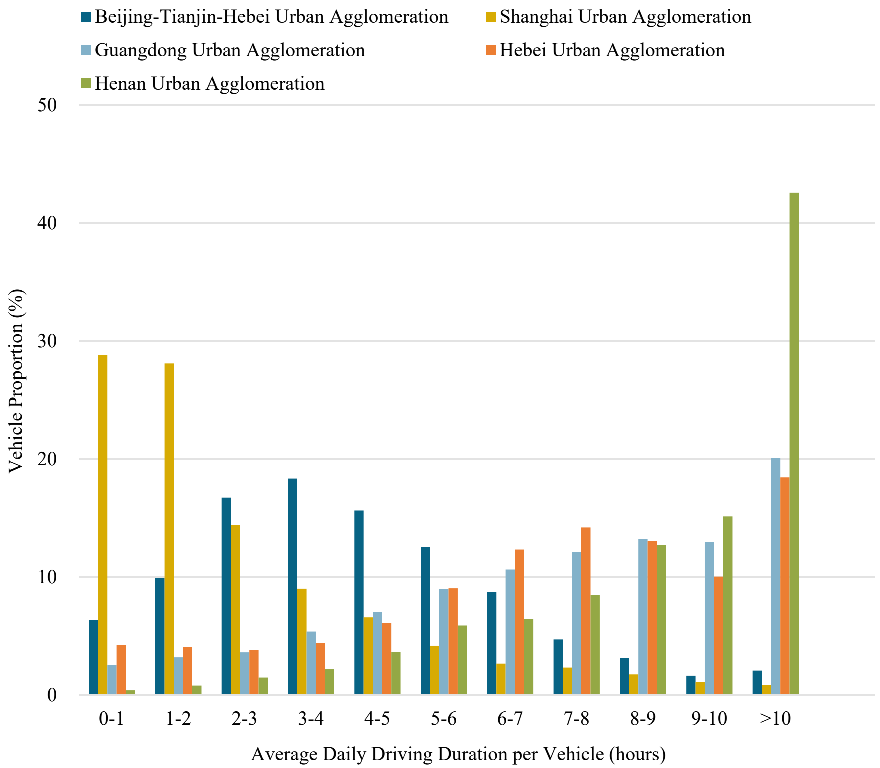


Fig. 7.35 Distribution of daily travel duration of FCEV buses in each demonstration urban agglomeration in 2021

high, up to 71.9%, and FCEV special vehicles in Guangdong Urban Agglomeration had relatively high daily mileage and hydrogen was charged for such vehicles intermittently; the proportion of FCEV special vehicles in Beijing-Tianjin-Hebei Urban Agglomeration with their daily hydrogen refueling times ≤ 1 was relatively high, up to 51.6%.

2. **Average hydrogen charging duration**

The average hydrogen charging duration of all types of FCEVs in each demonstration urban agglomeration in 2021 is shown in Fig. 7.41. The average hydrogen charging duration of FCEV buses in Beijing-Tianjin-Hebei Urban Agglomeration is 8.2 min which is lower than that of special vehicles; The average hydrogen charging duration of FCEV special vehicles in Shanghai Urban Agglomeration, Guangdong Urban Agglomeration, and Hebei Urban Agglomeration is lower than that of FCEV buses.

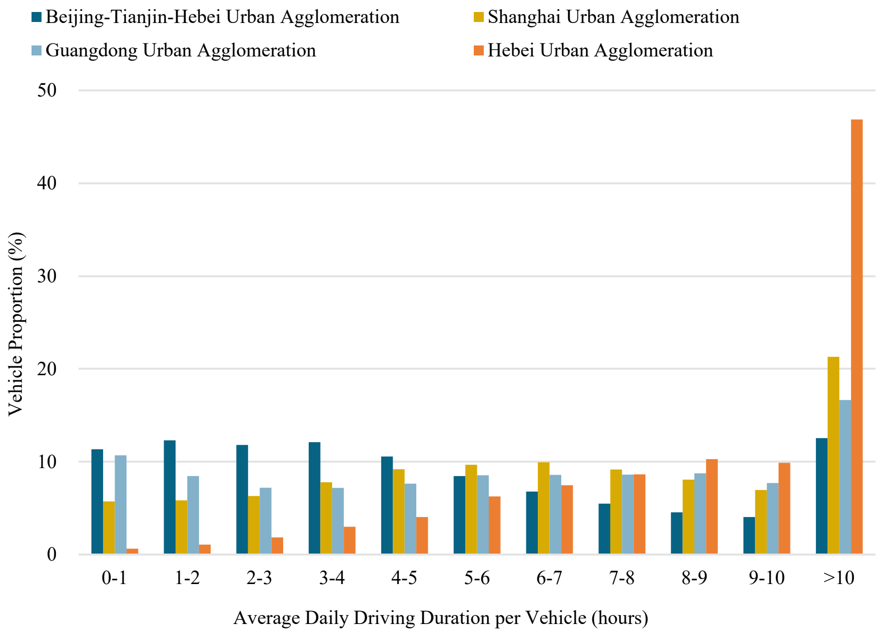


Fig. 7.36 Distribution of daily travel duration of FCEV special vehicles in each demonstration urban agglomeration in 2021

7.4 Summary

An ideal choice for large-scale and deep decarbonization in the transportation field is FCEVs because they are expected to drive upstream and downstream industrial resources and an important strategic industry to realize regional interconnected development. As the national and local governments continuously increase support and guidance for the hydrogen energy and fuel cell industry, the demonstration, promotion, and application of the hydrogen fuel cell industry in various regions have achieved remarkable results. In combination with the access and operation characteristics of FCEVs on the national regulatory platform, the following conclusions were drawn in this paper.

The FCEV industry has achieved remarkable promotion results throughout the country, and the vehicle promotion scale and application scenarios reached a new level in 2021. From the perspective of the promotion scale of FCEVs nationwide, the cumulative number of FCEVs promoted exceeded 8900, with a sales growth of 34.8% compared with 2020; Regarding FCEV promotion application scenarios, FCEVs are gradually expanding from a single scenario to a diversified application scenario. As of December 31, 2020, the access volume of FCEVs to the National Monitoring and Management Platform has exceeded 7737, of which, special vehicles have been accessed from a single scenario of logistics vehicles in 2020 to multiple

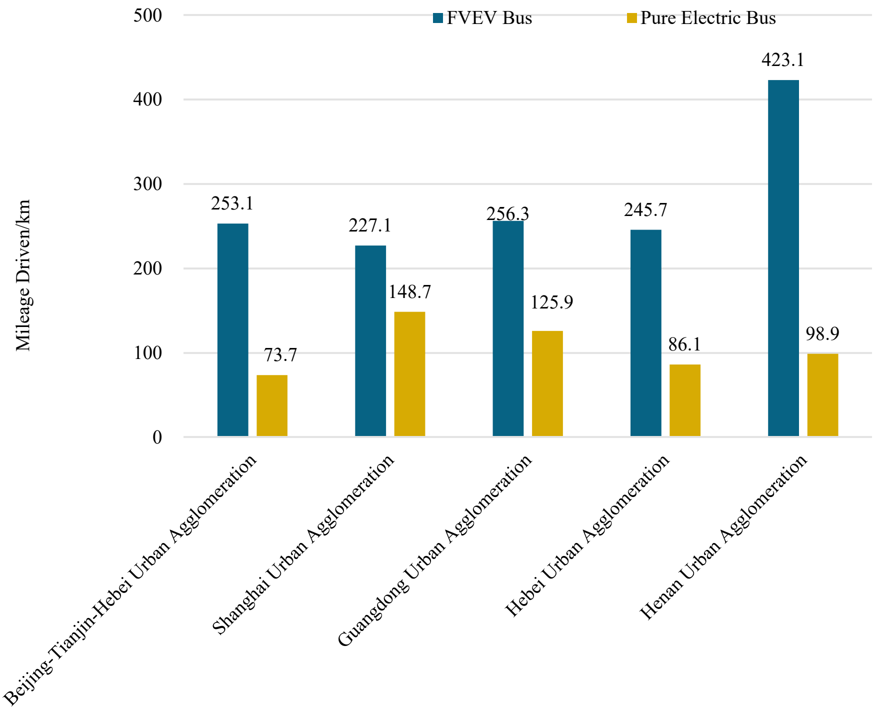


Fig. 7.37 Mileage between two energy supplement cycles of FCEV buses in demonstration urban agglomerations in 2021

application scenarios such as special logistics vehicles, special engineering vehicles, and special environmental sanitation vehicles, with diversified application scenarios.

From the perspective of vehicle operation characteristics, FCEVs have obvious advantages in mileage and energy supply efficiency, and complementary development with EVs in more application scenarios should be further explored. The mileage between two hydrogen refueling cycles of FCEVs is significantly higher than that of EVs between two battery charging cycles in the five demonstration urban agglomerations. FCEVs have significant advantages in long-term mileage and energy supply efficiency. Regarding vehicle hydrogen charging characteristics, the average hydrogen charging duration of FCEVs in Beijing-Tianjin-Hebei Urban Agglomeration, Shanghai Urban Agglomeration, and Guangdong Urban Agglomeration is about 10 min, and the energy supply duration is equivalent to that of fuel vehicles. In the future, FCEVs are expected to be promoted and applied in long-distance operating vehicles such as heavy-duty trucks and buses.

Since the hydrogen charging frequency of some FCEVs is still high, the pace of construction of hydrogen charging stations will be expedited, and the key technologies of the hydrogen storage system will be strengthened to improve the driving range of FCEVs. Regarding the hydrogen charging behavior characteristics

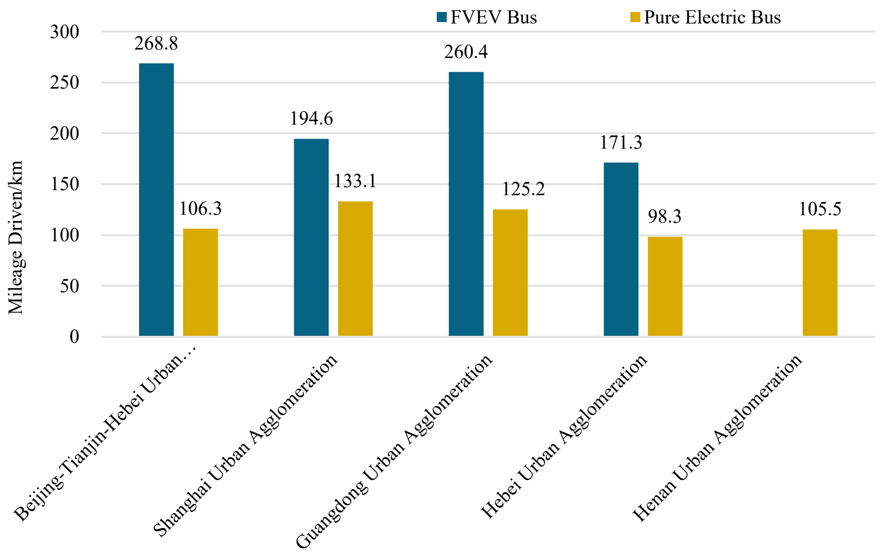


Fig. 7.38 Mileage between two energy supplement cycles of FCEV special vehicles in demonstration urban agglomerations in 2021

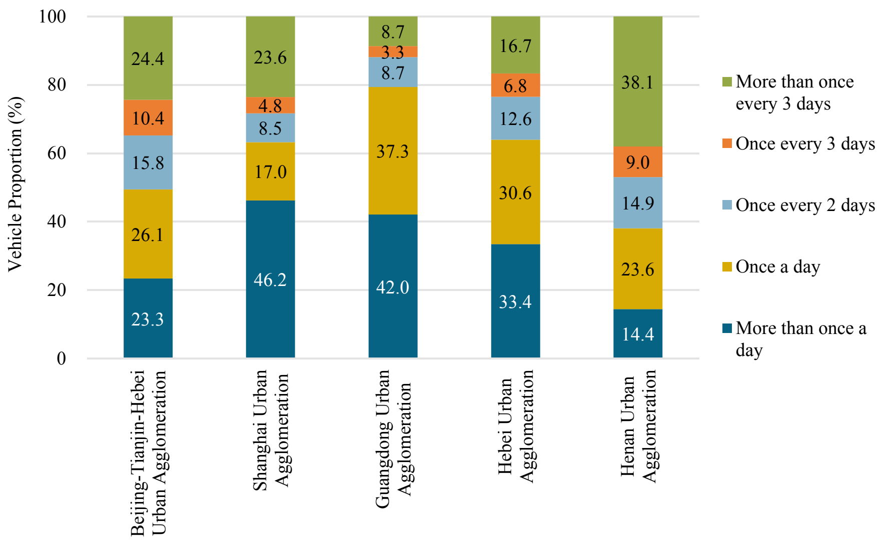


Fig. 7.39 Single-trip hydrogen refueling frequency distribution of FCEV buses in each demonstration urban agglomeration in 2021

