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Foreword by Xiangmu Zhang

The world economic and industrial patterns are now under great adjustment, transformation and development. In this period when a new round of global technological revolution and industrial reformation is accelerating, the electrification, connection and intelligence of automobile industry is quicker. In face of the "competition" from both developed countries and developing countries in our automobile industry, we must have a farsighted view and respond actively to win the initiative in the new round of global competition.

Automobile industry involves electrification, connection, intelligence, new materials, new equipment and other sectors, and features large scale effect and strong industrial linkage. In view of this, it has gradually become an important measure of the national manufacturing ability and economic strength, and plays an important role in actively exploring the industry transformation and ecosystem development trend in the new age, in which the development of automobile industry relies on the integration and innovation of digitalization and intelligence. The intelligent manufacturing development of industry is driven by two "wheels", namely the innovation of manufacturing technology, and the application of new information technologies such as big data and Internet of Vehicle (IoV). These two "wheels" are supplementary to each other. Specifically, the improvement of manufacturing technology will promote the deeper application of information technology, and the introduction of new information technology will in turn promote the improvement of manufacturing level. If either "wheel" is not well developed, the enterprise will be unable to grow fast and sustainably.

To promote the high-quality development of NEV industry and build China into a powerful automobile manufacturing country, we need to accelerate the integration and application of NEVs and big data, as their in-depth integration is a catalyst driving the sound development of the NEV industry. Specifically speaking, with massive big data, the NEV's operation characteristics can be analyzed from multiple dimensions systematically to provide enterprises with important decision-making reference in strategic planning and R&D; the layout of charging facilities can be optimized through the accurate analysis of the vehicle parking and charging track; and a customer requirement matrix can be created through the multivariate analysis of all kinds of data, so as to provide more data support for enterprises to develop products that are more user-friendly and more suitable for application scenarios.

The *Annual Report on the Big Data of New Energy Vehicle in China (2021)*, with an adherence to the data sharing concept and the continuous efforts in big data research, is intended to actively construct a big data ecosystem for the automobile industry to empower its development. It, based on an analysis of NEVs in different application scenarios including private cars, e-taxis, taxis, cars for sharing, logistics vehicles, buses and heavy-duty trucks, summarizes their travel characteristics and charging/battery swapping characteristics to provide important policy-making reference for governments and enterprises. In addition, this report draws some significant conclusions in the cross fields of NEV industry including energy conservation and emission reduction, infrastructure planning and etc., which will help promote industrial development, travel environment optimization and traffic efficiency improvement.

The year 2021 is the fourth year that we published the *Annual Report on the Big Data of New Energy Vehicle in China*. In the past four years, the report was created out of nothing and continuously improved, making many innovative research achievements around "NEV + big data". We hope that this report can go deeper in data analysis and go wider in exploring of the integration of transportation, environment and energy, comprehensively improving the big data development and utilization level, and providing more high-quality research results for governments, industry enterprises, scientific research institutes and users.

Beijing, China
October 2021

Xiangmu Zhang

Foreword by Fengchun Sun

China's automobile industry is developing quickly now, but along with this, the pressure on energy, environment and safety is also increasing. Carbon peak has become a task that is more and more arduous to complete. In face of this, we have to break internal and external constraints such as energy shortage, environmental pollution, product safety and traffic congestion. Then, the new energy vehicle, thanks to its lower life-cycle carbon emission than conventional fuel vehicles, will be a strategic way to relieve such energy pressure, develop green and low-carbon economy and promote the industrial transformation and upgrading. In recent years, China's Party Central Committee and State Council have attached great importance to the development of new energy vehicles. Xi Jinping, the CCP General Secretary of China, has given an important instruction: the development of new energy vehicles is the only way for China to transform from a big automobile country into a powerful automobile country.

After years of industry cultivation and development, China is now standing at the forefront of the automobile electrification around the world. By the end of 2020, the cumulative sales of new energy vehicles in China had exceeded 5,500,000, higher than the target of 5,000,000 in the *Energy Conservation and New Energy Vehicle Industry Development Plan* (2012–2020); the driver for the development of NEV industry has changed from policy to the combination of policy and market; the integrated development of NEV industry with information and communication industry, the energy industry and intelligent transportation industry has been accelerated, and the new energy vehicle industry has entered a new stage of high-quality development. Though we have made such remarkable achievements, it is also clearly realized that in face of a quicker global technological revolution and industrial reformation, core technologies and user needs are the keys to grasp new development opportunities and implement the new concept of green development. With the faster penetration of new technologies such as big data, Internet of Vehicle (IoV) and cloud computing, the automobile industry is gradually developing to a new direction where the software and hardware, and the virtuality and reality are combined. Digitization will provide rich data and elements for the electrification, connection and intelligence of automobile industry, and further deepens the development of a digital ecosystem.

The integration of NEVs with big data has become a paragon for the digital development of China's automobile industry, and intelligent NEV based on big data will be a critical strategy for the transformation and upgrading of China's automobile industry.

Under the guidance of the Ministry of Industry and Information Technology (MIIT), the National Monitoring and Management Platform for NEVs was established in 2017, which supports the collection, storage and analysis of NEVs' operation data around China, and technologically realizes data authenticity and effectiveness evaluation, vehicle energy conservation and emission reduction effect evaluation, vehicle safety warning, vehicle mileage accounting and operation effect evaluation, and vehicle performance evaluation, etc. The real-time operation big data system of NEVs has developed from the single-point data rapid outbreak stage to the digital development stage where vehicle, transportation, energy and environment are closely linked together, bringing forward great value improvement of the Pan automobile industry.

The *Annual Report on the Big Data of New Energy Vehicle in China (2021)* is a masterpiece integrating the painstaking efforts and wisdom of experts and scholars. Based on the real-time operation data of 4 million new energy vehicles in the National Monitoring and Management Platform, it comprehensively analyzes the operation characteristics as well as charging/battery swapping characteristics of new energy vehicles in China, with an aim to deeply exploring the vehicle data and promoting the sound development of automobile industry. This report, by applying rigorous and easy-to-understand language as well as copious graphs, detailed data and survey results, enables readers to understand the operation characteristics and practical application of China's NEV industry in an all-round way, popularizes the concept of automobile electrification; in addition, professionally evaluates the development status and technical progress of NEV industry objectively, and puts forward relevant suggestions for the sound and sustainable development of the NEV industry. Therefore, it can provide important policy-making reference for governments and automobile enterprises. We hope that it will make a certain contribution to the sound and sustainable development of China's NEV industry.

Beijing, China
October 2021

Fengchun Sun

Preface

The year 2020 was truly eventful. At the beginning, the COVID-19 broken out unexpectedly, exerting a huge impact on the automobile industry and the travel market. In face of such an unknown disease, we established a consensus of “no gathering and minimum mobility”. Due to this, the operation characteristics and charging characteristics of new energy vehicles in the first half of 2020 were quite different from those of previous years, but after the epidemic was quickly controlled, they were gradually recovered; the development of NEV industry was rebounded and even expanded in scale, with the production and sales exceeding 1,366,000 and 1,367,000 respectively.

The *Annual Report on the Big Data of New Energy Vehicle in China (2021)*, based on the real-time operation data of 4 million new energy vehicles in the National Monitoring and Management Platform for NEVs, and with industry concerns as focuses, makes an in-depth analysis to the operation characteristics and charging/battery swapping characteristics of NEVs in typical application scenarios from the perspective of vehicle operation and user needs, and summarizes the laws of vehicle operation and industrial development, aiming to promote the sound and sustainable development of China’s NEV industry. Finally, it draws the following views and opinions:

(1) Systematically sort out the operation characteristics of new energy vehicles in diversified application scenarios in an all-round way. The *Annual Report on the Big Data of New Energy Vehicle in China (2021)*, based on the operation big data of millions of vehicles and by applying the machine cognition method, comprehensively and systematically analyzes the operation laws, including online rate, mileage and travel duration, of NEVs in various application scenarios such as private cars, E-taxis, taxis, cars for sharing, logistics vehicles, buses and heavy trucks.

(2) Comprehensively analyze, from multiple dimensions, the industry concerns, including the operation and hydrogen charging behavior of fuel cell electric vehicles and the operation characteristics of new energy vehicles of battery swap type; summarize the energy consumption and carbon emission reduction

effect of new energy vehicles in the operation process, laying a good foundation for the faster establishment of a linkage mechanism with the carbon trading market.

(3) Put forward constructive suggestions for industrial development based on the problems in key links. This report makes relevant conclusions and puts forwards relevant suggestions for concerns including market-based development of NEV industry and service level improvement of charging facilities.

This report integrates the high expectations, supports and efforts of many people. We hope that it 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 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 hereby to express our sincere appreciation to the strong supports and assists 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 and other organizations. Without their support, this report may not be successfully published.

This report integrates the high expectations, supports and efforts of many people, and we hope that its publication can play a positive role in promoting the development of China's NEV big data industry.

However due to the limited knowledge of the author, the report may contain deficiencies in depth and breadth, and suggestions and corrections from experts and readers are welcomed!

Beijing, China Zhenpo Wang

National Big Data Alliance of New Energy Vehicles (NDANEV)

National Big Data Alliance of New Energy Vehicles, hereinafter referred as "Alliance" or "NDANEV", is a voluntary, joint, non-profit social organization, constituted by the National Monitoring and Management Center for NEVs, NEV manufacturers, auto parts suppliers, internet application service providers, scientific research institutions and related organizations. The Secretariat of NDANEV is located at the National Monitoring and Management Center for NEVs (National Engineering Research Center of Electric Vehicles).

NDANEV was established on July 18, 2017, jointly by the Beijing Institute of Technology, FAW, Changan, SAIC, Yutong, EVCRRC, BAIC and China Association of Automobile Manufacturers, China-SAE, China Automotive Technology and Research Center, China Automotive Engineering Research Institute Co., Ltd., China Academy of Transportation Sciences, Chang'an University and so on. Till now, it has convened more than 200 members.

NDANEV is governed by the Constitution and relevant laws and regulations of the People's Republic of China, and implement the guidelines and policies for the development and application of new energy vehicle big data. As the bridge of big data sharing for new energy vehicles, NDANEV is committed to integrate, develop and utilize new energy vehicle data resources, establish big data research and development fund, effectively promote data mining and analysis of new energy vehicles, and provide high quality data services for governments, enterprises and the public.

Beijing EV New Energy Vehicle Big Data Application Technology Research Center

Beijing EV New Energy Vehicle Big Data Application Technology Research Center, as a private non-enterprise organization registered in Beijing by the National Big Data Alliance of New Energy Vehicles (NDANEV), is mainly engaged in academic research, academic communication, professional training, achievement transformation, technology publicity and promotion, and achievement exhibition related to NEV big data application technology. It is committed to carry out comprehensive big data mining analysis as well as the study of big data application mode and big data standardization, aiming to comprehensively integrate, develop and utilize NEV data resources.

Contents

Chapter 1
Overview

In the context of a new round of technological revolution and industrial transformation, the electrification, connection and intelligence of vehicles have become the mainstream development trend of the automobile industry. The high-quality development of the new energy vehicle (NEV) industry is very critical to the improvement of the international competitiveness of the automobile industry and the efficient coordinated development of urban transportation, energy resources and the environment. This report, based on the big data of millions of new energy vehicles on the National Monitoring and Management Platform for NEVs (hereinafter referred to as the "National Monitoring and Management Platform"), makes an objective and in-depth analysis of the NEV market characteristics, the NEV operation characteristics, the NEV charging characteristics and other industry concerns, providing a significant reference for relevant governments, scientific research institutes, universities and enterprises in China's automobile industry. The NEVs referred to in this report mainly include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (FCEVs) (including extended-range electric vehicles (E-REVs)) and fuel cell electric vehicles (FCEVs).

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2021)*,
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1.1 Overview of the Development of New Energy Vehicle (NEV) Industry in 2020

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

The global new energy vehicle (NEV) market is growing rapidly, especially in China.

At the beginning of 2020, the NEV market showed a sluggish growth due to the COVID-19 outbreak. With the adoption of the subsidy policies in Europe and the rapid control of the epidemic in China, the NEV markets in both Europe and China showed a rapid growth trend, and in 2020, the global NEV sales were up to 3.28 million, increasing by 43.7% compared with 2019. Especially in China, the NEV sales in 2020 have reached 1.367 million, accounting for 41.7% (Fig. 1.1) of the global NEV sales of that year.

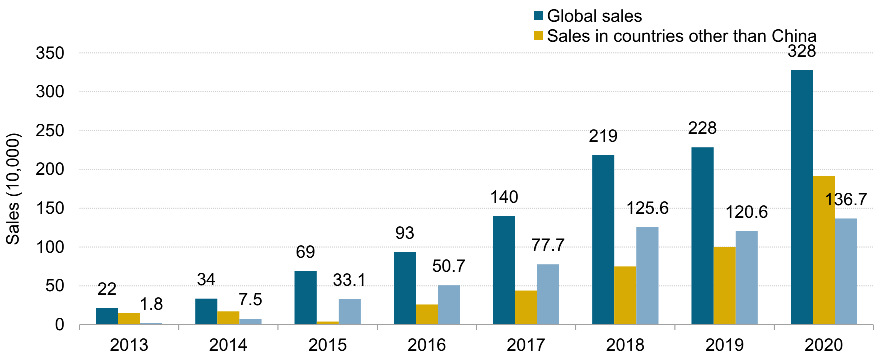


Fig. 1.1 Global sales of NEVs over the years. *Source* China Association of Automobile Manufacturers (CAAM) for sales data of NEVs in China; EV-volumes for sales data of NEVs in countries other than China

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

(1) China has made remarkable achievements in automobile electrification, and the market penetration rate of NEVs has steadily increased

The scale of the NEV industry is expanding, with the development in 2020 better than expected.

In 2019, due to cyclic fluctuations in the automobile industry, the reduction of subsidies, and the sales promotion of conventional fuel vehicles, the NEV market declined for the first time and developed not as well as expected. In the first half of 2020, the NEV market was severely hit by the COVID-19 outbreak, but it was recovered and showed a strong growth in the second half of the year. Throughout 2020, the sales of NEVs reached 1,367,000, with a YoY growth rate of 10.9% (Fig. 1.2). As of December 31, 2020, the cumulative access of NEVs in China was more than 5,500,000, exceeding the target of 5,000,000 NEVs in the *Energy Conservation and New Energy Vehicle Industry Development Plan (2012–2020).*

The automobile electrification process is accelerating, with the market penetration rate of NEVs exceeding 5% in 2020.

Since 2014, the electrification of China's automobile market has accelerated significantly. By 2020, China's NEV penetration rate has increased to 5.10% from 0.33% in 2014 (Fig. 1.3), indicating that China has made remarkable achievements in the marketization and scale development of NEVs. As expected in the *Notice on Issuing the New Energy Vehicle Industry Development Plan (2021–2035)* (GBF [2020] No. 39) issued by the General Office of the State Council on November 2, 2020 (hereinafter referred to as the "2021–2035 Plan"), the sales of NEVs will account for about

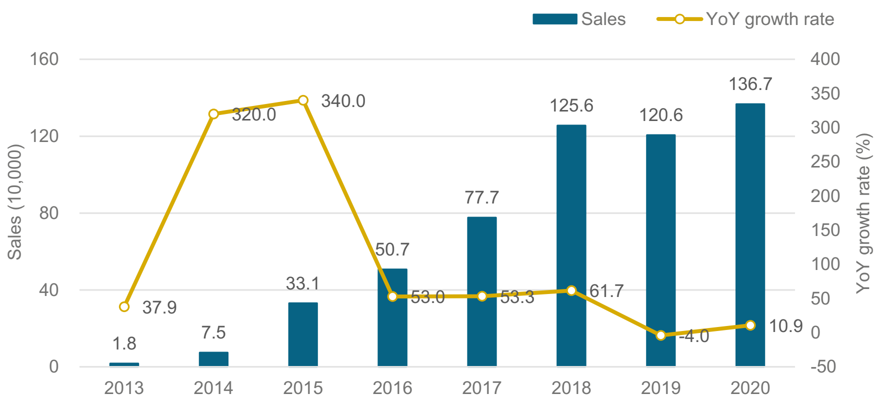


Fig. 1.2 Sales of NEVs in China over the years. *Source* China Association of Automobile Manufacturers (CAAM)

20% of the total sales of new vehicles by 2025. It is also expected that in the next five years, with the gradual maturity of the industrial chain and the further optimization of the operating environment, the market demand for NEVs will further expand, and the electrification process of the vehicle will be further accelerated.

(2) New energy passenger cars dominate the NEV market, with the market share increasing year by year

Considering the model construction, the new energy passenger cars dominate the NEV market, and in 2020, the market share of new energy passenger cars in China's NEV market has reached 86.3%, with an increase of 9.2% compared with 2018 and an increase of 4.6% compared with 2019; the driver of NEV development has gradually changed from policy to market (Fig. 1.4). In the segment of new energy passenger cars, the BEV passenger cars take a lion's share of 71.5% in 2020, showing a year by year increasing trend.

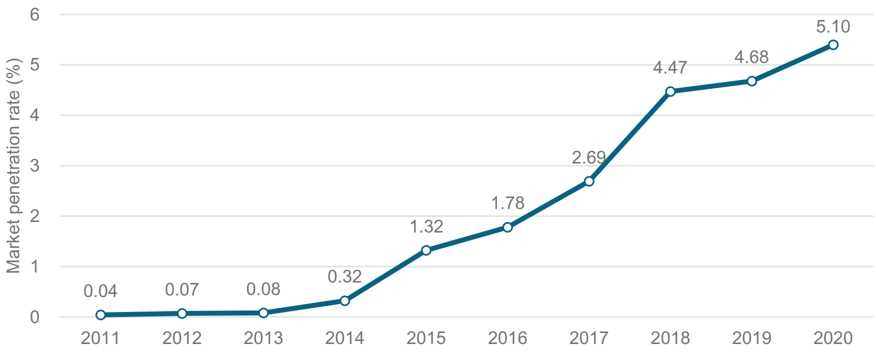


Fig. 1.3 Market penetration rate of NEVs in China over the years. *Source* China Association of Automobile Manufacturers (CAAM)

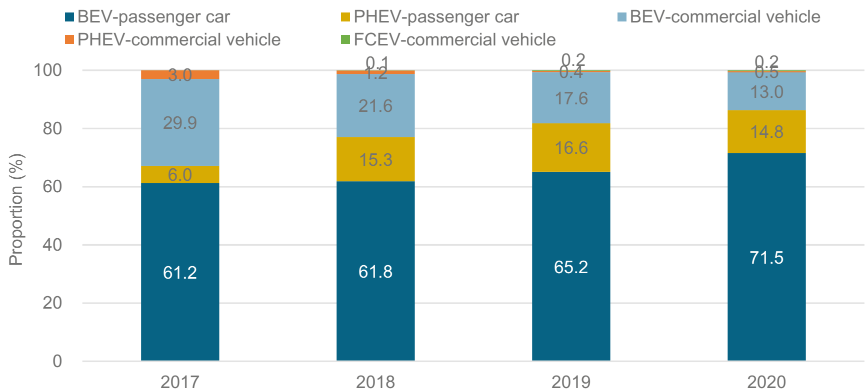


Fig. 1.4 Proportion of access of NEVs of different types over the years

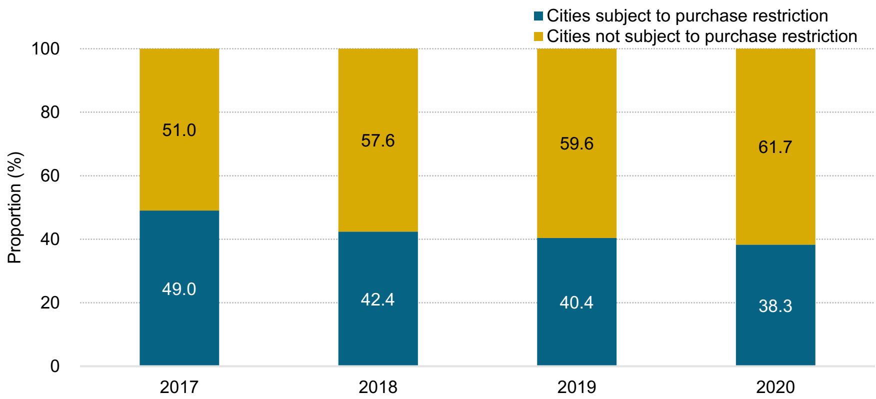


Fig. 1.5 Changes in the proportion of new energy passenger cars in cities subject to purchase restriction and cities not subject to purchase restriction

(3) The new energy passenger car has become more and more market oriented, and private purchase has become an important driving force

Consumer demand in cities not subject to purchase restrictions is strong, and the market share of new energy passenger cars is increasing year by year.

Under the stimulation of consumption promotion policies and the 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. Specifically, in 2020, the market share of new energy passenger cars in these cities was 61.7%, showing a year by year growth trend compared with 2017 and 2018 (Fig. 1.5).

Private purchase has become an important driving force for the growth of new energy private cars in the NEV market.

In 2020, the adoption of the countryside NEV promotion policy and the launch of economic products promoted the rapid release of private consumer demand for new energy passenger cars, with the proportion of private purchases in total sales increasing to 71.1%, indicating that the private purchase has become the important driving force of the growth of new energy private cars in the NEV market (Fig. 1.6).

(4) The overall technological level has been significantly improved, and the industry is moving towards a new stage of high-quality development

In the field of complete vehicles, the range of NEVs has increased year by year, with the ranges of new energy passenger cars, new energy buses, and new energy logistics vehicles increasing more or less, and the range of BEVs of different types enjoying a rapid growth. Specifically, the average range of BEV passenger cars increased by 34.9% over 2018 to 394 km in 2020, and the proportion of BEV passenger cars with a range of more than 400 km has increased quickly from the 2.6% in 2018 to the 58.7%

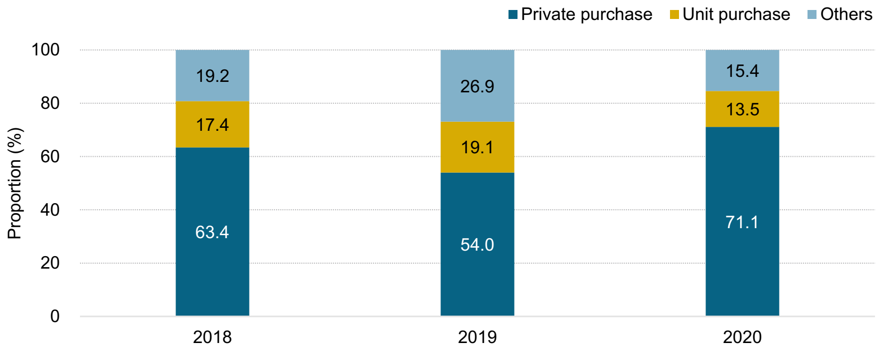


Fig. 1.6 Changes in the proportion of new energy passenger vehicles by nature of use

in 2020; the proportion of BEV buses with a range of more than 300 km increased from 44.7% in 2018 to 77.7% in 2020; and the proportion of BEV logistics vehicles with a range of 200–300 km has increased year by year.

Along with the fast increase of vehicle range, the body lightweight technology has also achieved a significant breakthrough, which, as an important part of the automobile technology system, is not only a common choice for China to cope with energy and environmental challenges, but also the only way for the sustainable development of the NEV industry. As a common key technology, lightweight is expected to coexist with the carbon neutrality target of the automobile industry for a long time. Talking from different types of vehicles, the curb weight of new energy passenger cars and buses has reduced significantly, and the lightweight technology for BEV passenger cars has progressed a lot. In recent years, with the substantial improvement of lightweight technology and the application of lightweight materials such as carbon fiber and aluminum alloy, lightweight technology has become an important means for NEVs to reduce energy consumption and carbon emission.

As for the key components of NEVs, taking the battery as an example for explanation, the ternary battery is the main type of battery used on the NEVs, but the application of lithium iron phosphate battery is gradually increasing, showing a market return trend. Talking from different types of vehicles, the ternary battery is mainly used by passenger cars, but the proportion of passengers with lithium iron phosphate battery increased in 2020, indicating that the lithium iron phosphate battery has gradually returned to the market. For BEV buses and logistics vehicles, a vehicle construction based on lithium iron phosphate battery is gradually into shape; the energy storage systems of NEVs are developing towards higher voltage, and specifically, the voltage of energy storage systems for new energy passenger cars and new energy buses are increasing significantly, and the energy storage systems for BEV passenger cars of different classes show obvious high-voltage development trend.

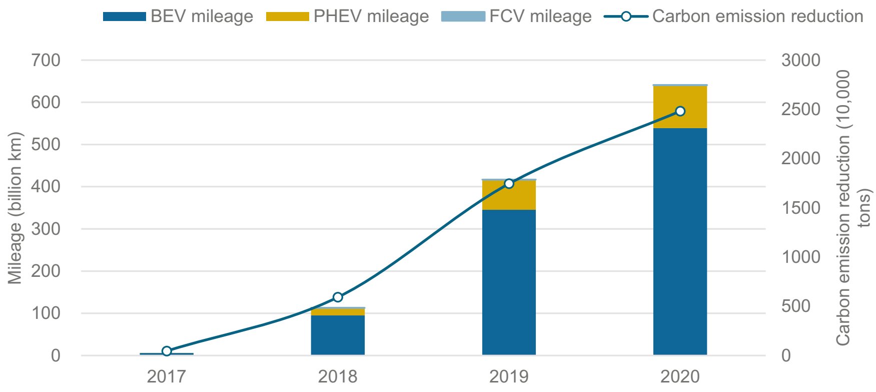


Fig. 1.7 Contribution of NEVs to carbon emission reduction in China-by year

(5) The NEVs demonstrate good energy saving and carbon emission reduction effects

In China, the mileage covered by NEVs has reached 117,690,000,000 km, which is equivalent to a cumulative carbon emission reduction of 48,641,000 tons.

As of December 31, 2020, the NEVs accessed to the National Monitoring and Management Platform have been up to 3,923,000, and the mileage covered by them has reached 117,690,000,000 km, which is equivalent to a cumulative carbon emission reduction of 48,641,000 million tons. According to the data over the years, the annual contribution of NEVs to carbon emission reduction has increased significantly since 2019, and in 2019 and 2020, it was 17,449,000 tons and 24,811,000 tons respectively (Fig. 1.7).

The electricity consumption per 100 km of BEV passenger cars has dropped significantly, and that of commercial vehicles has only increased slightly.

According to the operation data of vehicles of different types on the National Monitoring and Management Platform, the electricity consumption per 100 km of BEV passenger cars is decreasing year by year. Specifically, in 2020, the electricity consumption of BEV passenger cars of Class A0 and below was down to 12.4 kWh/100 km, and that of BEV passenger cars of Class A was 14 kWh/100 km. It is planned in the *Technology Roadmap for Energy Saving and New Energy Vehicles 2.0* (hereinafter referred to as the "*Technology Roadmap 2.0*") to reduce the combined electricity consumption of technically-leading Class A BEVs to below 11 kWh/100 km (CLTC[1]) by 2025. According to the combined electricity consumption of BEV passenger cars of different classes on the National Monitoring and Management Platform, there is still a certain gap from the planned target of the *Technology Roadmap 2.0*.

[1] China light-duty vehicle test cycle (CLTC), representing the driving cycle of vehicles in China.

In 2020, the electricity consumption of BEV buses was 73.6 kWh/100 km, and that of BEV logistics vehicles was 33.8 kWh/100 km, both of which increased slightly compared with last year. In the future, the commercial vehicle still embraces large potential for the application of lightweight technology.

1.2 NEV Operation Characteristics of China in 2020

For the purpose of this report, an overall assessment is made from such dimensions as the operation characteristics, charging characteristics, battery swap characteristics and fuel cell electric vehicles (FCEV).

1.2.1 NEV Operation Characteristics

(1) Due to the COVID-19 outbreak, the operation characteristics of some vehicles in 2020 were different from those of previous years

At the beginning of 2020, COVID-19 broke out, and in order to effectively control the epidemic, people around China have established a consensus of "No Gathering and Minimum Mobility", restaurants and entertainment venues are closed, and the vehicle movement is restrained due to such factors as regional isolation, restricted population mobility and extended holidays, and under this situation, some NEVs showed different operation characteristics from the previous years.

Specifically, at the beginning of 2020 when the epidemic prevention and control was in its most tough stage, the average single-trip speed of vehicles of different types was significantly higher than that of the same period in 2019, but after the epidemic was quickly brought under control and the population mobility was recovered, the average single-trip speed was gradually reduced to the level in 2019. For example, in February 2020, the average single-trip speed of private cars was 33.23 km/h, and after June, it was dropped to and maintained at about 28 km/h.

The logistics vehicles performed outstandingly in 2020, with the average daily mileage in each month significantly higher than that of the same period in 2019, and logistics vehicles played an important role in fighting the epidemic and ensuring the smooth operation of transportation. Taking Wuhan as an example, at the beginning of 2020 when the epidemic situation was extremely severe, the number of new energy logistics vehicles participated in the transportation of medical materials in Wuhan accounted for 55.8% of the new energy logistics vehicles put into operation at that time, greatly alleviating the pressure arising from the lack of medical materials in medical institutions.

From February to March 2020 when the epidemic was severe, residents were less willing to go outside, the operation of e-taxis and taxis were significantly restrained, and the average monthly travel duration and mileage of vehicles decreased compared with 2019. But then, with the rapid control of the epidemic, the operation of e-taxis and taxis gradually recovered.

The effect of the epidemic on the cars for sharing was limited, and the average monthly mileage was far greater than the expectation. But during the first half of 2020, the operation of cars for sharing was somehow affected, and since April when the epidemic was controlled, the daily mileage of cars for sharing has increased quickly to a level far more than that of the same period in 2019. To sum up, the average monthly mileage of cars for sharing throughout 2020 was 2613 km with a YoY increase of 65.06% year over year, and the proportion of cars for sharing with a daily mileage of more than 200 km increased from 13.81% in 2019 to 15.89% in 2020, indicating that demand for car sharing in long-distance travel is gradually increasing. Such an increase was out of our expectation, which is partly due to the stop of cross-province and cross-border tourism and the rapid development of suburban tourism under the repeated outbreaks of the epidemic in 2020.

(2) Vehicle mileage characteristics

As of December 31, 2020, the cumulative mileage covered by NEVs was up to 117,690,000,000 km.

According to data on the National Monitoring and Management Platform, the cumulative mileage covered by NEVs as of December 31, 2020, was up to **117,690,000,000** km, including 98,500,000,000 km (83.7%) covered by BEVs, 19,000,000,000 km (16.2%) covered by plug-in hybrid vehicles (FCEVs), and more than 100,000,000 km covered by FCEVs. Now, the NEVs have stepped into the large-scale demonstration and promotion stage (Fig. 1.8).

The average daily mileages in segments other than e-taxis and taxis have somehow increased.

In 2020, the average daily mileage of e-taxis and taxis decreased compared with 2019 (Fig. 1.9), while the average daily mileage in other segments including private cars, cars for sharing, logistics vehicles, buses and heavy-duty trucks increased.

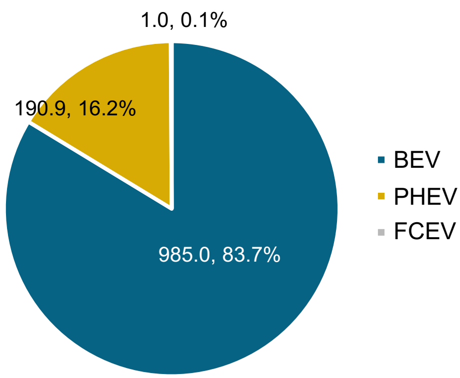


Fig. 1.8 Distribution of cumulative mileage of vehicles of different types (100,000,000 km, %)

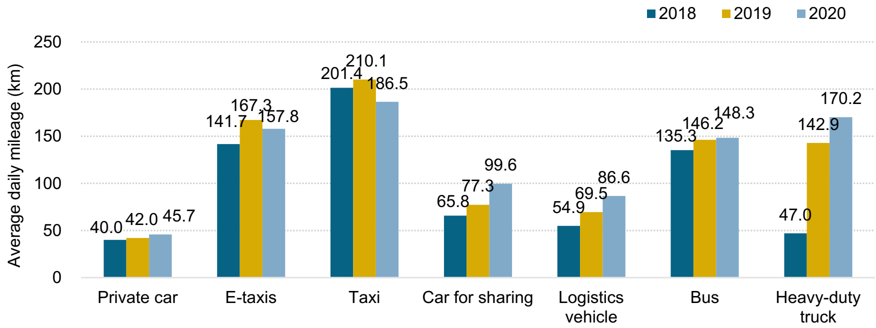


Fig. 1.9 average daily mileage of vehicles in key segments

Specifically, in 2020, the average daily mileage of cars for sharing and logistics vehicles increased by 28.9% and 24.6% respectively compared with 2019, indicating that the operation intensity of these two vehicles increased; the average daily mileage of heavy-duty trucks was 170.2 km, increasing by 19.1% compared with last year.

The average monthly mileages of vehicles other than e-taxis and taxis have somehow increased.

In 2020, the average monthly mileage of private cars, cars for sharing, logistics vehicles, buses, and heavy-duty trucks increased (Fig. 1.10). Specifically, the average monthly mileage of cars for sharing and logistics vehicles was 2613 km and 2169 km respectively, increasing by 65.1% and 52.2% respectively compared with last year; the average monthly mileage of heavy-duty trucks was 3294.54 km with an increase of 38.3% compared with last year, and the proportion of heavy-duty trucks with an average monthly mileage of more than 5000 km was up to 30.6%.

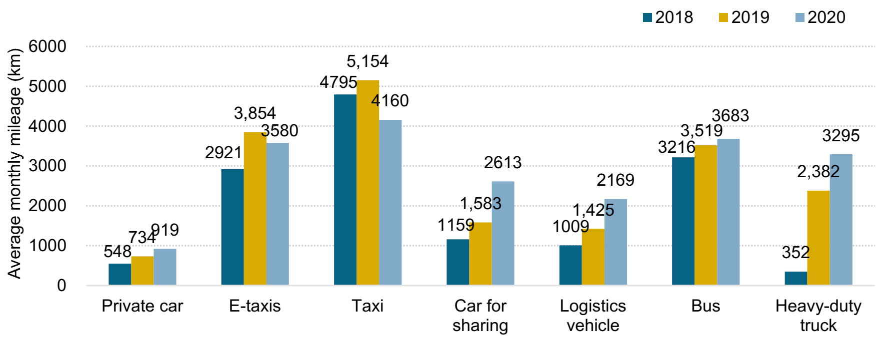


Fig. 1.10 Average monthly mileage of vehicles in key segments

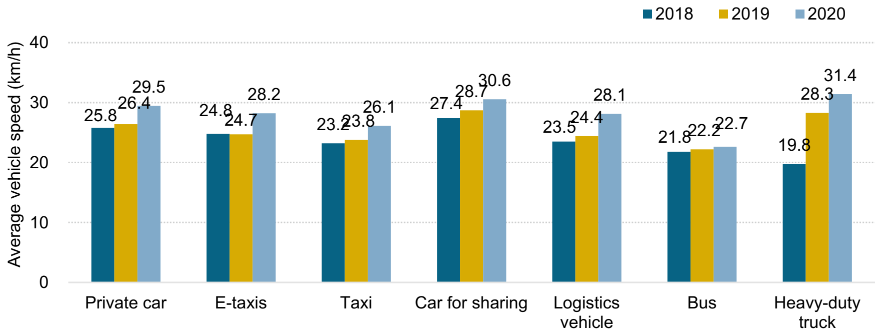


Fig. 1.11 Average speed of vehicles in key segments

(3) Vehicle speed characteristics

In 2020, the average single-trip speed of all types of vehicles increased compared with last year, and the traffic efficiency was improved significantly.

In 2020, the average single-trip speed of vehicles in key segments increased, the traffic efficiency was significantly improved, and user satisfaction was higher (Fig. 1.11). Specifically, in 2020, the average speed of private cars, e-taxis, taxis, cars for sharing, logistics vehicles, and heavy-duty trucks were all above 25 km/h, and among them, the average speed of heavy-duty trucks was up to 31.4 km/h, but the average speed of buses was relatively slow, i.e., only 22.7 km/h.

1.2.2 NEV Charging Characteristics

(1) Characteristics of changes in vehicle charging methods

The proportion of fast charging times in each segment is increasing year by year.

As shown in Fig. 1.12, the proportion of fast charging times in each segment is increasing year by year. As the distribution shows, the proportion of fast charging times of private cars is generally low, which was 15.4% in 2020, with an increase of 3.1% compared with last year; the proportion of fast charging times of e-taxis and taxis is the highest, and that of cars for sharing has increased quickly.

(2) Characteristics of charging duration

The average single-time charging duration of vehicles in each segment decreased compared with last year.

In 2020, the average single-time charging duration of each key segment decreased compared with 2019. Specifically, the average single-time charging duration of

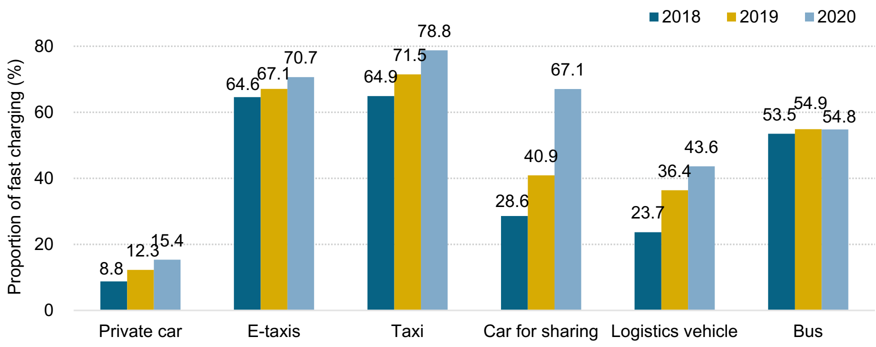


Fig. 1.12 Proportion of fast charging times in key segments

private cars was the highest with a value of 3.2 h, which is 0.8 h shorter than that in 2019 (Fig. 1.13).

In key segments, the average single-time charging duration is closely related with the proportion of fast charging times. That is, the lower the proportion of fast charging times, the longer the average single-time charging duration (Fig. 1.14).

(3) Characteristics of vehicle charging times

The average monthly charging times of vehicles in main segments other than logistics vehicles decreased compared with last year.

In 2020, the average monthly charging times of vehicles in other segments than logistics vehicles decreased compared with last year (Fig. 1.15), and among those vehicles, the decreases in average monthly charging times of e-taxis and taxis were the highest, which were 3.3% and 5.5% respectively; the monthly charging times is closely related to the monthly mileage (Fig. 1.16), and in view of this, the monthly charging times of taxis, buses and e-taxis are the highest, as their monthly mileages are longer.