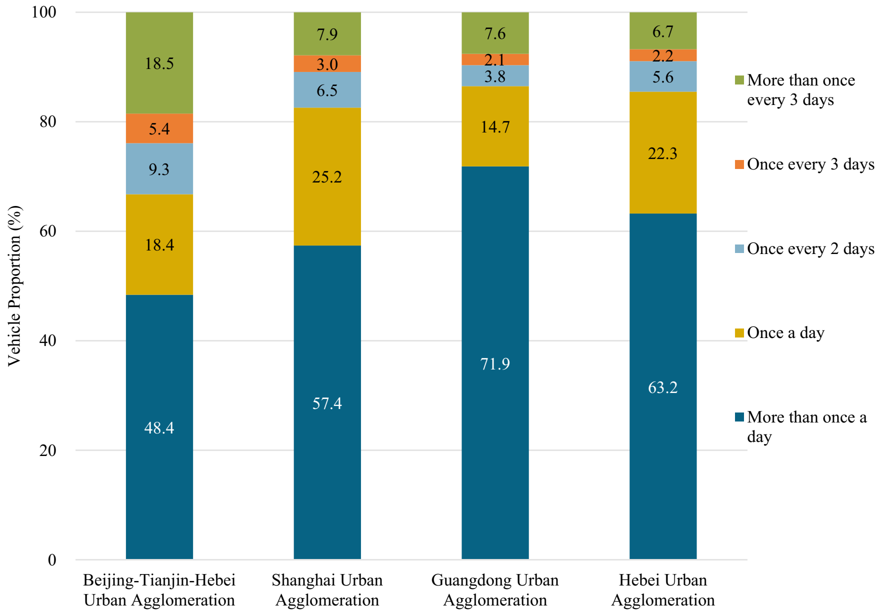


Fig. 7.40 Single-trip hydrogen refueling frequency distribution of FCEV special vehicles in each demonstration urban agglomeration in 2021

of FCEVs, some FCEVs' daily hydrogen charging frequency is still high. On the one hand, the number of hydrogen charging stations under construction is relatively small. In order to alleviate mileage anxiety, hydrogen should be charged for FCEVs; On the other hand, the pressure of current mainstream on-board hydrogen storage systems in China is 35 MPa, and the onboard hydrogen cylinder has high cost and low hydrogen storage density. In the future, on the one hand, it is necessary to strengthen the progress of hydrogen charging infrastructure construction; On the other hand, we will accelerate the research on hydrogen storage systems, accelerate the development towards III and IV cylinders with light weight, large volume, higher safety, and lower-cost, and promote the use of alternative composite materials to achieve lightweight hydrogen storage systems and improve hydrogen storage density.

Combining local industries and advantages, the promotion effects of the fuel cell industry in each demonstration urban agglomeration have their characteristics. With the gradual improvement of the hydrogen energy industry chain, the demonstration urban agglomeration is expected to take the lead in achieving large-scale pilot applications during the 14th Five-Year Plan period, and the industry will experience rapid growth. Beijing-Tianjin-Hebei Urban Agglomeration and Hebei Urban Agglomeration, taking advantage of the opportunity of 2022 Beijing Winter Olympics and the policy guidance of the Blue Sky Protection Campaign, and relying on the local industrial base and scientific research resources,

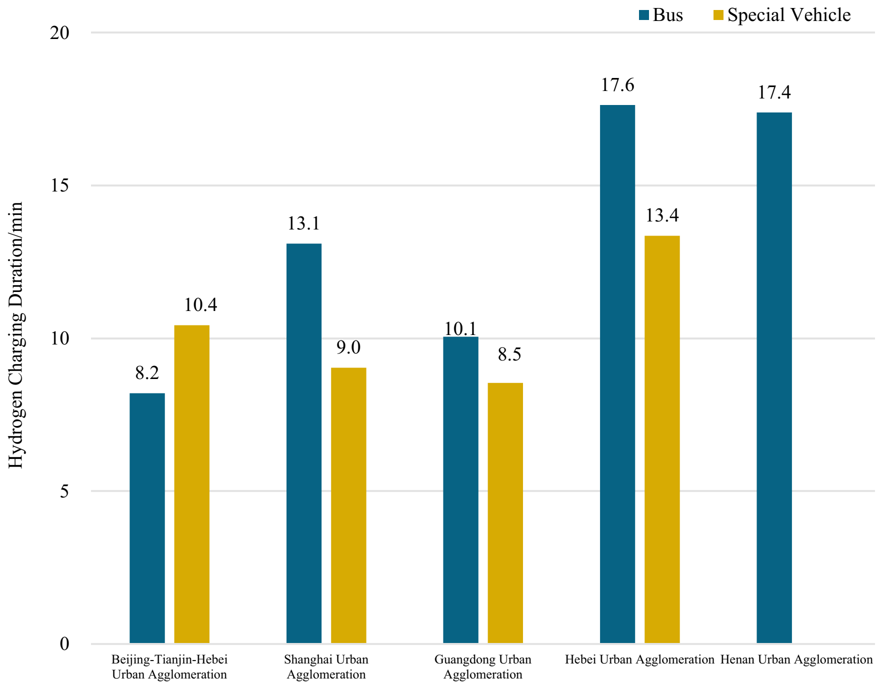


Fig. 7.41 Average hydrogen charging duration of FCEVs in each demonstration urban agglomeration in 2021

fully realize the close cooperation among industry, university, and research, promote the acceleration of industrialization process, and achieve remarkable promotion effects of FCEV buses; Taking Shanghai as the leading city, Shanghai Urban Agglomeration radiates Suzhou, Nantong and other surrounding developed cities, giving full play to the initiative of upstream and downstream enterprises in the industrial chain, and is expected to become a rapidly maturing region of the national hydrogen fuel cell industry chain; The number of promoted FCEVs in Guangdong Urban Agglomeration is significantly better than that in other demonstration urban agglomerations. Based on the data from the National Monitoring and Management Platform, by the end of 2021, there had been 2536 FCEVs in Guangdong Urban Agglomeration, accounting for 32.8% of the total FCEVs in China. Guangdong Urban Agglomeration has abundant enterprise resources, including Foshan Feichi Automobile, Changjiang Automobile, and Dongfeng Commercial Vehicle, and core component manufacturers include Sinosynergy, Ballard Power Systems, and Broad Ocean Motor. By taking Foshan as the core and fully leveraging its industrial resource advantages, Guangdong Urban Agglomeration radiates Yunfu, Guangzhou, Shenzhen, Zhongshan, and other places, achieving cross-regional industrial coordinated development and gradually forming a development demonstration area with multiple application scenario for FCEV buses and logistics vehicles in the Guangdong–Hong Kong–Macao Greater Bay Area; Henan Urban Agglomeration has obvious advantages in the fuel cell industry. Yutong Group provides a better carrier for developing the Hydrogen fuel cell industry in Henan Urban Agglomeration.

Chapter 8
Parallel Hybrid Electric Vehicles

As one of the most effective low-carbon solutions in the automotive industry, parallel hybrid electric vehicles (PHEVs) play an important role in promoting energy conservation and carbon reduction in the automotive industry in the short to medium term during its transformation and development. PHEVs can meet consumers' diverse application scenarios and usage needs, and the market demand has shown a rapid growth trend since 2021. With PHEVs as a research perspective, by comparing the industry policies and market overview of PHEVs at the national and local levels and deeply exploring the operation conditions of PHEVs and typical urban vehicle operation characteristics, this chapter summarizes vehicle operation rules and user usage habits to promote the technological progress and healthy development of PHEV products.

8.1 Development Status of PHEV Industry

8.1.1 Industrial Support Policy Tightening at the National Level

Compared to traditional fuel vehicles, PHEV products achieve a dual balance between power and economic performance and can meet the diverse usage needs of consumers. From a market perspective, PHEV products have a certain degree of market competitiveness, and the industrial support policies for promoting PHEVs at the national level are gradually tightening.

1. **Ease the intensity and pace of subsidy reduction, and continue the fiscal subsidy policy until the end of 2022**

In order to ease the intensity and pace of subsidy reduction, the subsidy policy, originally scheduled to expire at the end of 2020, has been reasonably extended until the

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2022)*,
https://doi.org/10.1007/978-981-99-6411-6_8

end of 2022. On April 23, 2021, the Ministry of Finance, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, and the National Development and Reform Commission of PRC jointly issued the *Notice on Improving the Financial Subsidy Policy for the Promotion and Application of NEVs* (CJ [2020] No. 86), intending to maintain support for the NEV industry, implementing precise policies, and promoting high-quality development of the industry. From 2020 to 2022, the subsidy funds were reduced by 10, 20, and 30% from the previous year (Table 8.1). In order to speed up the electrification of vehicles in public transport and other fields, the subsidy funds for conforming vehicles for urban public transport, road passenger transport, taxi service (including E-taxi service), environmental sanitation, urban logistics distribution, postal express, civil aviation airports and the official business of party and government agencies didn't decline in 2020. The subsidy funds were reduced by 10% and 20% respectively from the previous year. In principle, up to 2 million vehicles will be subsidized annually; In addition, we should underpin outstanding enterprises, optimize technical thresholds appropriately, and promote advantageous enterprises to become bigger and stronger.

On December 31, 2020, and December 31, 2021, the four ministries and commissions jointly issued the *Notice on Further Improving the Financial Subsidy Policy for the Promotion and Application of NEVs* (CJ [2020] No. 593) and the *Notice on the Subsidy Policy for the Promotion and Application of NEVs in 2022* (CJ [2021] No. 466), both of which stipulate that under the condition that $R \geq 50$ (NEDC condition)/$R \geq 43$ (WLTC condition), the subsidy amount for PHEV passenger cars will continue to decline.

2. **Encourage the purchase of NEVs and exempt them from vehicle purchase taxes for consecutive years**

In order to support the development of the NEV industry and promote consumption in the NEV market, relevant national ministries and commissions successively issued policy documents on exempting NEV purchase taxes. Such documents include the *Announcement on Exemption of New Energy Vehicle Purchase Tax* (Announcement No. 53, 2014 of the Ministry of Finance, the State Taxation Administration, the Ministry of Industry and Information Technology) issued by the Ministry of Finance, the State Taxation Administration, and the Ministry of Industry and Information Technology on August 1, 2014, with its valid period from September 1, 2014 to December 31, 2017, and the *Announcement on Exemption of New Energy Vehicle Purchase Tax* (2017 No. 172) jointly issued by the Ministry of Finance, the State

Table 8.1 Subsidy program for PHEV passenger cars in 2021 and 2022

Year	Non-public field		Public field	
	Reduction percentage (%)	Subsidy amount (10,000 yuan)	Reduction percentage (%)	Subsidy amount (10,000 yuan)
2021	20	0.68	10	0.9
2022	30	0.48	20	0.72

Taxation Administration, the Ministry of Industry and Information Technology and the Ministry of Science and Technology on December 26, 2017. New energy vehicles purchased were exempt from vehicle purchase taxes from January 1, 2018, to December 31, 2020.

On April 16, 2020, the Ministry of Finance, the State Taxation Administration, and the Ministry of Industry and Information Technology of China jointly issued the *Announcement on the Relevant Policies for the Exemption of New Energy Vehicle Purchase Tax* (Announcement 2020 No. 21) (referred to as the "Announcement"). The Announcement stipulates that from January 1, 2021, to December 31, 2022, new energy vehicles purchased will be exempt from vehicle purchase taxes. NEVs exempt from vehicle purchase taxes refer to EVs, PHEVs (including EREVs), and FCEVs. New energy vehicles exempt from vehicle purchase taxes shall be managed by releasing the *Catalogue of New Energy Vehicle Models Exempted from Vehicle Purchase Taxes* by the Ministry of Industry and Information Technology and the State Taxation Administration.

3. **Increased investment threshold for the PHEV industry**

Before January 10, 2019, investment projects in the PHEV industry fell into the category of new energy vehicles.

On January 6, 2017, according to the Decree of the Ministry of Industry and Information Technology of the People's Republic of China (No. 39), the *Regulations on New Energy Vehicle Manufacturing Enterprises and Product Access Management* were reviewed and approved on the 26th Ministerial Meeting of the Ministry of Industry and Information Technology on October 20, 2016. They will be implemented as of July 1, 2017. EVs and PHEVs are new energy vehicles, and the Ministry of Industry and Information Technology is responsible for implementing the supervision and management of new energy vehicle manufacturers and product access.

The Provisions for the Administration of Investment in the Automotive Industry of NDRC incorporate PHEV industry investment projects into the investment scope of fuel vehicles.