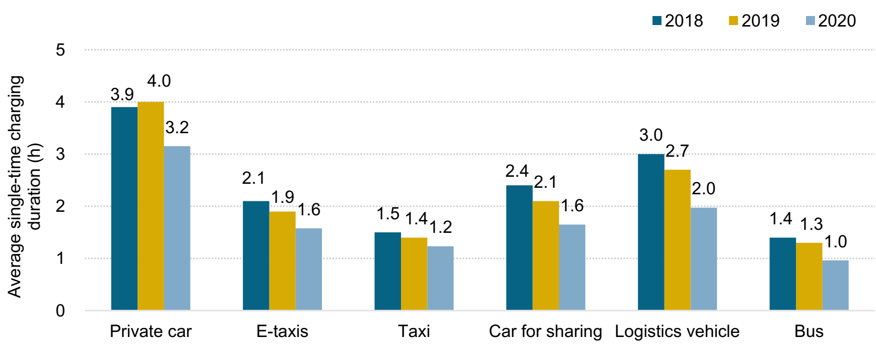


Fig. 1.13 Average single-time charging duration in key segments

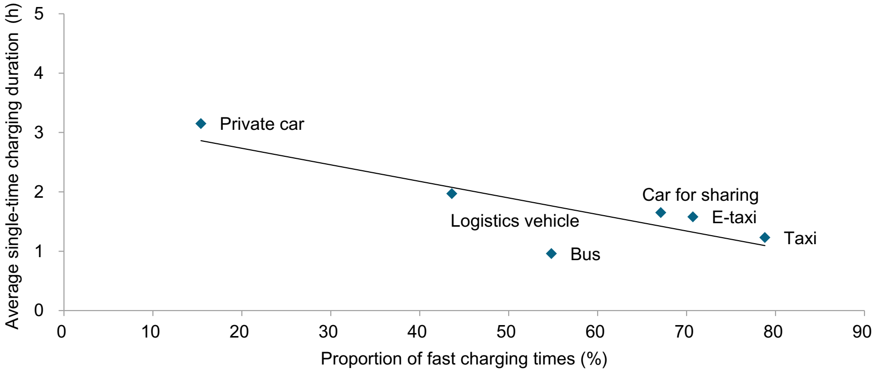


Fig. 1.14 Relationship between the average single-time charging duration and the proportion of fast charging times

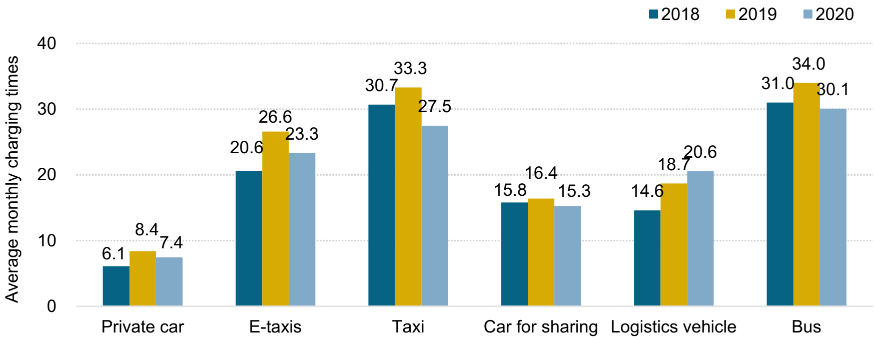


Fig. 1.15 Average monthly charging times in key segments

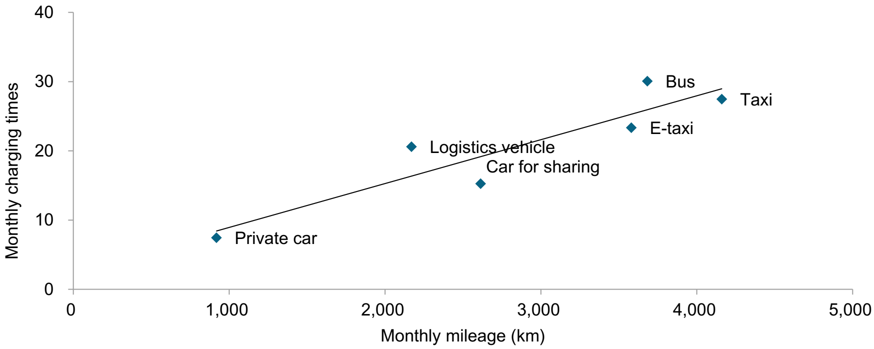


Fig. 1.16 Relationship between monthly charging times and monthly mileage in 2020

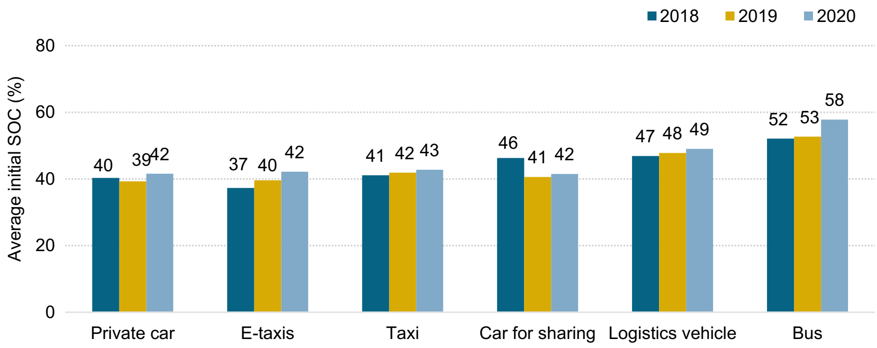


Fig. 1.17 Average start-of-charge SOC in key segments

(4) Start-of-charge SOC characteristics

The average start-of-charge SOC of vehicles in main segments increased compared with last year.

As shown in Fig. 1.17, the average start-of-charge SOC of vehicles in all key segments increased compared with 2019. Specifically, the average start-of-charge SOC of buses is the highest, and is increasing year by year. The average start-of-charge SOC of vehicles is closely related to the increase of range and the maturity of charging facilities.

1.2.3 NEV Battery Swapping Characteristics

The combination of "battery charging + battery swapping" has become the mainstream power supplement configuration for electric vehicles (EVs). According to the proportion of battery swapping times, the EVs of battery swap type are generally power supplemented by both charging and battery swapping, and for taxis/e-taxis and private cars, the battery swapping times are generally lower than the charging times; the battery swapping stations and their commercial innovation mode need to be improved. The average monthly battery swapping times of heavy-duty trucks is 24.9, which is significantly higher than the average monthly charging times (i.e., 15.7), and indicates that the heavy-duty trucks of battery swap type have higher operation intensity and better operation effect. From the perspective of power supplement method, the heavy-duty trucks of battery swap type can realize power supplement quickly, addressing the technical difficulty of slow charging speed of rechargeable heavy-duty trucks and thus improving the operational efficiency; from the perspective of economy, the heavy-duty trucks of battery swap type have the battery separated from the vehicle, and thus the battery can be rented, greatly reducing the purchase cost, and enabling an economy significantly higher than that of the fueled heavy-duty trucks of the same class. Therefore, the heavy-duty truck of battery swap type is of great value to be popularized in specific fields such as urban transportation, mines and ports, and will help to promote the application of BEV heavy-duty trucks.

1.2.4 Fuel Cell Electric Vehicles (FCEVs)

Fuel cell electric vehicles are still in the scale demonstration and promotion stage. According to the data on the National Monitoring and Management Platform, the cumulative access of fuel cell electric vehicles (FCEVs) to the Platform as of December 31, 2020, mainly including FCEV buses and FCEV logistics vehicles, has exceeded 6000.

Then, based on the operation characteristics of FCEVs, as of December 31, 2020, FCEVs have achieved a cumulative mileage of 106,420,000 km and a cumulative travel duration of 3,880,000 h; their overall online rate is growing steadily year by year, and in 2020, it was 2020 is 75%, which is higher than that in 2019, but is still lower than the overall online rate of NEVs. This gap is closely related to factors such as the maturity of infrastructures and the convenience of use of vehicles in the initial stage of industrial development.

1.3 Suggestions for the Sound and Sustainable Development of China's New Energy Vehicle Industry

In the next five years, we will embrace the accelerated technological revolution and industrial transformation around the world, as well as the critical period of complete NEV marketization under the construction of a new development pattern of domestic-international dual circulation. To grasp the new development opportunities of the NEV industry, implement the new concept of green development, and empower the strategic transformation of China from a big automobile country into a powerful automobile country, concerted efforts of many forces in the industry are required. This report, according to the development and operation characteristics of the NEV industry on the National Monitoring and Management Platform, concludes the relevant suggestions for the development of the NEV industry to provide decision-making reference for policy-making departments and related enterprises.

(1) Implement the new concept of green development, and take multiple measures to achieve the goals of carbon peak and carbon neutrality in the automobile industry as scheduled

At the general debate of the 75th Session of the United Nations General Assembly on September 22, 2020, President Xi Jinping announced that China would scale up its nationally determined contributions (NDCs) by adopting more vigorous policies and measures, striving to peak CO_2 emissions before 2030, and achieve carbon neutrality before 2060. The Central Economic Work Conference clearly listed "carbon peak and carbon neutrality" as one of the key tasks in 2021, and required to develop an action plan for peaking carbon emissions by 2030 to support places with conditions to take the lead in peaking carbon emissions. It is promised in the *Technology Roadmap for Energy Saving and New Energy Vehicles 2.0* that the automobile industry will peak carbon emissions ahead of the national carbon emission reduction commitment in 2028, and by 2035, the total carbon emissions will drop by more than 20% from the carbon peak.

According to the evaluation of the energy conservation and carbon emission reduction effect of NEVs on the National Monitoring and Management Platform, the top-level design, as well as the promotion and application of energy conservation and carbon emission reduction technologies in various dimensions such as the upstream energy link and production link of the NEV industry shall be strengthened, so as to improve the overall energy conservation and carbon emission reduction efforts of the automobile industry. The specific measures are as follows:

(1) Speed up the clean energy application for vehicles. The upstream energy link is the main contributor of carbon emissions of NEVs. It is recommended to actively promote coal abandoning in the power industry with clean electricity as the goal. Promotion of continuous deployment of clean energies is of great significance for accelerating the life-cycle carbon emission reduction of NEVs and promoting the achievement of long-term carbon neutrality goal of the automobile industry.
(2) Accelerate the deployment of green products and promote lightweight and downsizing as the main methods to promote carbon emission reduction in the automobile industry. The local governments shall accelerate the electrification in the public sector, speed up the application of electric vehicles for heavy emission vehicles such as muck trucks and mining vehicles; explore comprehensive electrification in the field of logistics; further, explore incentives for commercial innovation of electrification in the field of private cars, and accelerate electrification in the field of private consumption. The enterprises shall follow up and implement the national goals and paths of carbon emission reduction technology for the automobile industry, and accelerate the formulation and implementation of electrification strategies to promote the green transformation of automobile products.

(2) The NEV industry has a good long-term development potential, but a technological breakthrough is still necessary in the short term

Though remarkable achievements have been made, the NEV industry still faces many problems and contradictions in the course of development, such as long-term reliance on imports due to weak technical foundation of key core components and materials; inconvenient charging; low EV safety; and rapid deterioration of battery in winter and slow charging in low temperature environments. China's NEV industry is still in its critical stage where a series of difficulties are to be tackled and the quality is to be improved.

To solve those problems, the measures to be taken include: increasing the support for auto makers and parts manufacturers; establishing a common technology innovation model that combines production, education and research resources with key common technologies as focus; increasing collaboration in the research and development of key components such as heat pump and air conditioner, electronic brake and DC–DC converter to further improve the performance and economy of NEVs while ensuring the safety of the vehicle; and in addition, strengthening the joint innovation and research of comprehensive cross and basic cutting-edge technologies; strengthening international cooperation to enhance the innovation ability of the NEV industry chain and build a new industrial ecosystem.

(3) In the field of charging facilities, promote the deep integration of vehicles with grid, and accelerate the construction of a comprehensive charging system combining charging and battery swapping functions

Charging infrastructures, as the link between the automobile industry and the energy industry, will promote the low-carbon development and energy transformation of the automobile industry. With the large-scale market-based development, NEVs will play an important role in the adjustment of energy structure in the future, and as the largest mobile energy storage units, they will play an active role in the adjustment of energy structure and the construction of digital energy system. The specific recommendations are as follows.

Strengthen the top-level design, increase cross-sector coordination, promote the construction of NEV charging facilities, and optimize the operation environment of charging facilities. The application of NEVs is closely related to the convenience of the use of charging facilities. With the large-scale market-based promotion of NEVs, the popularization of charging infrastructures in cities of third tier or below and vast rural areas will become an important measure for the application satisfaction of NEVs.

Accelerate the two-way integration of vehicle and energy, and promote the deployment of mobile digital energy networks. The networking of charging facilities is of great significance for the balance of grid loads, peak-load shifting, and application of green energies. Charging facility operators are required to accelerate the deep integration of charging infrastructures and vehicles, speed up the realization of vehicle-grid interaction, and build an integrated "optical storage and charging/discharging" (integrated distributed PV power generation system-energy storage system-charging and discharging system) mobile energy network, and make comprehensive use of peak-valley price, NEV charging incentives and other preferential policies to realize the efficient energy interaction between the NEVs and the power grid, reduce the electricity cost of NEVs, and improve the peak shaving efficiency and emergency response capabilities of the power grid.

Specific fields are the focus for the development of battery swapping mode, and a comprehensive energy supply network combining charging and battery swapping functions should be established. According to the data on the National Monitoring and Management Platform, the application of fast charging has been increasing gradually, but as the scale development of the NEV industry proceeds, fast charging will exert a certain impact on the power grid. Therefore, in specific fields such as taxis and e-taxis, the application of battery swapping mode will help to alleviate the impact of high-voltage DC charging on the power grid and promote the high-quality development of charging facilities.

(4) Make full use of the National Monitoring and Management Platform for NEVs to provide operational support for the large-scale demonstration and promotion of fuel cell electric vehicles

With the increasing promotion of FCEVs in various demonstration cities, local governments are required to speed up the construction of a national monitoring and management platform for fuel cell electric vehicles (FCEVs), and link it with the National Monitoring and Management Platform to provide operational support for the large-scale demonstration and promotion of FCEVs. The specific recommendations are as follows:

(1) Comprehensively and systematically collect all the dynamic information in the process of "research, production, sale, service, repair and scraping" of FCEVs, so as to provide more credible data support for the formulation and implementation of FCEV's policies.
(2) Do a good job of data statistics through data interfaces by using information channels such as the National Monitoring and Management Platform to timely access to hydrogen charging characteristics, operating status and other data of FCEVs and build a data center with all-round technical analysis capability for FCEVs; build a simulation test platform for faults of hydrogen fuel cell systems and vehicles to carry out correlation analysis of the number of FCEV failures based on the faulty data and vehicle operation data, and establish an early warning model.
(3) Establish a national big data cloud center for FCEVs with the National Monitoring and Management Platform as the convergence point to provide data sharing services for FCEVs applied in various operating fields based on the principles of openness, sharing, win–win and mutual benefit.

Chapter 2
Promotion and Application of New Energy Vehicles

As an important strategic pillar industry to promote environmental protection and energy security, the new energy vehicle industry has become an important direction guiding the transformation and upgrading of the automobile industry in countries around the world. In recent years, China has attached great importance to the development of the new energy vehicle industry, and governments, ranging from the central government to the local provincial governments, have taken multiple measures collaboratively to promote the development of the new energy automobile industry, and have made significant achievements till now. This chapter, based on the vehicle access data on the National Monitoring and Management Platform, makes an in-depth analysis of the market concentration, production concentration and NEV marketization characteristics for the promotion of NEVs from different dimensions, laying a good foundation for us to summarize the development characteristics and laws of China's NEV industry and to predict its development trend in the future.

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

The sales of NEVs in China in 2020 was 1,367,000, with the BEV passenger cars dominating the market.

According to data from the China Association of Automobile Manufacturers (CAAM), the sales of NEVs in China in 2020 was 1,367,000 with a YoY increase of 10.9%. Among them, the sales of passenger cars were 1,246,000, which accounts for 91.1% of the total sales of NEVs, and in which the sales of BEV passenger cars increased significantly by 16.1% to 1,000.000, i.e., 73.2% of the total sales of NEVs; the sales of FCEV passenger cars were 247,000, with a YoY increase of 9.1%. The sales of new energy commercial vehicles, compared with last year, dropped slightly to 121,000, which accounts for 8.9% of the total sales of NEVs, and in which the

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2021)*,
https://doi.org/10.1007/978-981-19-5508-2_2

Table 2.1 Sales of NEVs in China in 2020

	Sales in 2020 (10,000)	Proportion (%)	YoY change (%)
NEVs (Total)	**136.7**	**–**	**10.9**
New energy passenger cars (Subtotal)	124.6	91.1	14.6
BEV	100.0	73.2	16.1
FCEV	24.7	18.1	9.1
New energy commercial vehicle (Subtotal)	12.1	8.9	−17.2
BEV	11.6	8.5	−16.3
FCEV	0.4	0.3	−22.2

Source China Association of Automobile Manufacturers (CAAM)

sales of BEV commercial vehicles was 116,000 with a YoY decrease of 16.3%; the decline of FCEV commercial vehicles was the highest, and specifically, the sales of PEHV commercial vehicles was only 4,000, with a YoY decrease of 22.2% (Table 2.1).

The monthly sales of NEVs throughout 2020 went from low to high.

The change in monthly sales of NEVs in 2020 was significantly different from that in 2019 (Fig. 2.1). In the first half of 2020, the NEV market grew sluggishly due to the COVID-19 outbreak. Specifically, the sales of NEVs from January to June was 393,000, decreasing by 37.4% compared with last year. In the second half of the year, the NEV market, driven by countryside NEV promotion policy, continuous product iteration and promotion mechanism of auto makers and other factors, showed a continuous growth trend. By November, the cumulative sales growth rate increased by 3.9%, putting an end to the negative growth and realizing positive growth. In December, the sales reached 248,000, increasing by 49.5% compared with last year. NEVs worked as the main force for the overall recovery of the automobile market.

2.2 Analysis on Vehicle Access Characteristics of National Monitoring and Management Platform

An important driver for the rapid development of China's NEV industry is the Internet. The NEV access big data characteristics of the National Monitoring and Management Platform is significant for understanding the current NEV promotion and application situation in China, promoting the reasonable layout of the NEV industry, and expanding and strengthening the NEV industry. In view of this, this section makes an analysis from two dimensions, namely the overall access characteristics of NEVs and the historical access characteristics of NEV.

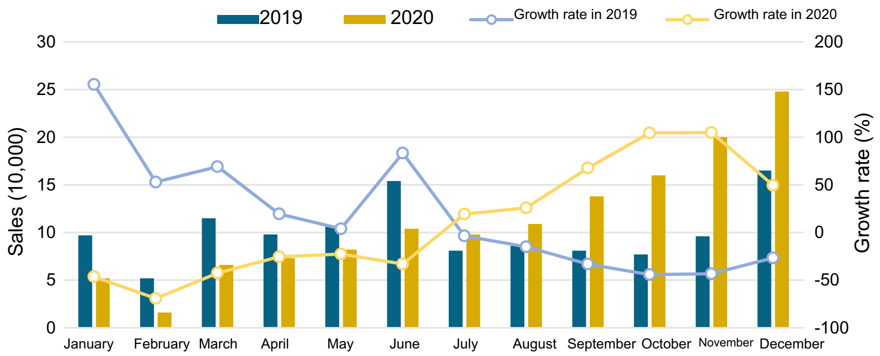


Fig. 2.1 Monthly sales growth of NEVs in China. *Source* China Association of Automobile Manufacturers (CAAM)

2.2.1 Overall Access Characteristics

(1) Overall access

As of December 31, 2020, totally 392,300 NEVs have been accessed to the National Monitoring and Management Platform.

As of December 31, 2020, the number of NEVs accessed to the National Monitoring and Management Platform has been up to 3,923,000, including 5863 models from 306 manufacturers. If we talk from the type of vehicles (Fig. 2.2), the number of accessed passenger cars, buses, and special vehicles are 316,000, 381,000 and 382,000, accounting for 80.5%, 9.7% and 9.8% respectively, which shows that the passenger car takes the main share.
According to the cumulative access of vehicles in different application scenarios, the cumulative access of private cars is the highest with a proportion of more than 50%. As of December 31, 2020, the cumulative access of private cars has reached 1,970,000, accounting for 50.23% of the total number of vehicles accessed to the National Monitoring and Management Platform; the vehicles following the private cars are cars for sharing, official vehicles, logistics vehicles and urban buses with a cumulative access of 557,000, 408,000, 366,000, and 324,000, accounting for 14.2%, 10.4%, 9.3%, and 8.3% respectively.

(2) Regional concentration

The number and proportion of provinces with a cumulative access of more than 300,000 vehicles in 2020 increased significantly compared with the previous two years.

According to the cumulative NEV access of different provinces (including autonomous regions and municipalities directly under the Central Government) on the National Monitoring and Management Platform (Table 2.2), there were 5 provinces with a cumulative access of more than 100,000 in 2018, among which,

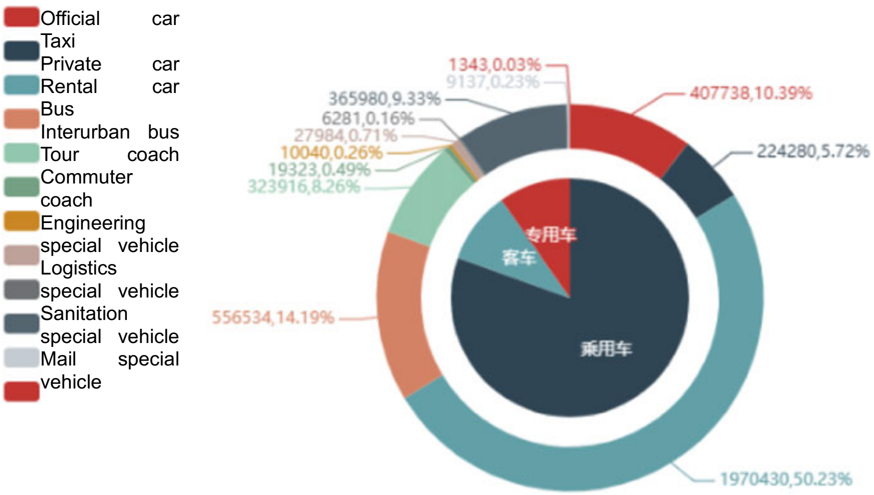


Fig. 2.2 Cumulative access and proportion of NEVs for different purposes

Table 2.2 The number of provinces of difference access levels and their proportion

Cumulative access level (10,000)	2018		2019		2020	
	Number of provinces	Proportion of cumulative access (%)	Number of provinces	Proportion of cumulative access (%)	Number of provinces	Proportion of cumulative access (%)
0–5	21	17.8	12	5.8	11	4.6
5–10	5	28.8	10	28.0	5	10.6
10–20	4	37.4	6	32.6	8	27.8
20–30	1	16.5	2	16.6	4	23.6
30–50	0	0.0	1	16.9	2	16.7
>50	0	0.0	0	0.0	1	16.7

Shanghai ranked first with a cumulative access in Guangdong of more than 200,000 (but less than 300,000), accounting for 16.5% of the total NEV access in China; other provinces with a cumulative access of more than 100,000 (but less than 200,000) are Beijing, Zhejiang, Shandong, and Shanghai, accounting for 37.4% of the total NEV access in China.

In 2019, there were 9 provinces with a cumulative access of more than 100,000, among which, the cumulative access in Guangdong was more than 300,000, accounting for 16.9% of the total NEV access in China; and the cumulative access in Beijing and Zhejiang was more than 200,000 (but less than 300,000), accounting for 16.6% of the total NEV access in China.

Table 2.3 The number of provinces with different NEV productions and the proportion of NEV production

Classification of proportion of NEV production (%)	2018		2019		2020	
	Number of provinces	Proportion of NEV production (%)	Number of provinces	Proportion of NEV production (%)	Number of provinces	Proportion of NEV production (%)
0–1	11	3.2	10	4.0	10	3.4
1–5	10	14.9	10	29.1	9	17.1
5–10	2	24.7	6	44.3	7	48.7
>10	5	57.2	2	22.6	2	30.8

In 2020, there were 15 provinces with a cumulative access of more than 100,000, among which, the cumulative access in Guangdong was more than 500,000, accounting for 16.7% of the total NEV access in China; the cumulative access in Beijing and Zhejiang was more than 300,000 (but less than 500,000), accounting for16.7% of the total NEV access in China; the cumulative access in Shanghai, Shandong, Henan and Anhui was more than 200,000 (but less than 300,000), accounting for 23.6% of the total NEV access in China (Table 2.2).

The promotion scale of NEVs in various provinces has increased steadily, and the cumulative promotion and application effect in Guangdong is significant.

According to the cumulative access of different types of vehicles over the years (Table 2.4), the cumulative access of new energy passenger cars is significantly higher than that of new energy buses and logistics vehicles.

According to the changes in the cumulative access of new energy passenger cars over the years (Table 2.5), the cumulative access of new energy passenger cars in TOP5 provinces increased from 588,800 in 2018 to 1.5322 million in 2020, and the cumulative access of new energy passenger cars in TOP10 provinces increased from 889,700 in 2018 to 2.2826 million in 2020.

According to the changes in the cumulative access of new energy buses over the years, the cumulative access of new energy buses in Guangdong, Jiangsu, Henan, Hunan and Shandong ranks in the forefront, the cumulative access in TOP5 provinces increased from 78,500 in 2018 to 143,900 in 2020, and the cumulative access in TOP10 provinces increased from 125,500 in 2018 to 233,100 in 2020, among which the cumulative access of new energy buses in Guangdong in 2020 was more than 50,000.

According to the changes in the cumulative access of new energy special vehicles over the years, the cumulative access of new energy special vehicles in TOP5 provinces increased from 95,600 in 2018 to 200,800 in 2020, and the cumulative access in TOP10 provinces increased from 144,500 in 2018 to 291,800 in 2020.

According to the access concentration of vehicles of different types over the years, the access concentration of new energy passenger cars and new energy buses in TOP3, TOP5 and TOP10 provinces has shown an overall downward trend; as for new energy

Table 2.4 Cumulative access of vehicles of different types in each province

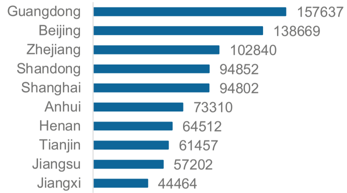
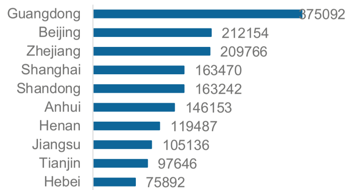
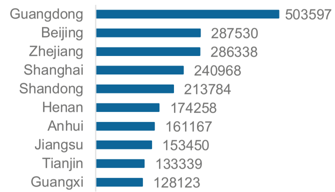
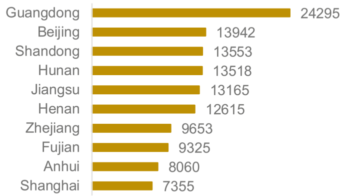
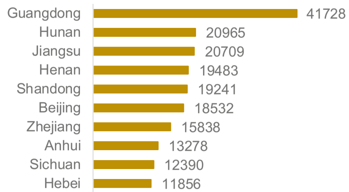
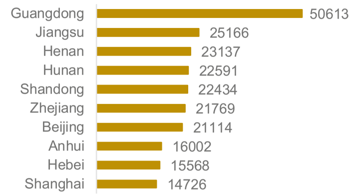
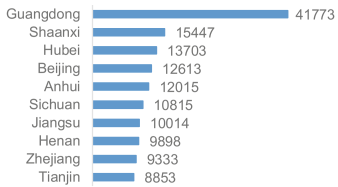
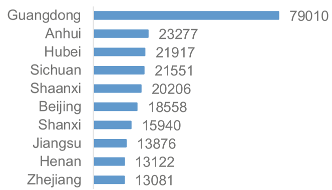
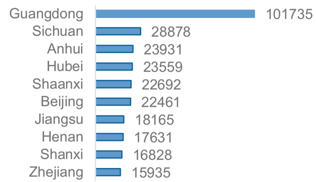
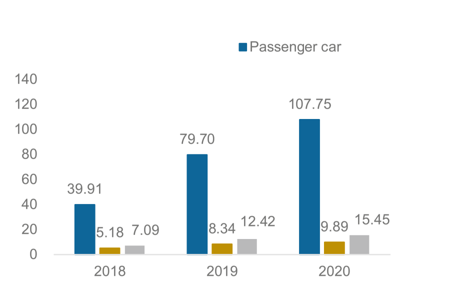
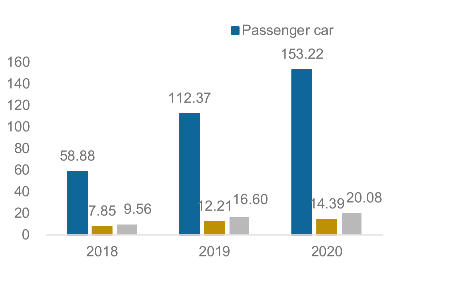
Type of vehicle	Cumulative access of each province (including autonomous region/municipality directly under the Central Government) in 2018	Cumulative access of each province (including autonomous region/municipality directly under the Central Government) in 2019	Cumulative access of each province (including autonomous region/municipality directly under the Central Government) in 2020
Passenger car			
Bus			
Special vehicle			

Table 2.5 Cumulative access and proportion of vehicles of different types in each province

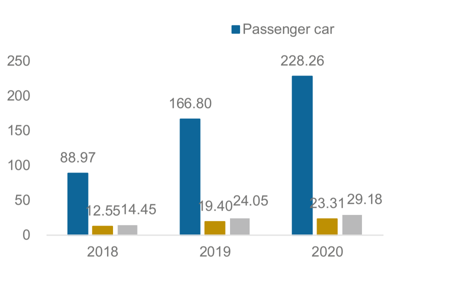
Cumulative access of TOP3 provinces over the years (10,000)



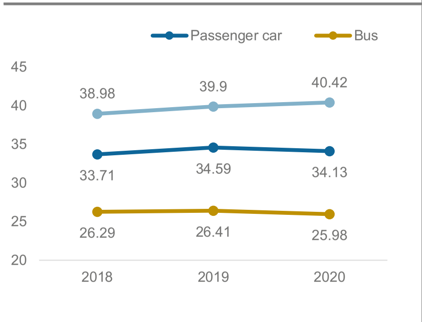
Cumulative access of TOP5 provinces over the years (10,000)



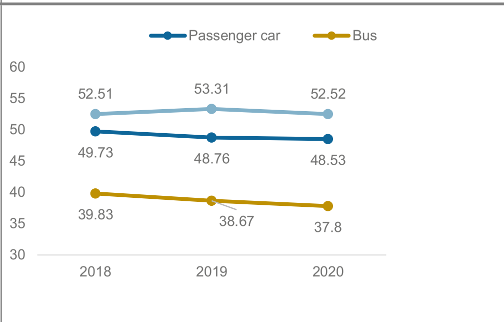
Cumulative access of TOP10 provinces over the years (10,000)



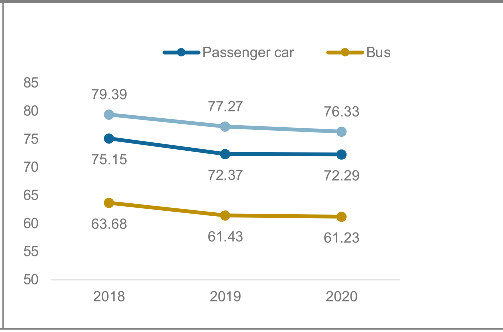
Proportion of cumulative access in TOP3 provinces over the years (%)



Proportion of cumulative access in TOP5 provinces over the years (10,000)



Proportion of cumulative access in TOP10 provinces over the years (10,000)



special vehicles, the proportion of cumulative access in TOP5 provinces increased from 52.51% in 2018 to 52.52% in 2020, and the regional access concentration in TOP5 provinces has remained basically stable.

According to the cumulative access concentration of different types of vehicles in various provinces, the development of new energy passenger cars and buses, after years of promotion and application, has been relatively mature, with the regional promotion concentration decreasing generally; but the new energy special vehicle is still in the early stage of industrial development, and its regional access concentration in TOP3 provinces and TOP5 provinces is relatively high, but as more and more provinces accelerate the pace of electrification in the public sector, the regional promotion concentration of new energy special vehicles will gradually decline.

(3) Production concentration

Compared with 2018, the number of provinces with a proportion of NEV production of more than 10% in 2020 was less.

According to the proportion of NEV production of each province over the years (Table 2.3), the number of provinces with a proportion of NEV production of more than 10% declined. In 2018, there were Anhui, Beijing, Shaanxi, Hunan and Shanghai, accounting for 57.2% of the total NEV production in China; in 2019, there were Beijing and Anhui, accounting for 22.6% of total NEV production in China; Then came to 2020, there were only Shanghai and Guangxi, accounting for 30.8% of total NEV production in China. The TOP2 provinces accounted for 30.8% of total NEV production in 2020, increasing by 8.2% compared with 2019.

The number of provinces with a proportion of NEV production of 5–10% increased. In 2018, there were only Zhejiang and Hubei, accounting for 24.7% of total NEV production in China; by 2020, there were Anhui, Guangdong, Chongqing, Beijing, Hunan, Shaanxi and Jilin, accounting for 48.7% of total NEV production in China (Table 2.3).

The proportion of production of new energy passenger cars and special vehicles in major provinces has fluctuated greatly, but that of new energy buses has been relatively stable.

According to the cumulative production of vehicles of different types over the years (Table 2.7), the gap of cumulative production of new energy passenger cars between the top provinces and other provinces is widening gradually.

As for new energy passenger cars, the proportion of cumulative production in TOP3 provinces increased from 34.3% in 2019 to 41.7% in 2020 (Table 2.8), and the cumulative production in Shanghai, Guangxi and Guangdong has increased significantly.

Table 2.6 Annual total access of NEVs to national monitoring and management platform in China

Year	2018	2019	2020
Access (10,000)	133.68	132.49	98.07

Table 2.7 Proportion of cumulative production of vehicles of different types in each province

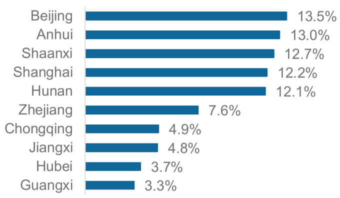
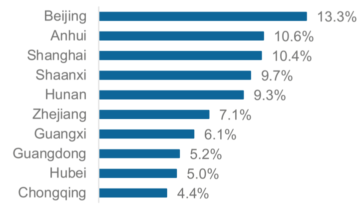
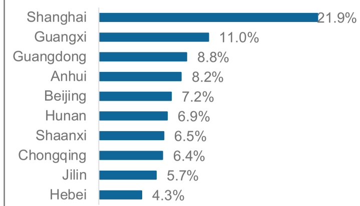
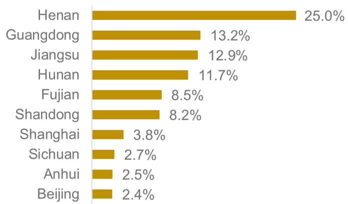
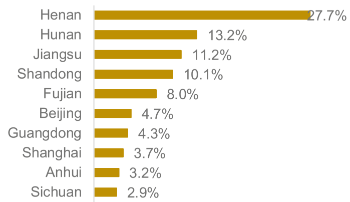
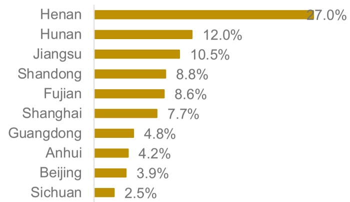
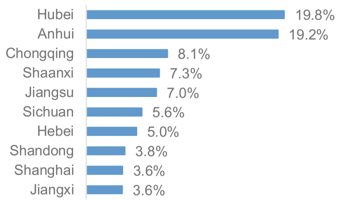
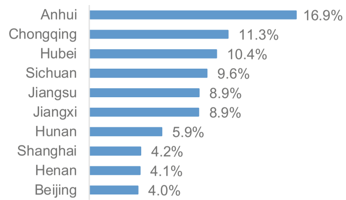
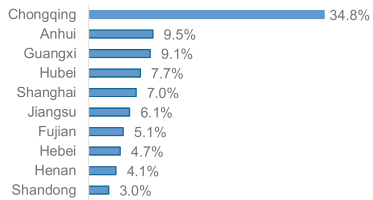
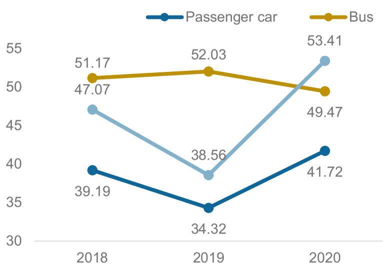
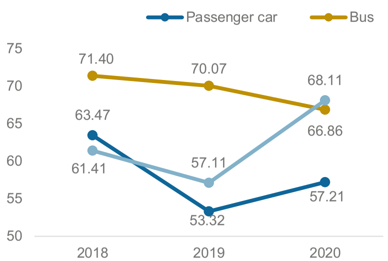
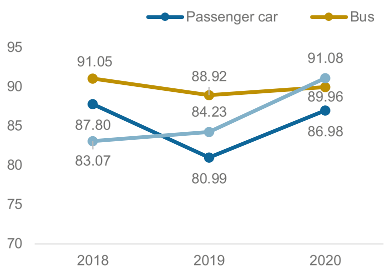
Type of vehicle	Proportion of NEV production in each province (including autonomous regions/municipalities directly under the Central Government) in 2018 (%)	Proportion of NEV production in each province (including autonomous regions/municipalities directly under the Central Government) in 2019 (%)	Proportion of NEV production in each province (including autonomous regions/municipalities directly under the Central Government) in 2020 (%)
Passenger car			
Bus			
Special vehicle			

Table 2.8 Proportion of cumulative production of vehicle of different types in each province

Proportion of production in TOP3 provinces over the years (%)	Proportion of production in TOP5 provinces over the years (%)	Proportion of production in TOP10 provinces over the years (%)
		

As for new energy buses, the production concentration in TOP3, TOP5 and TOP10 provinces is decreasing, with Henan, Hunan, Jiangsu, Shandong, and Fujian ranking in the forefront in terms of cumulative production.

As for new energy special vehicles, the production concentration in TOP3, TOP5 and TOP10 provinces in 2020 was increasing compared with 2019, among which, the proportion of cumulative production in Chongqing grew fastest from 8.1% in 2018 to 34.8% in 2020; the proportion of cumulative production in Guangxi also increased from 0.9% in 2018 to 9.1% in 2020.

2.2.2 Historical Access Characteristics of NEVs

(1) Historical access of NEVs to National Monitoring and Management Platforms

In 2020, there were 980,700 NEVs accessed to the National Monitoring and Management Platform.

As shown in Table 2.6, a total of 980,700 NEVs were accessed to the National Monitoring and Management Platform in 2020, which is lower than that in 2019 mainly due to the delay allowed for enterprises to access the National Monitoring and Management Platform. According to the comparison between the data of the National Monitoring and Management Platform and the actual sales of NEVs (Table 2.9), the access in January and February was significantly higher than the sales, indicating that some NEVs sold at the end of 2020 were accessed to the National Monitoring and Management Platform in January and February 2021.

According to the change in the monthly access of NEVs to the National Monitoring and Management Platform, the monthly access from October 2020 to January 2021 shows an obvious tail-raising trend (Fig. 2.3).

Table 2.9 Comparison of NEV access and sales in January–February 2021

Type of vehicle	January	February
Sales (10,000)	**17.90**	**11.00**
BEV	15.10	9.25
FCEV	1.89	1.71
Access	**21.53**	**19.79**
BEV	20.33	18.21
FCEV	1.20	1.58

Source Sales data from China Association of Automobile Manufacturers (CAAM)

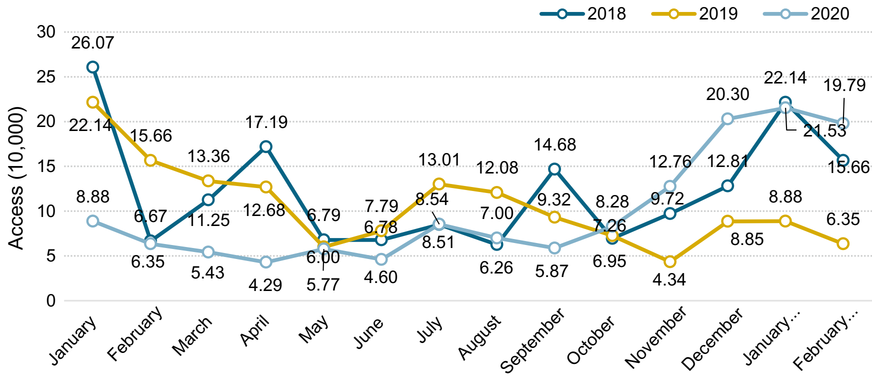


Fig. 2.3 Access of NEVs in China-by year

Table 2.10 Access of NEVs in China-by driving type

Driving type	BEV	FCEV	FCEV
Access (10,000)	84.97	12.87	0.23

(2) Access of vehicles of different driving types over the years

The access of BEVs takes a lion's share and shows a tail-raising trend in the fourth quarter.

As shown in Table 2.10, the total access of BEVs in 2020 was 849,700 with a proportion of 86.64%, and the access of PHCVs and FCEVs were 128,700 and 2,300 respectively. According to the distribution of monthly access throughout the year (Fig. 2.4), the access of BEVs in the fourth quarter of 2020 showed an obvious tail-raising trend, and some vehicles were accessed to the National Monitoring and Management Platform in early 2021 (Table 2.9).

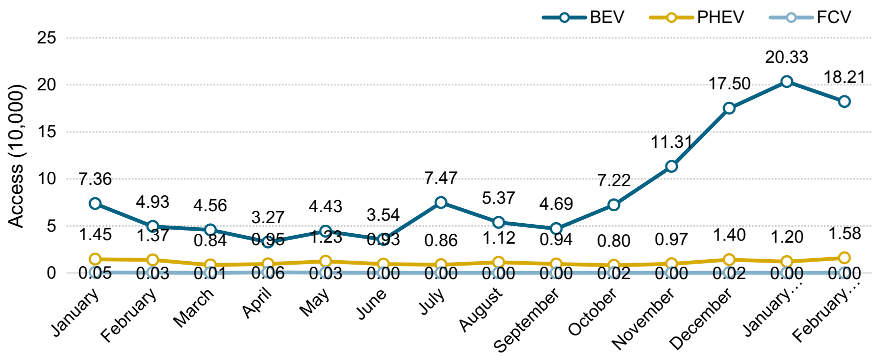


Fig. 2.4 Monthly access of NEVs in China in 2020-by driving type

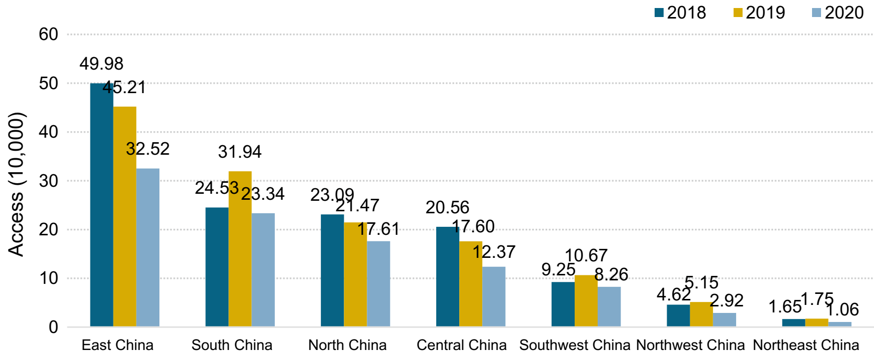


Fig. 2.5 Access in different regions of China

(3) Access of vehicles in different regions over the years

East China ranks first in terms of NEV access. According to the access in different regions (Fig. 2.5), East China boasts the highest access with a volume of 325,200, followed by South China and North China with an access of 233,400 and 176,100 respectively.

(4) Access in cities of different tiers over the years

The access of NEVs is closely related to the local economic development and the traffic & purchase restriction policy.