On December 18, 2018, the National Development and Reform Commission issued the *Provisions for the Administration of Investment in the Automotive Industry* (referred to as the "Provisions"), which was officially implemented on January 10, 2019. These Provisions explicitly state that the investment projects for automobiles are divided into two types based on the powertrain: fuel vehicles and electric vehicles, which means that all future automobile investment projects must be classified into these two types (Fig. 8.1). FCEVs, EVs, and EREVs are included in electric vehicle investment projects, while traditional fuel vehicles, hybrid electric vehicles, and PHEVs are included in the investment scope of fuel vehicles. This provision means that only enterprises with fuel vehicle production qualifications can produce PHEVs, while enterprises with electric vehicle production qualifications (such as new vehicle manufacturers) can only produce electric vehicles rather than PHEVs.

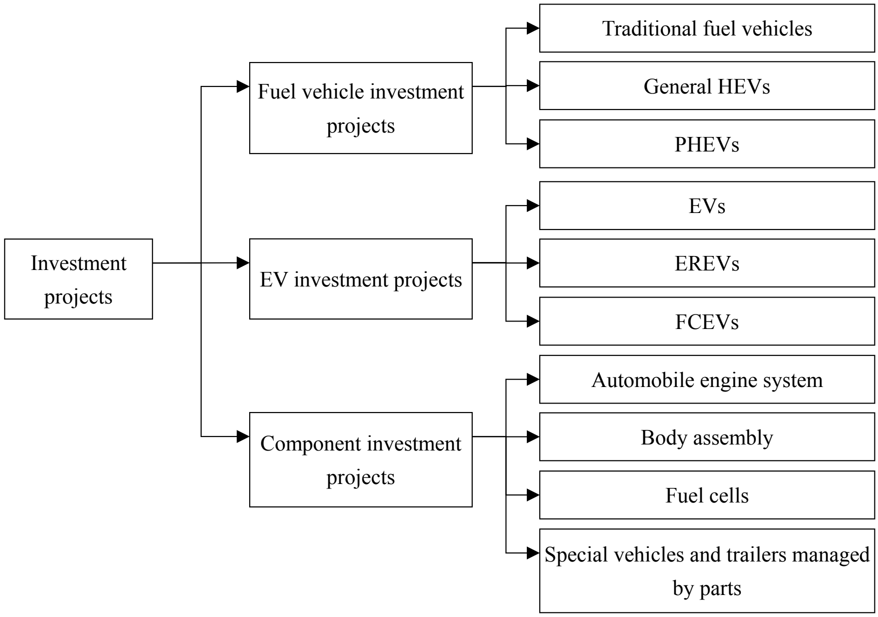


Fig. 8.1 Classification of investment projects in the Provisions for the *Administration of Investment in the Automotive Industry* (2018)

The *Provisions* issued on December 18, 2018, regulate the direction of production capacity investment and do not conflict with the current national support policies for new energy vehicles.

8.1.2 Differentiation of Support Policies at the Local Government Level

The policies for promoting PHEVs in key cities nationwide have significant differences. Beijing and Shanghai are gradually tightening their regulations on PHEVs, while Guangzhou and Shenzhen have relatively loose policies on PHEVs, occupying the quota of new energy vehicles.

1. **Beijing: PHEVs do not enjoy policies such as exemption from traffic restrictions**

In Beijing, PHEVs occupy fuel licenses and do not enjoy the "no restrictions" preferential policy.

According to the *Implementation Rules of the Interim Regulations on the Control of the Quantity of Small Passenger Cars in Beijing* (revised in 2017), new energy small buses refer to small electric buses. The quotas of small new energy buses are allocated through waiting mode. After selling or scrapping small new energy buses, entities or individuals can apply for updating the quotas of small new energy buses. According to the regulations on vehicle management in Beijing, there is a difference between JAD and JAF in the green license plates for new energy vehicles. Users can apply for green license plates starting from JAF for PHEVs (including EREVs) but do not enjoy the right-of-way privilege.

2. **Shanghai: from 2023, PHEVs will withdraw from the free license plate offer**

In February 2021, the Shanghai Municipal Government issued the *Regulations on Encouraging the Purchase and Use of New Energy Vehicles in Shanghai* (referred to as the "Regulations"). The NEVs referred to in the Regulations refer to electric vehicles, PHEVs (including EREVs), and FCEVs that have been included in the national *Catalog of Recommended Models for Promotion and Application of New Energy Vehicles* or other relevant model catalogs, sold and used in the city, and comply with the management regulations of this city. From January 1, 2023, dedicated license plates will no longer be issued for consumers who purchase PHEVs (including EREVs). Consumers who purchase NEVs for non-business purposes and have not registered using the city's dedicated license quota under their username will be granted free dedicated licenses under the principle of controlling the total number of non-business buses in this city. Consumers who purchase PHEVs (including EREVs) should apply for a dedicated license plate and also meet the following requirements: a charging facility that meets the requirements of intelligent technology and safety standards has been provided in this city; There is no proof of nonbusiness bus quota under the personal username, and there are no motor vehicles (excluding motorcycles) registered with non-business bus quota.

From the perspective of policy trends, the Shanghai government encourages consumers who do not own cars to purchase any type of new energy vehicle and can enjoy the free green license plate policy. From 2023, PHEVs (including EREVs) and small electric buses will withdraw from the list of free license plates.

3. **Guangzhou: enjoy the green license plate policy for PHEVs**

In July 2018, the Guangzhou Municipal Government issued the Regulations on the Control of the Total Quantity of Small and Medium-sized Buses in Guangzhou. NEVs refer to small and medium-sized Buses (including EVs, PHEVs, and FCEVs) listed in the *Catalog of Recommended Models for Promotion and Application of New Energy Vehicles* issued by the Ministry of Industry and Information Technology, as well as imported new energy small and medium-sized buses marked by relevant national departments. Units and individuals who need to register new energy vehicles can directly apply for their quotas based on vehicle information.

4. **Shenzhen: enjoy the green license plate policy for PHEVs**

In July 2019, the Shenzhen Municipal Government issued the *Rules for the Control and Management of Increased Cars in Shenzhen.* New energy vehicles refer to electric cars, PHEVs (including EREV), and fuel cell cars that comply with the automotive product announcement catalog of the Ministry of Industry and Information Technology of the People's Republic of China and original imported electric cars licensed by relevant national regulations. The incremental quotas are allocated through lottery, bidding, or directly applying according to regulations. There is no limit on the incremental quotas for hybrid and electric cars, which are directly allocated after application and qualification review.

On December 14, 2021, the Transport Bureau of Shenzhen Municipality proposed matters related to adjusting the incremental quotas of new energy cars. According to the *Notice of the General Office of the People's Government of Guangdong Province on Printing and Distributing Several Policies and Measures to Promote Urban Consumption* (YFB [2021] No. 36), non-Shenzhen registered residence persons with valid Shenzhen residence permits and overseas Chinese and residents of Hong Kong, Macao, and Taiwan with valid identity certificates who have gone through temporary accommodation registration for foreigners following the provisions of the municipal public security organ, as well as foreigners applying for visas or residence permits in this city, are not required to make payments (excluding supplementary payments) of basic medical insurance in this city for more than 24 consecutive months for the incremental quotas of new energy cars (including PHEVs and BEVs).

8.2 Promotion of PHEVs

8.2.1 Current Situation of the PHEV Market

PHEVs are gradually shifting from a supply side drive to a dual supply and demand drive, and the domestic market maintained a high growth demand trend in 2021.

PHEVs have shown a fluctuating growth trend in the past five years. After selling 267,000 PHEVs in 2018, the overall decline in the new energy vehicle market in 2019 resulted in a significant decrease in market sales compared with 2018. Since 2021, new models supplied by vehicle manufacturers have been diversified and abundant, such as BYD Qin, BYD Song PLUS, Li ONE, BYD Tang/Han, and BMW 5 Series. On the demand-side level, due to consumer demand for upgrades in fuel consumption, mileage, and other aspects, the sales of PHEVs in the domestic market increased from 79,000 to 603,000 from 2015 to 2021, the demand has increased by 7.6 times, and the market demand shows a rapid growth trend (Fig. 8.2).

Since 2021, with the successive launch of the new generation of domestic PHEV benchmarking products, some domestic proprietary brand PHEV products have been successively launched on the market, and some product functions have reached or exceeded the level of joint venture products, providing a variety of product specifications for the domestic consumer market, which is more in line with the actual needs of consumers in the domestic market. The TOP5 PHEV models in China in 2021, including the Qin PLUS DM-i, Li ONE, Song Pro DM, Tang PHEV, and Han

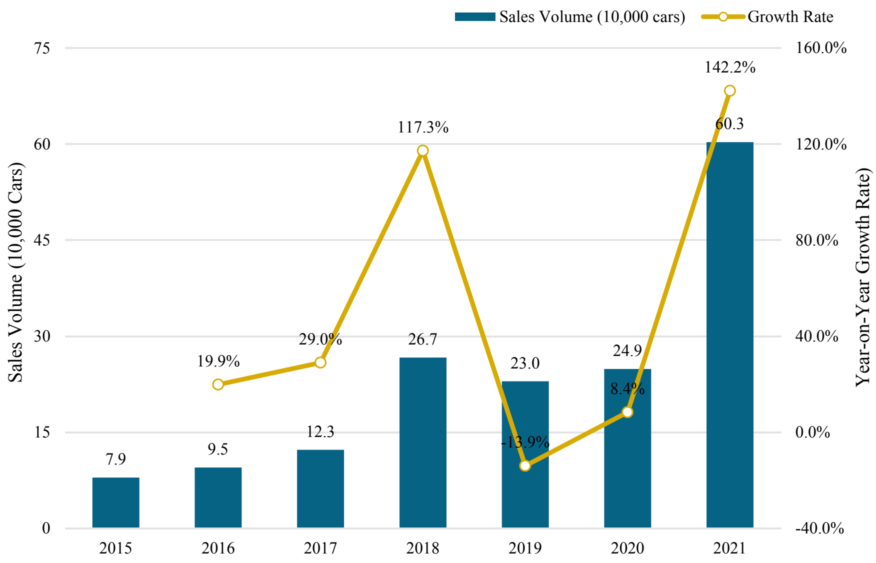


Fig. 8.2 Sales and growth of PHEVs over the years. *Source* China Association of Automobile Manufacturers

Table 8.2 TOP5 models of PHEV sales in 2021

Model	Sales volume (vehicles)	Vehicle level	NEDC (km)	Maximum battery capacity (kWh)	Guide price
Qin Plus DM-i	113,656	Class A car	120	18.30	132,800–148,800
Li ONE	90,491	Class C SUV	188	40.50	338,000
Song Pro DM	79,508	Class A SUV	81	15.70	169,800–219,800
Tang PHEV	48,152	Class B SUV	100	23.98	236,800–286,800
Han DM	30,476	Class C sedan	81	15.30	219,800–239,800

DM, are all domestic proprietary brands. Such models have set benchmarks in the domestic market Regarding mileage, price, and battery power and have received positive feedback from the market (Table 8.2).

8.2.2 Access of PHEVs

1. **Cumulative PHEV access characteristics**

The access quantity of PHEVs is rapidly increasing, and a total of over 1.1 million PHEVs have accessed the National Monitoring and Management Platform.

As of December 31, 2020, 1.1065 million PHEVs have been accessed to the National Monitoring and Management Platform, including 1,068,300 PHEVs passenger cars, accounting for 96.55% of PHEVs (Fig. 8.3). 875,800 private passenger cars have been accessed, accounting for nearly 80% of PHEV passenger cars.

The concentration of PHEVs in provinces is relatively high, with Shanghai and Guangdong provinces taking the lead.

From the cumulative access situation of PHEVs in various provinces (Fig. 8.4), the cumulative PHEVs in Shanghai and Guangdong are 245,900 and 240,000, ranking in the top two and accounting for 22.22 and 21.69% nationwide, both of which exceed 1/5, indicating a high concentration. Regarding the proportion of PHEV passenger cars in various provinces, the PHEV passenger cars in the TOP15 provinces account for more than 85% of local PHEVs, of which the PHEV passenger cars in Shanghai, Guangdong, and Tianjin account for more than 99%.

The passenger car promotion effect in Shanghai and Guangdong is significant; the cumulative registered PHEV buses in Zhejiang Province, Jiangsu Province, and Shandong Province account for over 10% of the total PHEVs in China.

From the perspective of the promotion concentration of PHEV passenger cars in various provinces (Fig. 8.5), Shanghai and Guangdong are far ahead in the cumulative access volume of PHEV passenger cars nationwide. As of December 31, 2021, the cumulative access volume of PHEV passenger cars in Shanghai and Guangdong has reached 245,200 and 238,600, accounting for 22.95 and 22.33% of the total in China; The cumulative access volume of PHEV passenger cars in Zhejiang Province has

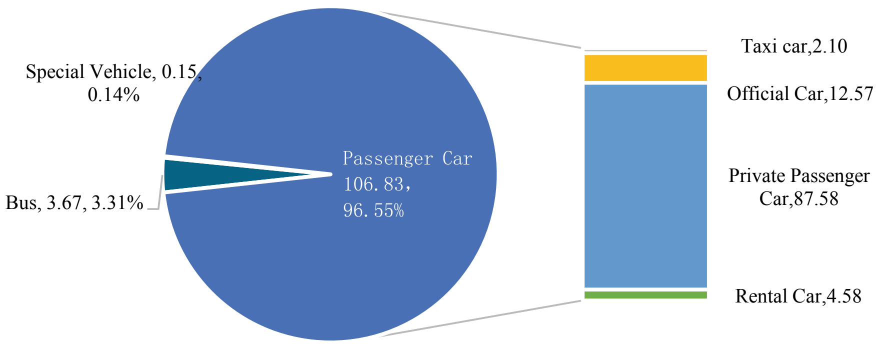


Fig. 8.3 Cumulative access and proportion of PHEVs—by type

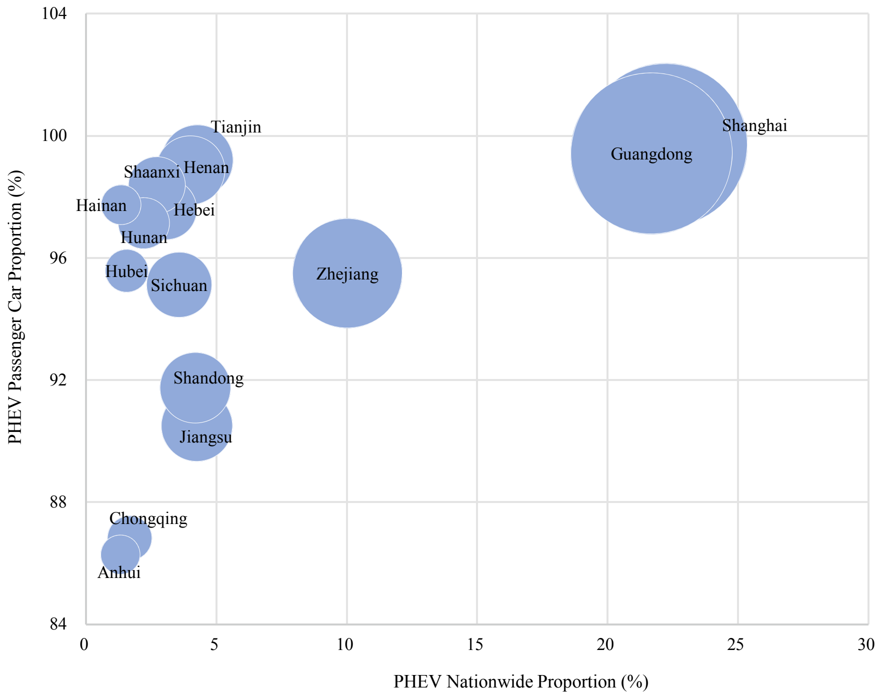


Fig. 8.4 Cumulative access and proportion of PHEVs in the TOP15 provinces. *Note* The bubble size indicates the cumulative access volume of PHEVs in each city by the end of 2021

exceeded 100,000, reaching 105,900, accounting for 9.91% of the total in China; The promotion quantity of PHEV passenger cars in other provinces is less than 100,000.

The cumulative access volume of PHEV buses in Zhejiang Province, Jiangsu Province, and Shandong Province ranked in the top three, with cumulative access volumes of 5000, 4300, and 3800, accounting for 13.60, 11.82, and 10.42% in China (Fig. 8.6).

Regarding the concentration of passenger cars in various cities, Shanghai and Shenzhen are leading other cities in China, with cumulative access accounting for over 10% of the total access in China.

From promoting PHEV passenger cars in various cities (Fig. 8.7), Shanghai, Shenzhen, and Hangzhou ranked among the top three Regarding cumulative access. As of December 31, 2021, the cumulative access volume of PHEV passenger cars in Shanghai, Shenzhen, and Hangzhou reached 245,200, 140,900, and 79,000, accounting for 22.95, 13.19, and 7.40% of the total in China. The access volume of PHEVs in the TOP3 cities was 465,100, accounting for 43.54% of the total in China. The access volume of PHEVs in the TOP10 cities was 681,800, accounting for 63.82% of the total in China.

Autonomous brands accelerate the layout of hybrid products and promote the reshaping of the PHEV market pattern.

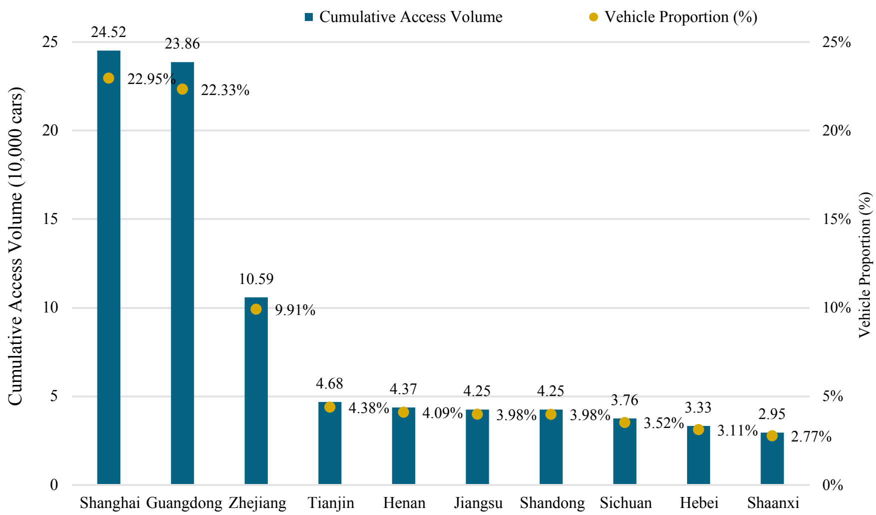


Fig. 8.5 Cumulative access and proportion of PHEV passenger cars in the TOP10 provinces

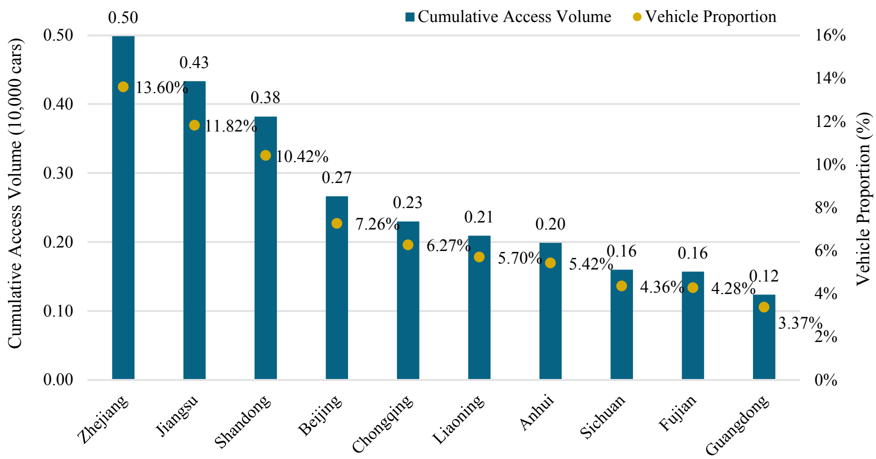


Fig. 8.6 Cumulative access and proportion of PHEV buses in the TOP10 provinces

From the perspective of the promotion concentration of all PHEV passenger car manufacturers (Fig. 8.8), as of December 31, 2021, the access volume of BYD Auto Automobile, SAIC Motor, and BYD Automobile Industry ranked first three, and the access volume of PHEV passenger cars reached more than 100,000. With the active deployment of hybrid technology by domestic brands, including the release of BYD DM-i, Great Wall Lemon DHT, Geely GHS2.0, Chery Kunpeng DHT, and Chang'an Blue Whale iDD platforms, the layout of domestic brand hybrid products has promoted the reshaping of the hybrid market pattern. The popular DM-i series

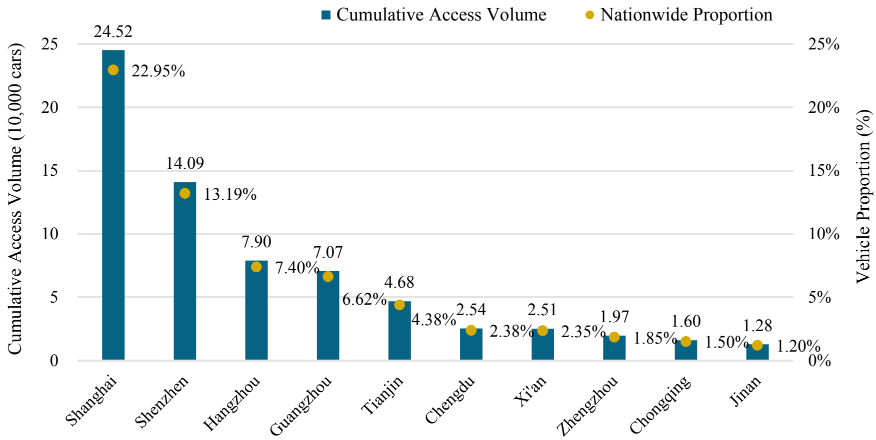


Fig. 8.7 Cumulative access and proportion of PHEV passenger cars in the TOP10 cities

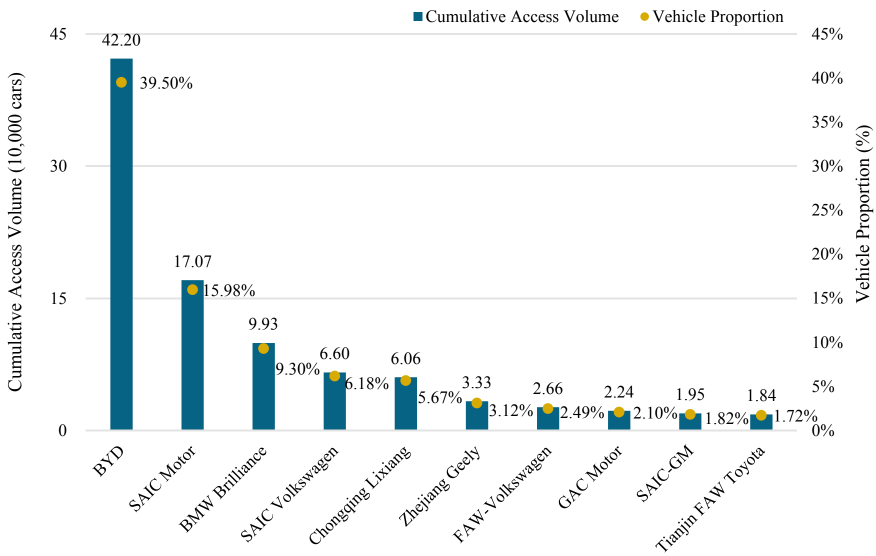


Fig. 8.8 Cumulative access characteristics of PHEV passenger cars from TOP10 manufacturers

has driven BYD's further breakthrough in the PHEV segment market. By the end of 2021, the cumulative access volume of BYD's PHEVs reached 422,000, accounting for 39.5% of the national market.

From the perspective of the promotion concentration of all PHEV bus manufacturers (Fig. 8.9), as of December 31, 2021, the access volume of Zhengzhou Yutong, Foton, and Golden Dragon ranked first three reached more than 9200, 5600, and

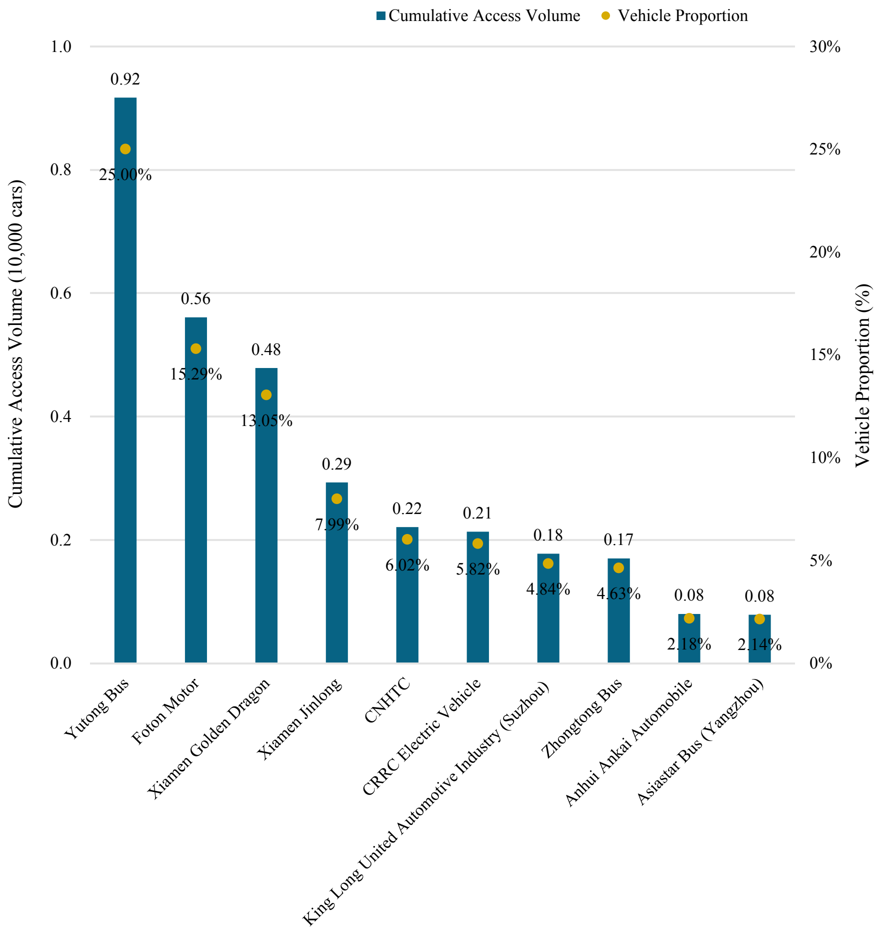


Fig. 8.9 Cumulative access characteristics of PHEV buses from TOP10 manufacturers

4800. Among them, the access volume of Zhengzhou Yutong's PHEV buses ranked first, accounting for 25.00% nationwide.

2. **Vehicle access characteristics over the years**

From the perspective of the access volume of PHEVs over the years (Table 8.3), the access volume of PHEVs was maximum in 2021, reaching 480,800, with a year-on-year increase of 2.2 times. From the perspective of monthly access over the years, the monthly access volume of PHEVs in 2021 was generally high. In the fourth quarter of 2021, the access volume of PHEVs showed a significant carryover effect, totaling 188,000 (Fig. 8.10).