According to the access in cities of different tiers (Fig. 2.6), the access in first-tier cities was the highest in 2020 with a volume of 426,200, which is due to, on the one hand, the implementation of traffic and purchase restriction policies, and on the other hand, the advanced economic development and users' low sensitivity to the price of NEVs; in addition, the year-by-year increase of users' acceptance to NEVs is also an important factor that drives the increase of market demand. In 2020, the access of NEVs in second-tier and third-tier cities exceeded 200,000.
According to the proportion of NEV access in cities of different tiers (Fig. 2.7), in 2020, the proportion of NEV access in first-tier cities was 43.6%, with an increase of 3% compared with last year; the proportion of NEV access in third-tier, fourth-tier, and fifth-tier cities showed an expanding trend; and the proportion of NEV access in cities of third-tier or below was 35.9%, with an increase of 5.03% compared with last year.

(6) Access of vehicles in different application scenarios

In order to better study the characteristics of vehicle behaviors in key segments, six segments, including private cars, e-taxis, taxis, cars for sharing, logistics vehicles, and buses, are selected by using the big data intelligent analysis technology from the National Monitoring and Management Platform as the key application scenarios for

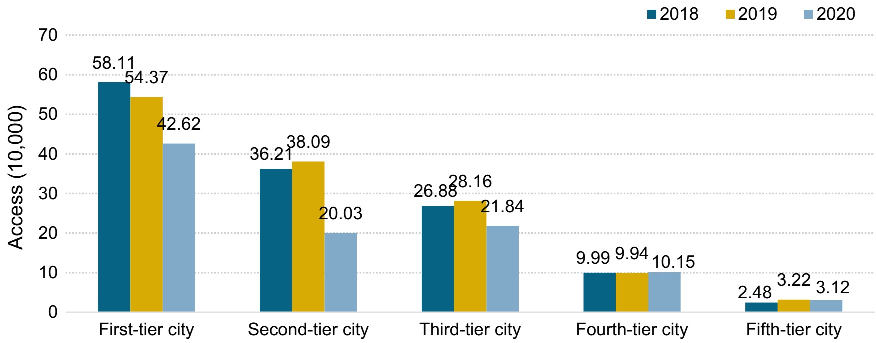


Fig. 2.6 NEV access in cities of each tier in China

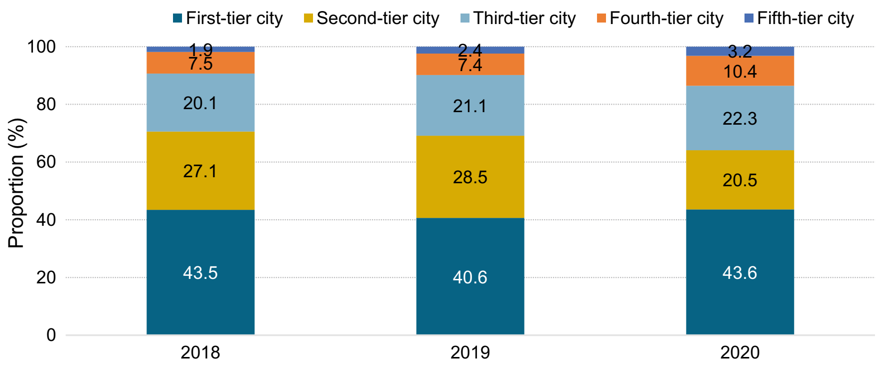


Fig. 2.7 Proportion of NEV access in cities of different tiers

research. In addition to those six key application scenarios, this report incorporates additionally the study of the operating characteristics of some new energy heavy-duty trucks, and the analysis of the battery swapping characteristics of some heavy-duty trucks of battery swap type, as described in the subsequent chapters. The vehicles of those main application scenarios are defined as follows:

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

As shown in Table 2.11, the accesses of private cars, e-taxis, taxis, cars for sharing, logistics vehicles and buses in 2020 were 618,400, 13,900, 71,100, 24,300, 47,500 and 62,000, and compared with the access in 2019, the access of private cars increased by 9.9%, the access of logistics vehicles decreased by 61.3%, and the access of buses decreased by 44.1%.

(7) Access of new energy private cars over the years

The NEV has been more than more market-oriented, and the proportion of access of private cars has been growing rapidly.

With the rapid release of private consumer demand, the demand on vehicles for daily travel has become an important force driving the growth of the NEV market. According to data on the National Monitoring and Management Platform, the proportion of access of new energy private cars in 2020 was significantly greater than that in 2018 and 2019 (Fig. 2.8), i.e., increased by 20.6 to 63.1% compared with 2019, which is mainly due to the market-oriented development of more products more suitable

Table 2.11 NEV access in key segments

Key segment	Access in 2018 (10,000)	Access in 2019 (10,000)	Access in 2020 (10,000)	2020 YoY change (%)
Private car	63.10	56.27	61.84	9.9
E-taxis	8.95	19.78	1.39	−93
Taxi	4.38	6.41	7.11	10.9
Car for sharing (time-based renting + long/short-term renting)	6.07	4.73	2.43	−48.5
Logistics vehicle	15.13	12.26	4.75	−61.3
Bus	14.09	11.09	6.2	−44.1

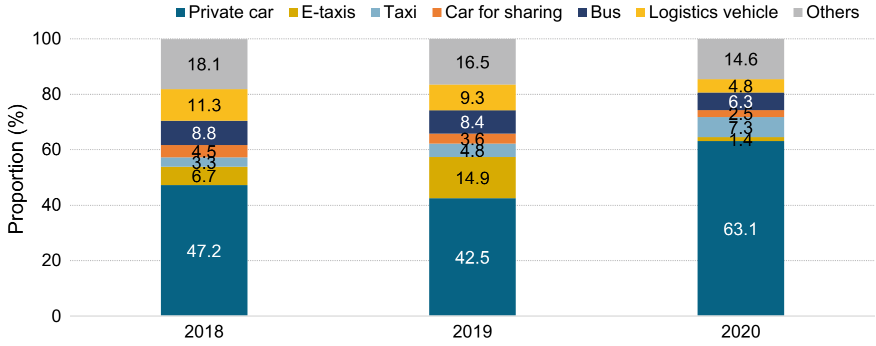


Fig. 2.8 Proportion of access of NEVs in different segments over the years

for consumer demand, coupled with the strengthened promotion of manufacturers in the peak consumer season, and the rapid release of private consumer demand.

In addition, in 2020, the proportion of access of taxis increased fast to 7.3% compared with 2019; the proportion of access of e-taxis, cars for sharing and logistics vehicles decreased compared with 2019; and the proportion of access of buses was generally stable.

Stimulated by the countryside NEV promotion policy, the proportion of access 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. 2.9), in 2020, the proportion of access of new energy private cars in cities of the third-tier or below increased rapidly by 7.5 to 39.2% compared with 2019, which is mainly driven by the countryside NEV consumption stimulation policies in various regions. Some NEV manufacturers have responded positively and launched products suitable for the travel needs of residents in cities of the third-tier or below, which further promotes the rapid growth of the private car market in these cities.

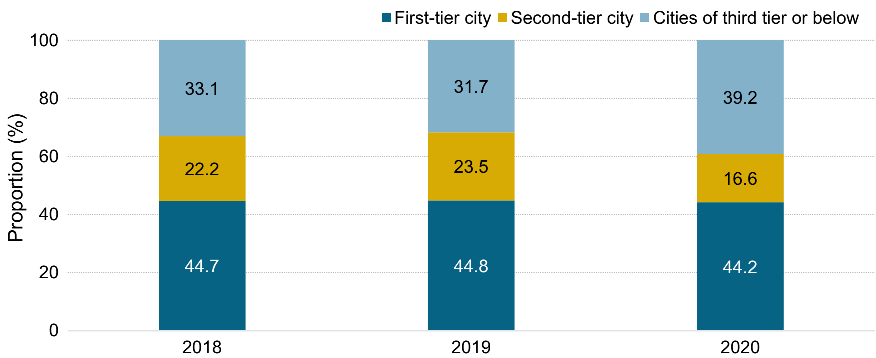


Fig. 2.9 Proportion of access of new energy private cars in cities of different tiers

2.3 Summary

With the improvement of the NEVs' cost performance, the upgrading of charging facilities and supporting environment, and the significant increase of consumers' recognition and acceptance to NEVs, the NEV industry has enjoyed explosive growth. According to the access data on the National Monitoring and Management Platform over the years, the NEV industry presents the following development characteristics:

The driver for the development of the NEV industry has changed from policy to the combination of policy and market. On the one hand, the proportion of access of new energy private cars is growing rapidly, and the demand in private consumption market is released rapidly. According to the data on the National Monitoring and Management Platform, the access of new energy private cars accounted for 63.1% of total NEV access to the platform in 2020, which is significantly higher than that in 2018 and 2019 mainly due to the market-oriented development of products suitable for customer needs by NEV manufacturers and the rapid release of the private consumer market; on the other hand, the market demand for NEVs in the cities of the third-tier or below is growing rapidly due to the adoption of countryside NEV promotion policy. In 2020, the proportion of access of new energy private cars in cities of the third-tier or below increased rapidly. Some small BEV passenger cars such as Hongguang MINIEV, Chery eQ1 and BAIC EC series were developed and launched according to the market demand of the cities of the third-tier or below, exploring a new path for the market-oriented development of NEVs.

BEVs are the main force in the marketization of NEVs, and among them, FCEVs have entered the steady development stage, and FCEVs are still in the scale demonstration and promotion stage. According to the data on the National Monitoring and Management Platform, in 2020, the access of BEVs was 849,700, accounting for 86.64% of the total NEV access in China; the monthly access of FCEVs maintained stable; the access of FCEVs was 2300, and FCEVs were still in the scale demonstration stage.

East China is the focus for the promotion of NEVs in China. According to the NEV access in different regions, East China and South China are the regions where the NEV application is the most concentrated; then according to the NEV access in cities of different tiers, the NEV access in first-tier cities in 2020 was significantly higher than that in cities of other tiers. The access of NEVs is closely related to the local economic development and the traffic & purchase restriction policy of cities. The eastern coastal region is economically developed and densely populated, and users therein have a high recognition to NEVs, and thus the promotion and application of NEVs in this region far exceeds that in other regions.

Chapter 3
Technical Progress of New Energy Vehicles

This chapter, based on the NEV access characteristics on the National Monitoring and Management Platform and also the data in the national announcements related to NEVs, makes an in-depth analysis of range, battery, vehicle lightweight characteristics, vehicle energy consumption change, and REESS rated voltage change as focuses, and summarizes the technical progress of new energy vehicles, providing a significant reference for promoting the technological innovation of NEVs and the development of the related industry.

3.1 Technical Progress in Range

The range of NEVs is increasing year by year.

According to the technical parameters of the NEVs' range in China (Fig. 3.1), the average range of NEVs of different types is increasing year by year. In the past three years, the average range of new energy passenger cars has increased from 215 to 300.3 km, that of new energy buses has increased from 258.6 to 400.6 km, and that of new energy logistics vehicles has increased from 243.3 to 287.6 km.

For BEVs of different types (Fig. 3.2), the average ranges of BEV passenger cars, BEV buses and BEV logistics vehicles in 2020 were 394 km, 457 km and 277 km, increasing by 34.9%, 46.5% and 8.2% respectively compared with 2018. As these data show, the increase in the range of BEV logistics vehicles is slow in these three years.

For FCEVs of different types (Fig. 3.3), the average all-electric range of FCEV passenger cars has basically maintained below 70 km with little change; the average all-electric range of FCEV buses increased by 63.0–112.3 km compared with 2018.

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2021)*,
https://doi.org/10.1007/978-981-19-5508-2_3

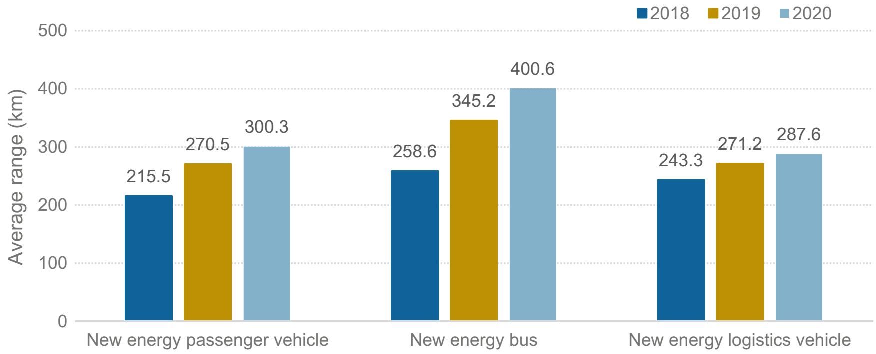


Fig. 3.1 Changes in average range of NEVs of different types over the years

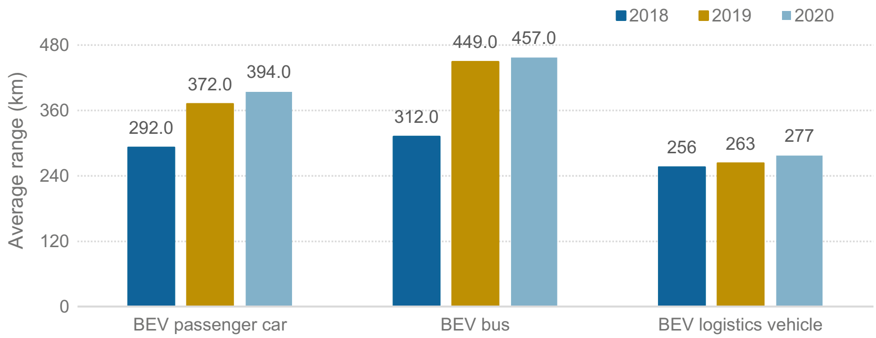


Fig. 3.2 Changes in average range of BEVs of different types over the years

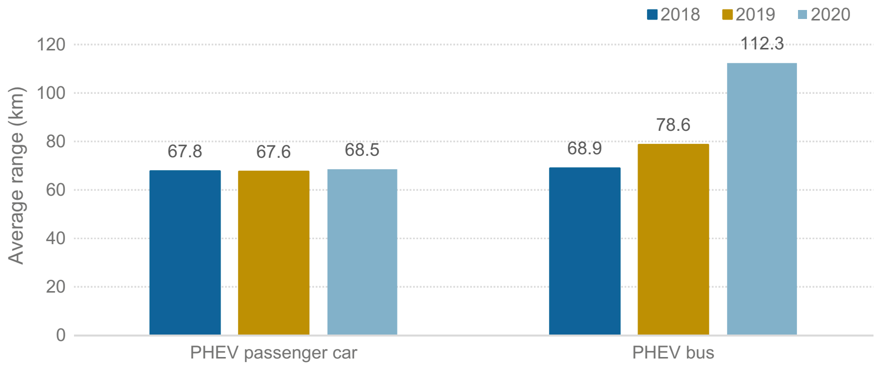


Fig. 3.3 Changes in average range of FCEVs of different types over the years

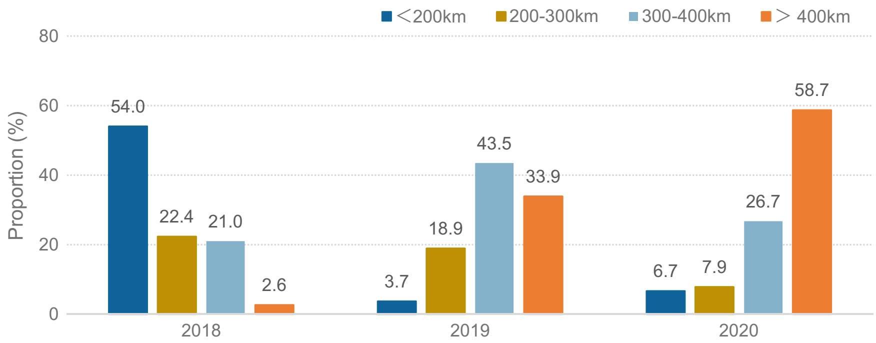


Fig. 3.4 Distribution of BEV passenger vehicles in different range sections. *Note* The sum of the proportion of vehicles in different range sections of each year is equal to 100%, which is the same below

The range of BEV passenger cars is increasing rapidly, so does the proportion of vehicles with a range of more than 400 km.

According to the change in the average range of BEV passenger cars (Fig. 3.4), the proportion of vehicles in the high range section increased rapidly, with the proportion of vehicles with a range of 400 km increased from 2.6% in 2018 to 58.7% in 2020; the proportion of BEV passenger cars with a range of less than 200 km increased faster than last year, which is mainly due to the rapid growth in the number of small BEV passenger cars.

The range of BEV passenger cars of different classes has increased rapidly, especially the cars of Class B and above.

According to the average range of BEV passenger cars of different classes (Fig. 3.5), their range is increasing rapidly year by year. In 2020, the average range of Class A0 + A00 cars, Class A cars, cars of Class B and above and SUVs were 284.2 km, 366.3 km, 443.1 km and 389.1 km, increasing by 54.9%, 34.5%, 55.8% and 29.7% respectively compared with 2018.

The proportion of BEV buses with a range of more than 300 km has increased significantly.

The proportion of BEV buses in different range sections changes greatly. According to the changes over the years (Fig. 3.6), the proportion of BEV buses with a range of more than 300 km is increasing year by year, i.e., from 44.7% in 2018 to 77.7% in 2020. The proportion of BEV buses with a range of 300–400 km increased from 15.3% in 2018 to 28.4% in 2020, and the proportion of BEV buses with a range of more than 400 km increased from 29.4% in 2018 to 49.3% in 2020. But, the proportion of BEV buses with a range of 200–300 km declined from 47.4% in 2018 to 13.0% in 2020.

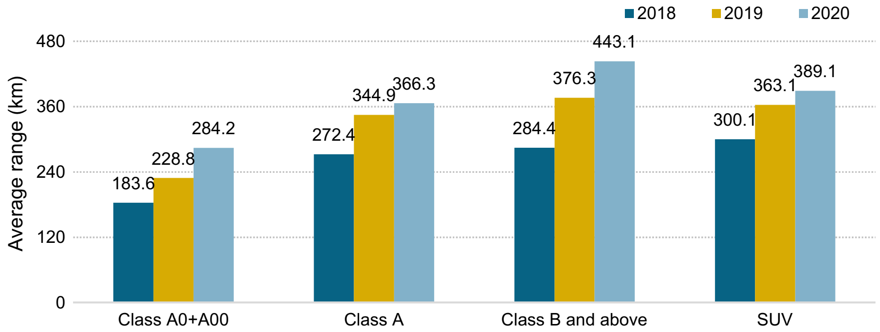


Fig. 3.5 Distribution of average range of BEV passenger cars of different classes

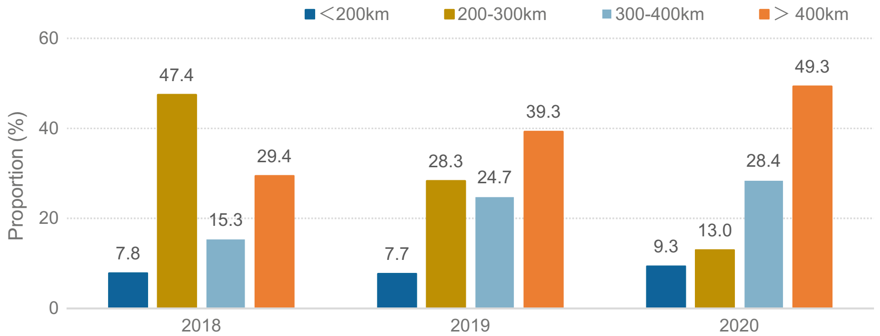


Fig. 3.6 Distribution of BEV buses in different range sections

The range of BEV logistics vehicles is mainly 200–300 km.

Since 2018, the proportion of BEV logistics vehicles with a range of 200–300 km has remained above 58% (Fig. 3.7), and in 2020, it increased to 78.2%, which is nearly 20% higher than that in 2019.

3.2 Progress in Lightweight Technology

In the past three years, the curb weight of new energy passenger cars has increased slightly.

According to the data over the years in China (Table 3.1), in 2020, the average curb weight of new energy passenger cars increased slightly to 1486.3 kg compared with 2019, which is mainly due to the increase in the curb weight of BEV SUVs, FCEV cars of Class B and above and FCEV SUVs.

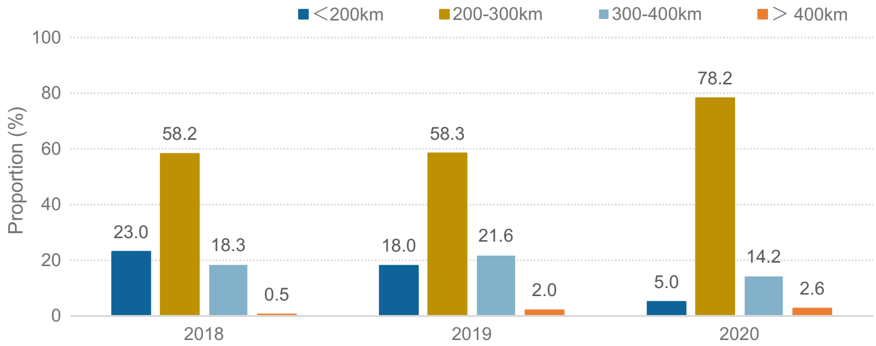


Fig. 3.7 Distribution of BEV logistics vehicles in different range sections

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

Year	2018	2019	2020
New energy passenger vehicle Average curb weight (kg)	1317.4	1477.0	1486.3

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

Year	2018	2019	2020
BEV passenger car Average curb weight (kg)	1273.4	1457.2	1441.0

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

According to the changes over the years (Table 3.2), the average curb weight of BEV passenger cars in 2020 was 1441.0 kg, which is higher than that in 2018 but 1.1% lower than that in 2019.

For BEV passenger cars of different classes (Fig. 3.8), the lightweight technology of BEV passenger cars has achieved significant progress, with the curb weight of Class A00 + A0 cars and Class A cars decreasing obviously; the average curb weight of cars of Class B and above cars in 2020 was basically the same as that of the previous year, showing a slow decrease trend; and the average curb weight of SUVs in 2020 was increased compared with 2019, suggesting that more intensive research on lightweight technology is required. On the whole, BEV passenger cars have higher requirements for lightweight, and have become a good 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 wide application of lightweight technology in the traditional automobile industry.

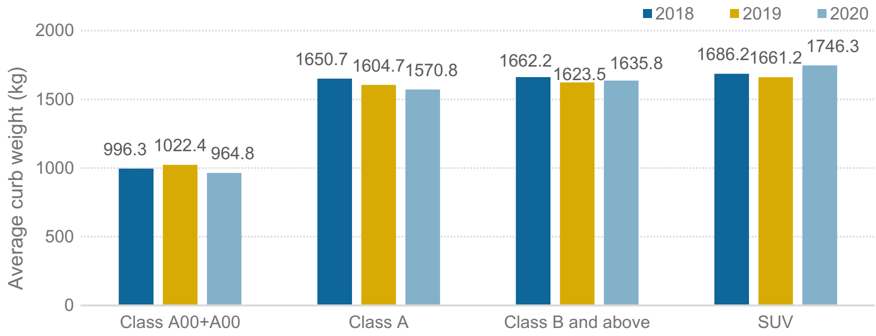


Fig. 3.8 Changes in average curb weight of BEV passenger cars of different classes over the years

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

Year	2018	2019	2020
Average curb weight of FCEV passenger cars (kg)	1647.7	1661.7	1891.5

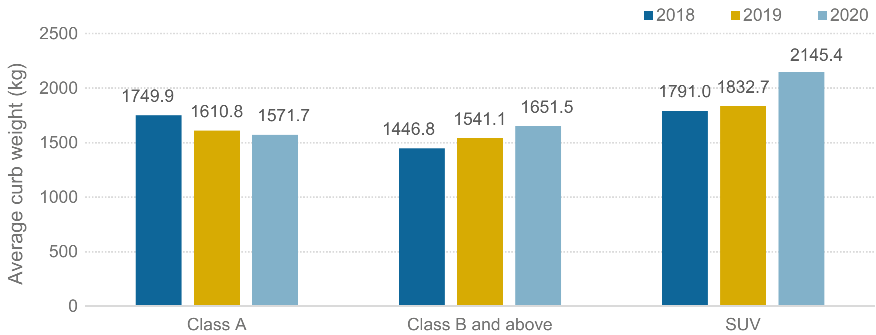


Fig. 3.9 Changes in average curb weight of FCEV passenger cars of different classes over the years

The curb weight of FCEV passenger cars is on the rise.

According to the changes over the years (Table 3.3), the average curb weight of FCEV passenger cars in 2020 was 1891.5 kg, increasing greatly compared with 2018 and 2019. According to the distribution of the average curb weight of FCEV passenger cars of different classes (Fig. 3.9), the Class A car has achieved an obvious lightweight effect, with the average curb weight decreasing year by year; the average curb weight of cars of Class B and above and SUVs has increased rapidly over the years.

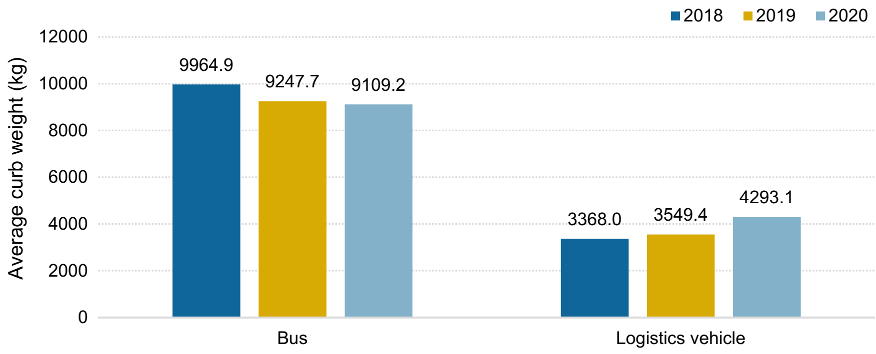


Fig. 3.10 Changes in average curb weight of new energy commercial vehicles of different types over the years

The average curb weight of new energy buses is decreasing year by year, while that of logistics vehicles is increasing year by year.

The average curb weight of new energy buses is decreasing year by year (Fig. 3.10), and compared with 2018, it was slightly reduced to 9109.2 kg in 2020.
The average curb weight of new energy logistics vehicles is increasing year by year, and compared with 2018, it was significantly increased to 4293.1 kg in 2020, which is due to, on the one hand, the significantly higher proportion of logistics vehicles with a range of more than 200 km, and on the other hand, the diversity of NEV logistics vehicle models and the rapidly-increased proportion of new energy medium-duty logistics vehicles with higher curb weight (specifically, the proportion of logistics vehicles with a curb weight above 4.5 ton accessed to the National Monitoring and Management Platform in 2020 increased by 1.1% compared with 2019).

3.3 Changes in Energy Consumption Over the Years

This section, according to the data of 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 per 100 km, 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.
Electricity consumption per 100 km refers to the average electricity consumption of BEVs every 100 km in the actual operating environment, which is expressed in kWh/100 km. The calculation formula is as follows:

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

where, E_{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 driving mileage (km).

(1) The energy consumption of BEV passenger cars of different classes shows a downward trend

In the past three years, the energy consumption per 100 km of BEV passenger cars of different classes has decreased. As shown in Fig. 3.11, in 2020, the electricity consumption of Class A00 + A0 cars was 12.4 kWh/100 km, decreasing by 3.1% compared with 2019 and by 5.3% compared with 2018; the electricity consumption of Class A cars was 14.1 kWh/100 km, decreasing by 2.1% compared with 2019 and by 7.8% compared with 2018; according to the distribution of average electricity consumption over the years, the average electricity consumption of BEV cars of Class B and above was 16.9 kWh/100 km, decreasing by 13.8% compared with 2019 and by 17.6% compared with 2018; and the average electricity consumption of BEV SUVs in 2020 was 18.1 kWh/100 km, decreasing by 2.2% compared with 2019 and by 9.5% compared with 2018.

(2) The energy consumption of BEV commercial vehicles increased in 2020 compared with last year

As for buses, 35 enterprises with an annual sales of more than 1000 were selected for analysis, and the calculation shows that the average electricity consumption of BEV buses in 2020 was 73.6 kWh/100 km, increasing by 2.3% (Table 3.4) compared with 2019; as for logistics vehicles, the average electricity consumption of BEV logistics vehicles in 2020 was 33.8 kWh/100 km, increasing by 1.5% (Table 3.5) compared with last year.

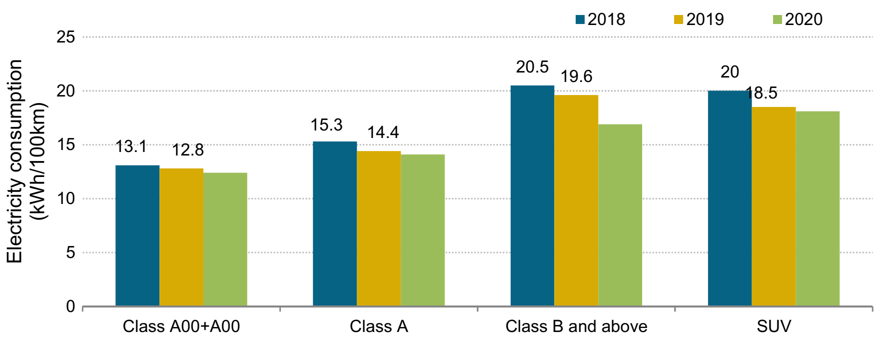


Fig. 3.11 Electricity consumption of BEV passenger cars of different classes per 100 km

Table 3.4 Electricity consumption of buses over the years-average

Year	2018	2019	2020
Average electricity consumption of buses (kWh/100 km)	66.9	71.9	73.6

Table 3.5 Electricity consumption of logistics vehicles over the years-average

Year	2018	2019	2020
Average electricity consumption of logistics vehicles (kWh/100 km)	33.6	33.3	33.8

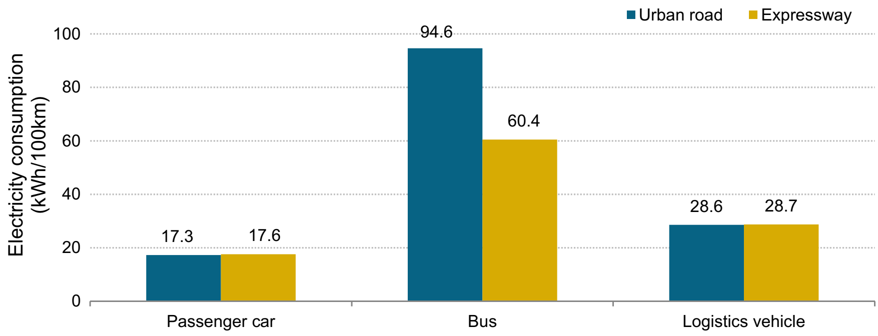


Fig. 3.12 Electricity consumption of vehicles of different types under different road conditions

(3) Energy consumption of vehicles under different road conditions

BEV passenger cars and logistics vehicles are more suitable for driving on urban roads than conventional fuel vehicles.

According to the electricity consumption of vehicles of different types under different road conditions, the electricity consumption of BEV passenger cars and logistics vehicles on urban roads and expressways is basically the same (Fig. 3.12); but the fuel consumption of conventional fuel vehicles on urban roads is far higher than that on expressways, indicating that their economy on urban roads is worse. In a word, BEV passenger cars and logistics vehicles are more suitable for driving on urban roads than conventional fuel vehicles.

The electricity consumption of buses on urban roads is significantly higher than that on expressways because, on urban roads, the frequent start and stop and low-speed running of buses increase their combined electricity consumption.

3.4 Change in Battery Type

Ternary batteries dominate the NEV market, but in 2020, the types of vehicles equipped with lithium iron phosphate batteries increased.

Considering the types of battery installed on the vehicle (Fig. 3.13), ternary batteries dominate the NEV market, with the proportion of vehicles equipped with such batteries higher than 70% in the past three years. According to the changes over the years, in 2020, the proportion of vehicles equipped with ternary batteries in 2020

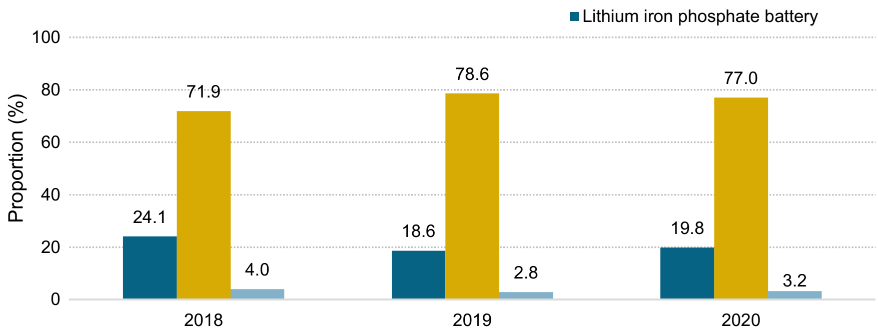


Fig. 3.13 Proportion of NEVs equipped with batteries of different types

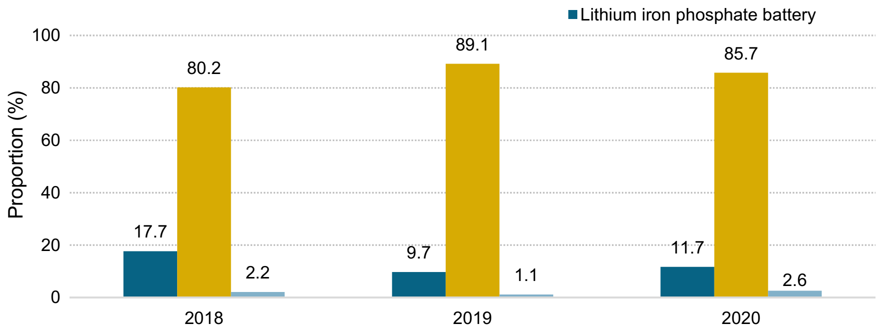


Fig. 3.14 Proportion of BEV passenger cars equipped with batteries of different types. *Note* The sum of the proportion of vehicles equipped with batteries of different types in each year is equal to 100%, which is the same below

was 77.0%, which is lower than that of last year, and the proportion of vehicles equipped with lithium phosphate batteries increased by 1.2–19.8% compared with last year.

The batteries on BEV passenger cars are mainly ternary batteries, but in 2020, the proportion of BEV passenger cars equipped with lithium iron phosphate batteries increased.

The batteries on BEV passenger cars are mainly ternary batteries, with the proportion of BEV passenger cars equipped with such batteries higher than 80% in the past three years. According to the annual change of batteries of different types (Fig. 3.14), the proportion of vehicles with lithium iron phosphate batteries, compared with 2019, increased by 2–11.7% in 2020, showing an upward trend.

The batteries on FCEV passenger cars are mainly ternary batteries.

In the past three years, a battery construction based on ternary batteries has been gradually formed for the FCEV passenger cars (Fig. 3.15). In 2020, the proportion

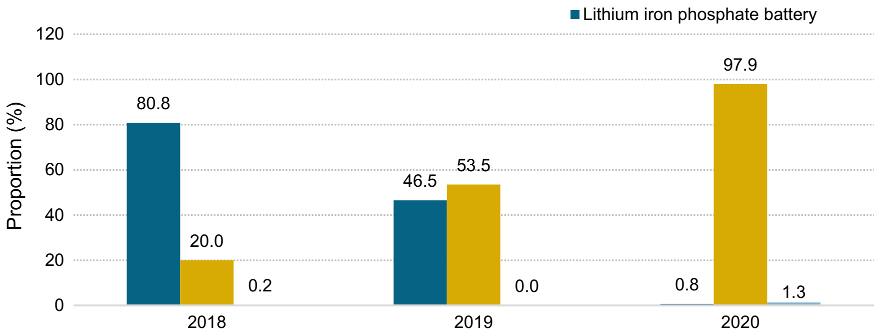


Fig. 3.15 Proportion of FCEV passenger cars equipped with batteries of different types

of FCEV passenger cars equipped with ternary batteries was 97.9%, increasing by 44.4% compared with 2019.

As for the BEV passenger cars, the market share of batteries in high and low energy density sections is rising, and that of batteries in the middle energy density section is declining.

As for the BEV passenger cars, the market share of batteries in high and low energy density sections is rising, and that of batteries in the middle energy density section is declining. Compared with 2019, the market share of batteries with an energy density lower than 125 Wh/kg and higher than 160 Wh/kg increased by more than 35%, while that of batteries with an energy density of 125–160 Wh/kg decreased; As for FCEV passenger cars, the installation of batteries with an energy density of 140–160 Wh/kg increased rapidly (Fig. 3.16).

The batteries on BEV buses are mainly lithium iron phosphate batteries, and only a small number of them are installed with other types of batteries.

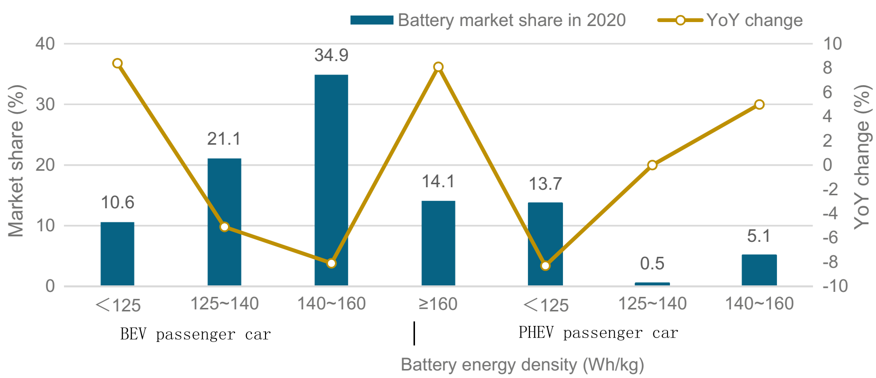


Fig. 3.16 Market share of batteries in different energy density sections

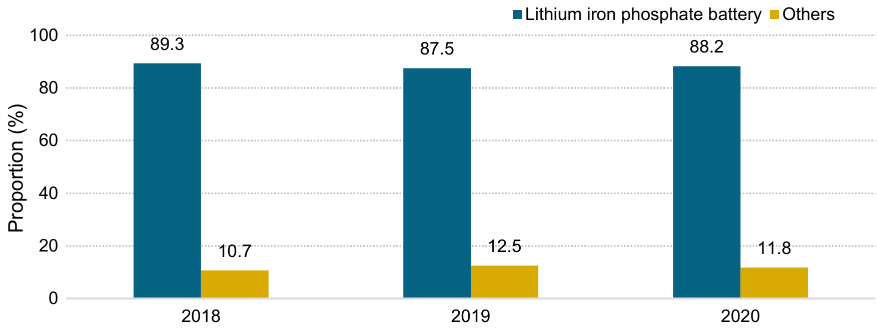


Fig. 3.17 Proportion of BEV buses equipped with batteries of different types

Most (namely 88.2%) BEV buses are installed with lithium iron phosphate batteries, and only a small number of BEV buses are installed with lithium titanate batteries, lithium manganate batteries and batteries of other types (Fig. 3.17).

For BEV logistics vehicles, a vehicle construction based on lithium iron phosphate battery is gradually into shape.

In the past three years, the structure of battery types of BEV logistics vehicles has changed greatly. Specifically, in 2018, the batteries used on BEV logistics vehicles were mainly ternary batteries, with a proportion of 67.4%, but in 2020, the proportion of BEV logistics vehicles with lithium iron phosphate batteries increased up to 80.3% (Fig. 3.18).

The assembly of batteries is concentrated in several battery manufacturers, especially CATL.

According to the production of NEVs and the assembly of batteries for those NEVs, the assembly of batteries has been gradually concentrated in some battery manufacturers (Fig. 3.19). The TOP3 battery manufacturers in 2020 were CATL, BYD

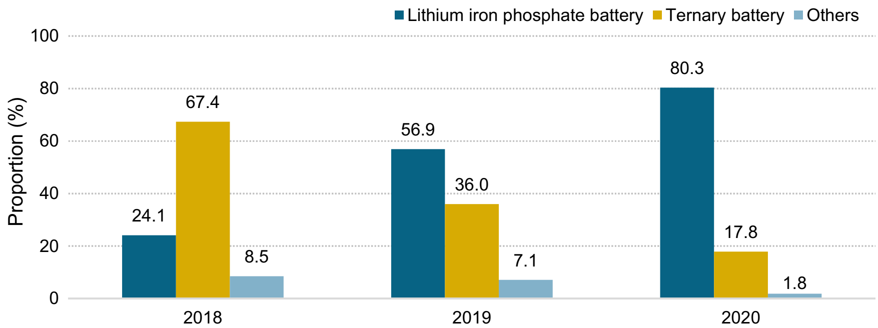


Fig. 3.18 Proportion of BEV logistics vehicles equipped with batteries of different types

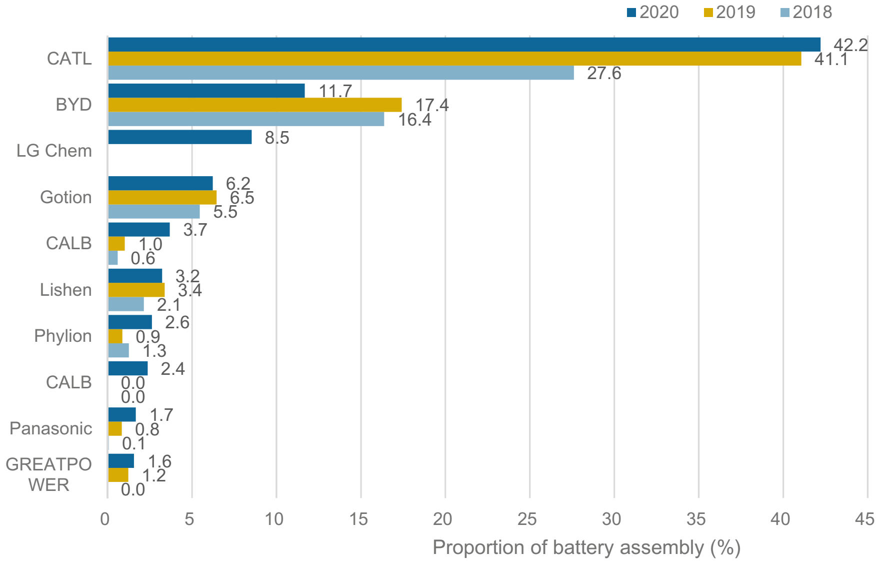


Fig. 3.19 Battery assembly of battery manufacturers. *Note* The proportion of battery assembly of different battery manufacturers in each year is equal to 100%

and LG Chem. Those three manufacturers occupy 62.4% of the total assembly of batteries, and among them, CATL performed best, with the proportion of battery assembly up to 42.2% and the market share gradually increased in 2020.