The market demand for PHEVs is gradually shifting to cities not subject to purchase restriction.

Table 8.3 Access volume of PHEVs over the year

Year	2019	2020	2021
Access volume of PHEVs over the years (10,000 vehicles)	23.35	14.99	48.08

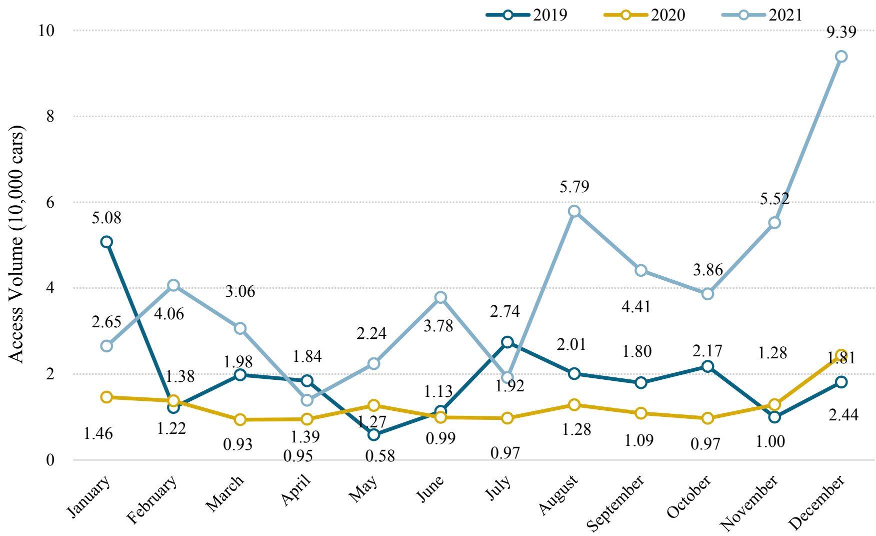


Fig. 8.10 Monthly access volume of PHEVs over the years

From the perspective of the access characteristics of PHEVs over the years, the market demand for PHEVs is gradually shifting to cities not subject to purchase restriction Fig. 8.11 shows that in the past three years, the market share of PHEVs in cities not subject to purchase restriction has proliferated, and the market share has significantly increased. In 2019, the market share of PHEVs in cities not subject to purchase restriction was 37.8%. By 2021, the market share of PHEVs reached 53.6%, with an increase of 15.8 percentage points compared with 2019. The market share of PHEVs in cities not subject to purchase restriction is rapidly expanding.

The share of PHEVs in first-tier cities has decreased, and market demand is gradually releasing to lower-tier cities.

Based on the access characteristics of PHEVs in cities of different tiers over the years (Fig. 8.12), the proportion of access volume of PHEVs in first-tier cities has shown a decreasing trend yearly. In 2019, the proportion of PHEVs in first-tier cities was 64%, and by 2021, the annual proportion of PHEVs was 50.3%, with a decrease of 13.7%; The market share of PHEVs in cities of other tiers has increased, and the market demand is gradually releasing to lower-tier cities. With the continuous expansion of domestic brands in the PHEV market, and the trend of gradually narrowing the "green channel" of PHEVs in China, domestic brands have seized the window period of favorable policies on the one hand, and on the

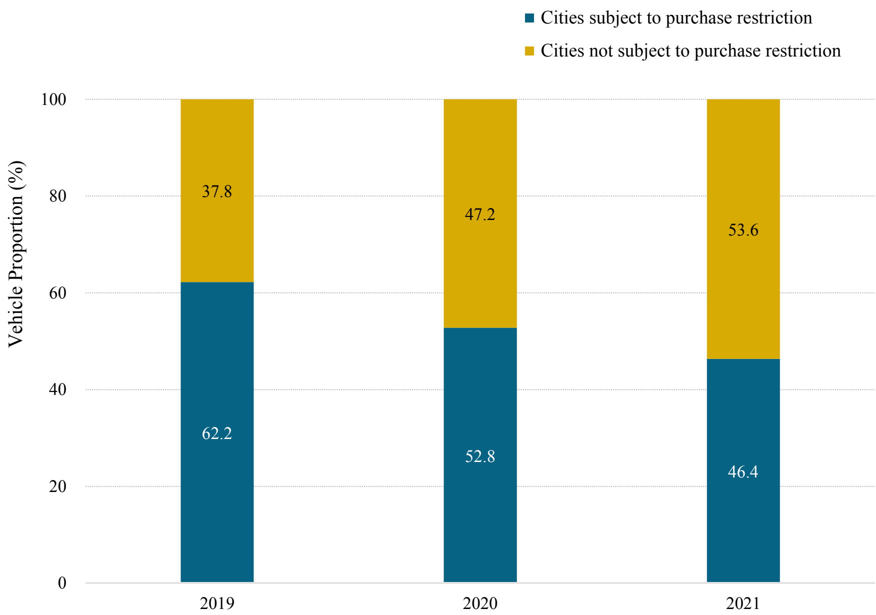


Fig. 8.11 Changes in the proportion of access volume of PHEVs in cities subject to and not subject to purchase restriction over the years

other hand, dispersing sales area distribution and getting rid of policy restrictions are conducive to sustained and stable growth in the medium to long term.

East China and South China are the main promotion regions. In 2021, the market share of PHEVs in Northeast, East, Central, and Northwest China increased.

Based on the access characteristics of PHEVs by region over the years (Fig. 8.13), East China and South China are the main promotion regions for PHEVs due to the great demand for PHEVs in Shanghai and Guangdong. From the change in PHEV access in the past three years, the proportion of PHEVs in Northeast China, East China, Central China, and Northwest China has shown an upward trend.

Individuals are the absolute main purchasing force, with a significant increase in private share.

Based on the access characteristics of PHEVs by type over the years (Fig. 8.14), individuals are the absolute main purchasing group, and the private share of PHEVs is gradually expanding rapidly. The proportion of PHEV private cars has shown a rapid growth trend, increasing from 85.1% in 2019 to 93.2% in 2021, an increase of 8.1%. The degree of marketization of PHEVs has significantly improved.

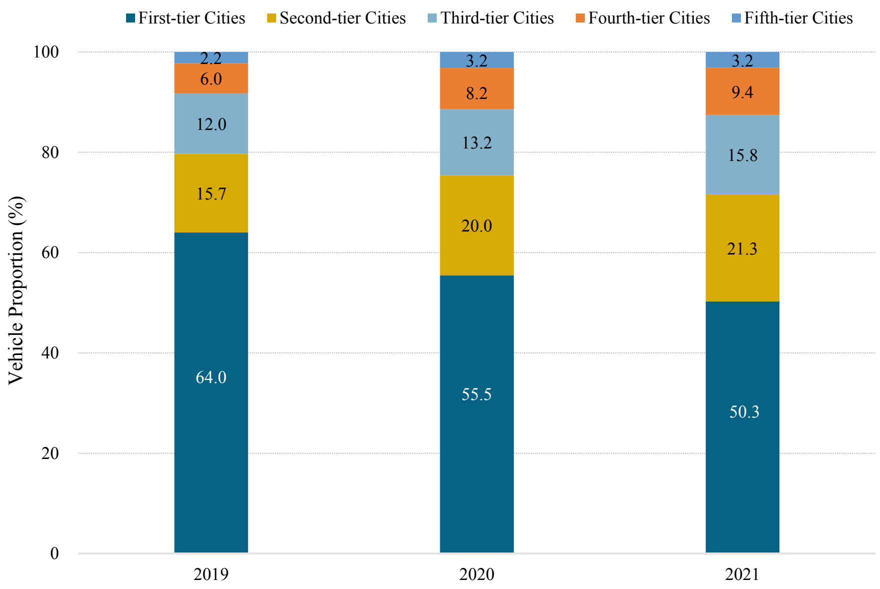


Fig. 8.12 Changes in the proportion of access volume of PHEVs in cities over the years—by city tier

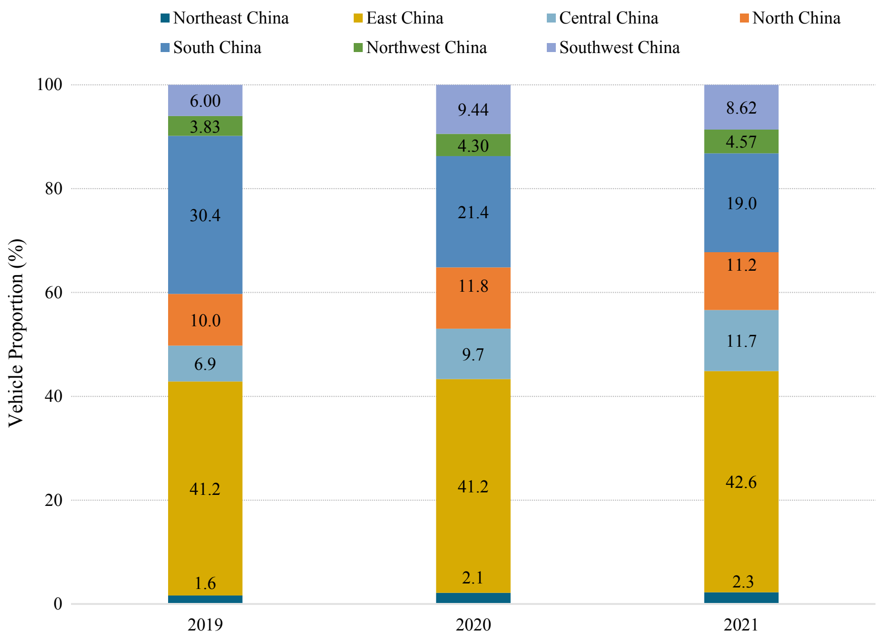


Fig. 8.13 Changes in the proportion of access volume of PHEVs in different regions over the years

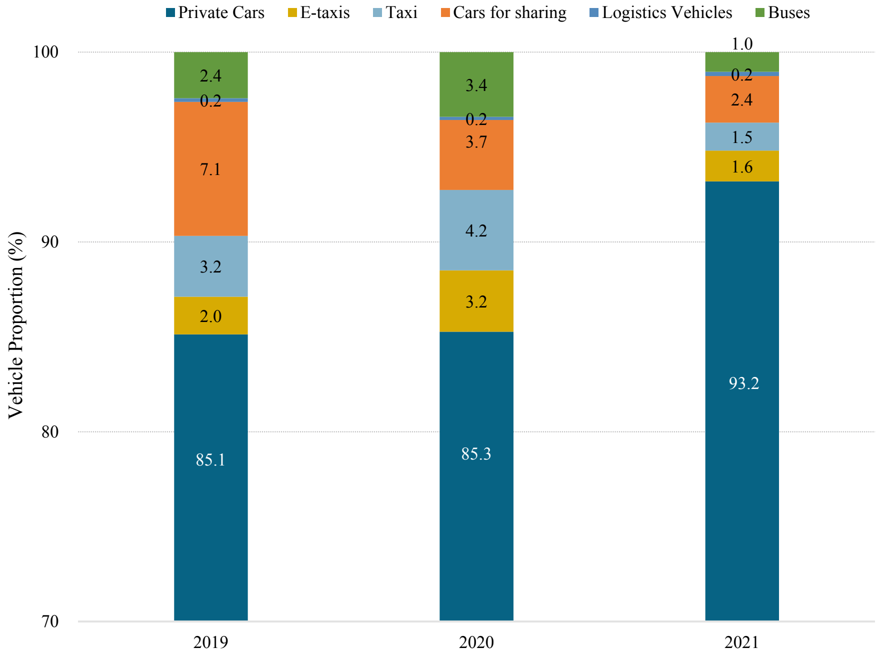


Fig. 8.14 Changes in the proportion of access volume of PHEVs in different application scenarios over the years

8.3 Operation Characteristics of PHEVs

8.3.1 Online Rate of PHEVs

The online rate of PHEVs remains at a high level, and the usage rate of PHEVs is relatively high.