3.5 Change in Voltage of Onboard Energy Storage System

The NEVs' energy storage system has become higher and higher, and especially, the energy storage system of passenger cars has progressed fast.

According to the changes in the voltage technology trend of onboard energy storage systems for vehicles of different types (Fig. 3.20), the voltage of energy storage systems for passenger cars and buses is increasing, especially the passenger cars, whose energy storage system in 2020 had a voltage 15.1% higher than that in 2019, i.e., 335.2 V. But in 2020, the voltage of the energy storage system of the new energy logistics vehicles decreased slightly compared with last year.

The voltage energy storage system of BEV passenger cars has increased greatly, especially the mini cars.

As for BEV passenger cars (Fig. 3.21), the average voltage of the battery pack of Class A00 + A0 cars increased from 182.2 V in 2018 to 253.1 V in 2020, showing an obvious high-voltage development trend; the energy storage systems for Class

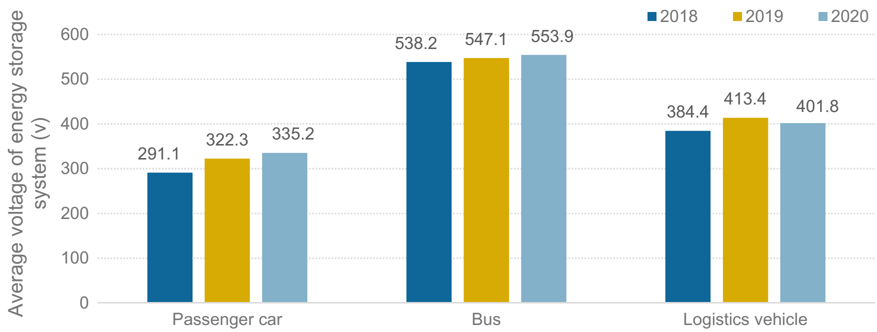


Fig. 3.20 Change in voltage of energy storage system of NEVs of different types

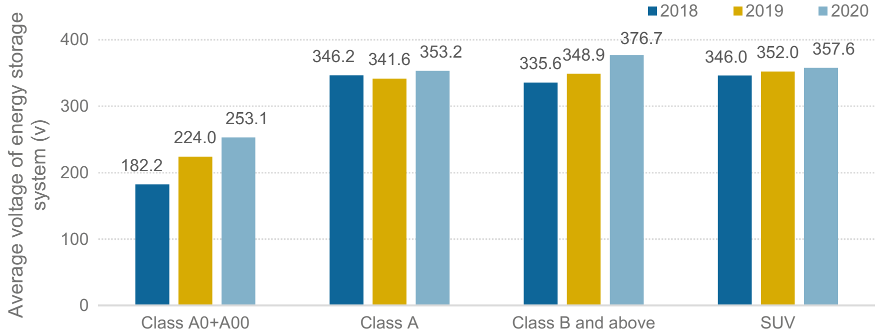


Fig. 3.21 Trend of change in battery pack voltage of cars of different classes

A cars, cars of Class B and above and SUVs realized high-voltage development in 2018, and since then, their voltage continued to increase gradually in the past two years.

3.6 Summary

For NEVs, significant progresses have been achieved in range, lightweight and other technical indicators. This chapter, through in-depth analysis of the technical parameters of NEVs, mainly draws the following conclusions:

The vehicle range has increased quickly, and meanwhile, the body's lightweight technology has also achieved significant achievements. The range of NEVs of different types is increasing year by year. From 2018 to 2020, the range of new energy passenger cars increased from 215 to 300.3 km, that of new energy buses increased from 258.6 to 400.6 km, and that of new energy logistics vehicles increased from 243.3 to 287.6 km, and among them, the range of BEVs increases faster. Specifically, the range of BEV passenger cars of Class B and above increases fastest; the proportion of BEV buses with a range of more than 300 km has increased rapidly; the proportion of BEV logistics vehicles with a range of 200–300 km has expanded quickly, and in 2020, it was increased by nearly 20–78.2% compared with last year. The body lightweight technology, with the industrial application of aluminum alloy and carbon fiber composite materials, has achieved significant progress. Compared with 2019, the average curb weight of NEVs decreased by 7.5% to 1910.0 kg in 2020, and the cars of Class A and above were obviously lighter than before.

As for the battery, the batteries on passenger cars are mainly ternary batteries, and in 2020, the lithium phosphate batteries returned to the market; the buses and logistics vehicles have gradually formed a vehicle construction based on lithium iron phosphate battery. Considering the types of batteries equipped on vehicles of different types, the batteries equipped on BEV passenger cars are mainly ternary batteries, with a proportion of more than 80%. The lithium iron phosphate battery gradually returns to the market, with the proportion of vehicles equipped with this battery increased by 2–11.7% compared with 2020; the batteries equipped on FCEV passenger cars are mainly ternary batteries. For BEV buses and logistics vehicles, a vehicle construction based on lithium iron phosphate battery is gradually into shape, and in the past three years, the main type of batteries on logistics vehicles has changed from ternary battery to lithium iron phosphate battery.

The NEVs' energy storage system has become higher and higher. The voltage of energy storage systems for new energy passenger cars and buses is increasing year by year. The voltage of energy storage systems for BEV cars of different classes has increased greatly, but the voltage of energy storage systems for SUVs has not increased a lot.

Chapter 4
Operation of New Energy Vehicles

As of December 31, 2020, totally 3,923,000 NEVs have been accessed to the National Monitoring and Management Platform. With the scale growth of the number of NEVs accessed to the National Monitoring and Management Platform, it is of great significance to study the operation intensity and travel characteristics of NEVs. 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, buses and heavy-duty trucks, providing important research basis and references for the study and evaluation of the electrification characteristics of the automobile industry and the low-carbon trend of energy structure, and for the construction of an intelligent traffic system (ITS).

4.1 NEV Online Rate in 2020

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. This section, 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, 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 (2021)*,
https://doi.org/10.1007/978-981-19-5508-2_4

4.1.1 NEV Online Rate in China

The average monthly online rate of NEVs in 2020 was 81.1%, 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 has increased steadily for two consecutive years: in 2020, it was 81.1%, increased by 10.9% compared with 2018 and by 1.1% compared with 2019 (Table 4.1).
At the beginning of 2020, the monthly online rate was relatively low due to the COVID-19 outbreak, but after the epidemic was stably controlled, it gradually returned to the level of the same period last year. As the distribution shows (Fig. 4.1), the online rate was lower than 80% in February and March 2020, and after March, it was recovered and grew steadily to above 80% and the operation frequency of NEVs was maintained at a high level.

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

As shown in Table 4.2, the average online rate of FCEVs in 2020 was significantly higher than that of BEVs and FCEVs. Specifically, the average monthly online rate of FCEVs was 93.7%, and boasted a higher reliance from the users; BEVs followed the FCEVs in the average monthly online rate with a value of 78.9% in 2020; FCEVs had a relatively low average monthly online rate of 75.0%. According to the distribution

Table 4.1 Average monthly online rate in China

Year	2018	2019	2020
Average online rate in China (%)	70.2	80.0	81.1

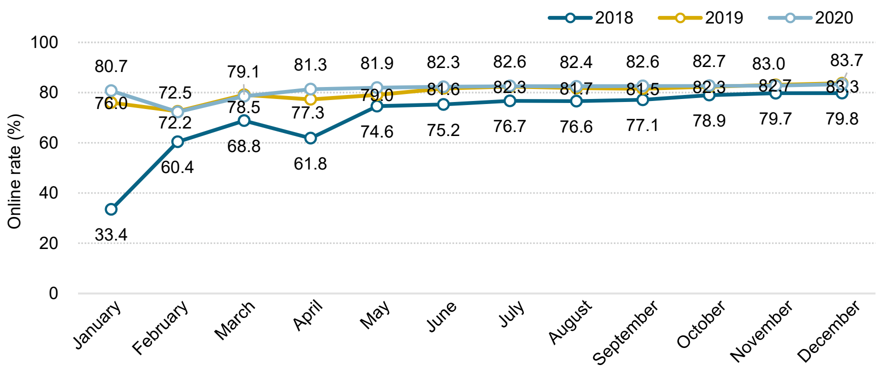


Fig. 4.1 Monthly online rate in China-by year

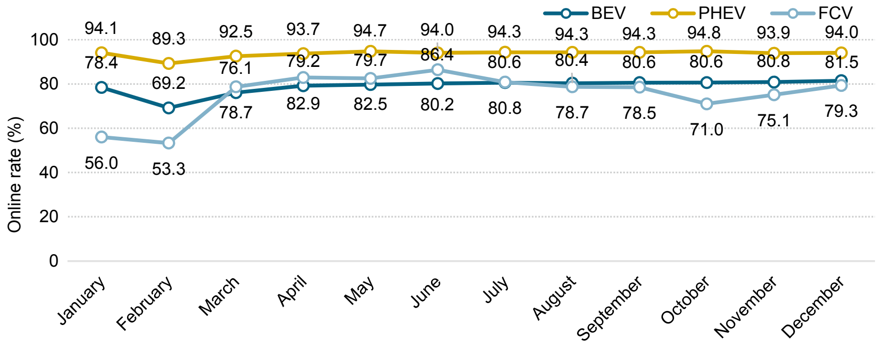


Fig. 4.2 Monthly online rate of China in 2020-by driving type

Table 4.2 Average online rate of China in 2020-by driving type

Driving type	BEV	PHEV	FCEV
Average online rate in China (%)	78.9	93.7	75.0

of monthly online rate of vehicles of different types (Fig. 4.2),the monthly online rate of PHEVs was relatively higher than BEVs and FCEVs.

4.1.2 Online Rate in Each Segment

The average monthly online rate of buses is higher than that of other segments.

According to the online rate of key segments (Fig. 4.3), the average monthly online rate of buses was the highest in 2020 with a value of 89.6%; according to the change of online rate over the years, the average monthly online rate of e-taxis, private cars, and heavy-duty trucks is increasing year by year.

4.2 Operation Characteristics of Vehicles in Key Segments

This section studies the operation characteristics of vehicles in key segments, and summarizes the travel characteristics of users, providing important 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 makes analysis by dividing the NEV market into seven segments including private cars, e-taxis, taxis, cars for sharing, logistics vehicles, buses and heavy-duty trucks, and summarizes the

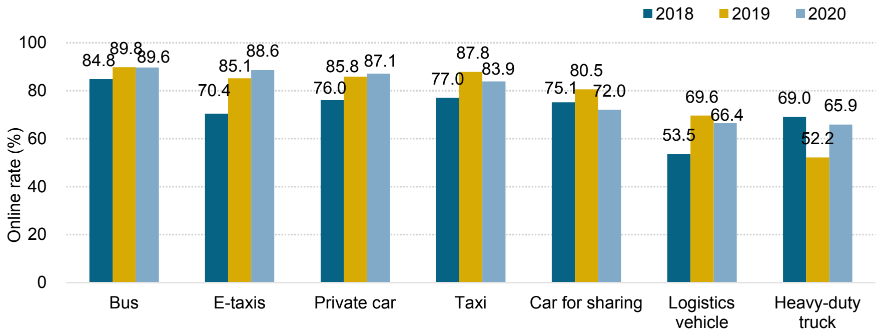


Fig. 4.3 Online rate of vehicles in key segments

travel characteristics of vehicles in those segments (Table 4.3). The specific indicators under analysis are as follows.

In this section, the average single-trip travel characteristics, the average daily travel characteristics, and the average monthly travel characteristics are analyzed for application scenarios including private cars and heavy-duty trucks; and for other application scenarios including e-taxis, taxis, cars for sharing, logistics vehicles, buses and heavy-duty trucks, the average daily travel characteristics and average monthly travel characteristics are selected as focuses for analysis.

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 travel mileage of a single trip
	Average single-trip speed	Average travel speed of a single trip
	Single-trip initial SOC	Average initial SOC of a single trip
Average daily travel characteristics	Average daily travel duration	Average travel duration in a single day
	Average daily mileage	Average travel 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 travel mileage in a single month

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 2020 was lower than that of the same period in 2019.

According to data from the National Monitoring and Management Platform, the average single-trip travel duration of private cars in China has been declining year by year, and in 2020, it was only 0.42 h, which is lower than that in 2018 and 2019 (Table 4.4).
The average single-trip travel duration of private cars is mainly within 0.5 h. As the distribution shows (Fig. 4.4), the proportion of private cars with an average single-trip travel duration of less than 0.5 h has increased for two consecutive years: in 2020, it was 71.4%, with an increase of 9.2% and 3.9% compared with 2018 and 2019, respectively.

The average single-trip mileage of private cars is mainly within 20 km, and the average single-trip mileage in 2020 was lower than that in 2019.

According to the monthly average over the years (Table 4.5), the single-trip average monthly mileage of private cars in 2020 was lower than that in 2019 due to the COVID-19 outbreak, but by November, it was finally recovered to the level of the same period in 2019.
The average single-trip mileage of private cars is mainly within 20 km. According to the distribution of average single-trip mileage over the years (Fig. 4.5), the proportion of private cars with an average single-trip mileage of 0–10 km was nearly 50% in

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

Year	2018	2019	2020
Average single-trip travel duration (h)	0.51	0.47	0.42

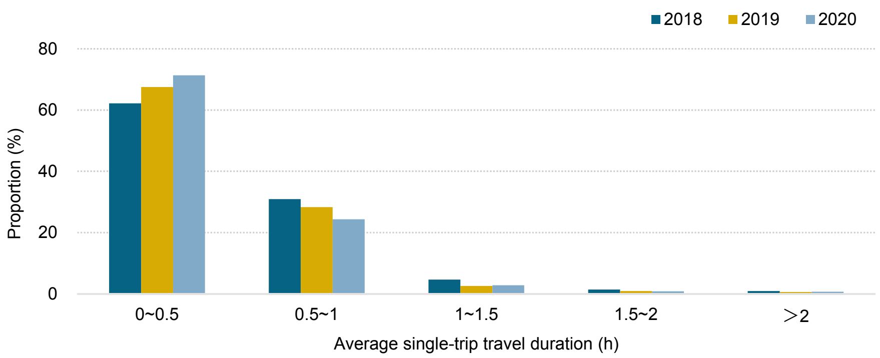


Fig. 4.4 Distribution of average single-trip travel duration of private cars-by year

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

Year	2018	2019	2020
Average single-trip mileage (km)	13.99	13.15	11.44

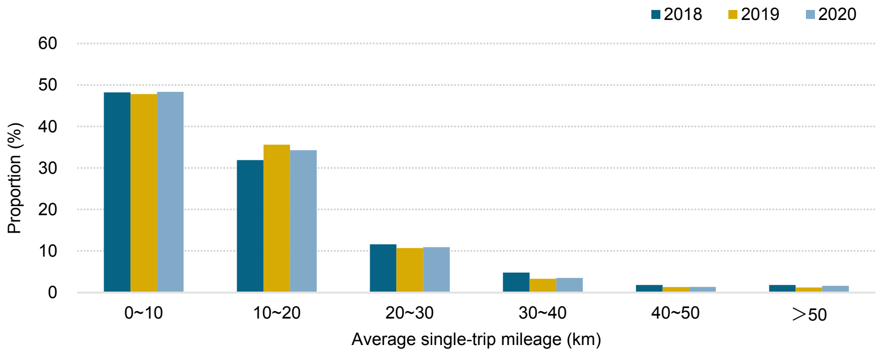


Fig. 4.5 Distribution of average single-trip mileage of private cars-by year

the past year, and in 2020, the proportion of private cars with an average single-trip mileage of 10–20 km was 34.3%.

The distribution of average single-trip mileage of private cars in first-tier and fifth-tier cities is quite different from that in other cities. First-tier cities have such a size that the average single-trip mileage of private cars is somehow affected. As shown in Fig. 4.6, in 2020, the average single-trip mileage of private cars in first-tier cities was mainly within 30 km, with a proportion up to 86.9%; also in fifth-tier cities, the proportion of private cars with an average mileage of more than 50 km was as high up to 15%, which suggests that in fifth-tier cities, the passenger cars are used not only for short-distance daily travel but also for long-distance cross-town travel.

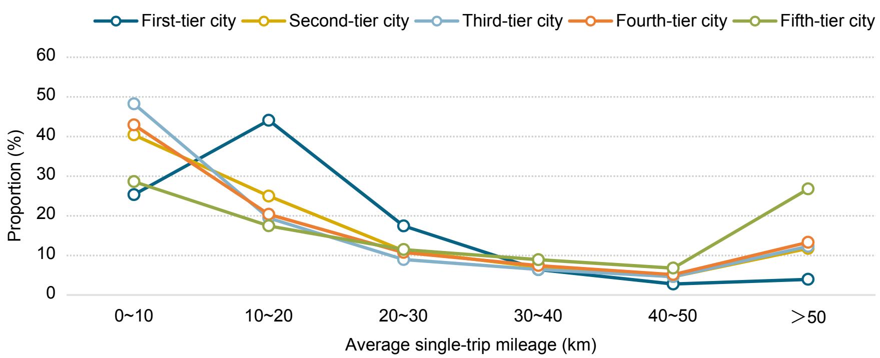


Fig. 4.6 Distribution of average single-trip mileage of private cars in 2020-by city tier

The average single-trip speed of private cars is mainly 20–40 km/h, and in 2020, it was 29.46 km/h.

The single-trip average speed of private cars is increasing year by year. In 2020, it was 29.46 km/h with a YoY increase of 11.6% (Table 4.6), contributing to a significant improvement of the traffic environment. According to the data over the years (Fig. 4.7), the average single-trip speed of private cars in the first half of 2020 was significantly higher than that of the same period in 2019 and 2018 due to the COVID-19 outbreak, and as the epidemic was quickly controlled, the monthly average of single-trip average speed of private cars, by June 2020, approximately dropped to the level of the same period in 2019, and the willingness of private car users to travel returned to normal.

The single-trip initial SOC of private cars is mainly 60–80%, and the proportion of private cars with such a single-trip initial SOC is increasing year by year

The single-trip initial SOC of private cars is increasing year by year. As shown in Table 4.7, the average single-trip initial SOC of private cars in 2020 was 63.29%, and increased by 1.36% and 0.64% compared with 2018 and 2019, respectively.

The single-trip initial SOC of private cars is mainly 60–80%. As shown in Fig. 4.8, in 2020, the proportion of private cars with such a single-trip initial SOC was 66.98%,

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

Year	2018	2019	2020
Average single-trip speed (km/h)	25.76	26.39	29.46

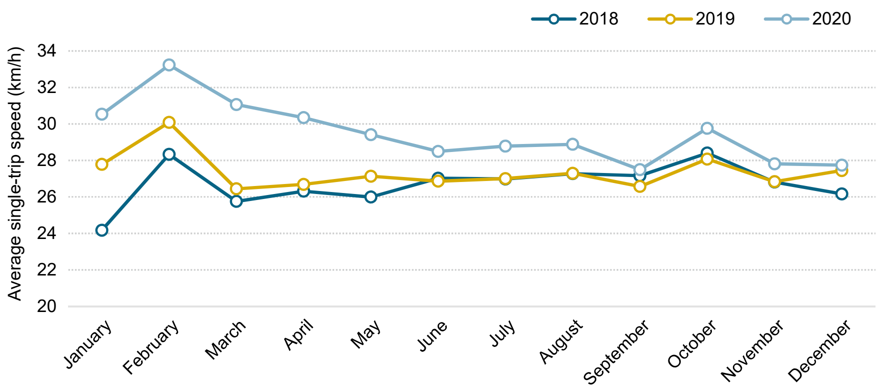


Fig. 4.7 Monthly average of average single-trip speed of private cars over the years

Table 4.7 Single-trip initial SOC of private cars-average

Year	2018	2019	2020
Single-trip initial SOC (%)	61.29	62.65	63.29

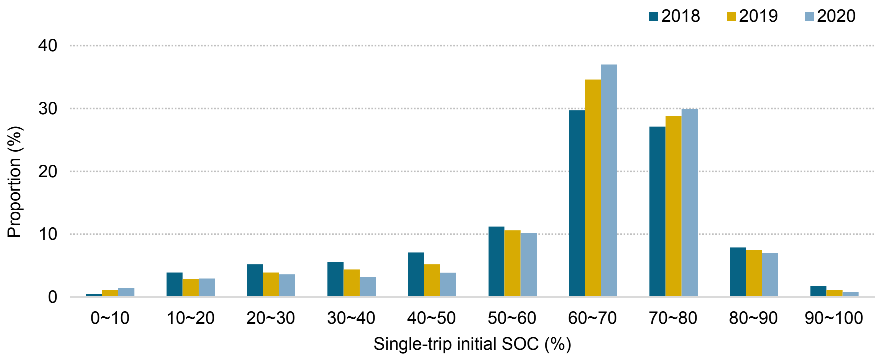


Fig. 4.8 Distribution of single-trip initial SOC of private cars-by year

which is 6.6% and 3.55% higher than that of 2018 and 2019, respectively. The increase in the single-trip initial SOC is caused not only by the increase in anxiety, but also by the wide deployment of private charging piles and the resulting improved convenience of charging.

The single-trip initial SOC characteristics of BEV and FCEV private cars are quite different (Fig. 4.9). The distribution of single-trip initial SOC of BEV private cars is basically the same as that of new energy private cars, i.e., relatively concentrated, but the single-trip initial SOC of BEV private cars is mainly 60–80%. In 2020, the proportion of BEV private cars with a single-trip initial SOC of more than 60% was 89%, but the distribution of the single-trip initial SOC of FCEV private cars is relatively discrete, for example, in 2020, the proportion of FCEV private cars with a single-trip initial SOC of more than 60% was only 26.6%.

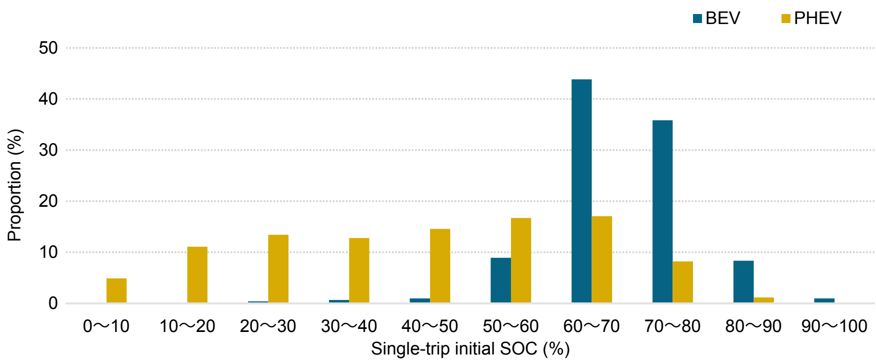


Fig. 4.9 Distribution of single-trip initial SOC of private cars-by driving type

(2) Average daily travel characteristics of private cars

At the beginning of 2020 when the epidemic prevention and control was in its most tough stage, the average daily travel duration of private cars was very low, but it was quickly restored after the epidemic was controlled.

The average daily travel duration of private cars has been maintained at about 1.5 h with slow increase in the past three years. In 2020, the average daily travel duration of private cars was 1.58 h, which is 6.04% and 2.60% higher than that of 2018 and 2019, respectively (Table 4.8).
The average daily travel duration of private cars is mainly 1–2 h. According to the distribution over the years (Fig. 4.10), the private cars with an average daily travel duration of 1–2 h in 2020 accounted for 55.19% of the number of private cars accessed to the National Monitoring and Management Platform, which is significantly higher than that in 2018 and 2019.

The travel of private cars was curbed in early 2020 due to the COVID-19 outbreak, but after March, it was recovered and was generally higher than that of the same period last year.

According to the monthly changes over the years (Fig. 4.11), the average daily mileage of private cars was very low in early 2020 due to the COVID-19 outbreak, but after March when the epidemic was well controlled, the average daily mileage of private cars increased rapidly, and even exceeded the level of the same period in 2019. According to the monthly average over the years (Table 4.9), the average daily mileage of private cars in 2020 was 45.73 km, which is 8.9% higher than that of 2019.

Table 4.8 Average daily travel duration of private cars-average

Year	2018	2019	2020
Average daily travel duration (h)	1.49	1.54	1.58

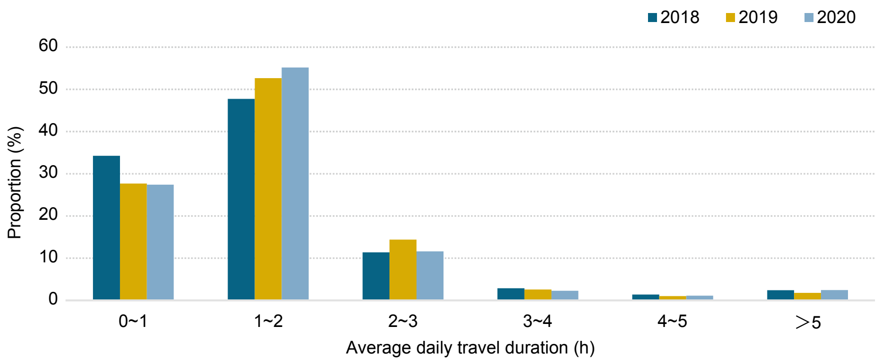


Fig. 4.10 Distribution of average daily travel duration of private cars-by year

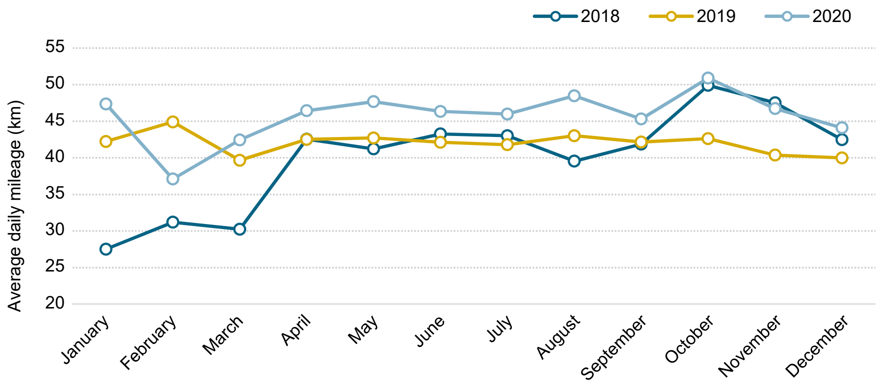


Fig. 4.11 Monthly average of average daily mileage of private cars over the years

Table 4.9 Average daily mileage of private cars-average

Year	2018	2019	2020
Average daily mileage (km)	40.02	42	45.73

As shown in Fig. 4.12, the average daily mileage of private cars in first-tier cities is significantly higher than that in other cities. Specifically, the average daily mileage in first-tier cities is more than 40 km, and the proportion of private cars with such average daily mileage is 59.5%, while in other cities, the proportion of private cars with an average daily mileage of more than 40 km is 46.9% at maximum, suggesting that the size of first-tier cities has a certain impact on driving intensity.

The driving time of private cars is mainly concentrated in the morning and evening commuting period, and thus it shows obvious "double-peak" characteristics.

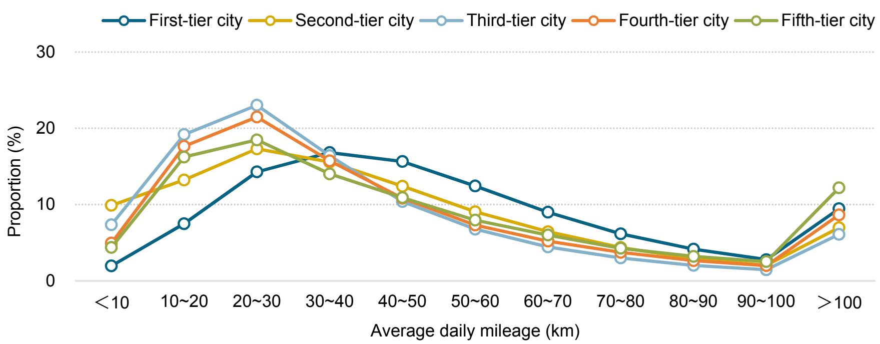


Fig. 4.12 Distribution of average daily mileage of private cars in 2020-by city tier

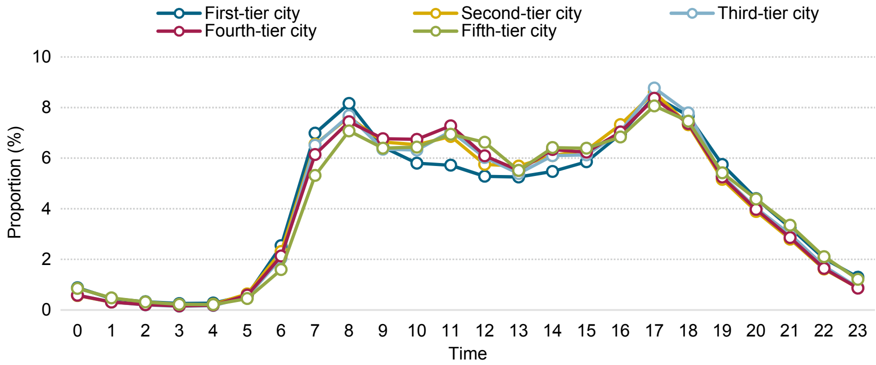


Fig. 4.13 Distribution of driving time of private cars in 2020-by city tier

As the distribution shows (Fig. 4.13), the traffic of private cars mainly peaks at two time points, namely 8:00 and 17:00. During the morning rush hour, the traffic of private cars climbs rapidly after 5:00, especially from 6:00 to 7:00, and reaches the peak at 8:00; during the evening rush hour, the traffic of private cars is mainly concentrated around 17:00. Considering from the city tier, the travel of private cars in first-tier cities shows more obvious morning peak characteristics, with the proportion of private cars traveling during the morning rush hour significantly higher. In addition, the proportion of private cars traveling in the period from 10:00 to 15:00 in first-tier cities is lower.

(3) Average monthly travel characteristics of private cars

In 2020, the average monthly travel days of private cars was less limited by the COVID-19 outbreak and even increased.

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 4.10, the average monthly travel days in 2020 was 18.68, which is 7 days and 3 days more than that in 2018 and 2019, respectively.
As the distribution shows (Fig. 4.14), the average monthly travel days of private cars in the past two years is mainly 15–20 and 20–25, and the proportion of private cars with average monthly travel days in these two sections increased greatly in the past two years, which reflects to a certain extent the gradual improvement of the operation environment of NEVs, and also the gradual increase in the user's stickiness to NEVs.

Table 4.10 Average monthly travel days of private cars-average

Year	2018	2019	2020
Average monthly travel days	11.97	15.62	18.68

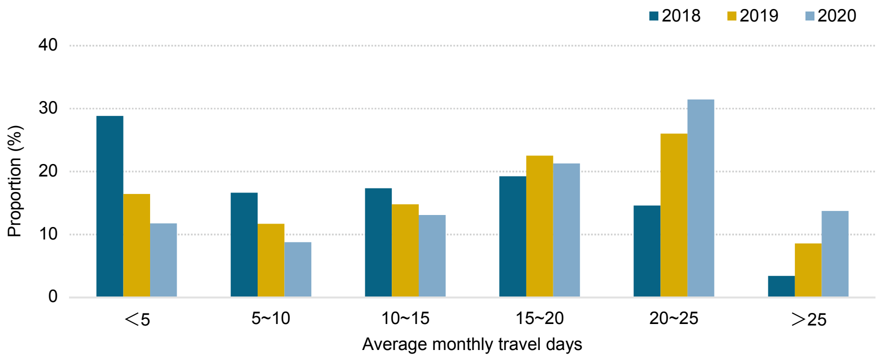


Fig. 4.14 Distribution of average monthly travel days of private cars-by year

The average monthly mileage of private cars is increasing year by year, and in 2020, it was 918.54 km, increasing by 25.2% compared with last year (Table 4.11).

According to the average of monthly average mileage over the years (Fig. 4.15), in early 2020 when the residents' willingness to travel decreased and the work resumption was delayed due to the COVID-19 outbreak, the average monthly mileage of passenger cars in February was extremely low, but after the epidemic was quickly brought under control, residents' travel was quickly recovered, and since March, the average monthly mileage of private cars exceeded the level of the same period in 2019.

As the distribution shows (Fig. 4.16), the proportion of passenger cars with an average monthly mileage of less than 1000 km is the highest, and has increased greatly in the past two years. The proportion of private cars with a monthly average mileage of more than 1,000 km increased from 14.5% in 2018 to 27.2% in 2020.

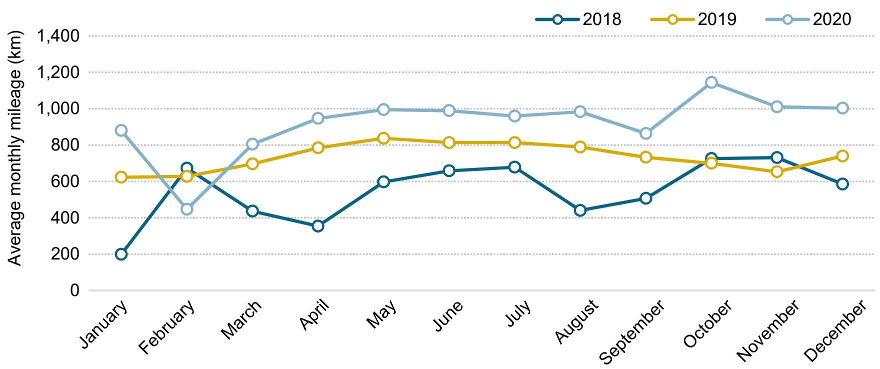


Fig. 4.15 Average of average monthly mileage of private cars over the years

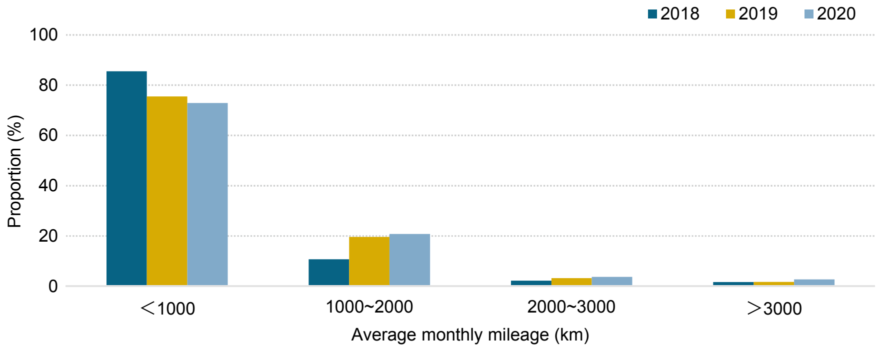


Fig. 4.16 Distribution of average monthly mileage of private cars-by year

Table 4.11 Average monthly mileage of private cars-average

Year	2018	2019	2020
Average monthly mileage (km)	548.44	733.84	918.54

4.2.2 Operation Characteristics of E-taxis

(1) Average daily travel characteristics of e-taxis

Due to the COVID-19 outbreak, the daily travel duration of e-taxis in 2020 decreased compared with 2019.

In the past three years, the average daily travel duration of e-taxis has been maintained at about 6 h. In 2020, the average daily travel duration of e-taxis was 6.1 h (Table 4.12), which is slightly lower than that in 2019.

According to the data over the years (Fig. 4.17), in February and March 2020, the travel of e-taxis was curbed due to the COVID-19 outbreak, and in February, it was as low as 2.62 h; then since May 2020, the average of the average daily travel duration was almost the same as that of the same period in 2019, and after September, it declined slightly.

As the distribution shows (Fig. 4.18), the proportion of e-taxis with a daily average travel duration of more than 6 h in 2020 was 62.7%, which is 4.1% lower than that in 2019 but still higher than that in 2018.

The average daily mileage of e-taxis is mainly 100–250 km, and in 2020 due to the COVID-19 outbreak, it reduced slightly compared with 2019.

Table 4.12 Average daily travel duration of e-taxis-average

Year	2018	2019	2020
Average daily travel duration (h)	5.88	6.99	6.1

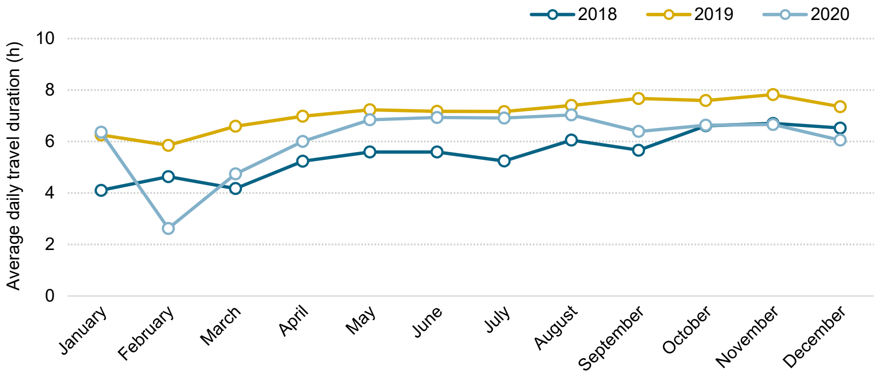


Fig. 4.17 Monthly average of average daily travel duration of e-taxis over the years

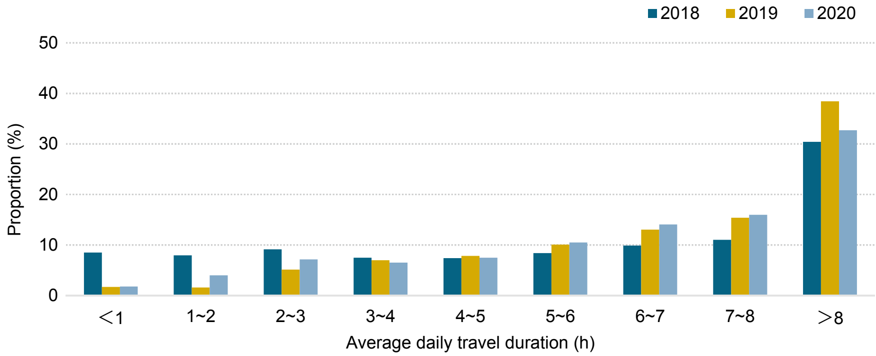


Fig. 4.18 Distribution of average daily travel duration of e-taxis-by year

According to the data over the years, the average daily mileage of e-taxis in 2020 was 157.81 km, decreasing by 5.6% compared with last year (Table 4.13). According to the monthly changes in the average daily mileage over the years (Fig. 4.19), in February, the travel of e-taxis was curbed by the epidemic, and the average daily mileage was only 84.84 km, but after the epidemic was quickly controlled, the monthly average of daily mileage average was almost recovered to the level of the same period in 2019, and after September, it was lower than that of the same period in 2019.

The average daily mileage of e-taxis is mainly 100–250 km. As the distribution shows (Fig. 4.20), the proportion of e-taxis with an average daily mileage of 100–250 km was up to 74.4% (nearly 3/4).

Table 4.13 Average daily mileage of e-taxis-average

Year	2018	2019	2020
Average daily mileage (km)	141.67	167.25	157.81

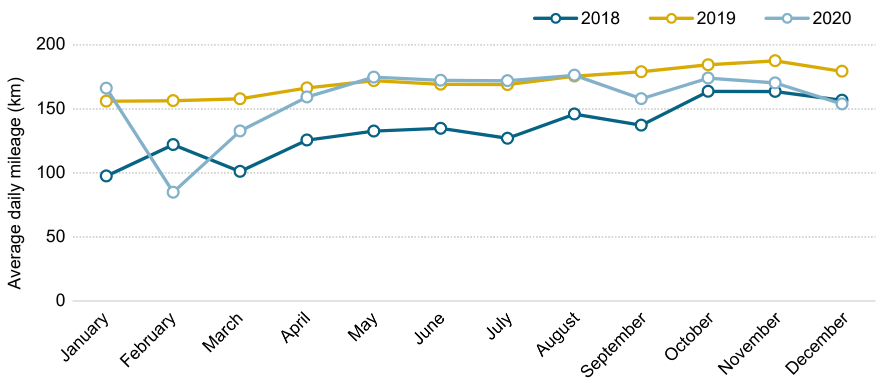


Fig. 4.19 Monthly average of average daily mileage of e-taxis over the years

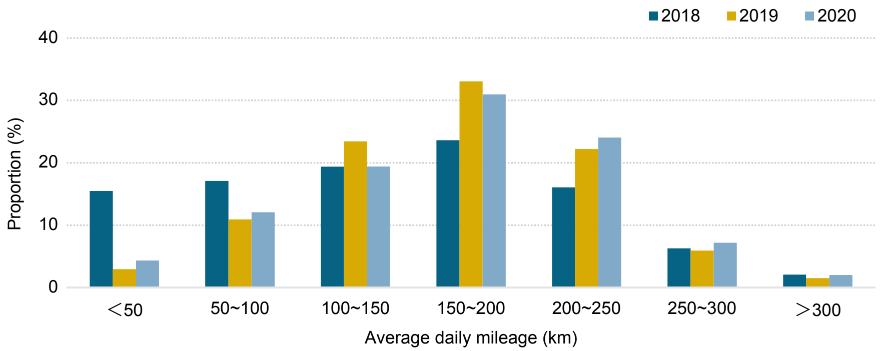


Fig. 4.20 Distribution of average daily mileage of e-taxis-by year

The driving time of e-taxis is mainly 7:00–21:00, and the proportion of vehicles traveling at night is relatively high.

According to the distribution of driving time, the driving time of e-taxis is mainly 7:00–21:00, and in this period, the distribution is relatively balanced with small fluctuation. According to the distribution of driving time of e-taxis in different cities (Fig. 4.21), the proportion of e-taxis travelling at night (23:00 to 5:00 the next day) in first-tier cities is 11.9%, which is significantly higher than that in the other cities.

(2) Average monthly travel characteristics of e-taxis

The average monthly travel days of e-taxis market is increasing year by year, and in 2020, it was 21.6, which is 0.83 days more than that in 2019.

In the past three years, the average monthly travel days of e-taxis has increased year by year. Specifically, in 2020, the average monthly travel days of e-taxis was 21.6 days, which is 4.69 days and 0.83 days more than that in 2018 and 2019, respectively

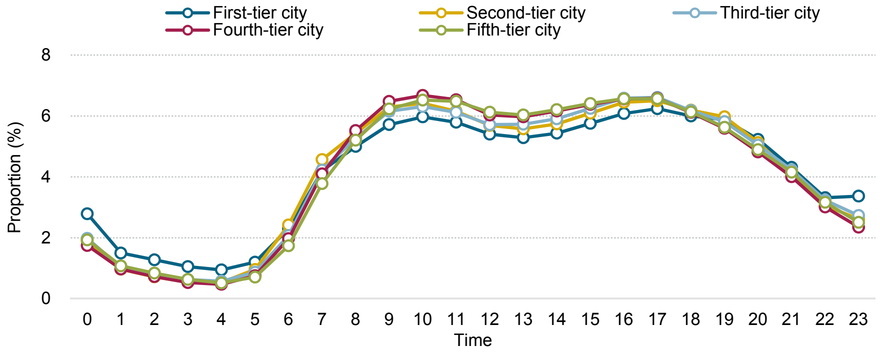


Fig. 4.21 Distribution of driving time of e-taxis in 2020-by city tier

Table 4.14 Average monthly travel days of e-taxis-average

Year	2018	2019	2020
Average monthly travel days	16.91	20.77	21.6

(Table 4.14). As the distribution shows (Fig. 4.22), the proportion of e-taxis with an average monthly travel days of 20–25 in 2020 was 38.96%, which is 1.27% lower than that in 2020, but still 4.76% higher than that in 2018.

In 2020 due to the outbreak of epidemic, the average monthly mileage of e-taxis decreased compared with 2019.

According to the data over the years, the average of average monthly mileage of e-taxis in 2020 was 3580.24 km, which is 5.6% lower than that in 2019 (Table 4.15), but still 22.6% higher than that in 2018.
According to the average of average monthly mileage over the years (Fig. 4.23), in February and March 2020, the average of average monthly mileage of e-taxis was

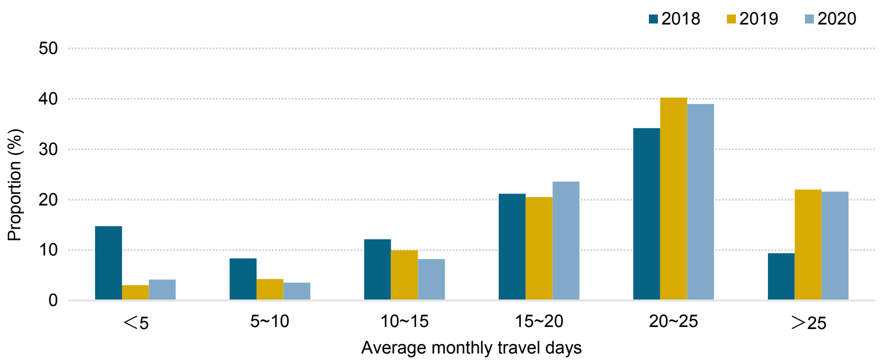


Fig. 4.22 Distribution of average monthly travel days of e-taxis-by year

Table 4.15 Average monthly mileage of e-taxis-average

Year	2018	2019	2020
Average monthly mileage (km)	2921.32	3854.08	3580.24

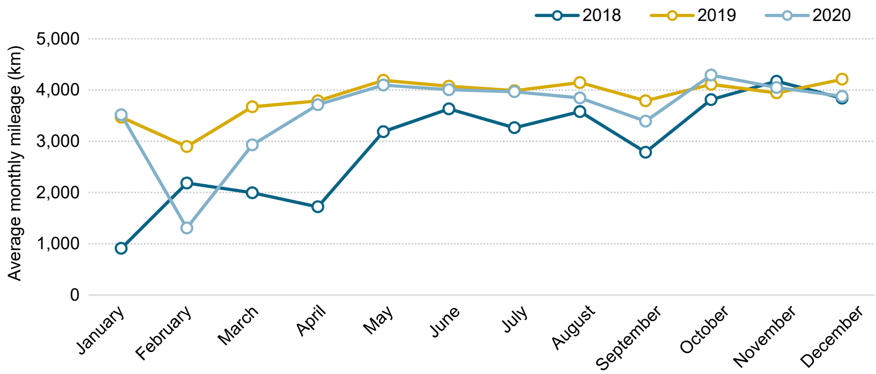


Fig. 4.23 Average of average monthly mileage of e-taxis over the years

very low, but since April 2020 when people's willingness to travel was gradually restored, the average monthly mileage of online ride-hailing was almost recovered to the level of the same period in 2019.

As the distribution shows (Fig. 4.24), the proportion of e-taxis with an average monthly mileage of more than 2000 km in 2020 was 79.3%, which is lower than the 84.5% in 2019, but still higher than the 60.7% in 2018.

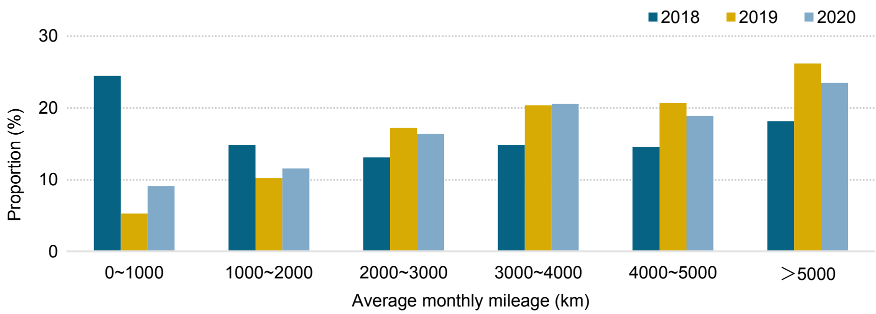


Fig. 4.24 Distribution of average monthly mileage of e-taxis-by year

4.2.3 Operation Characteristics of Taxis

(1) Average daily travel characteristics of taxis

Due to the COVID-19 outbreak, the average daily travel duration of taxis in 2020 decreased compared with 2018 and 2019.

In the past three years, the average daily travel duration of taxis was mainly about 8 h, and in 2020, it was only 7.36 h, decreasing by 16.6% compared with last year (Table 4.16).

According to the monthly average of average daily travel duration over the years (Fig. 4.25), the outbreak of the COVID-19 epidemic in early 2020 had a significant impact on the travel of taxis, and in February and March, the average daily travel duration was very low, but after the epidemic was quickly controlled, in June 2020, the monthly average of average daily travel duration of taxis almost recovered to the level of the same period in 2019, and by November 2020, it was higher than that of the same period in 2019.

Due to the COVID-19 outbreak, the average daily mileage of taxis in 2020 was reduced compared with 2019.

According to the data over the years, the average daily mileage of taxis in 2020 was 186.46 km, which is 14.95 km and 23.61 km lower than that in 2018 and 2019, respectively (Table 4.17).

According to the monthly change of average daily mileage of taxis over the years (Fig. 4.26), the average daily mileage of taxis from February to April 2020 was very low., but after the epidemic was quickly brought under control, it gradually returned

Table 4.16 Average daily travel duration of taxis-average

Year	2018	2019	2020
Average daily travel duration (h)	8.66	8.82	7.36

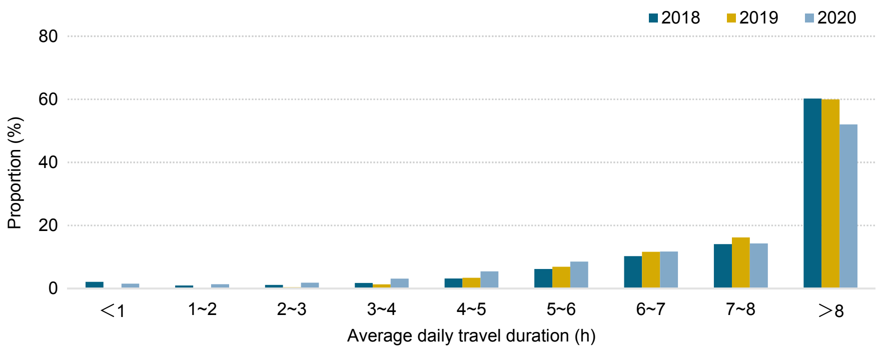


Fig. 4.25 Distribution of average daily travel duration of taxis-by year

Table 4.17 Average daily mileage of taxis-average

Year	2018	2019	2020
Average daily mileage (km)	201.41	210.07	186.46

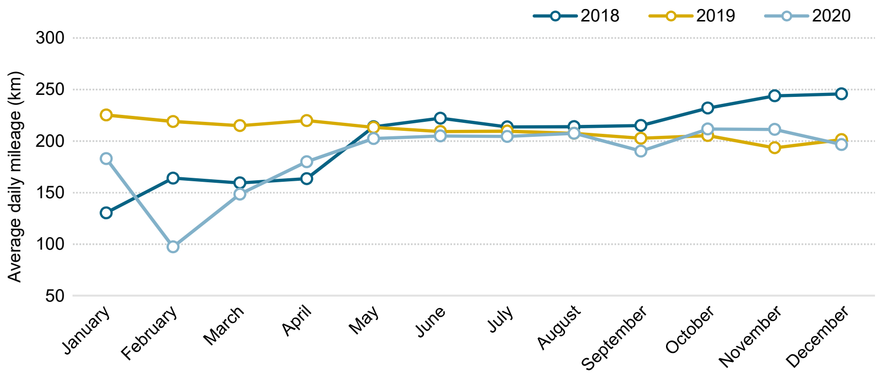


Fig. 4.26 Monthly average of average daily mileage of taxis over the years

to the level of the same period last year, and by May 2020, it is almost at the same level of the same period in 2019.

As the distribution shows (Fig. 4.27), the proportion of taxis with an average daily mileage of more than 200 km decreased from 47.5% in 2019 to 44.4% in 2020, indicating that the operation intensity of taxis decreased.

In 2020, the proportion of taxis traveling from 0:00 to 5:00 the next day was higher than that in 2018 and 2019, and considering from the city tier, the proportion of taxis traveling at night in first-tier cities is higher.

According to the distribution of driving time of taxis, the driving time of taxis is mainly 7:00–19:00, in which the proportion of operating taxis fluctuates less. The

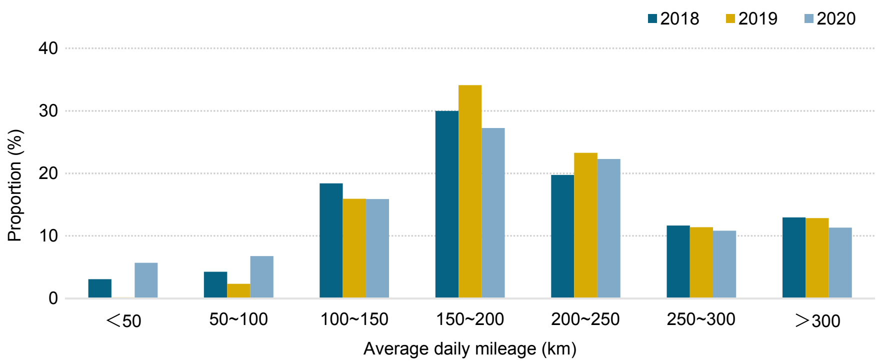


Fig. 4.27 Distribution of average daily mileage of taxis-by year

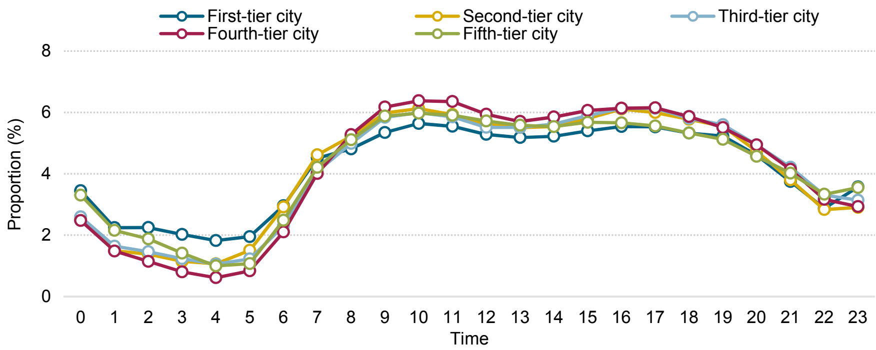


Fig. 4.28 Distribution of driving time of taxis in 2020-by city tier

proportion of taxis traveling from 0:00 to 5:00 the next day in 2020 was higher than that in 2018 and 2019. Considering from the city tier (Fig. 4.28), the proportion of taxis traveling from 0:00 to 5:00 the next day in first-tier cities is 13.72%, which is significantly higher than that in cities of other cities mainly due to the blooming commercial and entertainment activities in first-tier cities at night.

(2) Average monthly travel characteristics of taxis

The average monthly travel days of taxis is mainly 20+, and in 2020, it reduced slightly (Table 4.19).

According to the data over the years, the average travel days of taxis in 2020 was 22.28, with a YoY decrease of 3.4% (Table 4.18). According to the distribution of average monthly travel days of taxis over the years, the proportion of taxis with an average monthly travel days of more than 20 decreased in 2020. According to the distribution of average monthly travel days of taxis (Fig. 4.29), in 2020, the proportion of taxis with an average monthly travel days of more than 20 was 65.4%, which is nearly 10% lower than that in 2019, and indicates that the travel frequency of taxis decreased.

Due to the COVID-19 outbreak, the average monthly mileage of taxis in 2020 was 4159.89 km, which is lower than that in 2018 and 2019.

As the distribution shows (Fig. 4.30), the proportion of taxis with an average monthly mileage of more than 4000 km in 2020 was 54.7%, which is lower than the value of 68.5% in 2019 and also 61.2% in 2018.

Table 4.18 Average monthly travel days of taxis-average

Year	2018	2019	2020
Average monthly travel days	21.93	23.07	22.28

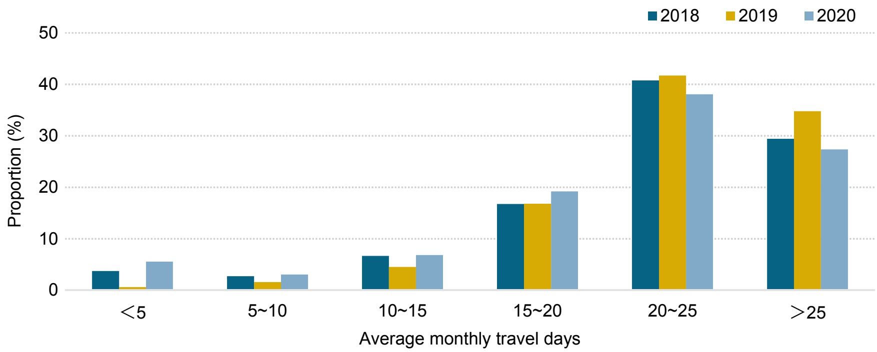


Fig. 4.29 Distribution of average monthly travel days of taxis-by year

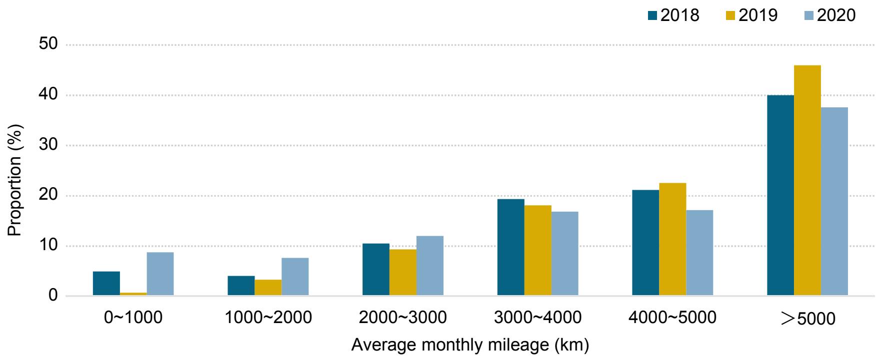


Fig. 4.30 Distribution of average monthly mileage of taxis-by year

Table 4.19 Average monthly mileage of taxis-average

Year	2018	2019	2020
Average monthly mileage (km)	4794.66	5154.38	4159.89

4.2.4 Operation Characteristics of Cars for Sharing

(1) Average daily travel characteristics of cars for sharing

The average daily travel duration of cars for sharing is mainly 1–3 h, and in 2020, it was basically the same as that of the last year.

The average daily travel duration of cars for sharing is more than 2 h, and compared with 2018, it increased in 2019 and 2020 (Table 4.20).
According to the distribution over the years (Fig. 4.31), the average daily travel duration of cars for sharing is mainly 1–3 h, with the proportion of cars for sharing with such an average daily travel duration up to 64.9% in 2020.

Table 4.20 Average daily travel duration of cars for sharing—average

Year	2018	2019	2020
Average daily travel duration (h)	2.46	2.78	2.74

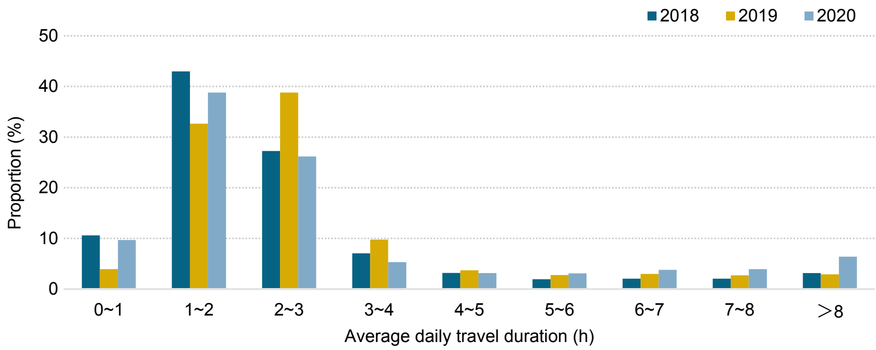


Fig. 4.31 Distribution of average daily travel duration of cars for sharing-by year

The average daily mileage of cars for sharing in 2020 was 99.63 km, which is significantly higher than that in 2019.

In the past three years, the average daily mileage of cars for sharing in China has increased year by year, and in 2020, it reached 99.63 km, increasing by 28.9% compared to last year (Table 4.21). According to the monthly average over the years (Fig. 4.32), the monthly average of average daily mileage of cars for sharing increased rapidly after the epidemic, and exceeded the level of the same period in 2019 after April.
As the distribution shows (Fig. 4.33), the average daily mileage of cars for sharing is mainly less than 100 km. In 2020, the proportion of cars for sharing with an average daily mileage of more than 200 km was increased by 13.81% to 15.89% compared with 2019, indicating that the daily mileage of vehicles gradually transitioned to a high mileage range.

(2) Average monthly travel characteristics of cars for sharing

The average monthly travel days of cars for sharing is mainly 15–25.

According to the data over the years (Table 4.22), the average monthly travel days of cars for sharing in China, compared with 2018, has increased rapidly since 2019.

Table 4.21 Average daily mileage of cars for sharing-average

Year	2018	2019	2020
Average daily mileage (km)	65.80	77.30	99.63

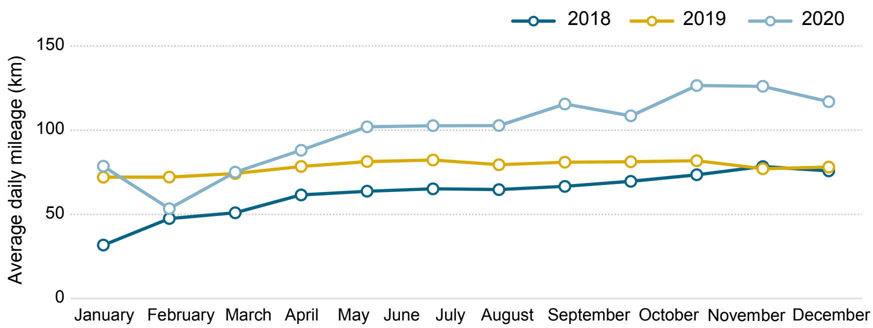


Fig. 4.32 Monthly average of average daily mileage of cars for sharing over the years

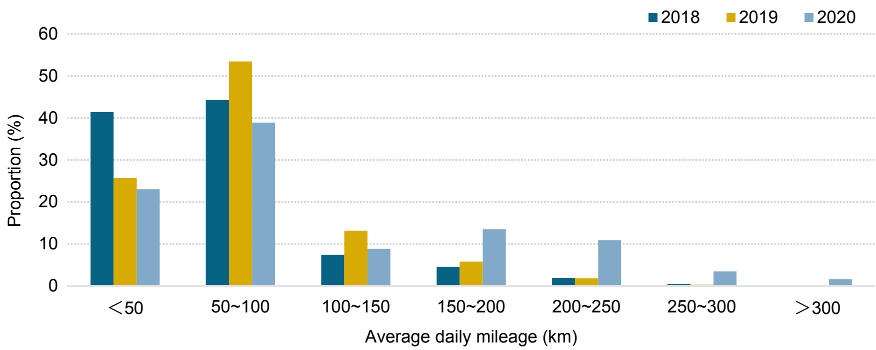


Fig. 4.33 Distribution of average daily mileage of cars for sharing-by year

Table 4.22 Average monthly travel days of cars for sharing-average

Year	2018	2019	2020
Average monthly travel days	14.77	18.57	18.43

As the distribution shows (Fig. 4.34), the average monthly travel days of cars for sharing is mainly 15–25, with the proportion of cars for sharing, with such average monthly travel days, up to 57.27% in 2020.

The average monthly mileage of cars for sharing is increasing year by year.

In the past three years, the average monthly mileage of cars for sharing has increased year by year, and in 2020, it reached 2612.85 km, increasing by 65.1% compared with last year (Table 4.23).

According to the average over the years (Fig. 4.35), the average monthly mileage of cars for sharing far exceeded the level of the same period in 2019 since March 2020, and it maintained at a high level throughout the year.

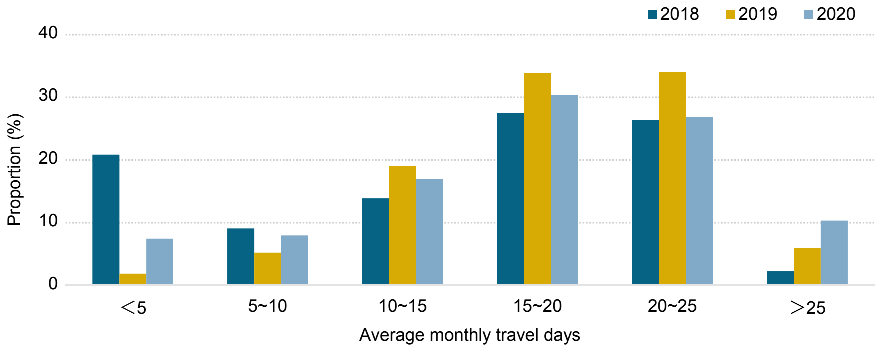


Fig. 4.34 Distribution of average monthly travel days of cars for sharing-by year

Table 4.23 Average monthly mileage of cars for sharing-average

Year	2018	2019	2020
Average monthly mileage (km)	1159.07	1582.7	2612.85

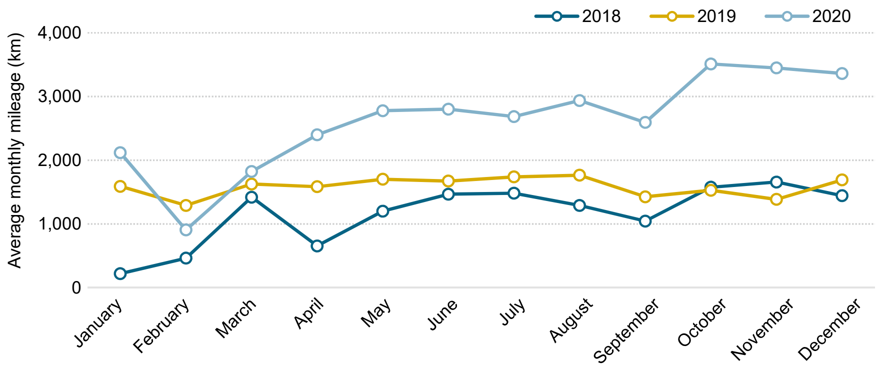


Fig. 4.35 Average of average monthly mileage of cars for sharing over the years

As the distribution shows (Fig. 4.36), the average monthly mileage of cars for sharing is mainly 1000–2000 km; in 2020, the proportion of cars for sharing with an average daily mileage of more than 3000 km increased to 28.3% from 7.3% in 2018, which indicates that the operation environment of cars for sharing has improved.

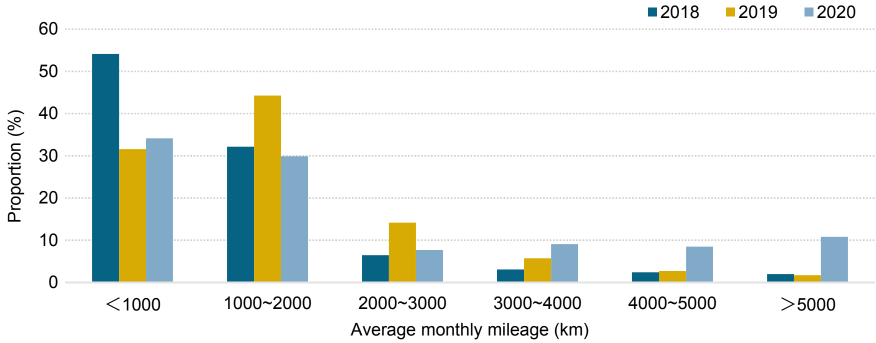


Fig. 4.36 Distribution of average monthly mileage of cars for sharing-by year

4.2.5 Operation Characteristics of Logistics Vehicles

(1) Average daily travel characteristics of logistics vehicles

The average daily travel duration of logistics vehicles is increasing year by year.

In the past three years, the average daily travel duration of logistics vehicles in China has increased year by year; in 2020, it reached 3.24 h, which is 0.91 h and 0.39 h longer than that in 2018 and 2019, respectively (Table 4.24).
As the distribution shows (Fig. 4.37), the proportion of logistics vehicles with an average daily travel duration of more than 3 h has increased gradually, and in 2020, it increased by 23.5 to 55.5% compared with 2018, indicating that the average daily travel duration of logistics vehicles increased significantly.

In 2020, the average daily mileage of logistics vehicles increased significantly, and in the fight against the COVID-19 epidemic, the logistics vehicles played an important role in the smooth operation of transportation.

According to the data over the years (Table 4.25), the average daily mileage of logistics vehicles in 2020 was 86.62 km with an increase of 57.8% and 24.6% compared with 2018 and 2019 respectively, indicating that the average daily mileage of logistics vehicles has been rapidly improved.
According to the monthly average over the years (Fig. 4.38), the average daily mileage of logistics vehicles in each month of 2020 was higher than that of the same period in 2019, and especially during the period from February to March 2020 when the fight against the epidemic was in the crucial stage, logistics vehicle played an important and active role in the smooth operation of transportation.

Table 4.24 Average daily travel duration of logistics vehicles-average

Year	2018	2019	2020
Average daily travel duration (h)	2.33	2.85	3.24

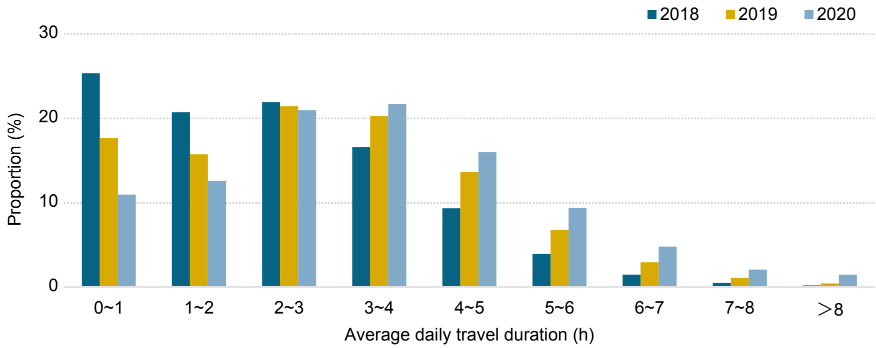


Fig. 4.37 Distribution of average daily travel duration of logistics vehicles-by year

Table 4.25 Average daily mileage of logistics vehicles-average

Year	2018	2019	2020
Average daily mileage (km)	54.89	69.53	86.62

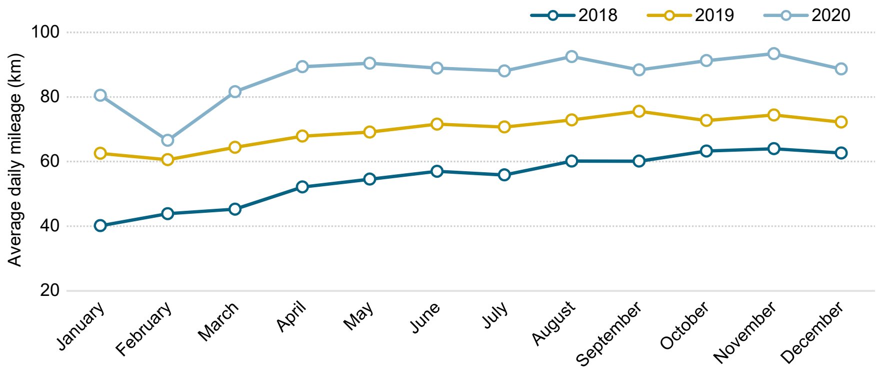


Fig. 4.38 Monthly average of average daily mileage of logistics vehicles over the years

As the distribution shows (Fig. 4.39), the average daily mileage of logistics vehicles is mainly below 150 km, and the proportion of logistics vehicles with an average daily mileage of more than 100 km increased significantly from 13.1% in 2018 to 36.9% in 2020.

(2) Average monthly travel characteristics of logistics vehicles

The average monthly travel days of logistics vehicles in 2020 increased significantly compared with 2018 and 2019.

In the past three years, the average monthly travel days of logistics vehicles has increased year by year, and in 2020, it reached 19.65 days with an increase of 6.55

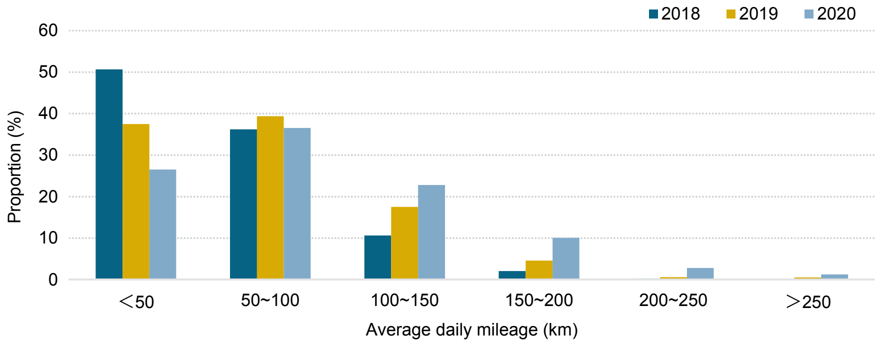


Fig. 4.39 Distribution of average daily mileage of logistics vehicles-by year

Table 4.26 Average monthly travel days of logistics vehicles-average

Year	2018	2019	2020
Average monthly travel days	13.1	15.62	19.65

and 4.03 days compared with 2018 and 2019, indicating that the travel frequency of logistics vehicles has increased significantly (Table 4.26).

According to the average over the years (Fig. 4.40), the travel days of logistics vehicles in each month of 2020 were higher than that of the same period in 2019, indicating that the epidemic drove but not curbed the increase of the times of travel of logistics vehicles.

As the distribution shows (Fig. 4.41), the proportion of logistics vehicles with an average monthly travel days of more than 15 increased from 44.5% in 2018 to 67.1% in 2020, and the operation days of logistics vehicle has increased significantly, indicating that the operation mode of new energy logistics vehicles has gradually matured.

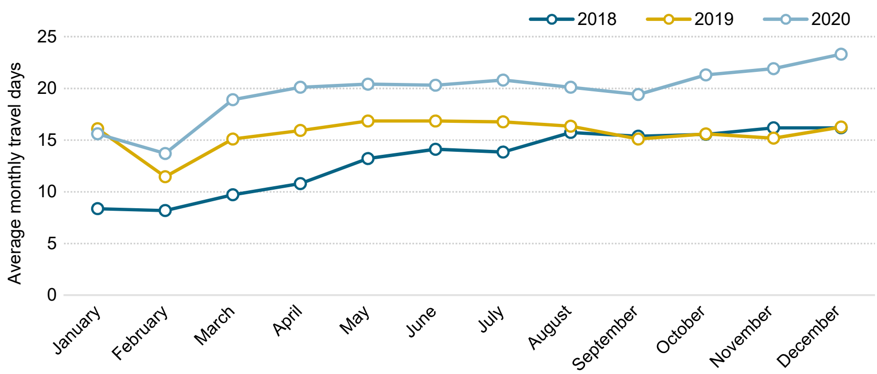


Fig. 4.40 Average of average monthly travel days of logistics vehicles over the years

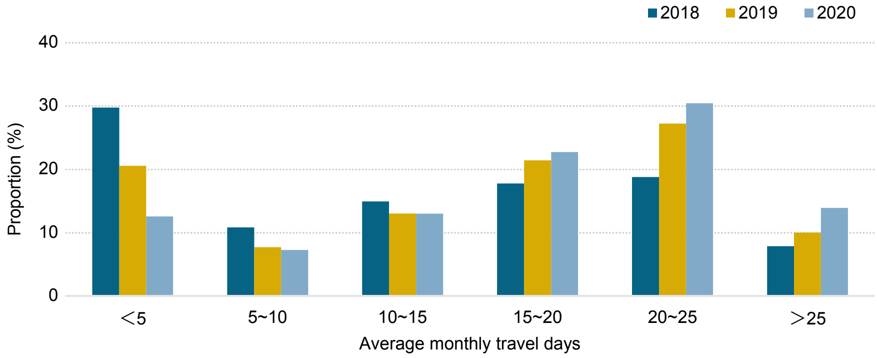


Fig. 4.41 Distribution of average monthly travel days of logistics vehicles-by year

The average monthly mileage of logistics vehicles has steadily increased over the years, and in 2020, it rose above 2000 km.

In the past three years, the average monthly mileage of logistics vehicles has shown a rapid growth trend. In 2020, it reached 2169.17 km, increasing by 52.2% compared to last year (Table 4.27). According to the data over the years (Fig. 4.42), the average monthly mileage of logistics vehicles in the months of 2020 other than April was more than that of the same period in 2019.
As the distribution shows (Fig. 4.43), the proportion of logistics vehicles with an average monthly mileage of more than 2000 km has been significantly increased,

Table 4.27 Average monthly mileage of logistics vehicles-average

Year	2018	2019	2020
Average monthly mileage (km)	1009.02	1425.45	2169.17

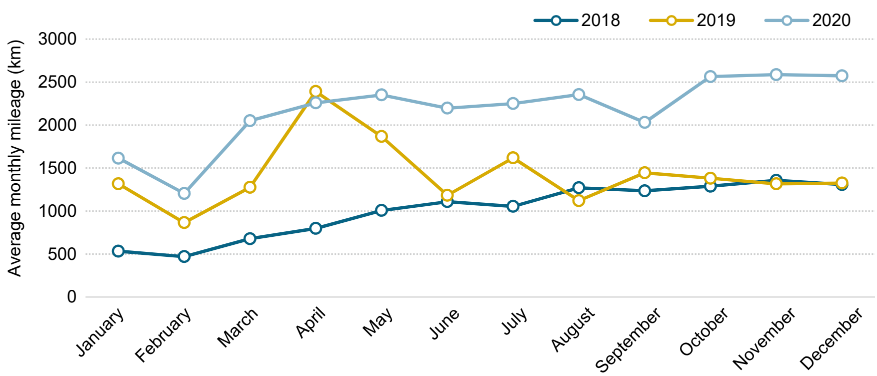


Fig. 4.42 Average of average monthly mileage of logistics vehicles over the years

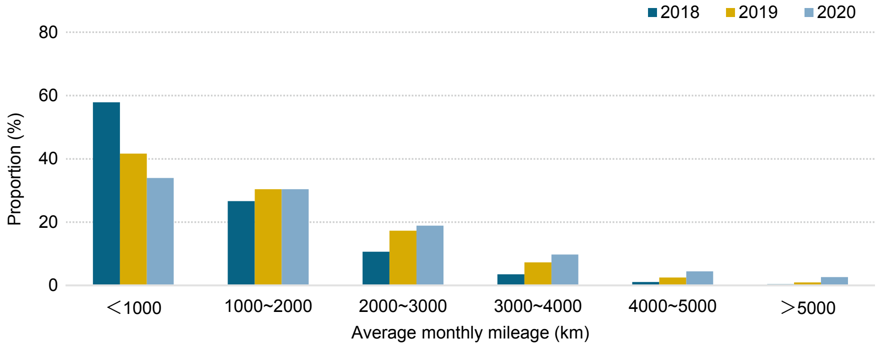


Fig. 4.43 Distribution average monthly mileage of logistics vehicles-by year

i.e., from 15.53% in 2018 to 35.65% in 2020, indicating that the operation of new energy logistics vehicles has gradually improved.

4.2.6 Operation Characteristics of Buses

(1) Average daily travel characteristics of buses

The daily operation of buses is very regular, and their daily travel duration is mainly above 8 h.

In 2020, the average daily travel duration of buses was stabilized at 6.75 h (Table 4.28). According to the distribution of the average daily travel duration (Fig. 4.44), the proportion of buses with an average daily travel duration of more than 8 h is the highest, i.e., more than 30%; according to the distribution over the years, the proportion of buses with an average daily travel duration of more than 6 h has increased slightly, i.e., from 59.9% in 2018 to 67.1% in 2020.

In the past three years, the average daily mileage of buses has gradually increased.

In 2020, the average daily mileage of buses reached 148.29 km, increasing by 1.4% compared with last year (Table 4.29). According to the monthly average over the years (Fig. 4.45), the average daily mileage of buses in months of 2020, except for February when the epidemic was in prevention and control stage, was basically the same as that of the same period in 2019.

Table 4.28 Average daily travel duration of buses-average

Year	2018	2019	2020
Average daily travel duration (h)	6.62	7.01	6.75

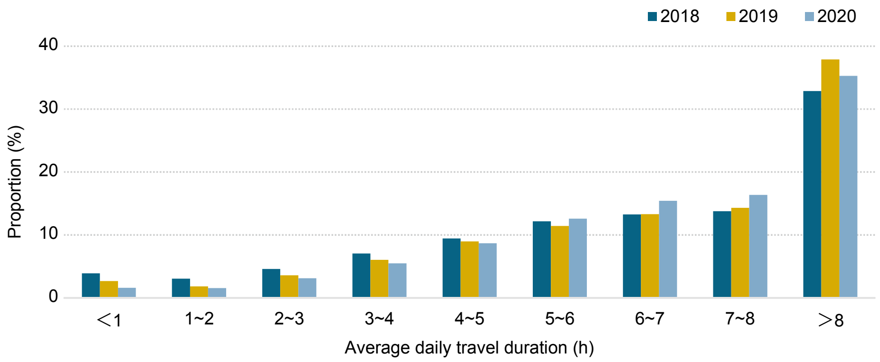


Fig. 4.44 Distribution of average daily travel duration of buses-by year

Table 4.29 Average daily mileage of buses-average

Year	2018	2019	2020
Average daily mileage (km)	135.26	146.21	148.29

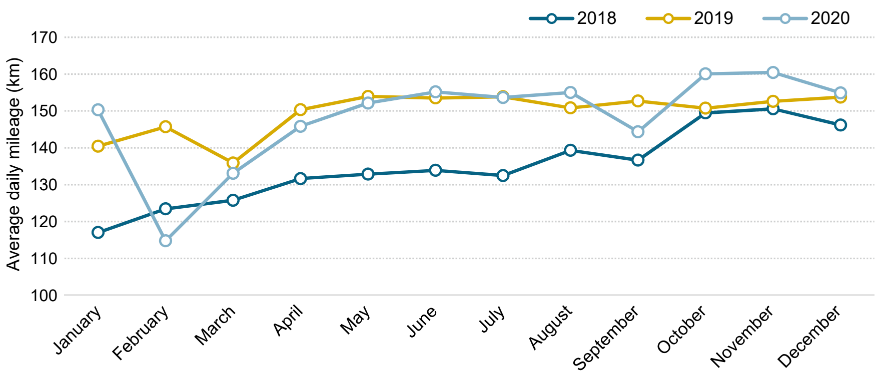


Fig. 4.45 Monthly average of average daily mileage of buses over the years

As the distribution shows (Fig. 4.46), the proportion of buses with an average daily mileage of 100–200 km is relatively higher; the proportion of buses with an average daily mileage of more than 150 km increased from 38.1% in 2018 to 51.5% in 2020.