From the perspective of the online rate of PHEVs in various regions (Fig. 8.15), in 2021, the average online rate of PHEVs in all regions of China was over 90%, indicating a high usage rate of PHEVs. From the historical changes in the online rate of PHEVs in various regions, the overall online rate in East China, Central China, North China, and Southwest China has shown an upward trend in recent three years.

From the perspective of the online rate of PHEVs in cities of different tiers (Fig. 8.16), the online rate of PHEVs in cities of different tiers remains above 90%. There are slight differences in vehicle online rates in cities of different tiers. The online rate in first-tier cities is the highest, and the online rate has been relatively stable in the past three years; The online rate in second and third-tier cities shows an upward trend.

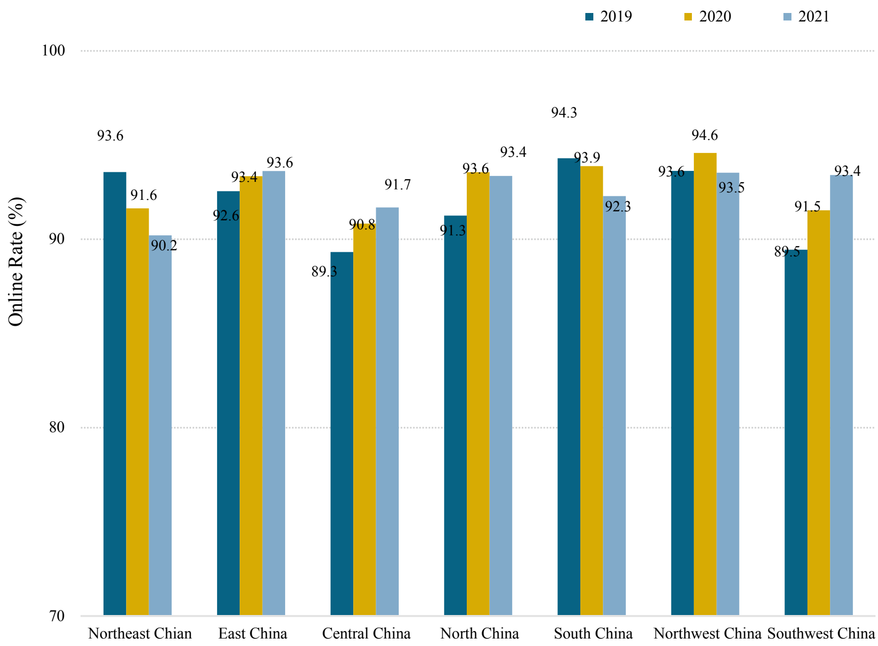


Fig. 8.15 Monthly average online rate of PHEVs in various regions of China

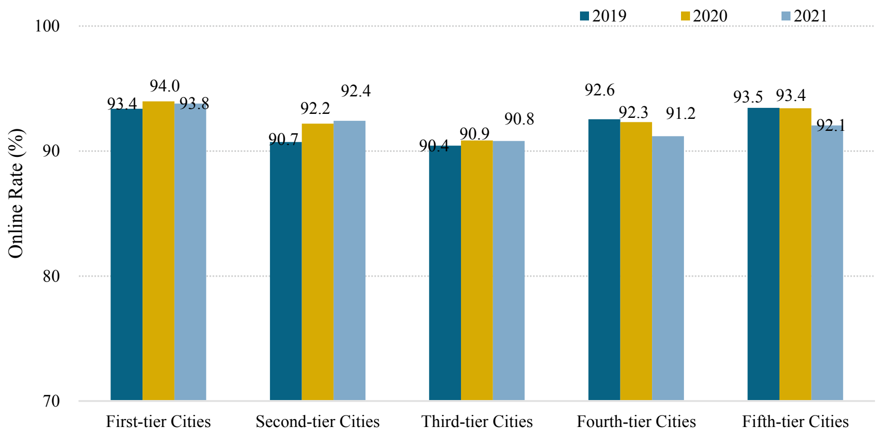


Fig. 8.16 Monthly average online rate of PHEVs in cities of different tier

From the perspective of the online rate of PHEVs by type (Fig. 8.17), the online rate of private cars, e-taxis, and taxis is generally at a high level, and the online rate of logistics vehicles is lower than that of other types of vehicles.

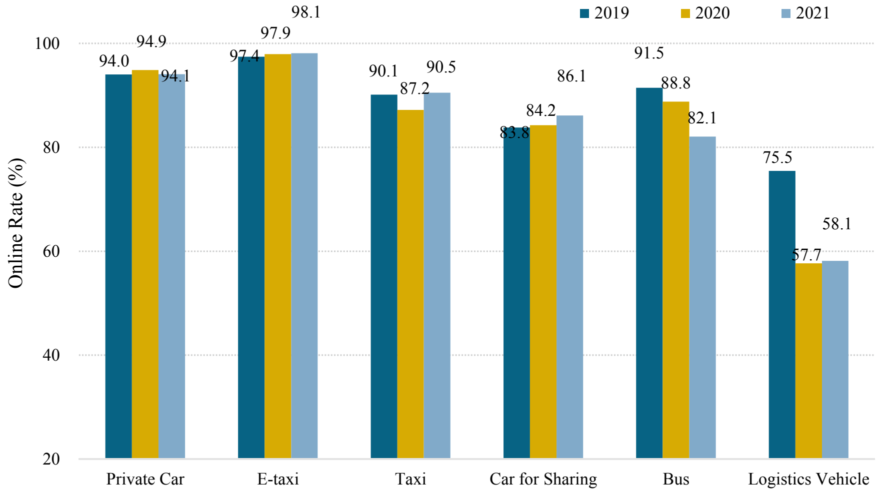


Fig. 8.17 Calendar year average monthly uptime rates by segment for PHEVs nationally

8.3.2 Vehicle Operation Characteristics

The operating modes of PHEVs are divided into electric driving mode, hybrid driving mode, and fuel-powered driving mode. From the proportion of mileage of PHEV passenger cars in different driving modes by type (Fig. 8.18), the electric mileage of private cars and e-taxis is relatively high, and the average daily mileage of private cars and e-taxis in the electric driving mode accounts for 45.0% and 45.6% of the total average daily mileage respectively; Taxis take second place, with an average daily mileage in the electric driving mode accounting for 40.6%; The average daily mileage of cars for sharing in the electric driving mode accounts for 37.6%, and the utilization rate of the electric driving mode is relatively low. Regardless of the type, the proportion of fuel-powered driving mode is less than 10%, indicating that in actual use, PHEV passenger cars are low-carbon and environmentally friendly among vehicles of the same class.

From the proportion distribution of different types of vehicles with different mileages in the electric driving mode (Fig. 8.19), it can be seen that the proportion distribution of private cars with different mileages in the electric driving mode is relatively uniform; e-taxis, taxis, and cars for sharing with the mileages in the electric driving mode accounting for 40–60% of the total mileage in the electric driving mode are dominated.

From the distribution of PHEV passenger cars with different average single-trip travel duration in the electric driving mode in cities of different tiers (Fig. 8.20), it can be seen that vehicles with average single-trip travel duration in the electric driving mode ranging from 0.5 to 1 h in first-tier cities account for a large proportion, i.e.,

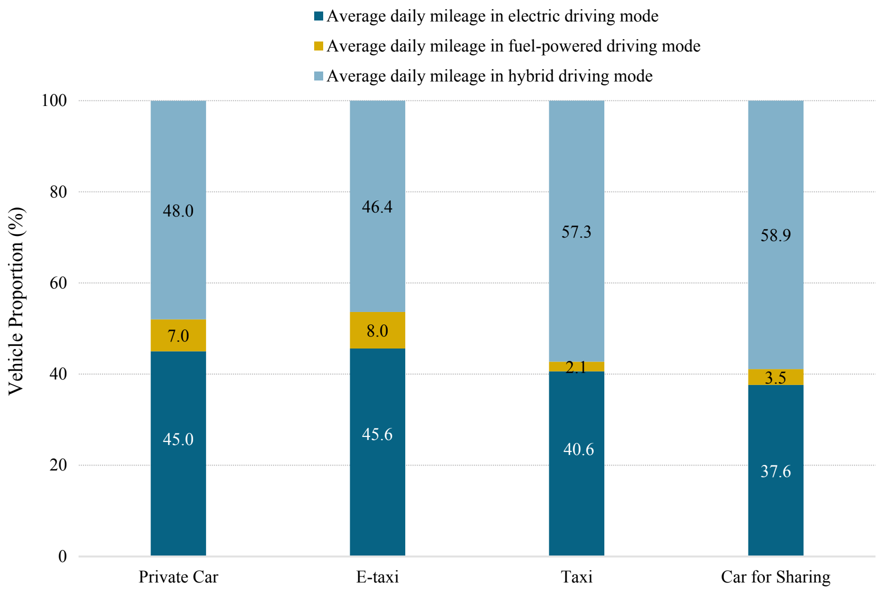


Fig. 8.18 Proportion of average daily mileage of PHEV passenger cars in different driving modes in 2021

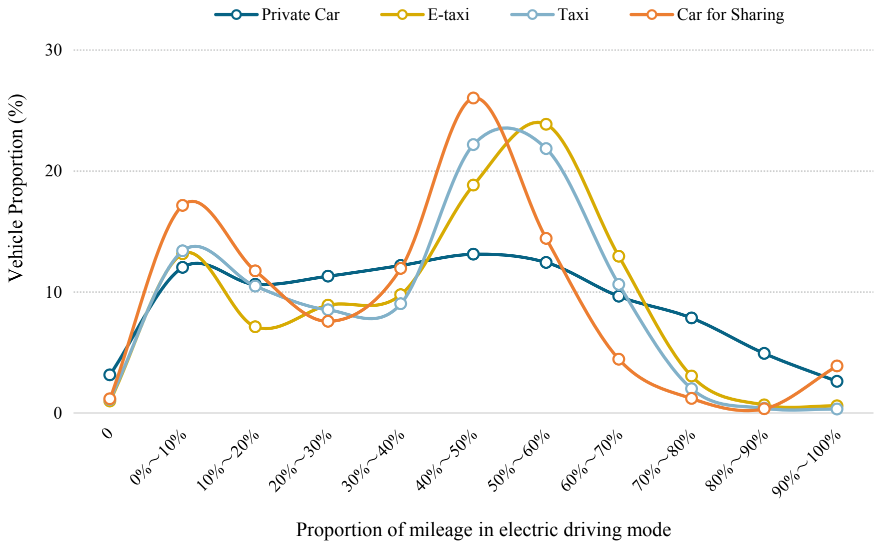


Fig. 8.19 Distribution of PHEV passenger cars with different mileages in the electric driving mode in different scenarios in 2021

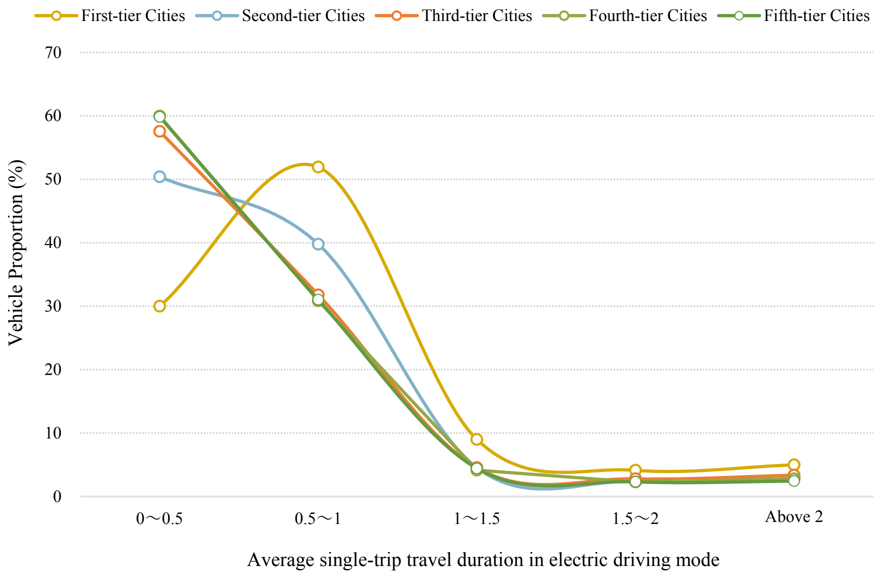


Fig. 8.20 Distribution of PHEV passenger cars with average single-trip travel duration in cities of different tiers in 2021

51.92%, which is affected by urban area and traffic conditions; The average single-trip travel duration in the electric driving mode in other tiers of cities is 0.5 h, and the PHEVs with such average single- trip travel duration in the electric driving mode account for over 50%.