(2) Average monthly travel characteristics of buses

The average monthly travel days of buses is more than 22 days, and in first-tier cities, the proportion of buses with longer travel days is relatively high.

In the past three years, the average monthly travel days has remained above 22 (Table 4.30). According to the monthly average over the years (Fig. 4.47), the average monthly travel days of buses in the months of 2020, except for February when the epidemic broken out, was basically the same as that of the same period in 2019.

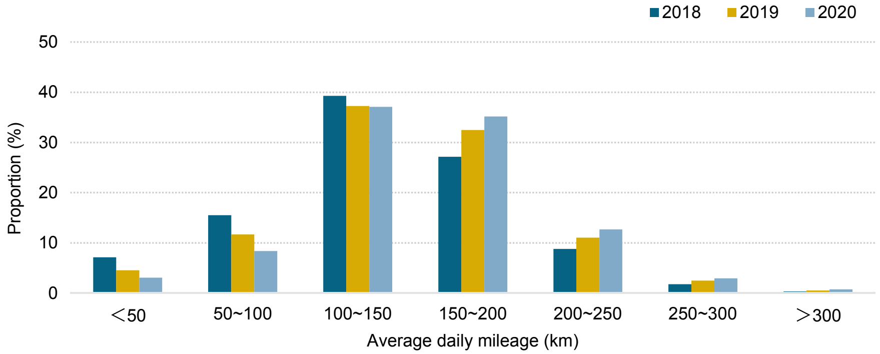


Fig. 4.46 Distribution of average daily mileage of buses-by year

Table 4.30 Average monthly travel days of buses-average

Year	2018	2019	2020
Average monthly travel days	21.37	22.15	22.55

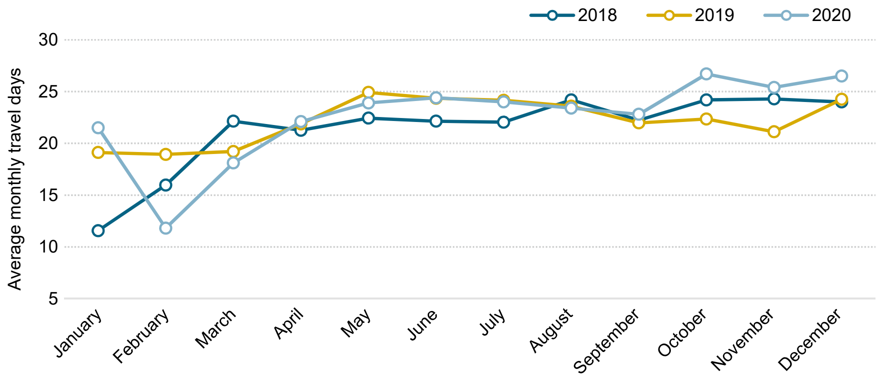


Fig. 4.47 Average of average monthly travel days of buses over the years

As the distribution shows (Fig. 4.48), the proportion of vehicles traveling for 20–25 days per month increased significantly, i.e., from 32.61% in 2018 to 43.4% in 2020.

The average monthly mileage of buses has increased year by year, and in 2020, it reached 3682.57 km (Table 4.31).

According to the average over the years (Fig. 4.49), the travel of buses was curbed in February due to the outbreak of the epidemic, and since March 2020, it was almost recovered to the level of the same period in 2019, and after October, it rose above the level of the same period in 2019. The average monthly mileage of buses throughout

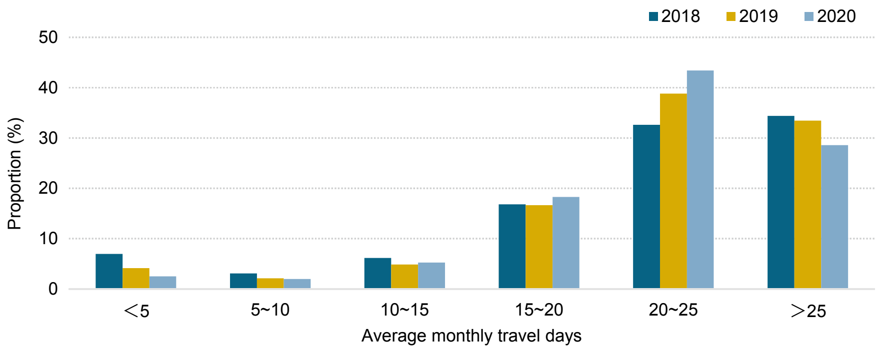


Fig. 4.48 Distribution of average monthly travel days of buses-by year

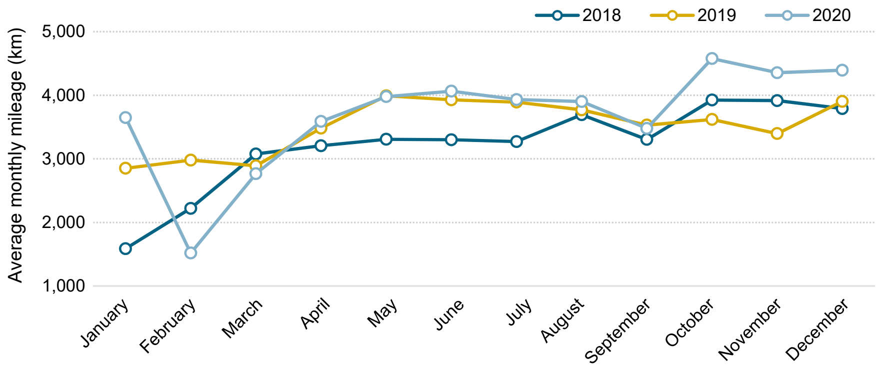


Fig. 4.49 Average of average monthly mileage of buses over the years

2020 was higher than that of the same period in 2019; as the distribution shows (Fig. 4.50), the average monthly mileage of buses is mainly more than 2000 km.

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 is mainly within 1 h, and the average single-trip mileage is within 20 km.

According to the distribution of average single-trip travel duration (Fig. 4.51), the proportion of heavy-duty trucks with an average single-trip travel duration of less than 0.5 h is relatively high, i.e., 45.7%. As for the average single-trip mileage, the average of average single-trip mileage of heavy-duty trucks in 2020 was 24.4 km, increasing by 23.8% compared with 2019 (i.e., 19.7 km). According to the distribution of average

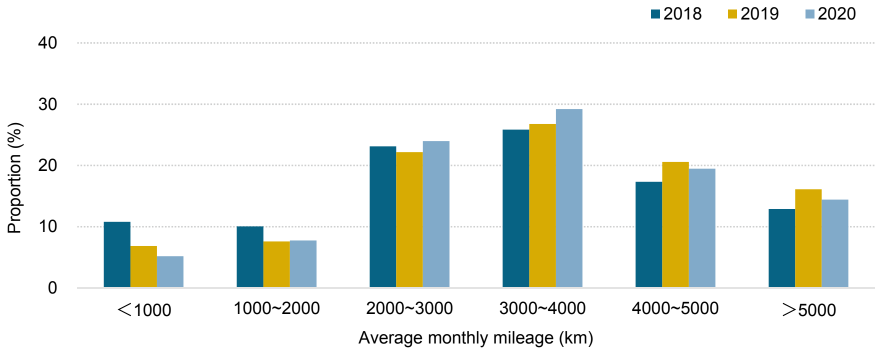


Fig. 4.50 Distribution of average monthly mileage of buses-by year

Table 4.31 Average monthly mileage of buses-average

Year	2018	2019	2020
Average monthly mileage (km)	3216.02	3519.06	3682.57

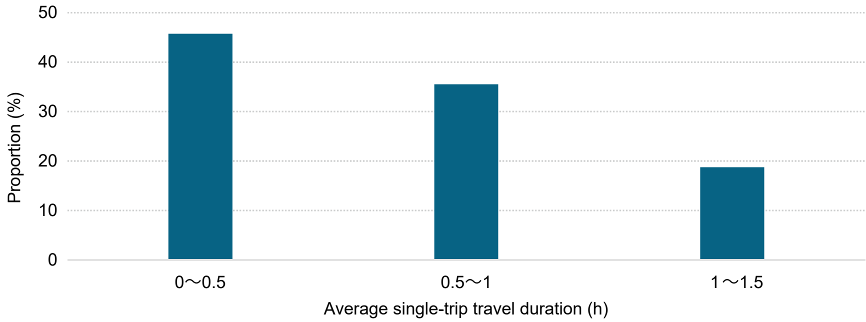


Fig. 4.51 Distribution of heavy-duty trucks of different average single-trip travel durations in 2020

single-trip mileage (Fig. 4.52), the proportion of heavy-duty trucks with an average single-trip mileage of less than 20 km is the highest, i.e., 60%.

According to the distribution of the average single-trip speed (Fig. 4.53), the average single-trip speed of heavy-duty trucks is mainly 20–50 km/h, in which the proportion of heavy-duty trucks with an average single-trip speed of 20–30 km/h is 32.9%, and that of heavy-duty trucks with an average single-trip speed of 30–40 km/h is 29.3%.

According to the distribution of the single-trip initial SOC (Fig. 4.54), the single-trip initial SOC of heavy-duty trucks is mainly 70–80%, and the proportion of heavy-duty trucks with such a single-trip initial SOC is 58.3%.

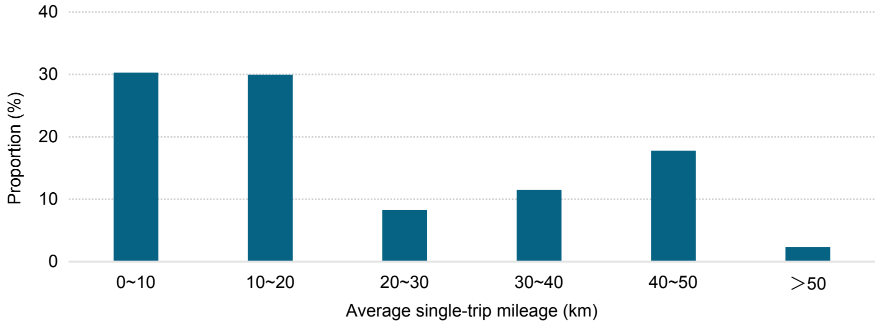


Fig. 4.52 Distribution of heavy-duty trucks of different average single-trip mileages in 2020

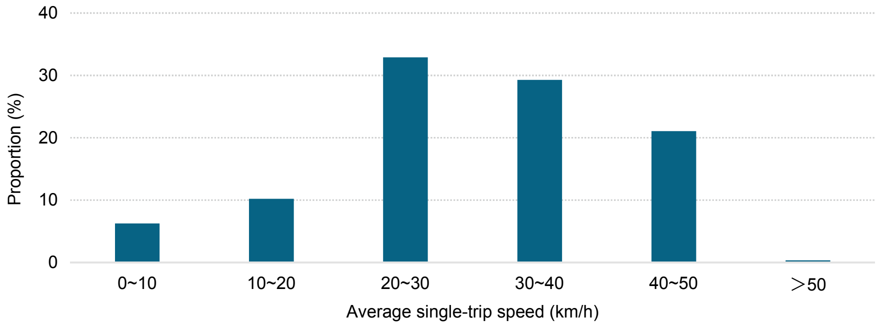


Fig. 4.53 Distribution of heavy-duty trucks of different average single-trip speeds in **2020**

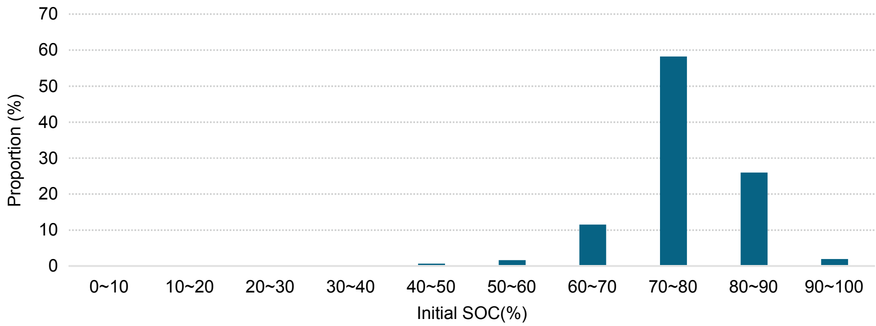


Fig. 4.54 Distribution of heavy-duty trucks of different single-trip initial SOCs in 2020

(2) Average daily travel characteristics of heavy-duty trucks

The average daily travel duration of heavy-duty trucks is mainly more than 8 h.

The average of average daily travel duration of heavy-duty trucks in 2020 was 4.77 h. As the distribution shows (Fig. 4.55), the proportion of heavy-duty trucks with an

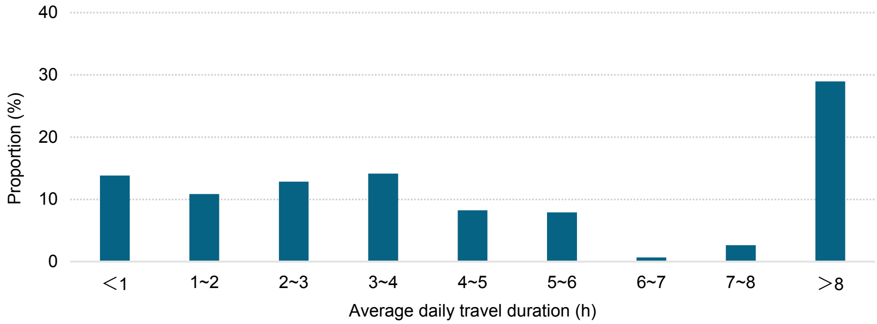


Fig. 4.55 Distribution of heavy-duty trucks of different daily average travel durations in 2020

average daily travel duration of more than 8 h is the highest, i.e. 29%, and the heavy-duty trucks of other average daily travel durations are distributed in a relatively discrete way.

The average daily mileage of heavy-duty trucks is mainly below 100 km and above 300 km.

In 2020, the average of average daily mileage of heavy-duty trucks is 170.2 km. As the distribution shows (Fig. 4.56), heavy-duty trucks with an average daily mileage of 50 km and 50–100 km account for 52.32%. The heavy-duty trucks with an average daily mileage of 50 km take the highest proportion of 29.3%, which is followed by the heavy-duty trucks with an average daily mileage of more than 300 km with a proportion of 26.6%.

The driving time of heavy-duty trucks is mainly concentrated during the daytime working hours, with only a small number of heavy-duty trucks running at night.

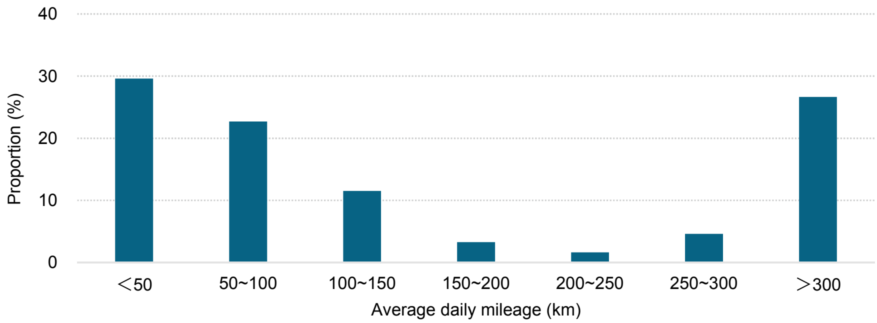


Fig. 4.56 Distribution of heavy-duty trucks of different average daily mileages in 2020

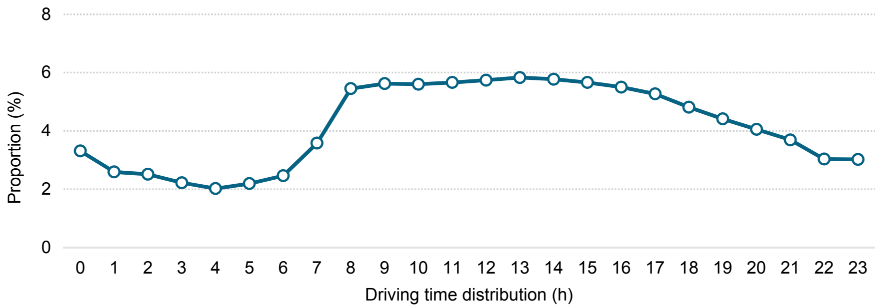


Fig. 4.57 Distribution of heavy-duty trucks of different driving times in 2020

From the distribution of daily driving time of heavy-duty trucks (Fig. 4.57), the proportion of heavy-duty trucks which travel during 8:00–17:00 is high up to 56.1%; there are also certain heavy-duty trucks running at night.

(3) Average monthly travel characteristics of heavy-duty trucks

The overall online rate of heavy-duty trucks in 2020 was significantly higher than that in 2019. In early 2020, the online rate of heavy-duty trucks was affected by the outbreak of the epidemic, but since March when the epidemic was mitigated, it steadily increased (Fig. 4.58).

The average monthly travel days of heavy-duty trucks is mainly 20–25, and the average monthly mileage is mainly below 1000 km and above 5000 km.

According to the distribution of the average monthly travel days of heavy-duty trucks (Fig. 4.59), the proportion of heavy-duty trucks driving for 20–25 days per month is

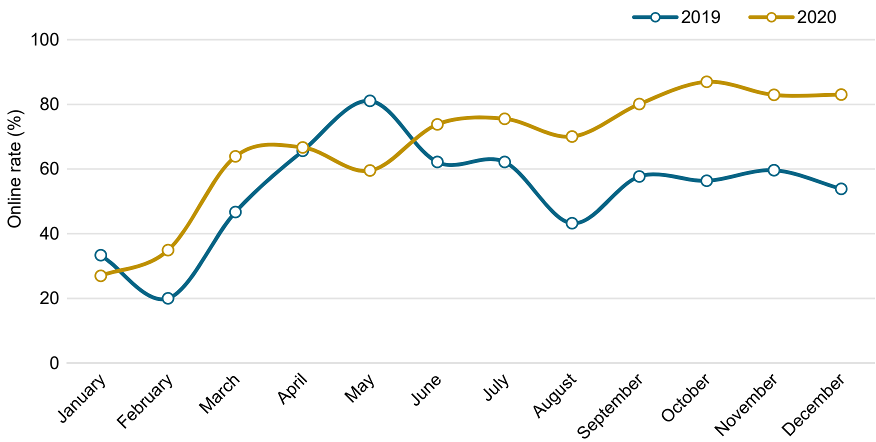


Fig. 4.58 Online rate of heavy-duty trucks in different months

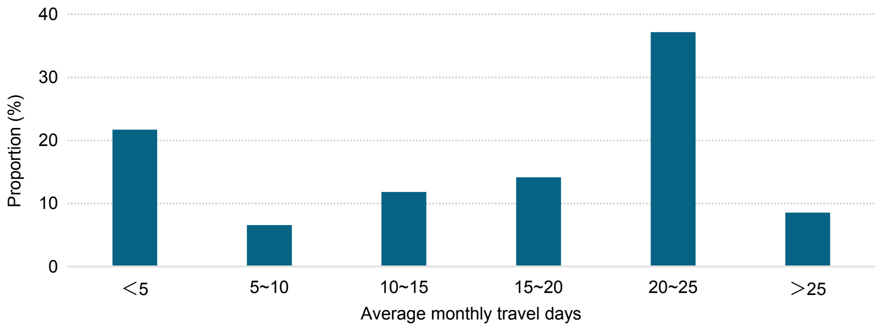


Fig. 4.59 Distribution of heavy-duty trucks of different average monthly travel days in 2020

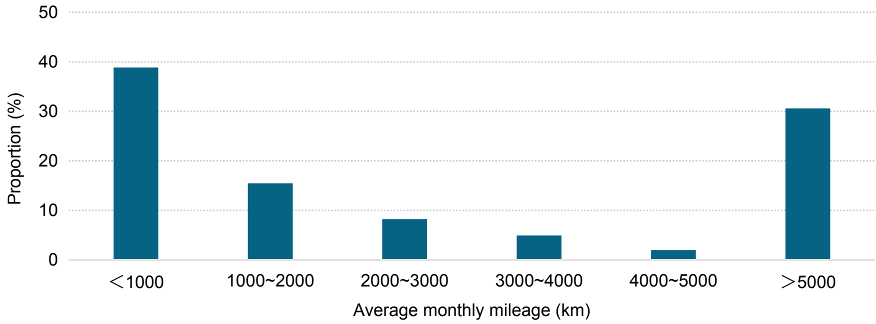


Fig. 4.60 Distribution of heavy-duty trucks of different monthly average mileages in 2020

the highest, i.e. 37.2%; according to the distribution of the average monthly mileage (Fig. 4.60), the heavy-duty trucks with an average monthly mileage of less than 1,000 km take the highest proportion of 38.8%, followed by heavy-duty trucks with an average monthly mileage of more than 5,000 km with a proportion of 30.6%.

4.3 Summary

This chapter makes a comprehensive analysis to the operation laws of vehicles in different segments, and is of great significance for improving the traffic management system and promoting the enterprise product development and market. Through the perspective analysis of the data on operation characteristics of vehicles of each segment in the National Monitoring and Management Platform, the following conclusions are made.

(1) Passenger cars

- **Private cars**

As for the single-trip travel characteristics, the average single-trip travel duration of new energy private cars is distributed in a relatively concentrated way and is mainly within 1 h, and the average single-trip mileage is mainly 0–10 km and 10–20 km. The distribution of private cars in the short travel mileage section in cities of low tiers is more concentrated than that in cities of high tiers; the single-trip initial SOC of private cars, as the charging convenience is improved due to the wide application of private charging piles, is mainly 60–80%, and the proportion of private cars with such a single-trip initial SOC is increasing year by year.

As for the daily travel characteristics, the daily travel duration of private cars is mainly 1–2 h, and in 2020, it was 45.73 km, increasing by 8.9% compared with last year. The driving time of private cars is mainly concentrated in the morning and evening commuting period, and thus it shows obvious "double-peak" characteristics. In addition, in February and March 2020 when the residents' travel was restricted due to the epidemic, the average daily mileage and travel duration of private cars were low, and then after the epidemic was quickly brought under control, the travel of private cars was quickly recovered, and in the second half of 2020, the daily average mileage and travel duration of private cars were far higher than the level of the same period in 2019.

As for the monthly travel characteristic, the average monthly travel days and mileage are increasing year by year.

- **Taxis and e-taxis**

The travel characteristics of taxis and e-taxis well reflect their attribute as operation cars, and specifically, their average daily travel duration is mainly above 6 h, their average daily mileage is mainly 100–250 km and their average monthly travel days is more than 20. At the beginning of 2020 when the travel frequency of residents decreased due to the COVID-19 outbreak, the market of taxis and e-taxis was somehow affected, and their travel duration and mileage decreased compared with 2019.

Such a short-term decline is only the result of periodical factors. At present, the carsharing concept has won great support, and our travel habits have gradually changed. It is expected that the travel duration and mileage of new energy taxis and e-taxis will continue to grow in the future, and these two segments still have a high development potential.

- **Cars for sharing**

As for the daily travel characteristics, the average daily travel duration of cars for sharing is mainly 1–3 h, and the average daily mileage is increasing year by year, and reached 99.63 km in 2020. After the epidemic was quickly brought under control, residents' travel returned to normal, and the average daily mileage and average daily travel duration of cars for sharing were far higher than the level of same period in 2019.

As for the monthly travel characteristics, the monthly travel days of cars for sharing is mainly 15–25, and the average monthly mileage is increasing year by year.

(2) Commercial vehicles

- **Logistics vehicles**

As for the daily travel characteristics, the average daily travel duration of logistics vehicles is increasing year by year, and in 2020, it reached 3.24 h, which is 0.91 h and 0.39 h longer than that in 2018 and 2019, respectively. Specifically, in February 2020, the travel duration of logistics vehicles was affected due to the outbreak of the epidemic, and after the epidemic was brought into control, the average daily mileage and travel duration of logistics vehicles increased rapidly to a level far higher than those of the same period in 2019.

As for the average monthly travel characteristics, the average monthly travel days of logistics vehicles has increased year by year in the past three years, and in 2020, it reached 19.65 days with an increase of 6.55 and 4.03 days compared with 2018 and 2019. The average monthly mileage of logistics vehicles has increased gradually year by year, and in 2020, it rose above 2000 km. The proportion of logistics vehicles in high mileage sections in first-tier and second-tier cities is significantly higher than that in cities of third-tier and below.

- **Buses**

The daily operation of buses is very regular, and their daily travel duration is mainly above 8 h. The proportion of buses in long travel duration section in first-tier cities is 49%, which is significantly higher than that in other cities.

The average monthly travel days of buses is more than 22, and in first-tier cities, the proportion of buses with long travel days is relatively high; the average monthly mileage is increasing gradually year by year, and reached 3682.57 km in 2020.

- **Heavy-duty trucks**

Heavy-duty trucks normally operate under high load for a long time. According to the research results of the State Grid Demonstration Project, the fuel consumption of a 90-ton mine-purpose heavy-duty truck is equivalent to the fuel consumption of 100 passenger cars, and electrification can reduce the diesel consumption by 180,000 L per vehicle per year. Therefore, electrification of heavy-duty trucks is an important measure to achieve the carbon peak goal in 2030 and the carbon neutrality goal in 2060. According to the operation characteristics of heavy-duty trucks, the overall online rate of heavy-duty trucks in 2020 was significantly higher than that in 2019; as for the single-trip travel characteristics of heavy-duty trucks, the average single-trip duration of heavy-duty trucks is mainly within 1 h, the average single-trip mileage is mainly within 20 km, the average single-trip speed is mainly 20–50 km/h, and the average single-trip initial SOC is mainly 70–80%. The average daily travel duration of heavy-duty trucks is more than 8 h, the average daily mileage is more than 300 km, and the monthly travel mileage is more than 5000 km. In a word, the heavy-duty trucks have the capability to meet the actual production needs.

Chapter 5
Charging of New Energy Vehicles

With the phase-out of fiscal and tax subsidies for new energy vehicles, as well as the transition of national and local policies from "vehicle subsidy" to "use subsidy", governments, including central governments and local governments, work hand in hand to establish a good and stable industrial environment for charging facilities. By the end of 2020, a total of 1,681,000 charging infrastructures had been built nationwide with a YoY increase of 37.9%, including 807,000 public charging piles and 874,000 charging facilities constructed with the vehicle delivery. In 2020, the increment in charging infrastructures was 462,000, indicating that the construction speed of charging infrastructures was significantly accelerated. This chapter analyzes the charging characteristics of new energy vehicles in key segments and the charging behavior characteristics of users in different charging scenarios, and summarizes the charging characteristics and charging laws of users, with a view to providing reference for the formulation of national charging infrastructure policies and the operation and management of charging facilities by operators.

5.1 Construction Situation of Charging Infrastructures

5.1.1 Accelerated Construction of Public Charging Piles

By the end of 2020, the units in operation (UIO) of public charging piles in China was 807,000, and the number of new charging piles had increased significantly.

With the continuous development of the scale market of new energy vehicles, the number of public charging infrastructures in China have grown rapidly. According to the statistics from the China Electric Vehicle Charging Infrastructure Promotion Alliance (hereinafter referred to as the "EVCIPA"), the cumulative number of public charging piles by the end of 2020 in China was 807,000 (Fig. 5.1), increasing by

Z. Wang, *Annual Report on the Big Data of New Energy Vehicle in China (2021)*,
https://doi.org/10.1007/978-981-19-5508-2_5

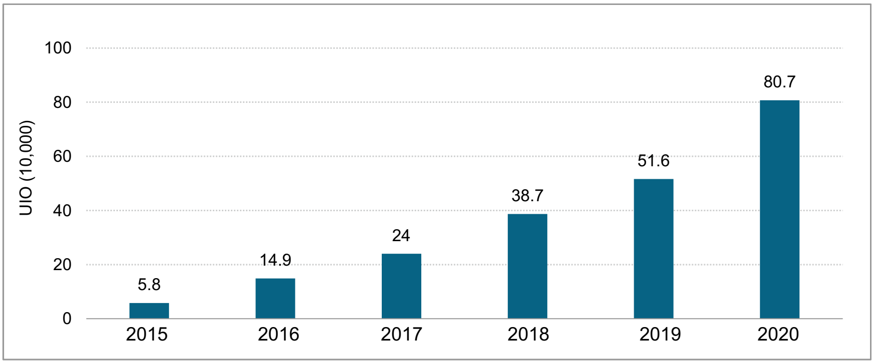


Fig. 5.1 UIO of public charging piles in China over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

56.4% compared with 2019. In 2020, operators increased their efforts in the construction and access of public charging piles, with 291,000 public charging piles newly constructed.

AC charging piles take a large proportion among public charging facilities. As shown in Fig. 5.2, by the end of 2020, the UIO of AC charging piles reached 498,000, accounting for 62% of the total UIO of charging infrastructures; the UIO of DC charging piles was 309,000, accounting for 38% of the total UIO of charging infrastructures; the UIO of AC and DC integrated charging piles was 481. In 2020, 281,000 public charging piles are newly constructed, most of which are AC charging piles.

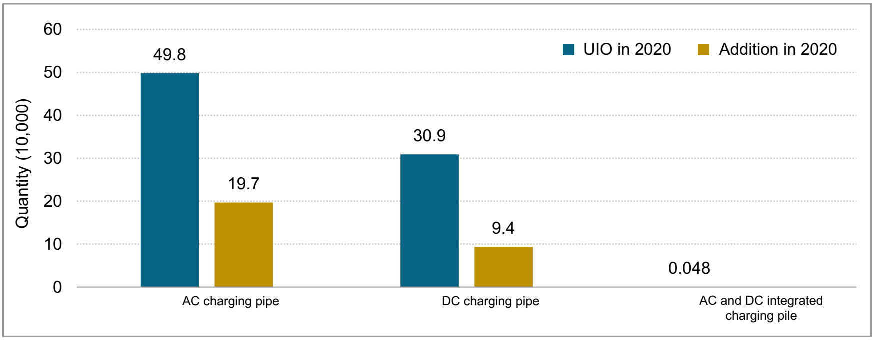


Fig. 5.2 UIO and new additions of public charging piles in China. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

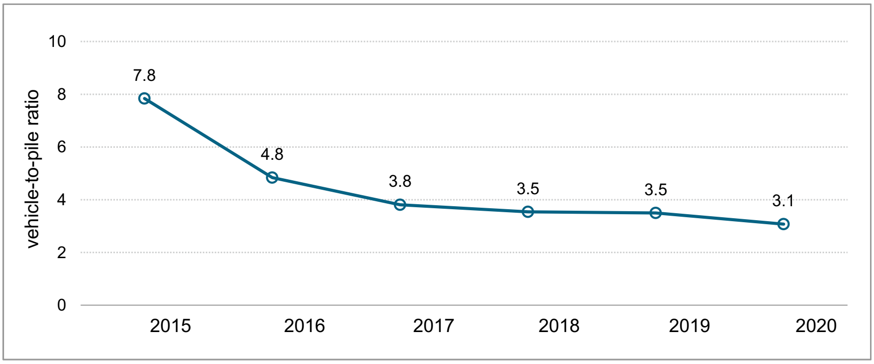


Fig. 5.3 Vehicle-to-pile ratio of NEVs in China over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

5.1.2 Gradual Rationalization of Vehicle-To-Pile Ratio

By the end of 2020, the overall vehicle-to-pile ratio of new energy vehicles in China was 3.1:1.

According to statistics from the Ministry of Public Security, the UIO of new energy vehicles in China was 4,920,000 by the end of 2020. As shown in Fig. 5.3, the overall vehicle-to-pile ratio of new energy vehicles has increased from 7.8:1 in 2015 to 3.1:1 in 2020, with the stress on vehicle-to-pile ratio greatly alleviated. It is expected that with the rapid growth of the charging infrastructure industry in the next few years, the vehicle-to-pile ratio will further improve.

5.1.3 Further Optimization of Vehicle-to-Pile Power Matching

With the continual progress of charging technology, the overall charging power of public charging piles has steadily increased.

In the past three years, the average power of public DC charging piles has exceeded 100 kW to meet the requirements of long range and short charging duration of electric vehicles. The configuration of public AC charging piles has changed, i.e., from 7 kW AC charging pile to 20 kW/40 kW three-phase AC charging pile. The available charging powers of DC charging piles include 30, 60, 120, 240 and 380 kW (Fig. 5.4).

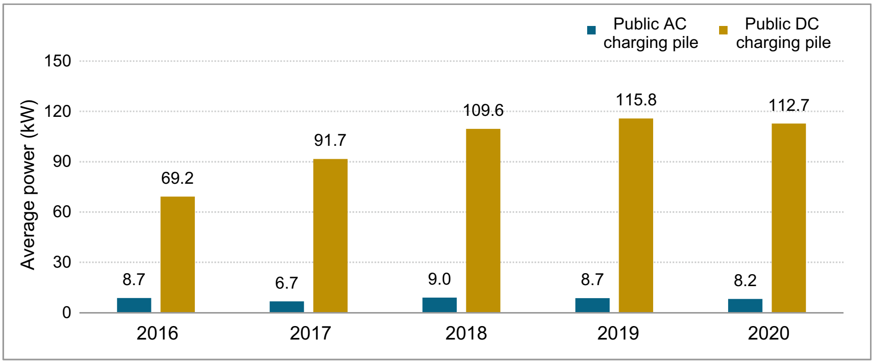


Fig. 5.4 Changes in average power of public charging piles over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

5.2 Charging Characteristics of Vehicles in Key Segments

This section, 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, analyzes and summarizes the charging characteristics of vehicles at different time 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, with a view to providing 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.

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 each of a single charging
	Average single-time charging initial SOC	Average initial SOC of a 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

5.2.1 *Charging Characteristics of New Energy Private Cars*

(1) Average single-time charging characteristics of new energy private cars

In 2020, the average single-time charging duration of new energy private cars was mainly below 4 h, and the proportion of new energy private cars with an average single-time charging duration above 4 h is decreasing.

In 2020, the average single-time charging duration of new energy private cars was 3.15 h, which is 0.82 h shorter (i.e., 20.7% lower) than that in 2019 (Table 5.2). According to the distribution in weekdays and weekends, the average single-time charging duration of BEV private cars is more than 4 h during weekends, which is significantly higher than that in weekdays (Fig. 5.5); the average single-time charging duration of FCEV private cars is basically the same in weekdays and weekends, and is mainly 1–3 h (Fig. 5.6).
Considering from the charging method (Fig. 5.7), the fast charging duration of new energy private cars is mainly below 2 h with a proportion of 93.3%; the distribution of slow charging duration of new energy private cars is relatively discrete, with the proportion of new energy private cars with a slow charging duration of 2–4 h is equal to 60.2%.

In 2020, the single-time charging initial SOC of new energy private cars was 41.6%, which is higher than that of the previous year.

Table 5.2 Average charging duration of new energy private cars

Year	2018	2019	2020
Average single-time charging duration (h)	3.90	3.97	3.15

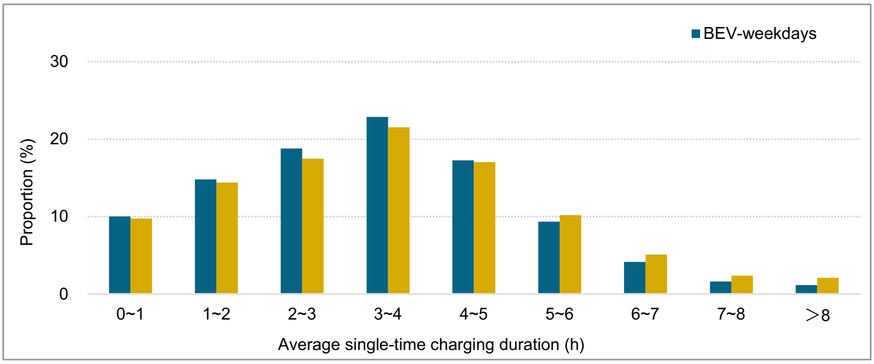


Fig. 5.5 Distribution of average single-time charging duration of BEV private cars in 2020-by weekday and weekend

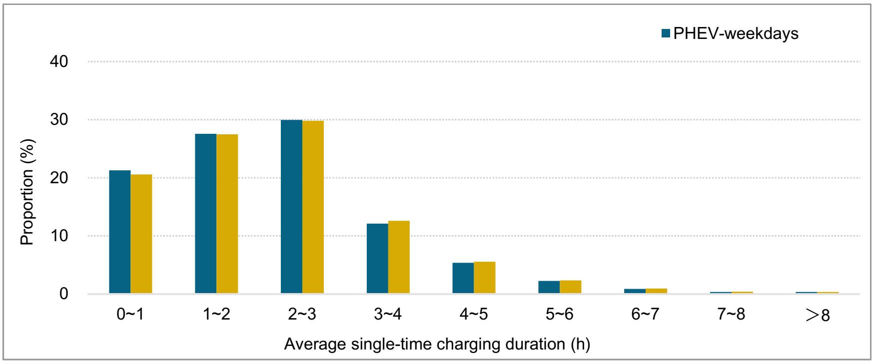


Fig. 5.6 Distribution of average single-time charging duration of FCEV private cars in 2020-by weekday and weekend

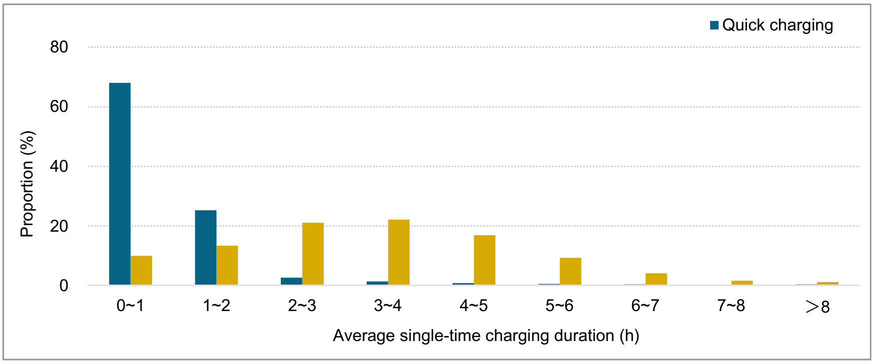


Fig. 5.7 Distribution of average single-time charging duration of BEV private cars in 2020-by quick charging and slow charging

According to the data over the years, the single-time charging initial SOC of new energy private cars in 2020 was 41.6%, which is 2.3% higher than that in 2019 (Table 5.3). As the distribution shows (Fig. 5.8), the proportion of new energy private cars with a single-time charging initial SOC of 30–50% is increasing year by year, and in 2020, the proportion of new energy private cars with such a single charging initial SOC was 50.4%, which is 3.5 and 2.0% higher than that in 2018 and 2019, respectively.

Table 5.3 Single-time charging initial SOC of new energy private cars-average

Year	2018	2019	2020
Single-time charging initial SOC (%)	40.3	39.3	41.6

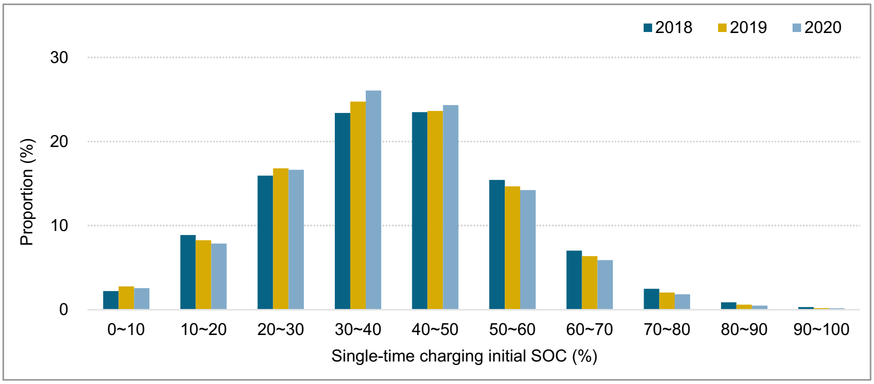


Fig. 5.8 Distribution of single-time charging initial charging SOC of new energy private cars-by year

(2) Average daily charging characteristics of new energy private cars

The average daily charging time of new energy private cars is mainly concentrated at night.

According to the distribution of charging time, the charging of new energy private cars mainly occurs at night. Specifically, the proportion of new energy private cars which are charged during 20:00–24:00 is 30.14%, which is significantly higher than that in other time periods (Fig. 5.9).
Considering from the charging method, the proportion of new energy private cars charged by fast charging is significantly higher than that of new energy private cars charged by slow charging; while at night, slow charging is applied more, with the proportion of new energy private cars charged by slow charging from 20:00 to 5:00 the next day by up to 51.3% (Fig. 5.10).

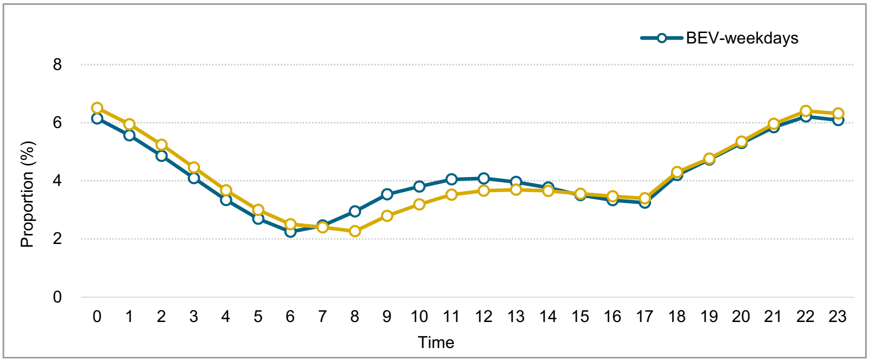


Fig. 5.9 Distribution of charging time of BEV private cars in 2020-by weekday and weekend

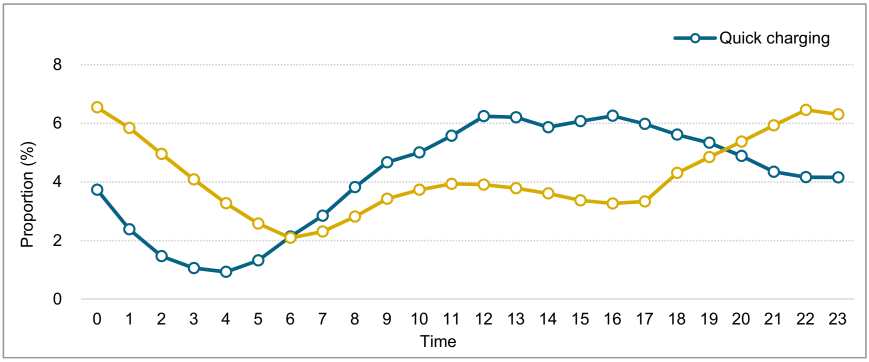


Fig. 5.10 Distribution of charging time of BEV private cars in 2020-by quick charging and slow charging

(3) Average monthly charging characteristics of new energy private cars

In 2020, the average monthly charging time of new energy private cars was 7.4, and slow charging was more adopted (Table 5.4).

As the distribution shows, the proportion of new energy private cars with an average monthly charging times of less than 5 was 53.4%, which is 8.22% higher than that in 2019 (Fig. 5.11) mainly due to a higher proportion of PHEV private cars with an average monthly charging time of less than 5 than 2019 (Fig. 5.13). The proportion of BEV private cars with average monthly charging times of less than 5 is 52.3%, and that of BEV private cars with average monthly charging times of 5–10 is significantly increased (Fig. 5.12).

Considering from the charging method, slow charging is the main charging method adopted by new energy vehicles. In 2020, the proportion of slow charging of new energy private cars in average monthly charging times was 84.6% (Figs. 5.13 and 5.14).

In 2020, the average monthly charge of new energy private cars was 84.2 kWh, and the proportion of new energy private cars with an average monthly charge higher than 50 kWh increased significantly (Table 5.5).

In 2020, the new energy private cars with an average monthly charge of less than 50 kWh took the main proportion of 48.7%, and according to the change over the years (Fig. 5.15), the proportion of new energy private cars with an average monthly charge of more than 50 kWh has increased greatly, i.e. from 24.6% in 2018 to 51.3% in 2020.

Table 5.4 Average monthly charging times of new energy private cars-average

Year	2018	2019	2020
Average monthly charging times	5.9	8.0	7.4

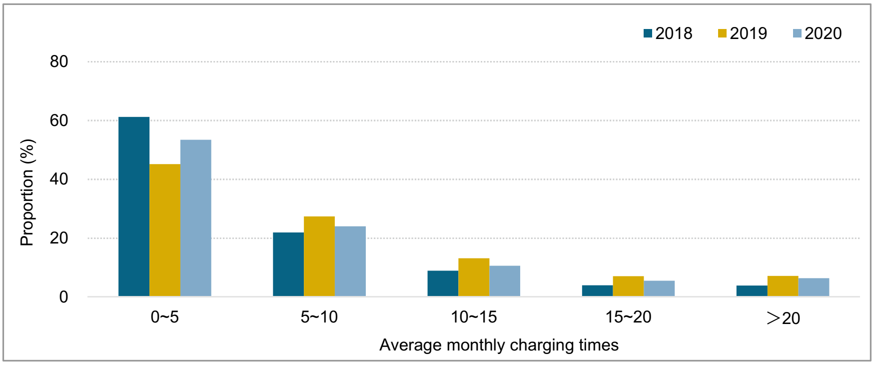


Fig. 5.11 Distribution of average monthly charging times of new energy private cars-by year

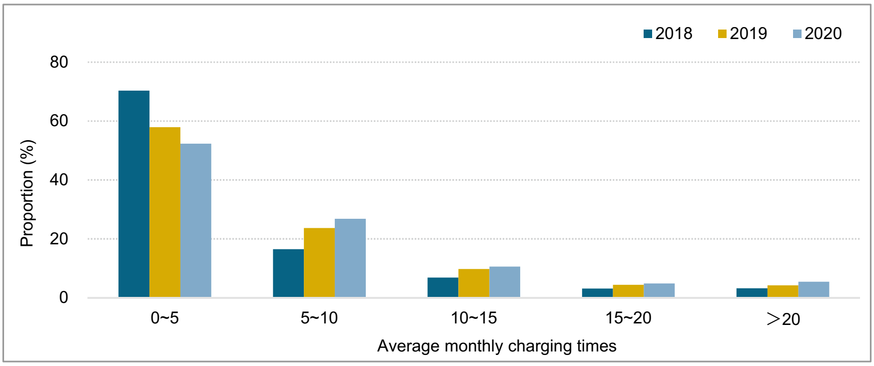


Fig. 5.12 Distribution of average monthly charging times of BEV private cars-by year

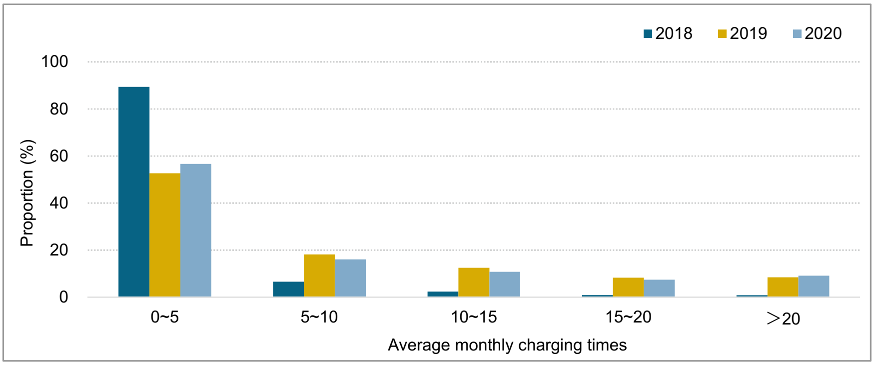


Fig. 5.13 Distribution of average monthly charging times of PHEV private cars-by year

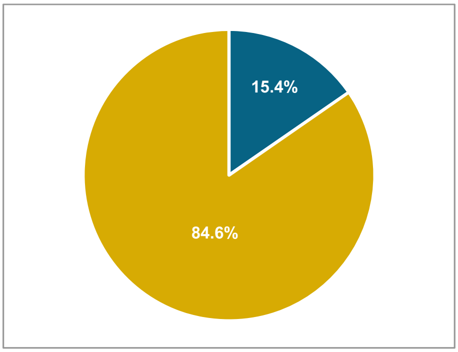


Fig. 5.14 Proportion of fast charging and slow charging in average monthly charging times of new energy private cars in 2020

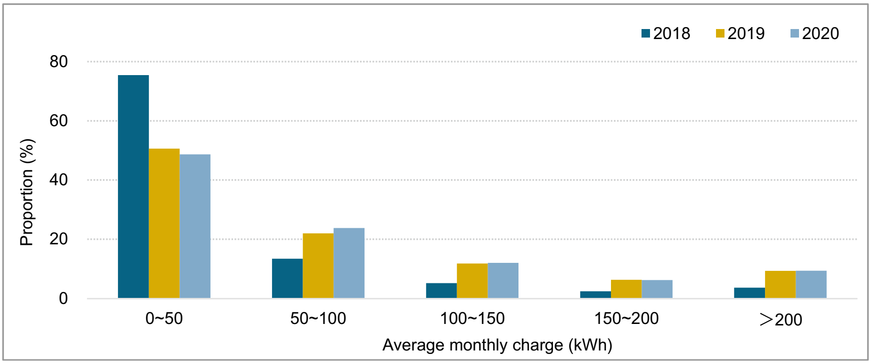


Fig. 5.15 Distribution of average monthly charge of new energy private cars-by year

Table 5.5 Average monthly charge of new energy private cars—average

Year	2018	2019	2020
Average monthly charge (kWh)	41.5	86	84.2

5.2.2 *Charging Characteristics of BEV E-taxis*

(1) Average single-time charging characteristics of BEV e-taxis

The average charging duration of BEV e-taxis has decreased year by year, and in 2020, it was 1.5 h.

As shown in Table 5.6, the average charging duration of BEV e-taxis was 1.5 h in 2020, which is shorter than that in 2019 and more shorter than that in 2018. Considering from the charging method, the fast charging duration of BEV e-taxis is mainly

Table 5.6 Average single-time charging duration of NEV E-taxis-average

Year	2018	2019	2020
Average single-time charging duration (h)	1.7	1.8	1.5

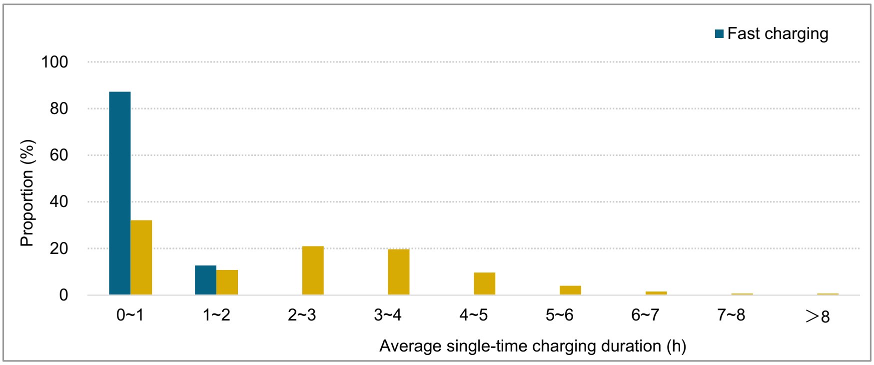


Fig. 5.16 Distribution of average single-time charging duration of BEV E-taxis in 2020-by fast charging and slow charging

within 1 h with a proportion high up to 87.2%; the distribution of average single-time charging duration of e-taxis by slow charging is relatively discrete (Fig. 5.16).

In 2020, the single-time charging initial SOC of BEV e-taxis was 43.4%, which is higher than that of the previous two years.

According to the data over the years, the single-time charging initial SOC of BEV e-taxis in 2020 was 43.4%, which is 0.7% and 0.2% higher than that in 2018 and 2019, respectively (Table 5.7). As the distribution shows (Fig. 5.17), the proportion of BEV e-taxis with a single-time charging initial SOC of more than 40% increased from 53.1% in 2018 to 56.3% in 2020. As the construction of public charging piles is improved and the charging becomes more convenient, more users of BEVs e-taxis select on-demand charging.

(2) Average daily charging characteristics of BEV e-taxis

For BEV e-taxis, the slow charging mainly occurs at night, and at daytime when the charging demand is high, the fast charging is adopted.

Considering from the charging method, the slow charging of BEV e-taxis mainly occurs at night, with the proportion of e-taxis charged from 20:00 to 5:00 the next

Table 5.7 Single-time charging initial SOC of BEV E-taxis-average

Year	2018	2019	2020
Single-time charging initial SOC (%)	42.7	43.2	43.4

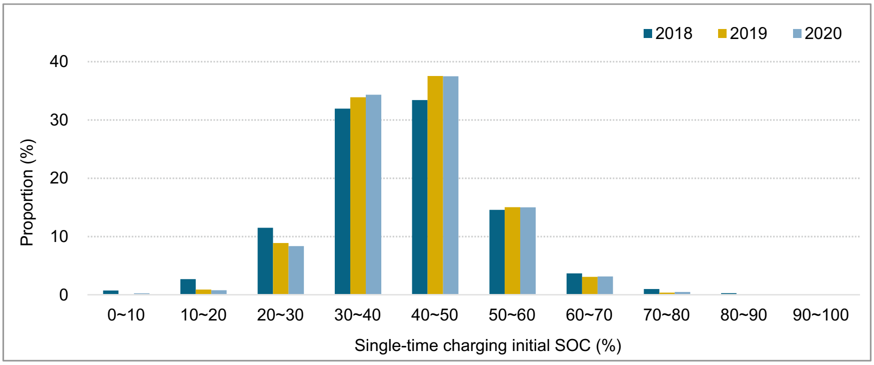


Fig. 5.17 Distribution of single-time charging initial SOC of BEV E-taxis-by year

day as high up to 68.7%; the fast charging, due to the attribute of the e-taxis as an operation car, mainly occurs from 11:00 to 17:00 in the daytime and from 23:00 to 1:00 at night. As some e-taxis operate at night, demand for fast charging is also high at night (Fig. 5.18).

(3) Average monthly charging characteristics of BEV e-taxis

The average monthly charging time of BEV e-taxis is mainly 20–30, and the proportion of e-taxis which are charged more than 20 times per month decreases.

As the distribution shows (Table 5.8), the proportion of BEV e-taxis with monthly average charging times of more than 20 has dropped from 67.2% in 2019 to 59.7% in 2020, i.e., a decrease of 7.5%. Considering from the charging method, fast charging is mainly adopted, and the proportion of fast charging times in monthly average charging times is 72% (Figs. 5.19 and 5.20).

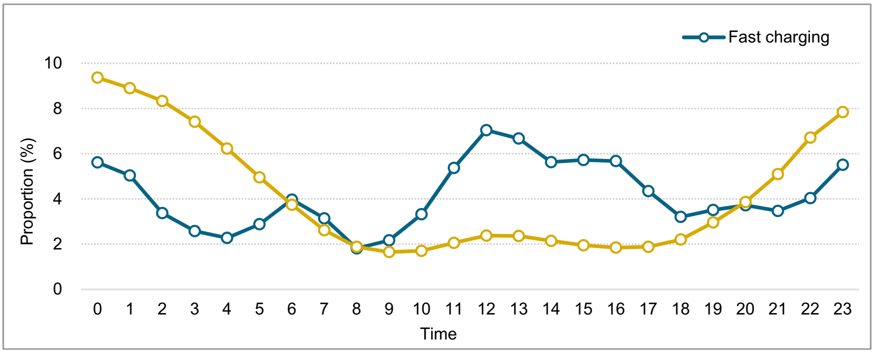


Fig. 5.18 Distribution of charging time of BEV E-taxis in 2020-by fast charging and slow charging

Table 5.8 Average monthly charging times of BEV E-taxis-average

Year	2018	2019	2020
Average monthly charging times	20.8	26.6	25.0

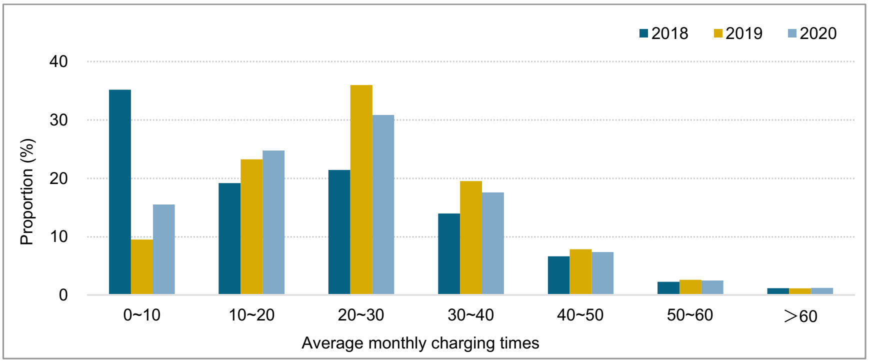
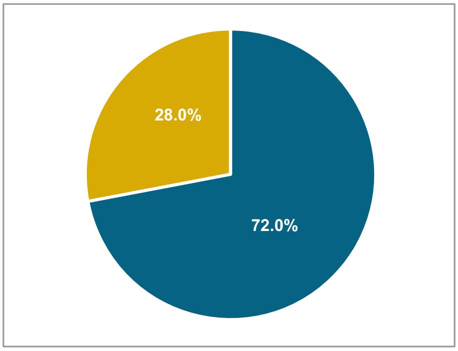


Fig. 5.19 Distribution of average monthly charging times of BEV E-taxis-by year

Fig. 5.20 Proportion of fast charging and slow charging in average monthly charging times of BEV E-taxis in 2020



In 2020, the average monthly charge of BEV e-taxis was 548.4 kWh, which is lower than that of the last year.

As the distribution shows (Table 5.9), the proportion of BEV e-taxis with an average monthly charge of more than 600 kWh was 31.7% in 2020, which is lower than the 40.4% in 2019, but still higher than the 28.5% in 2018 (Fig. 5.21); the average monthly charge of slow charging of BEV e-taxis is mainly within 100 kWh, and the distribution of e-taxis with an average monthly charge of slow charging of higher than 100 kWh is relatively uniform (Fig. 5.22).

Table 5.9 Average monthly charge of BEV E-taxis-average

Year	2018	2019	2020
Average monthly charge (kWh)	437.0	640.4	548.4

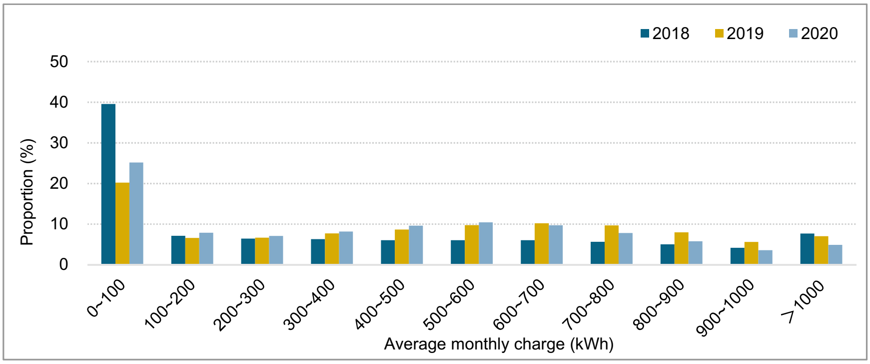


Fig. 5.21 Distribution of average monthly charge of BEV E-taxis-by year for fast charging

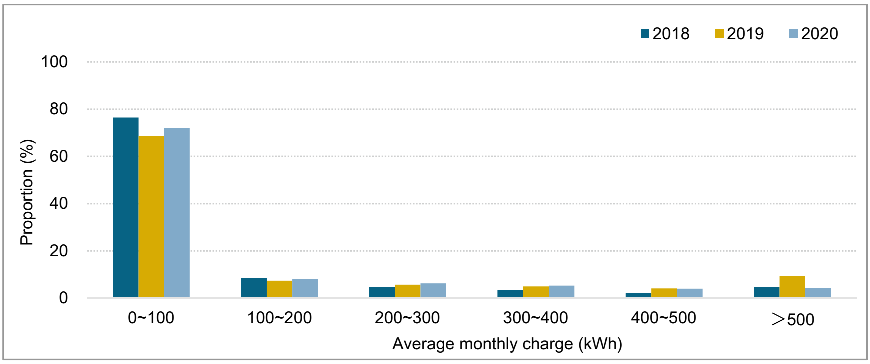


Fig. 5.22 Distribution of average monthly charge of BEV E-taxis-by year for slow charging

5.2.3 Charging Characteristics of BEV Taxis

(1) Average single-time charging characteristics of BEV taxis

The annual average single-time charging duration of BEV taxis is mainly within 1 h, and is decreasing year by year.

According to the data over the years, the average single-time charging duration of BEV taxis in 2020 was 1.2 h, decreasing by 20% compared with 2019 (Table 5.10). Considering from the charging method, the average single-time charging duration

Table 5.10 Average single-time charging duration of BEV taxis-average

Year	2018	2019	2020
Average single-time charging duration (h)	1.8	1.5	1.2

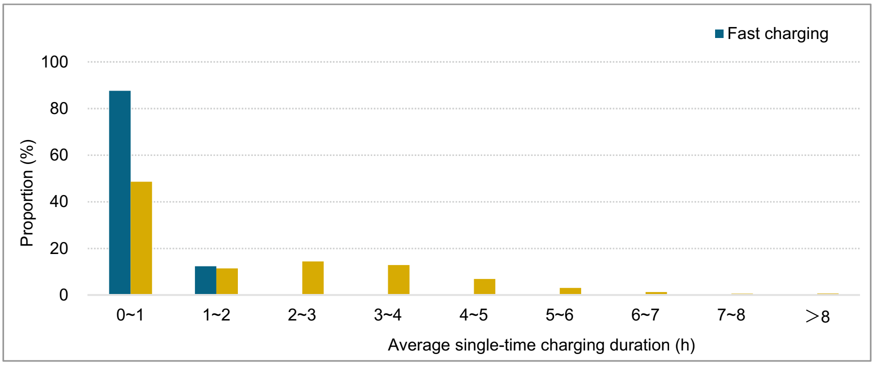


Fig. 5.23 Distribution of average single-time charging duration of BEV taxis in 2020-by fast charging and slow charging

of BEV taxis is short, with the proportion of BEV taxis with an average single-time charging duration of fast charging of less than 1 h up to 87.6%, and the proportion of BEV taxis with an average single-time charging duration of slow charging of less than 2 h up to 60% (Fig. 5.23).

The single-time charging initial SOC of BEV taxis has decreased.

In 2020, the single-time charging initial SOC of BEV taxis was 43.3%, decreasing slightly compared with 2019 (Table 5.11). As the distribution shows (Fig. 5.24), the single-time charging initial SOC of BEV taxis is mainly 30–50%, and in 2020, the proportion of BEV taxis with a single-time charging initial SOC above 40% decreased to 55.6%, which is lower than 60.4% in 2019 and also 57% in 2018.

(2) Average daily charging characteristics of BEV taxis

The charging duration of BEV taxis in 2020 was basically the same as that in 2019, and the proportion of BEV taxis charged between 19:00 and 23:00 in 2019 and 2020 was significantly lower than that in 2018.

Table 5.11 Single-time charging initial SOC of BEV taxis-average

Year	2018	2019	2020
Single-time charging initial SOC (%)	42.2	44.2	43.3

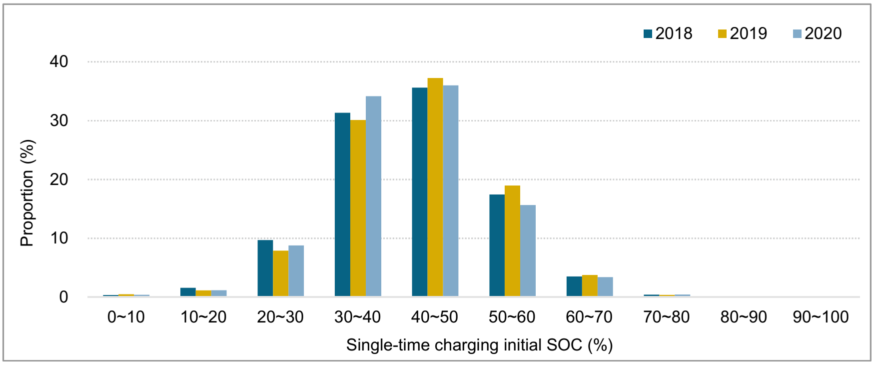


Fig. 5.24 Distribution of single-time charging initial SOC of BEV taxis-by year

Considering from the charging method, the fast charging of BEV taxis mainly occurs in the period from 11:00 to 17:00 and in the period from 23:00 to 1:00; the slow charging mainly occurs at night (Fig. 5.25).

(3) Average monthly charging characteristics of BEV taxis

The average monthly charging times of BEV taxis was 28.6 in 2020, which is lower than that in 2019.

As the distribution shows (Table 5.12), the proportion of BEV taxis with an average monthly charging time of more than 30 decreased from 44.2% in 2018 to 41% in 2020, but the proportion of BEV taxis with an average monthly charging time of more than 50 increased from 8.3% in 2018 to 10.4% in 2020 (Fig. 5.26). Considering from the charging method, the fast charging is mainly adopted, and in 2020, the proportion of BEV taxis charged by fast charging was 79.6% (Fig. 5.27).

In 2020, the average monthly charge of BEV taxis was 656.5 kWh, which is lower than that of the last year.

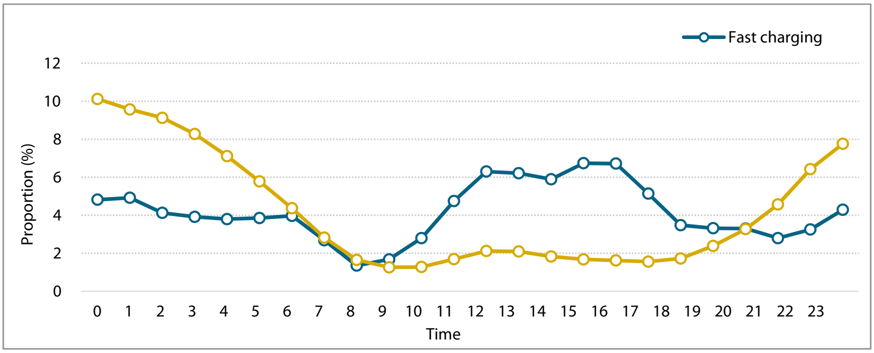


Fig. 5.25 Distribution of charging time of BEV taxis in 2020-by fast charging and slow charging

Table 5.12 Average monthly charging times of BEV taxis-by year

Year	2018	2019	2020
Average monthly charging times	26.8	31.2	28.6

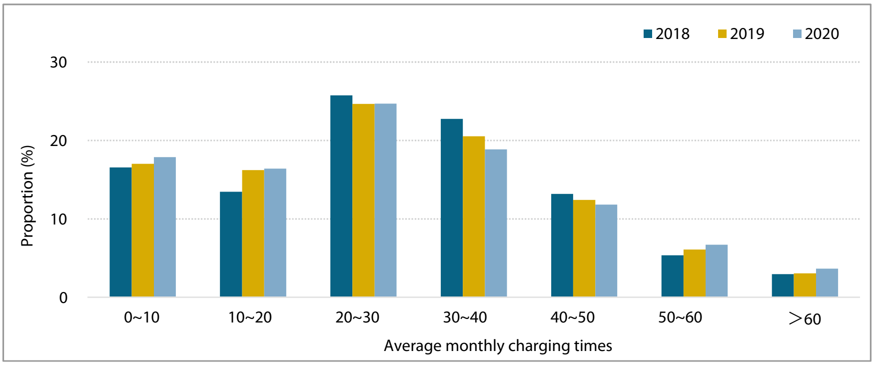
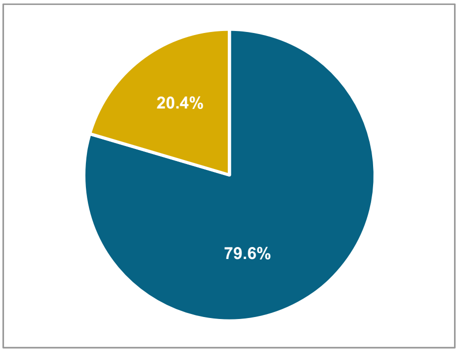


Fig. 5.26 Distribution of average monthly charging times of BEV taxis-by year

Fig. 5.27 Average monthly charging times of BEV taxis in 2020-by fast charging and slow charging



In 2020, the average monthly charge of BEV taxis was 656.5 kWh, decreasing by 11.6% compared with last year (Table 5.13). As the distribution shows (Fig. 5.28), the proportion of BEV taxis with an average monthly charge of fast charging higher than 600 kWh increased from 31.2% in 2018 to 40.1% in 2020; the proportion of BEV taxis with an average monthly charge of fast charging higher than 1000 kWh increased year by year; and the proportion of BEV taxis with an average monthly charge of slow charging higher than 200 kWh decreased from 26.5% in 2018 to 14.7% in 2020 (Fig. 5.29).

Table 5.13 Average monthly charge of BEV taxis-average

Year	2018	2019	2020
Average monthly charge (kWh)	554.0	742.8	656.5

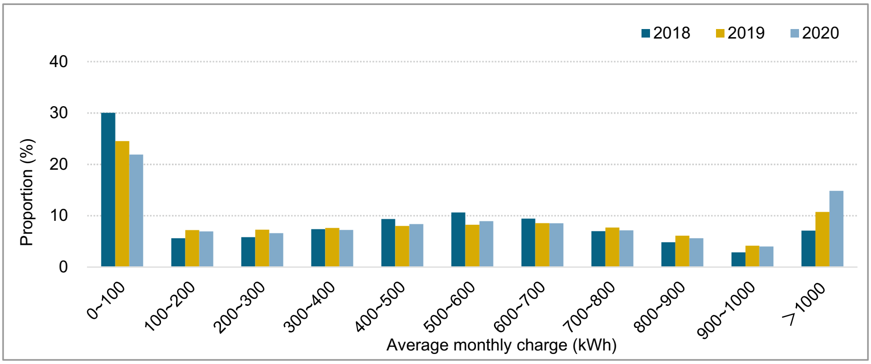


Fig. 5.28 Distribution of average monthly charge of BEV taxis-by year for fast charging

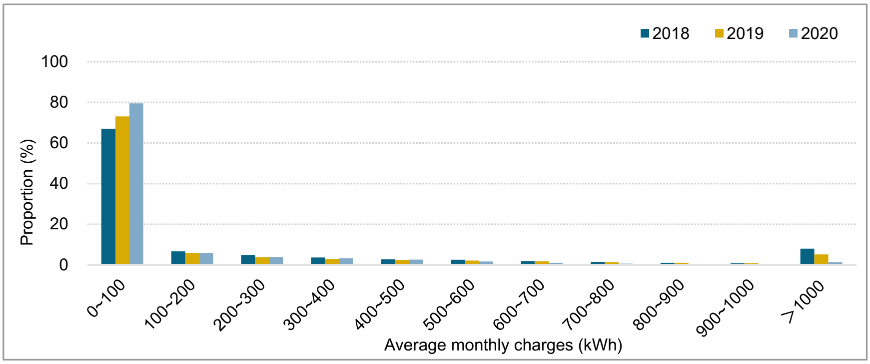


Fig. 5.29 Distribution of average monthly charge of BEV taxis-by year for slow charging

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 within 2 h, and is decreasing year by year.

In 2020, the average single-time charging duration of BEV cars for sharing was 1.7 h, which is 0.4 h and 0.5 h shorter than that of 2018 and 2019, respectively (Table 5.14). Considering from the charging method, the fast charging duration of BEV cars

Table 5.14 Average single-time charging duration of BEV cars for sharing-average

Year	2018	2019	2020
Average single-time charging duration (h)	2.1	2.2	1.7

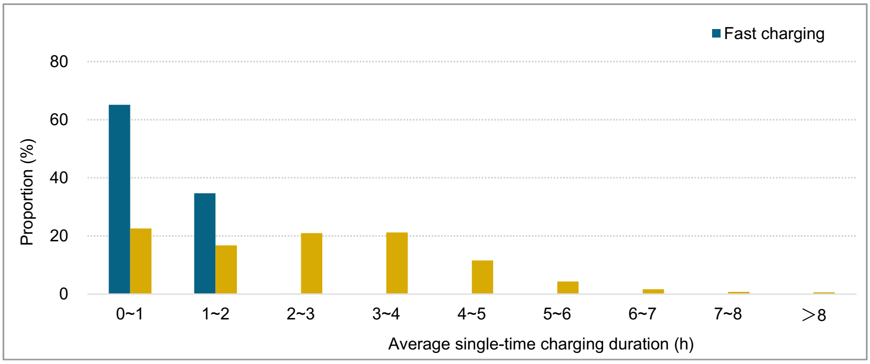


Fig. 5.30 Distribution of average single-time charging duration of BEV cars for sharing in 2020-by fast charging and slow charging

for sharing is mainly within 1 h, while the distribution of slow charging duration is relatively discrete (Fig. 5.30).

The single-time charging initial SOC of BEV cars for sharing is mainly 30–50%.

In 2020, the single-time charging initial SOC of BEV cars for sharing was 42.6%, decreasing by 1.4% compared with 2019 (Table 5.15). As the distribution shows (Fig. 5.31), the single-time charging initial SOC of BEV cars for sharing is mainly 30–50%, and in 2020, the proportion of BEV cars for sharing with such a single-time charging initial SOC was 72.8%, which is 12% higher than that in 2019.

(2) Average daily charging characteristics of BEV cars for sharing

The distribution of BEV cars for sharing of different charging time period is relatively uniform, and the distribution of BEV cars for sharing charged by fast charging is more concentrated.

Considering from the charging method, the fast charging mainly occurs in the time period from 12:00 to 16:00 and in the time period from 21:00 to 4:00 the next day; the distribution of charging duration of slow charging is relatively discrete, and more cars are charged by slow charging at night (Fig. 5.32).

Table 5.15 Single-time charging initial SOC of BEV cars for sharing-average

Year	2018	2019	2020
Single-time charging initial SOC (%)	52.3	44.0	42.6

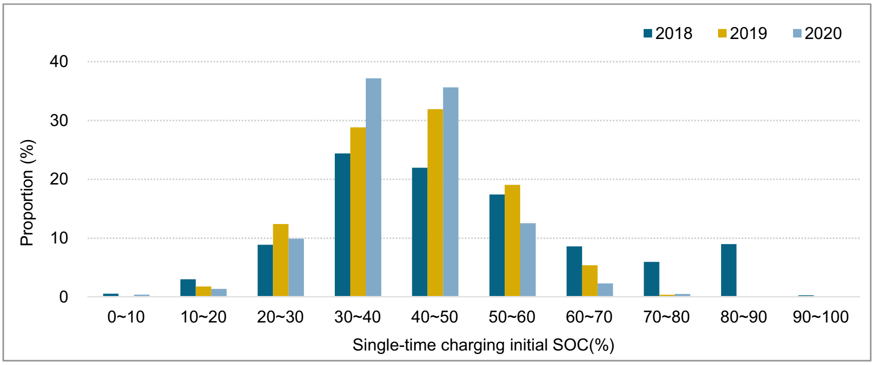


Fig. 5.31 Distribution of average single-time charging initial of BEV cars for sharing-by year

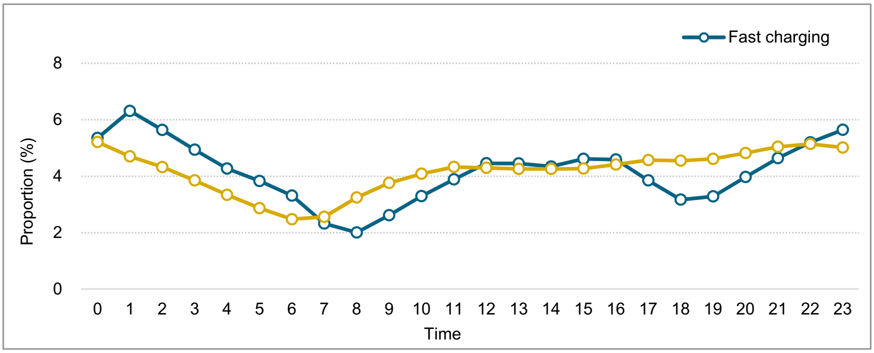


Fig. 5.32 Distribution of charging time of BEV cars for sharing in 2020-by fast charging and slow charging

(3) Average monthly charging characteristics of BEV cars for sharing

The average monthly charging times of BEV cars for sharing has decreased year by year, and in 2020, it was 16.1.

In 2020, the average monthly charging time of BEV cars for sharing was 16.1, which is lower than that in 2018 and 2019 (Table 5.16). As the distribution shows (Fig. 5.33), the proportion of BEV cars for sharing with an average monthly charging time above 30 in 2020 was 14.4%, which is higher than that in 2018 and 2019, but the proportion of BEV cars for sharing with an average monthly charging time no more than 20 was lower than that in 2019; considering from the charging method, the fast charging is mainly adopted, and the proportion of fast charging times in average monthly charging times is 67.6%(Fig. 5.34).

Table 5.16 Average monthly charging times of BEV cars for sharing-average

Year	2018	2019	2020
Average monthly charging times	18.4	16.7	16.1

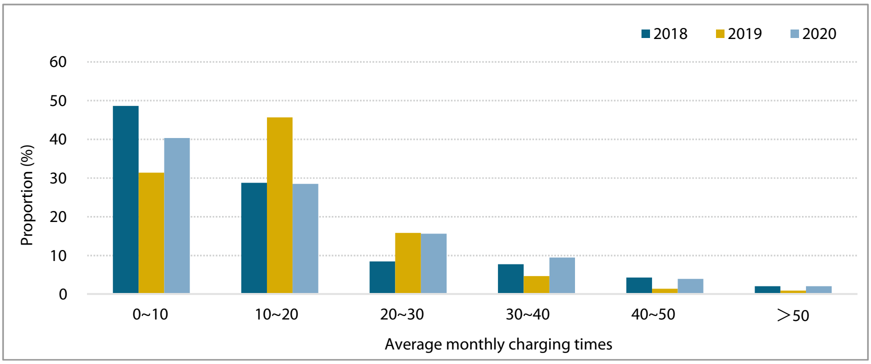
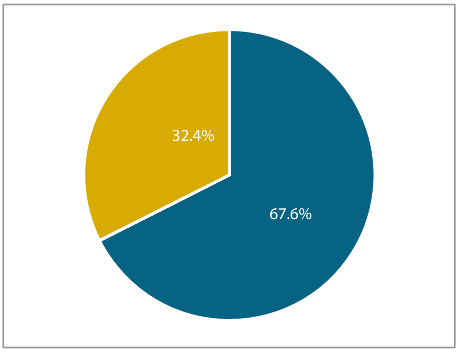


Fig. 5.33 Distribution of average monthly charging times of BEV cars for sharing-by year

Fig. 5.34 Average monthly charging times of BEV cars for sharing in 2020-by fast charging and slow charging



The average monthly charge of BEV cars for sharing is increasing year by year.

In 2020, the average monthly charge of BEV cars for sharing was 293.9 kWh, increasing by 33.2% compared with last year (Table 5.17). As the distribution shows (Fig. 5.35), the proportion of BEV cars for sharing with an average monthly charge higher than 200 kWh increased from 12.4% in 2018 to 36.5% in 2020, and the proportion of BEV cars for sharing with an average monthly charge higher than 500 kWh in 2020 was 21.8%, which is much higher than that in 2018 and 2019. As shown in Fig. 5.36, the proportion of BEV cars for sharing with an average monthly charge of slow charging of more than 100 kWh decreased from 28.9% in 2018 to 18.6% in 2020.

Table 5.17 Average monthly charge of BEV cars for sharing-average

Year	2018	2019	2020
Average monthly charge (kWh)	158.2	220.6	293.9

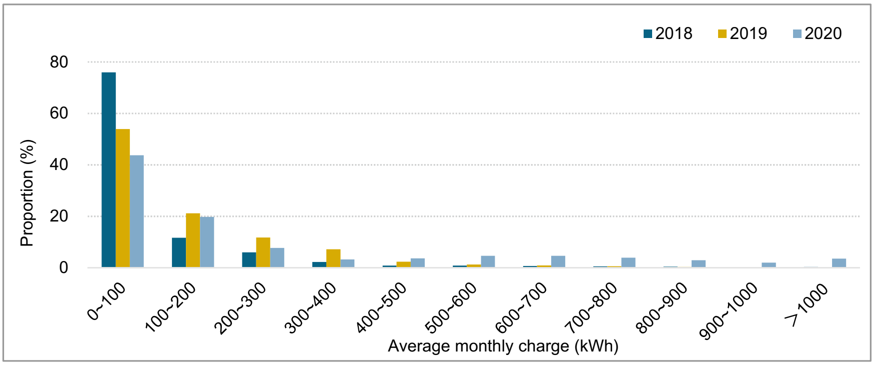


Fig. 5.35 Distribution of average monthly charge of BEV cars for sharing-by year for fast charging

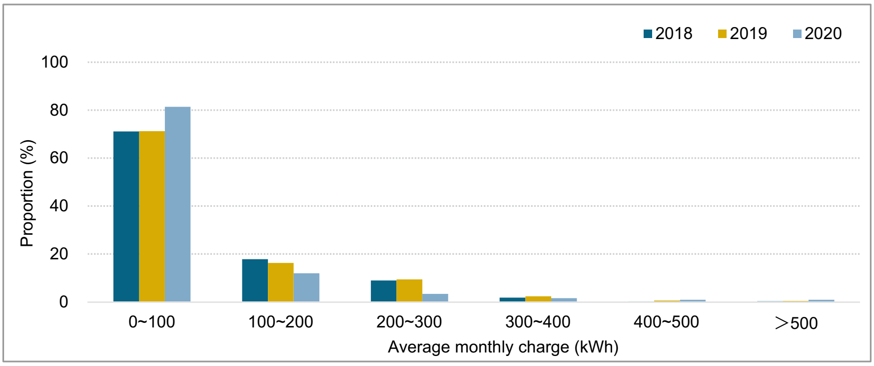


Fig. 5.36 Distribution of average monthly charge of BEV cars for sharing-by year for slow charging

5.2.5 Charging Characteristics of BEV Logistics Vehicles

The average monthly charging times of BEV logistics vehicles is increasing year by year.