8.4 PHEV Charging Characteristics

In the field of passenger cars, in the Chapter—Vehicle Charging, a detailed comparative analysis of the charging characteristics of PHEV private cars and EV private cars has been made. This Chapter will compare the charging characteristics of private cars, e-taxis, taxis, and cars for sharing based on different application scenarios of passenger cars.

8.4.1 Average Single-Time Charging Characteristics

The average single-time charging duration of PHEV passenger cars has been about 3.0 h over the years.

The average single-time charging duration of PHEV passenger cars has remained stable over the years, and in the past three years, the average single-time charging

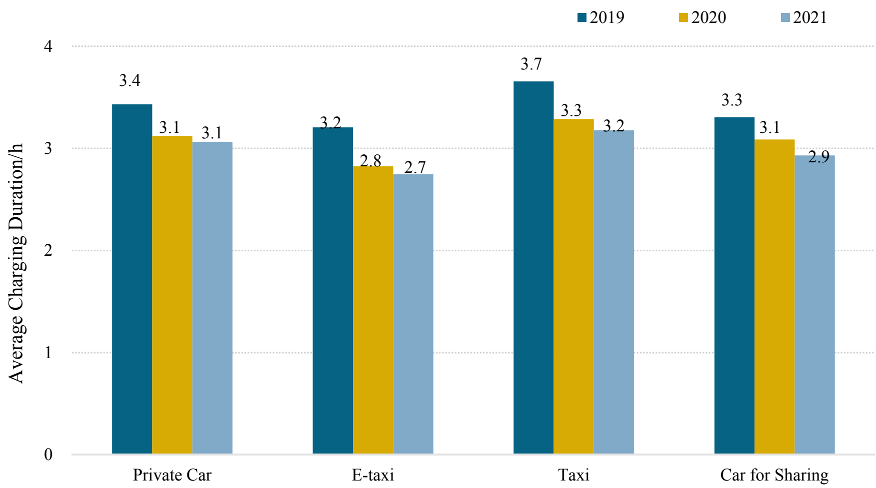


Fig. 8.21 Average single-time charging duration of classified PHEV passenger cars over the years

time has been about 3.0 h. As seen from the average single-time charging duration of different types of PHEVs over the years (Fig. 8.21), the average single-time charging duration of each type of vehicle has shown an overall downward trend in the past two years. From the average single-time charging duration of all types of PHEVs in 2021, the average charging duration of private cars is mostly 3.1 h, the same as that of the previous year. The average single-time charging durations of e-taxis and cars for sharing are relatively short, 2.7 h and 2.9 h, respectively.

From the perspective of vehicle charging methods (Fig. 8.22), the fast charging duration of each type of PHEV is mostly less than 0.5 h, and the slow charging duration is about 3.0 h; From the perspective of the fast charging duration of all types of PHEVs, the fast charging duration of cars for sharing is slightly lower than that of other types of vehicles, and the slow charging duration of e-taxis is relatively low.

As seen from the proportion of PHEVs with different average charging durations (Fig. 8.23), compared with other types of PHEVs, e-taxis with an average single-time driving duration of 2–3 h have the highest proportion, reaching 36.79%, and the average single-time charging duration of PHEVs shows obvious aggregation; The proportion of cars for sharing with different average single-time charging durations is relatively flat.

In 2021, the average single-time initial SOC of PHEV passenger cars was 29.8% at the beginning of charging, and the average initial SOC was 85.5% at the end. Compared to other types of vehicles, the average initial SOC at the beginning and end of charging private cars was higher than that of other vehicles (Fig. 8.24).

From the distribution of initial SOC of charging in different segments (Fig. 8.25), e-taxis, taxis, and cars for sharing account for 10–20% and 20–30% of the PHEVs in charging initial SOC segments, all of which exceed 30%; The proportion of private

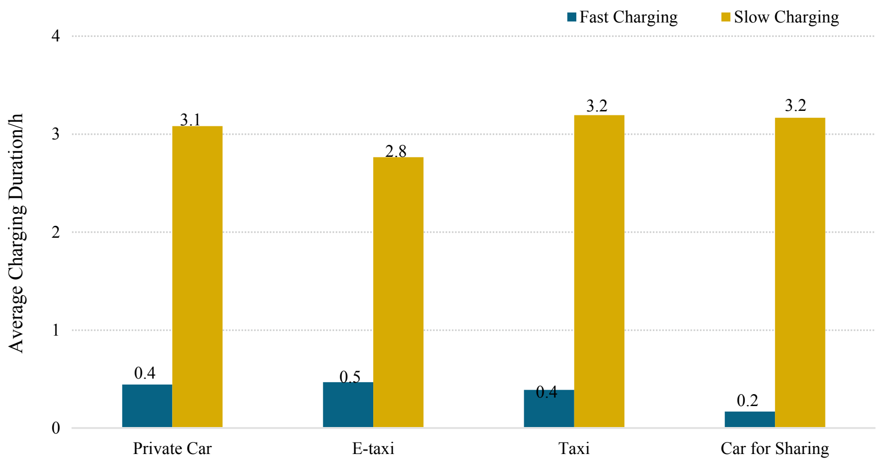


Fig. 8.22 Average single-time charging duration of PHEV passenger cars in different charging modes in 2021

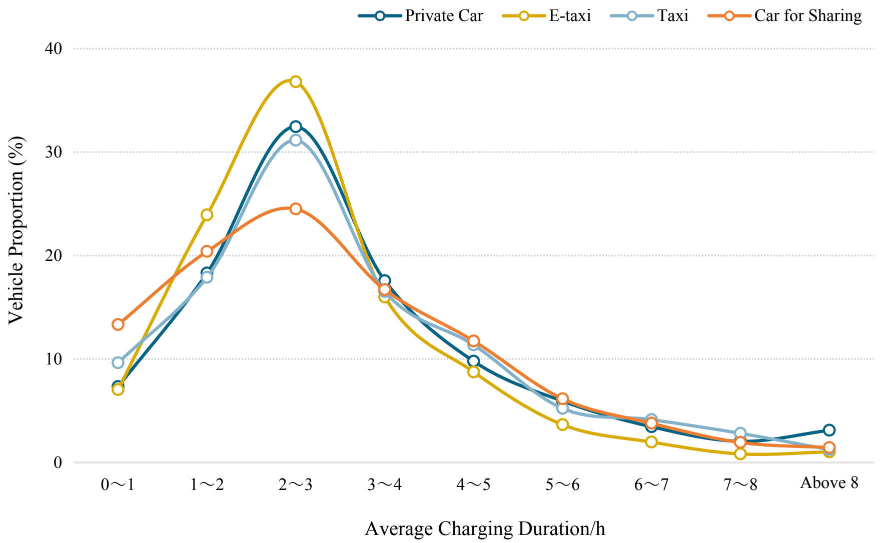


Fig. 8.23 Proportion of PHEV passenger cars with different average single-time charging durations in 2021—by type

cars in the PHEVs in two average single-time charging initial SOC segments is significantly lower than that of other types of vehicles, while the proportion of PHEVs in the charging initial SOC segments of 30–40%, 40–50%, and 50–60% was significantly higher than that of other types of vehicles. The phenomenon of private cars charging on demand is more obvious.

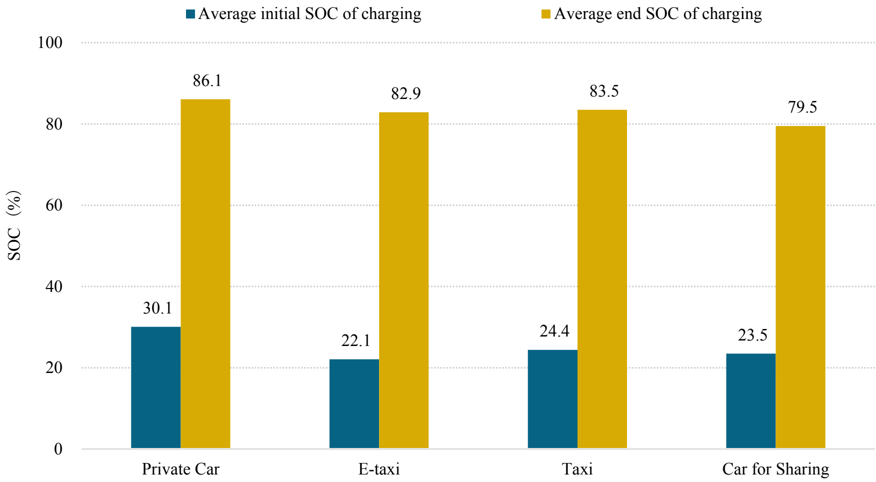


Fig. 8.24 Distribution of PHEV passenger cars with average single-time charging SOC in 2021—by type

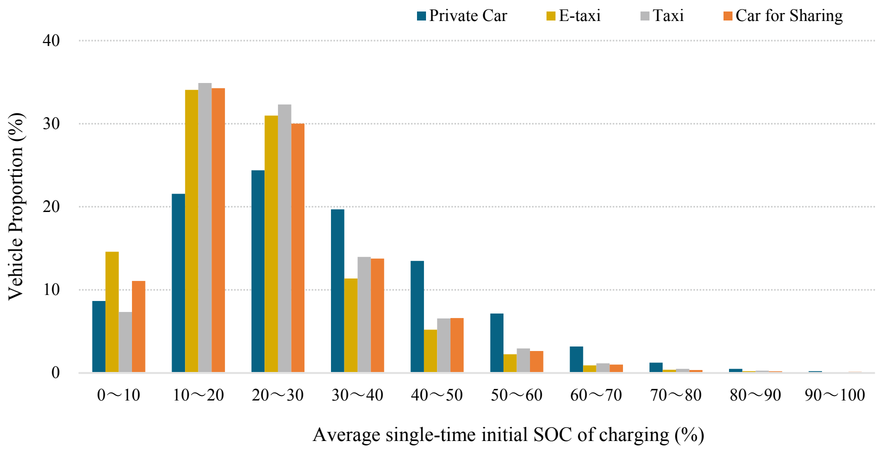


Fig. 8.25 Distribution of PHEV passenger cars with average single-time initial SOC of charging in 2021—by type

The distribution of PHEVs in different charging end SOC segments (Fig. 8.26) shows that the distribution of private cars in the 90–100% charging end SOC segment was significantly higher than that of other types of vehicles, accounting for 63.4%.

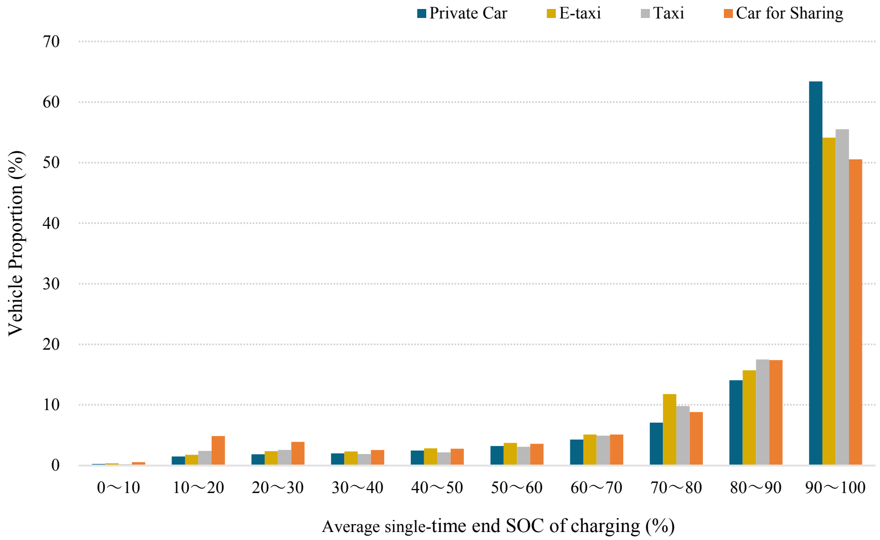


Fig. 8.26 Distribution of PHEV passenger cars with average single-time end SOC of charging in 2021—by type

8.4.2 Monthly Average Charging Characteristics

The average monthly charging frequency of PHEV passenger cars in 2021 was slightly higher than that in 2020.

The average monthly charging frequency of PHEV passenger cars in 2021 was 7.5, with an increase of 4.9% compared with 2020. Due to the gradual regularity of vehicle operation after the normalization of epidemic prevention and control, the charging frequency shows an upward trend (Table 8.4).

Figure 8.27 shows that the average monthly charging frequency of e-taxis is significantly higher than that of other types of vehicles. In 2021, the average monthly charging frequency of e-taxis reached 15.1; the average monthly charging frequency of private cars was relatively low, mostly about 6.

The slow charging method is often suitable for PHEV passenger cars.

In 2021, PHEV passenger cars' average monthly fast and slow charging frequencies were 1.6 and 6.0, respectively. More PHEV passenger cars are slowly charged. Judging from the charging methods of different types of PHEV passenger cars (Fig. 8.28), the charging frequency of e-taxis was higher, and the average monthly fast and slow charging frequencies were 4.7 and 10.4 respectively. e-taxis has a slightly

Table 8.4 Monthly average charging frequency of PHEV passenger cars

Year	2019	2020	2021
Monthly average charging frequency of PHEV passenger cars (times)	6.2	7.2	7.5

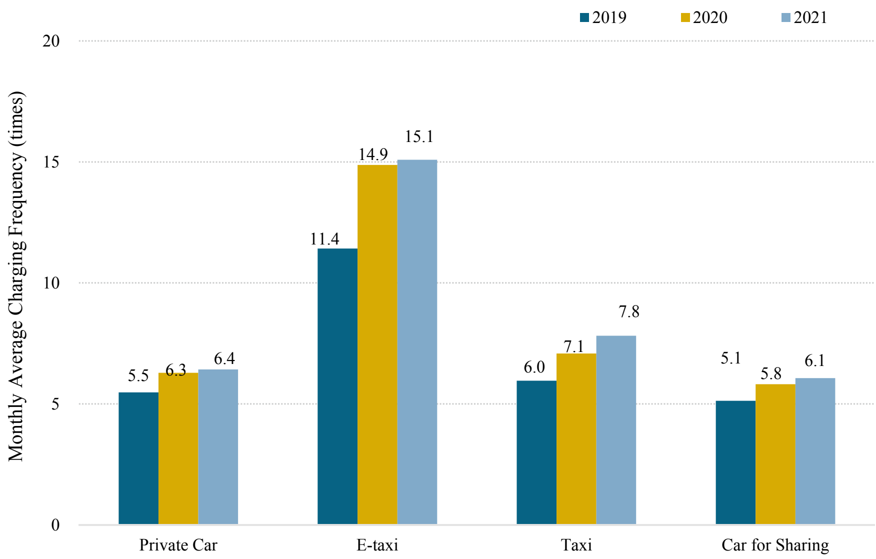


Fig. 8.27 Monthly average charging frequency of PHEV passenger cars over the years—by type

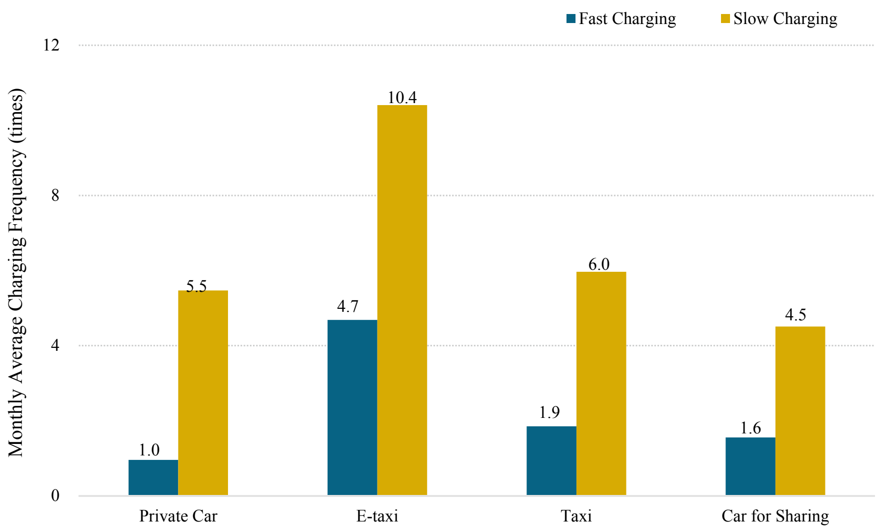


Fig. 8.28 Average monthly charging frequency of PHEV passenger cars in different charging modes in 2021

higher average monthly charging frequency than other types of vehicles due to the temporary power supply demand.

As seen from the distribution of vehicles in different monthly average charging frequency segments (Fig. 8.29), the average monthly charging frequency of private

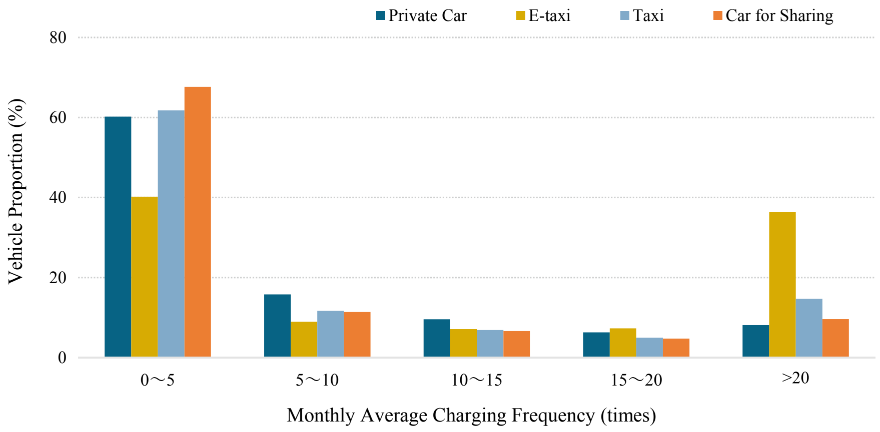


Fig. 8.29 Proportion of PHEV passenger cars with different average monthly charging frequencies in 2021—by type

cars was less than 5 times, and private cars, taxis, and cars for sharing with an average monthly charging frequency of less than 5 times accounted for over 60%; The average monthly charging frequency of e-taxis was maximum, and the vehicles with an average monthly charging frequency of more than 20 times accounted for 36.4%, significantly higher than other types of vehicles.

As seen from the distribution of monthly charging frequencies of PHEV passenger cars in different cities (Fig. 8.30), the charging frequencies in December, January, and February in Beijing were significantly lower than those in other months because the temperature in winter is low, the battery performance is reduced, and the mileage in the electric driving mode is reduced. To alleviate mileage anxiety, users use the electric drive mode less often. Since the temperature difference in Guangzhou is relatively small throughout the year, the battery performance is less affected by temperature, and the monthly average driving power consumption is relatively stable, the charging frequency is relatively stable.

From the distribution of monthly charging frequencies of PHEV SUVs in different cities (Fig. 8.31), PHEV SUVs' average monthly charging frequency in Beijing was 10.6, while the average monthly charging frequency in Guangzhou was 10.0. There is no significant difference in the average monthly charging frequency between Beijing and Guangzhou because the main promotion model in Beijing is the Li ONE with high battery capacity.

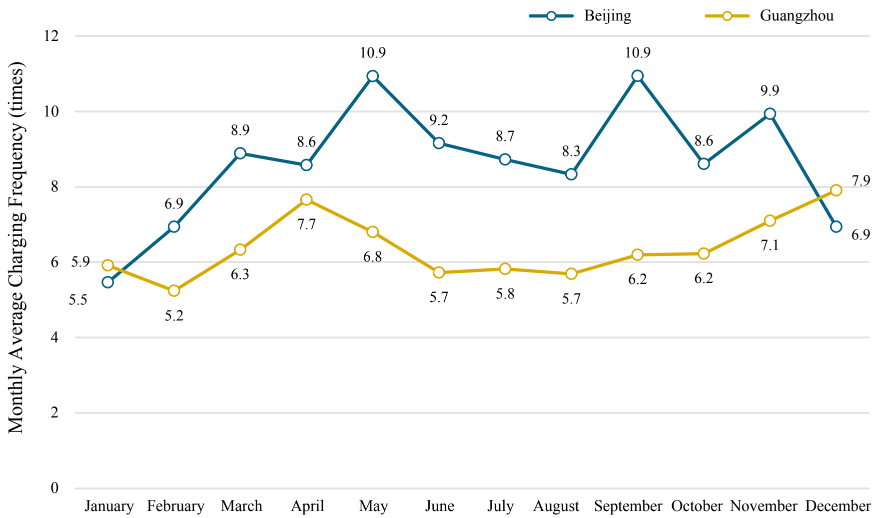


Fig. 8.30 Average monthly charging frequencies of PHEV passenger cars in 2021—cars

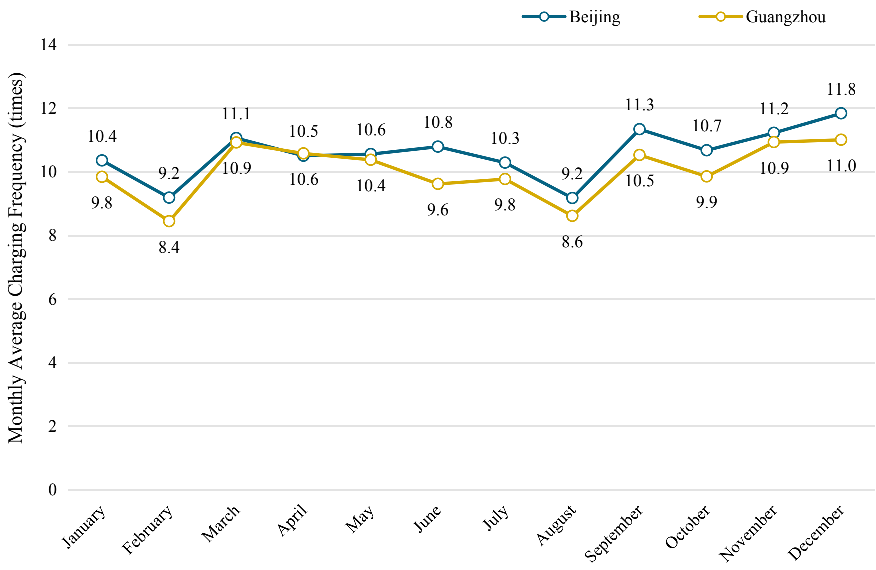


Fig. 8.31 Average monthly charging frequencies of PHEV passenger cars in 2021—SUVs

8.5 Summary

At present, new energy vehicles have become an important strategic path to accelerate China's automobile industry towards carbon peaking and carbon neutrality, and PHEVs play an important role in achieving rapid replacement of fuel models in the automotive industry in the short to medium term, and promoting energy conservation and carbon reduction in the automotive industry as soon as possible. Based on the access characteristics, vehicle operation characteristics, and vehicle charging characteristics of PHEVs on the National Monitoring and Management Platform, the market characteristics, vehicle operation laws, and charging laws of China's rapidly growing demand for PHEVs were summarized in this report. The main research results are described as follows:

PHEVs in China are gradually shifting from a supply-side drive to a supply-and-demand drive, and the domestic market maintained a high growth demand trend in 2021. PHEVs can meet the diverse application scenarios of consumers and have a certain market demand space. The supply of domestic brand models has diversified with the breakthrough of various technologies in the field of PHEVs by vehicle manufacturers. In 2021, the sales of PHEVs showed a rapid growth trend, reaching 603,000 throughout the year, with a year-on-year increase of 7.6 times, and the market demand has rapidly released.

The degree of marketization of PHEVs has significantly improved, with private purchases being the leading consumer force and demand gradually releasing in lower-tier cities. From the perspective of the access characteristics of PHEVs to the National Monitoring and Management Platform over the years, personal purchases have become the absolute mainstay. The proportion of PHEV private cars in the national PHEVs has increased from 85.1% in 2019 to 93.2% in 2021, with an increase of 8.1%, and the market share of private cars has rapidly increased; From the perspective of cities subject to purchase restriction/cities not subject to purchase restriction, the market demand for PHEVs is gradually shifting to cities not subject to purchase restriction. In 2021, the market share of PHEVs in cities not subject to purchase restriction was 53.6%, with an increase of 15.8% compared with 2019; From the perspective of cities of different tiers, the market share of PHEVs in the first-tier cities is gradually decreasing, and the market demand is gradually releasing to lower-tier cities.

The usage rate of PHEVs is relatively high, and the vehicle online rate remains high. The online rate of PHEVs remains at a high level, and the usage rate of PHEVs is relatively high over the years. From the perspective of the mileage in the electric driving mode, private cars and e-taxis have a relatively high proportion of average daily mileage in the electric driving mode in the total average daily mileage, and the utilization rate of the electric driving mode is high.

The charging duration of PHEVs is mostly stable, and their batteries are often slowly charged. The average charging duration of PHEV passenger cars has remained stable at around 3.0 h over the years, the slow charging method is often used, and the fast charging duration remains at around 0.5 h; With the normalization of epidemic prevention and control, vehicle operation is gradually becoming more regular, and the charging frequency is showing an apparent upward trend; From the perspective of average monthly charging frequencies of all types of vehicles, the running mileage of e-taxis is longer, and the average monthly charging frequencies of e-taxis are significantly higher than those of other types of vehicles.