In 2020, the average monthly charging times of BEV logistics vehicles was 20.6, showing a year by year increase trend compared with the previous two years (Table 5.18). As the distribution shows (Fig. 5.37), the proportion of BEV logistics vehicles with an average monthly charging time of more than 20 increased from 26.6% in 2018 to 40.9% in 2020, owing to the increase of average monthly mileage and the

Table 5.18 Average monthly charging times of bev logistics vehicles-average

Year	2018	2019	2020
Average monthly charging times	11.8	17.7	20.6

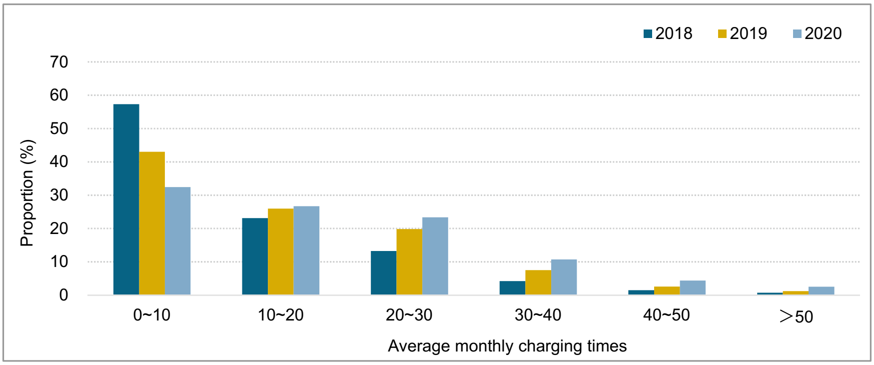
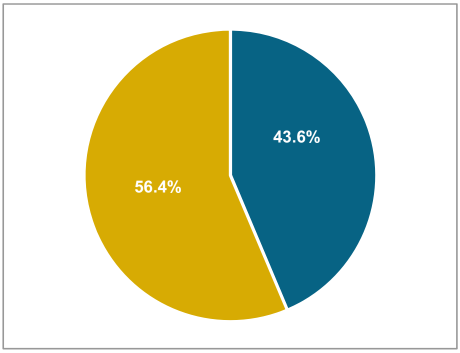


Fig. 5.37 Distribution of average monthly charging times of BEV logistics vehicles-by year

Fig. 5.38 Proportion of fast charging and slow charging in average monthly charging times of BEV logistics vehicles in 2020



improvement of public charging facilities; considering from the charging method, slow charging is mainly adopted. As shown in Fig. 5.38, the proportion of slow charging times of BEV logistics vehicles in average monthly charging times was high up to 56.4% in 2020.

The average monthly charge of BEV logistics vehicles is increasing year by year.

In 2020, the average monthly charge of BEV logistics vehicles was 435.6 kWh, increasing by 10% compared with last year (Table 5.19). As the distribution shows (Fig. 5.39), the BEV logistics vehicles with an average monthly charge of less than 100 kWh take the largest proportion. Considering from the charging method, the proportion of BEV logistics vehicles with an average monthly charge of more than

Table 5.19 Average monthly charge of BEV logistics vehicles-average

Year	2018	2019	2020
Average monthly charge (kWh)	257.0	396.1	435.6

100 kWh increased from 15% in 2018 to 42.8% in 2020. The proportion of BEV logistics vehicles with an average monthly charge of slow charging higher than 200 kWh decreased from 36.2% in 2019 to 30.6% in 2020 (Fig. 5.40).

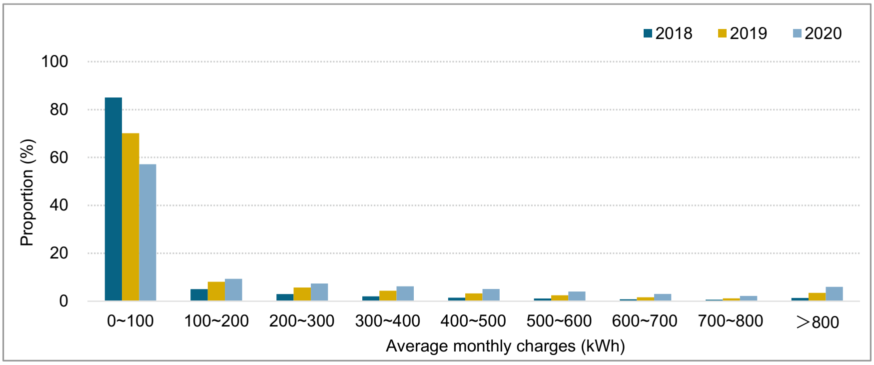


Fig. 5.39 Distribution of average monthly charge of BEV logistics vehicles-by year for fast charging

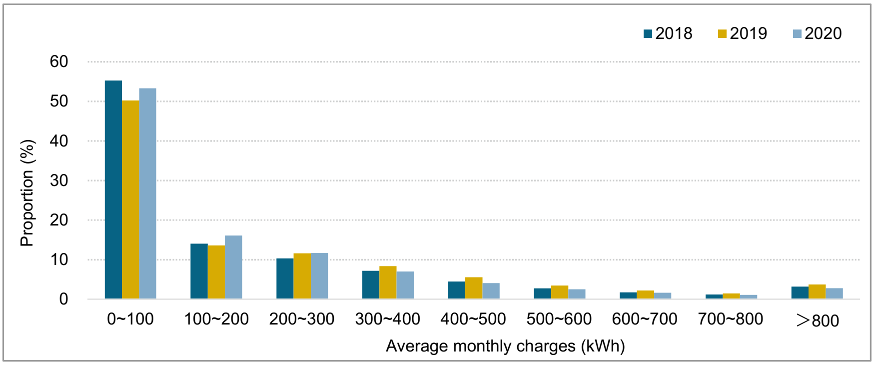


Fig. 5.40 Distribution of average monthly charge of BEV logistics vehicles-by year for slow charging

5.2.6 *Charging Characteristics of BEV Buses*

(1) Average single-time charging characteristics of BEV buses

The charge rate of BEV buses is increasing year by year.

According to the change over the years (Table 5.20), the charge rate of BEV buses is increasing year by year, and in 2020, it reached 0.78C, increasing by 1.29% compared with 2019.
According to the distribution of charging times of BEV buses under different charge rates over the years (Fig. 5.41), the proportion of charging times of BEV buses with a charge rate of 0.4–1.0C in 2020 was lower than that in 2018. In the high charge rate section, for example, the proportion of BEV buses with a charge rate above 2.4C was 4.19% in 2020, increasing by 2% as compared to 2018.

(2) Average monthly charging characteristics of BEV buses

The average monthly charging times of BEV buses is about 30 (Table 5.21).

As the distribution shows (Fig. 5.42), the proportion of BEV buses charged more than 30 times per month increased from 35.5% in 2018 to 38.2% in 2020, but the proportion of BEVs charged more than 60 times per month in 2020 was lower than that in 2019.
In 2020, the average monthly charge of BEV buses was 1913.1 kWh, decreasing by 14.7% compared with last year (Table 5.22); as the distribution shows (Fig. 5.43),

Table 5.20 Charge rate of BEV buses over the years-average

Year	2018	2019	2020
Average charge rate of BEV buses (c)	0.73	0.77	0.78

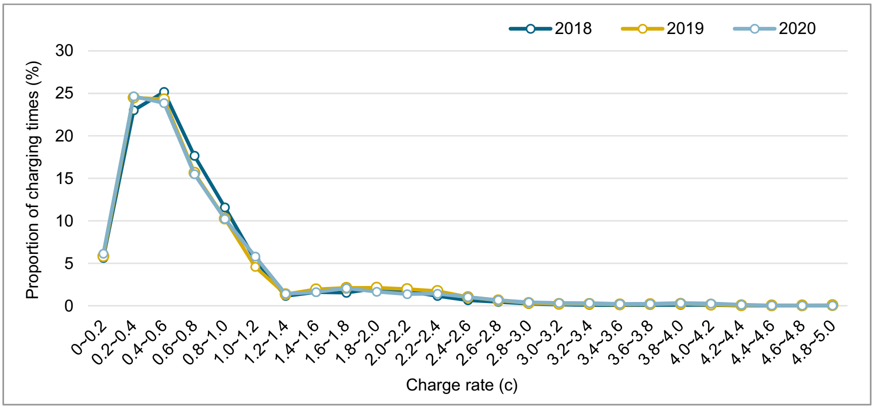


Fig. 5.41 Distribution of charging times of BEV buses under different charge rates

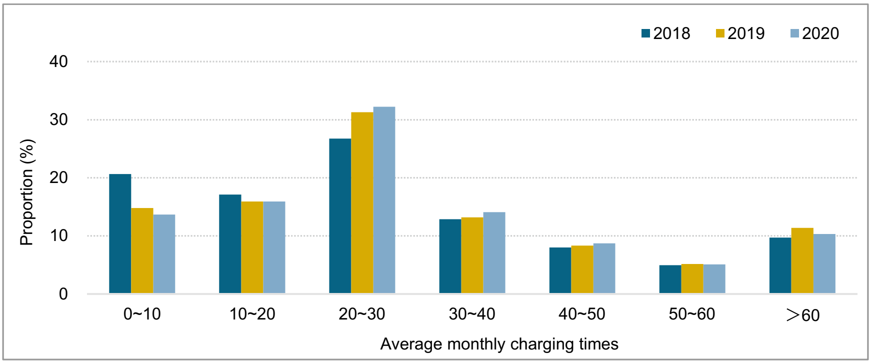


Fig. 5.42 Distribution of average monthly charging times of BEV buses-by year

Table 5.21 Average monthly charging times of BEV buses-average

Year	2018	2019	2020
Average monthly charging times	28.8	34.6	32.3

Table 5.22 Average monthly charge of BEV buses-average

Year	2018	2019	2020
Average monthly charge (kWh)	1778.9	2242.5	1913.1

the proportion of BEV buses with an average monthly charge of 1000–3000 kWh decreased year by year, i.e. from 51.6% in 2018 to 60.6% in 2020, among which, the proportion of BEV buses with an average monthly charge of 1000–2000 kWh was 36.1%, with an increase of 6.45% compared with 2018.

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 urban public charging station, community charging station and expressway charging station, analyzes the user's charging behavior characteristics.

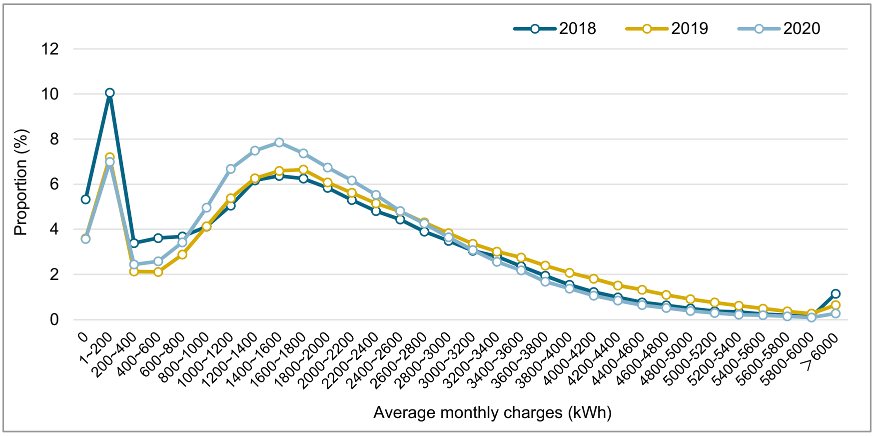


Fig. 5.43 Distribution of average monthly charge of BEV buses

5.3.1 Analysis of Charging Behavior of Users in Public Charging Stations

The charging in public charging stations peaks at 8:00–9:00, 11:00–13:00 and 18:00–19:00, and most vehicles stay no more than 1 h there after charging.

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. 5.44, the service targets of public charging stations are mainly private cars and taxis/e-taxis, which are mainly due to their high operation intensity and unavailability of private charging piles.

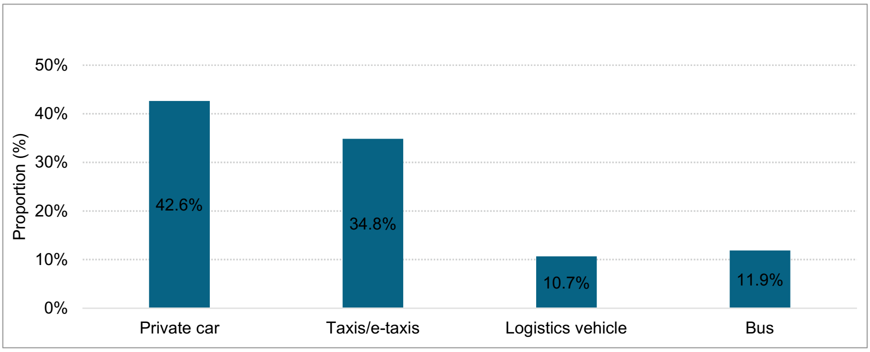


Fig. 5.44 Difference in distribution of vehicles charged in public charging stations-by key segments

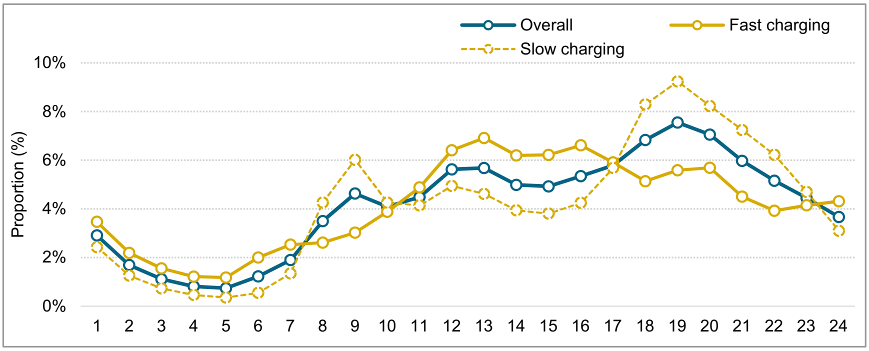


Fig. 5.45 Distribution of vehicle charging time in public charging stations-by fast charging and slow charging

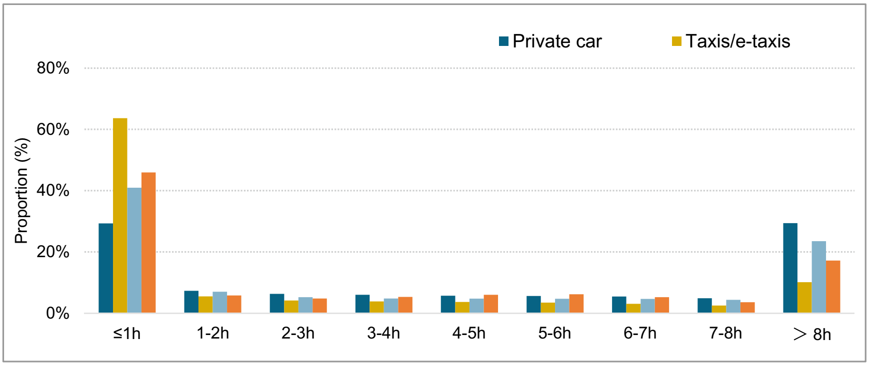


Fig. 5.46 Distribution of single-time charging staying duration of vehicles in public charging stations-by key segments

As shown in Fig. 5.45, the charging in public charging stations peaks at 8:00–9:00, 11:00–13:00 and 18:00–19:00, among which, the two periods of 8:00–9:00 and 18:00–19:00 are the slow charging peaks, and the time period of 11:00–13:00 is the fast charging peak. The distribution of charging duration is an important measure for V2G (vehicle-to-grid), and the vehicles which are charged at electricity load valley point and stop for a long time have a great value for V2G.

As shown in Fig. 5.46, most vehicles stay at public charging stations for no more than 1 h, with proportion of private cars, taxis, taxis/e-taxis, logistics vehicles, and buses which stay in public charging stations for no more than 1 h being 29.3%, 63.6%, 41% and 45.9%, respectively.

5.3.2 Analysis of Charging Behavior of Users in Community Charging Stations

The charging in the community charging stations mainly takes place from 17:00 to 24:00, and the proportion of private cars staying for more than 8 h in community charging stations is up to 37.2%.

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. The community charging stations mainly serve private cars and taxis/e-taxis, among which, the private cars take the highest proportion of 90.4%, and taxis/e-taxis only account for 9.6%. As shown in Fig. 5.47, the users of community charging stations are mainly private cars, the charging time in community charging stations is mainly 17:00–24:00, and the staying duration of vehicles in community charging stations is more than 8 h.

As shown in Fig. 5.48, the vehicles charged at community charging stations are mainly private cars and taxis/e-taxis. The proportions of private cars and taxis/e-taxis which stay for more than 8 h in community charging stations after charging are high, i.e., 37.2% and 21.3%, respectively.

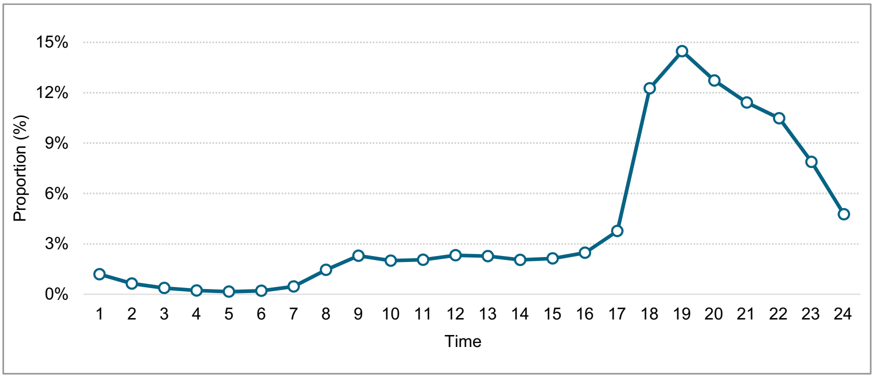


Fig. 5.47 Distribution of vehicle charging time in community charging stations

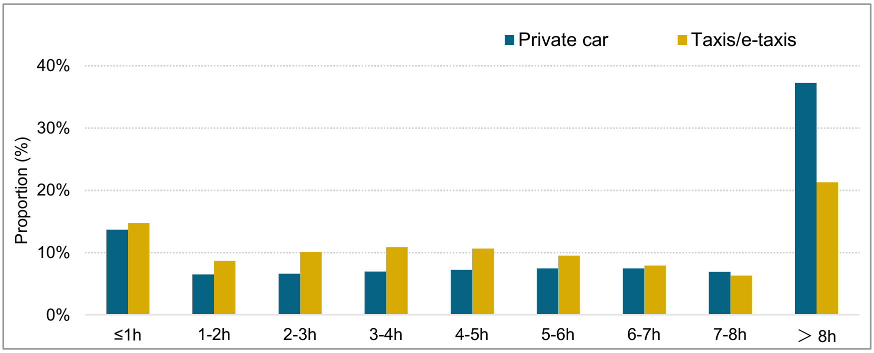


Fig. 5.48 Distribution of single-time charging staying duration of vehicles in community charging stations-by key segments

5.3.3 Analysis of Charging Behavior of Users in Expressway Charging Stations

The charging in expressway charging stations peaks at 8:00–9:00, 11:00–13:00 and 18:00–19:00, and most vehicles stay no more than 1 h in expressway charging stations after charging.

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 data of the charging station, the expressway charging stations will be identified. As shown in Fig. 5.49, private cars take the largest proportion among all vehicles charged in expressway charging stations, followed by taxis/e-taxis. The proportion of buses charged in expressway charging stations is 14.7%, which is higher than that in special charging stations; however, due to the limited number of expressway charging stations, the number of buses charged in special charging station is 2.1 times that in the expressway charging stations.

As shown in Fig. 5.50, the charging in expressway charging stations peaks at 8:00–9:00, 11:00–13:00 and 18:00–19:00, that is to say, expressway charging stations involve multiple charging peak periods. With the large-scale construction and promotion of expressway charging facilities, the fluctuation of expressway charges can be used as an important reference for power grid companies to adjust grid load.

As shown Fig. 5.51, most vehicles stay no more than 1 h in expressway charging stations after charging, and specifically, the proportion of taxis/e-taxis which stay for no more than 1 h in expressway charging stations is high up to 57%, followed by buses, logistics vehicles and private cars with a proportion of 46.4%, 39.9% and 27.7%, respectively.

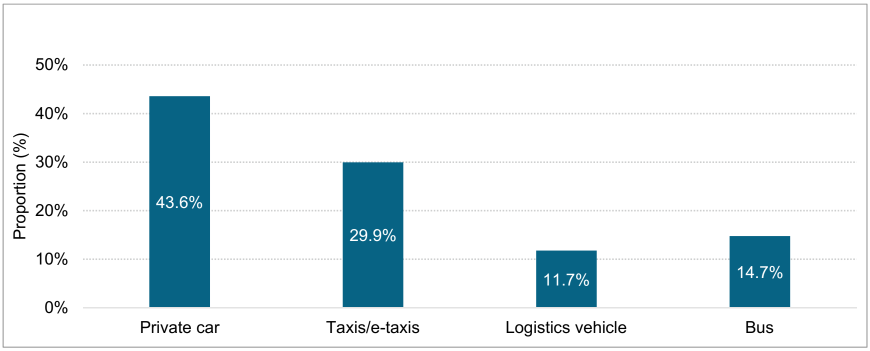


Fig. 5.49 Difference in distribution of vehicles charged in expressway charging stations-by key segments

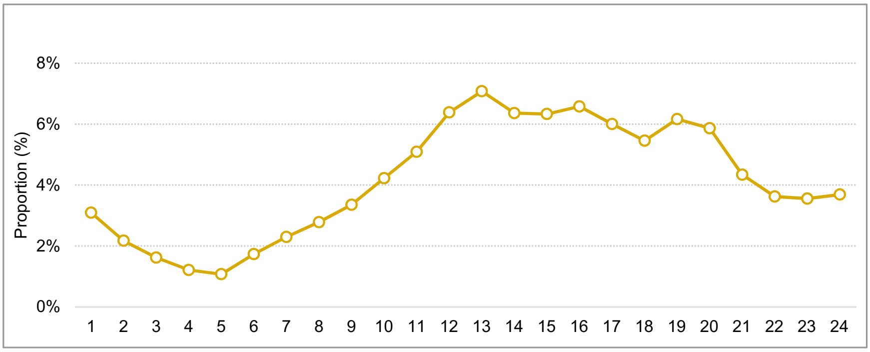


Fig. 5.50 Distribution of vehicle charging time in expressway charging stations

5.4 Battery Swapping Characteristics of Vehicles in Key Segments

At present, the vehicles of battery swap type are mainly concentrated in the fields of taxis, private cars and heavy-duty trucks. This section, with 9169 private cars of a certain brand, 326 taxis of a certain brand, and 332 heavy-duty trucks from specific enterprises selected from the vehicles of battery swap type[1] on the National Monitoring and Management Platform, analyzes the battery swapping characteristics of these vehicles, and compares them with the charging characteristics of vehicles, with

[1] Note for battery swapping behavior: If no charging behavior occurs between the shutdown and the restart, the difference between restart SOC and shutdown SOC is ≥40%, and the interval between the shutdown and the restart is no more than 15 min, such a parking section can be defined and marked as a one battery swapping.

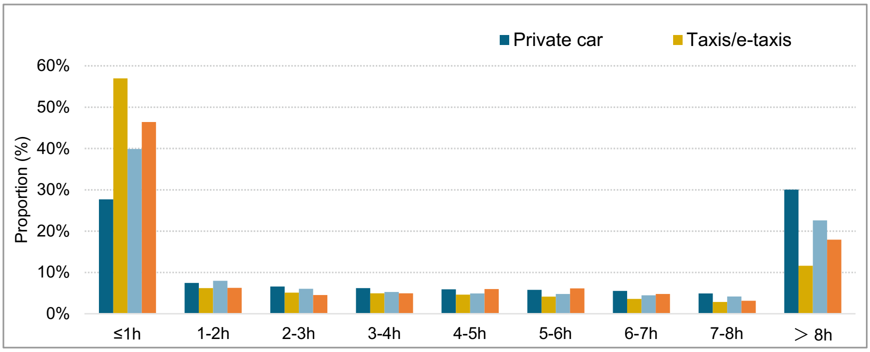


Fig. 5.51 Distribution of single-time charging staying duration of vehicles in expressway charging stations-by key segments

an aim to providing reference for the improvement of the operation and management system of electric vehicles.

The average monthly mileage of single battery swapping of private cars changes season by season.

As per the distribution shows, the average monthly mileage of single battery swapping of taxis/e-taxis and private car changes season by season, especially in winter when the ambient temperature is low, the mileage of single battery swapping is affected by the use of in-vehicle HVAC. As for taxis/e-taxis, the mileage of single battery swapping in spring and autumn is more than 200 km, while that in winter (December, January and February) is mainly 150–180 km (Fig. 5.52); as for private cars, the mileage of single-time battery swapping in spring and autumn is more than 300 km, while that in winter is obviously lower; for heavy-duty trucks, the average monthly mileage of single battery swapping remains above 150 km all the year around.

(1) Initial SOC of battery swapping

The initial SOC of battery swapping is lower than the initial SOC of charging.

Considering that the vehicles of the battery swap type can be power supplemented by either battery swapping or charging, this section makes a comparison between the initial SOC of battery swapping and the initial SOC of charging.

As shown in Fig. 5.53, the initial SOC of battery swapping of NEVs of battery swap type is generally lower than the initial SOC of charging. As for vehicles in different segments, in 2020, the initial SOC of battery swapping of taxis/e-taxis, private cars and heavy-duty trucks were 29.6%, 20.6% and 24.1%, which are lower than the corresponding initial SOC of charging by 13.1%, 20% and 23.6%, respectively.

As the distribution of initial SOC of charging in different segments is shown in Fig. 5.54, the initial SOC of charging of taxis mainly includes 30–40% and 40–50%, with the proportion of taxis with an initial SOC of charging in these two sections equal to 24.8% and 28.3%, respectively; the initial SOC of charging of private cars

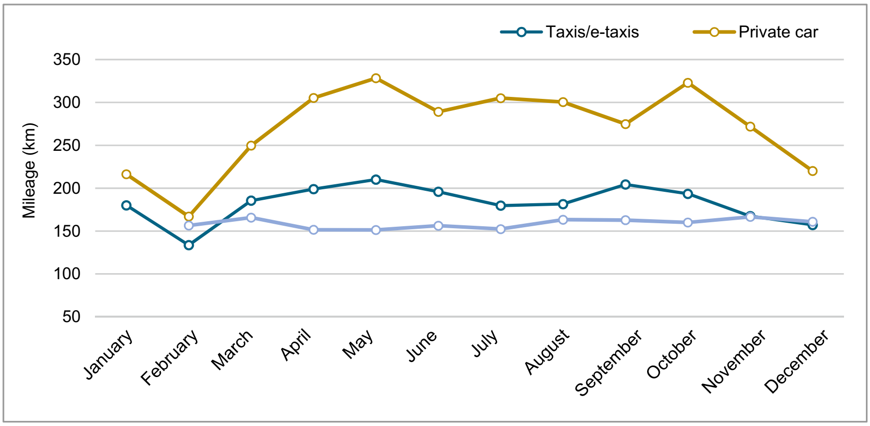


Fig. 5.52 Average mileage of single-time battery swapping of vehicles in different segments in 2020

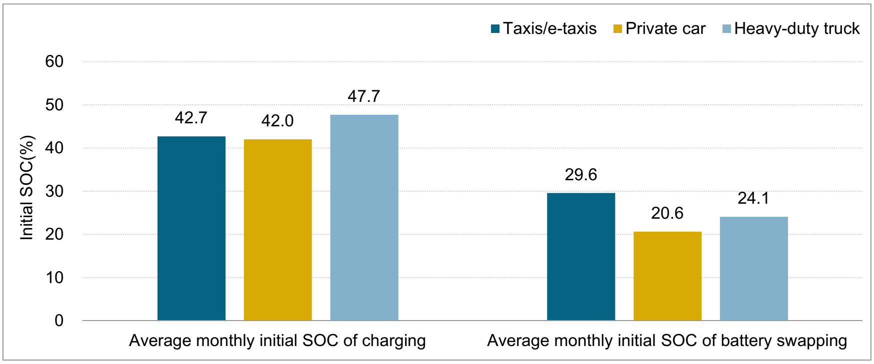


Fig. 5.53 Comparison of initial SOC of charging and initial SOC of battery swapping of vehicles in different segments in 2020

mainly includes 30–40% and 40–50%, with the proportion of private cars with an initial SOC of charging in these two sections equal to 33.4% and 28.6%, respectively; the initial SOC of charging of heavy-duty trucks mainly includes 40–50% and 50–60%, with the proportion of heavy-duty trucks with an initial SOC of charging in these two sections equal to 32.6% and 27.7%, respectively.

As the distribution of initial SOC of battery swapping in different segments is shown in Fig. 5.55, the initial SOC of battery swapping of taxis/e-taxis mainly includes 20–30% and 30–40%, with the proportion of taxis/e-taxis with an initial SOC of battery swapping in these two sections equal to 39.8% and 39.4%, respectively; the initial SOC of battery swapping of private cars mainly includes 10–20% and 30–40%, with the proportion of private cars with an initial SOC of battery swapping in these two sections equal to 41.6% and 40.6%, respectively; the initial SOC of battery swapping

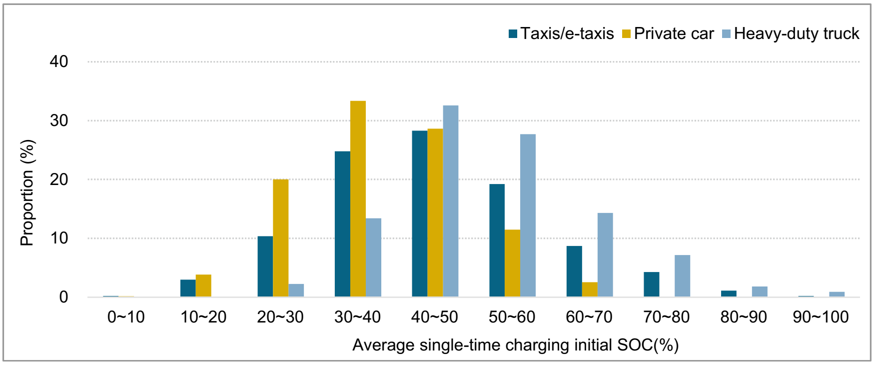


Fig. 5.54 Distribution of initial SOC of charging of vehicles in different segments in 2020

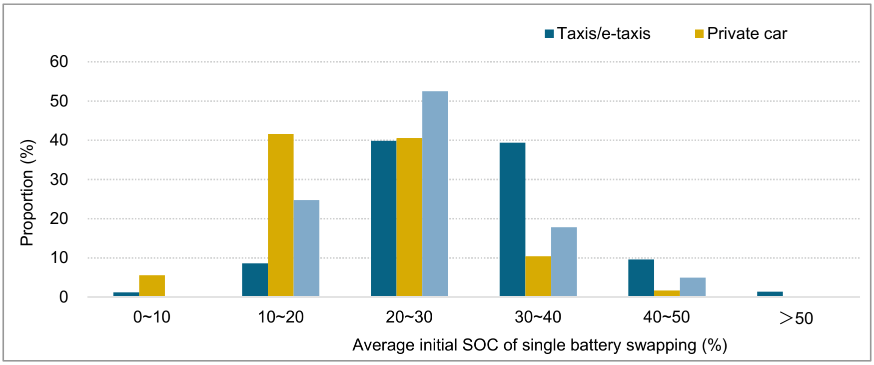


Fig. 5.55 Distribution of initial SOC of battery swapping of vehicles in different segments in 2020

of heavy-duty trucks is mainly 20–30%, with the proportion of heavy-duty trucks with an initial SOC of battery swapping in this section equal to 52.5%.

(2) End SOC of battery swapping

The end SOC of battery swapping is generally higher than the end SOC of charging.

As shown in Fig. 5.56, the end SOC of battery swapping of NEVs of battery swap type is generally higher than the end SOC of charging. As for vehicles in different segments, in 2020, the end SOC of battery swapping of taxis/e-taxis, private cars and heavy-duty trucks were 94.95, 93.07 and 99.3%, which are higher than the end SOC of charging by 7.6%, 4.3% and 13.5%, respectively, indicating that the battery swapping has obvious advantages with respect to rapid energy supplement.

As the distribution of end SOC of charging in different segments is show in Fig. 5.57, the end SOC of charging of taxis and heavy-duty trucks is mainly more than 90%, with the proportion of taxis and heavy-duty trucks with such an end SOC of charging

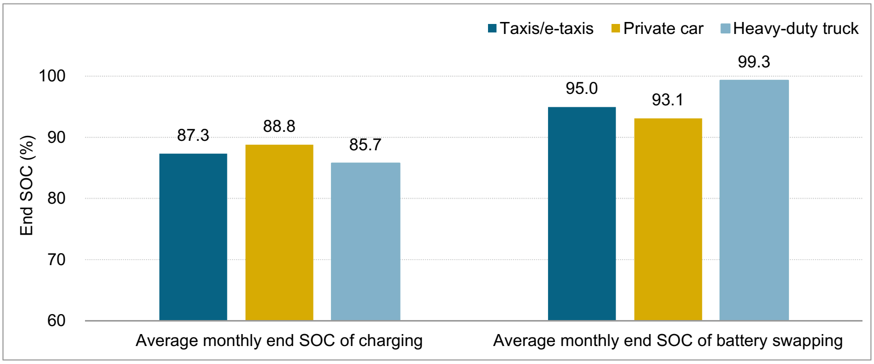


Fig. 5.56 Comparison of end SOC of charging and end SOC of battery swapping of vehicles in different segments in 2020

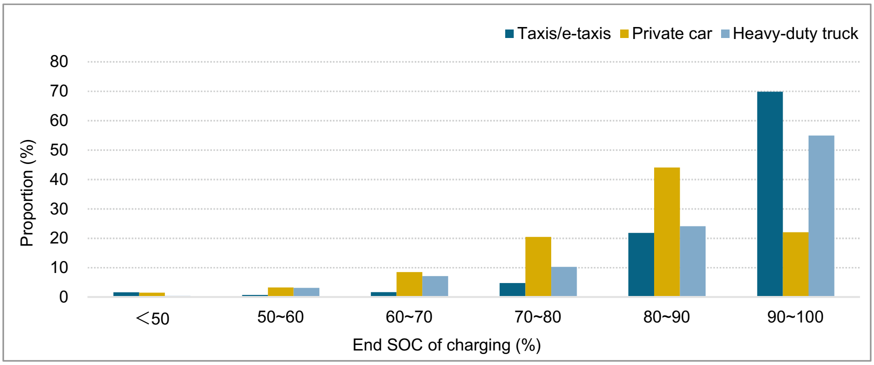


Fig. 5.57 Distribution of end SOC of charging of vehicles in different segments in 2020

equal to 69.9% and 54.9%, respectively; the end SOC of charging of private cars is mainly 80–90%, with the proportion of private cars with such an end SOC of charging up to 44.1%.

As the distribution of end SOC of battery swapping in different segments is shown in Fig. 5.58, the proportions of heavy-duty trucks, taxis/e-taxis and private cars with an end SOC of battery swapping above 90% are 100%, 91.0% and 87.3%, respectively.

(3) Average monthly battery swapping characteristics

Most of the electric vehicles are power supplemented by charging and battery swapping, and specifically, the battery swapping times of passenger cars is generally lower than the charging times, and the commercial vehicles have a good battery swapping effect.

As shown in Fig. 5.59, the battery swapping time of NEVs is generally lower than the charging time. As for BEV taxis/e-taxis, the average monthly charging time is

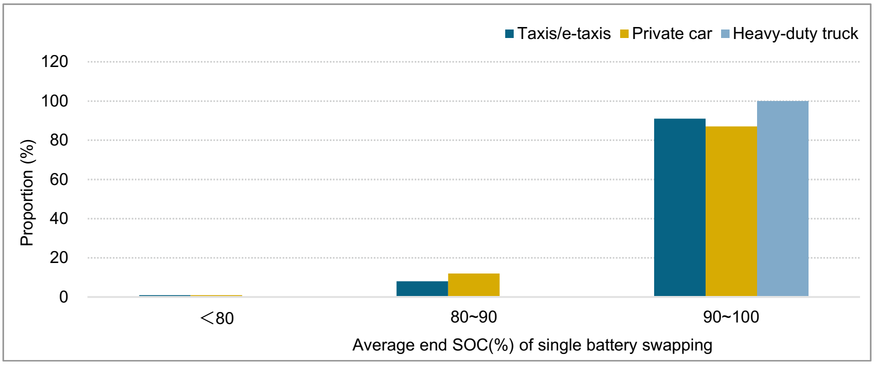


Fig. 5.58 Distribution of end SOCs of battery swapping of vehicles in different segments in 2020

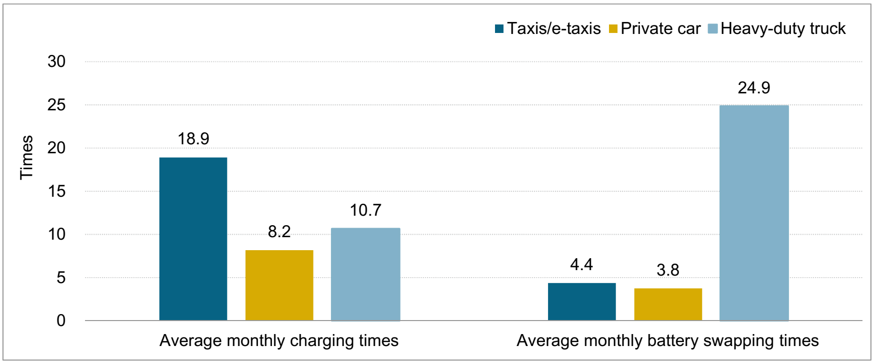


Fig. 5.59 Comparison of average monthly charging times and battery swapping times of vehicles in different segments in 2020

18.9, which is obviously higher than the battery swapping times of 4.4; the average monthly charging times of private cars are 8.2 and their average monthly battery swapping time is 3.8; the average monthly charging time of heavy-duty trucks is 15.7 and their average monthly battery swap time is 24.9. As described above, the commercial vehicles have a good battery swapping effect.

As the distribution of different segments is shown in Fig. 5.60, the average monthly battery swapping time of taxis/e-taxis and private cars is mainly 5, with the proportion of taxis/e-taxis and private cars with such average monthly battery swapping times of up to 75.3% and 87.5%, respectively. However, the average monthly battery swapping times of heavy-duty trucks are mainly 30–40 and 40–50, with the proportion of heavy-duty trucks an average monthly battery swapping time of 30–40 and 40–50 equal to 33.7% and 25.7%, respectively.

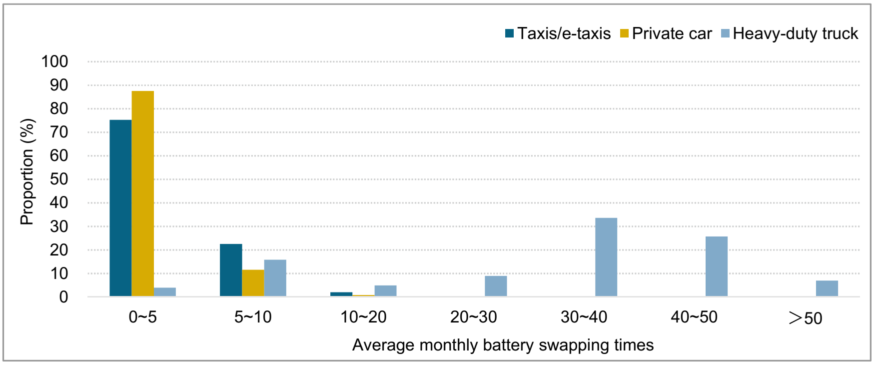


Fig. 5.60 Distribution of average monthly battery swapping times of vehicles in different segments in 2020

5.5 Summary

This chapter, through the analysis of charging characteristics of new energy vehicles on the National Monitoring and Management Platform, draws the following conclusions for the charging characteristics of vehicles in key segments:

The technology and construction of charging infrastructures in China are gradually improving, and the charging convenience of users is gradually increasing. On the one hand, the vehicle-to-pile ratio is further optimized: the charging power of public charging piles in China continues to increase, and the charging power of DC charging piles has been maintained above 100 kW for the past three years to continuously meet the requirements of long range and short charging duration of electric vehicles; On the other hand, the average charging duration of vehicles in each segment shows a downward trend.

As for the development trend of charging methods, a charging mode with orderly slow charging as the main charging method and emergency fast charging as the supplementary charging method have been gradually formed. According to the average monthly charging times of new energy private cars, the monthly average slow charging time in 2020 was 6.5, and the monthly fast charging time was 1.2. Slow charging is the mainstream charging method adopted, and the average weekly slow charging time is 1–2. **Operating vehicles except for logistics vehicles have gradually formed a charging mode with fast charging as the main charging method and slow charging as the supplementary charging method**. As the distribution of different segments shows, for operating vehicles including e-taxis, taxis, cars for sharing and buses but excluding logistics vehicles, the fast charging takes a large proportion, and according to the distribution of charging time of vehicles in all segments, the fast charging peaks at daytime, suggesting that operating vehicles are accustomed to be fast charged at daytime.

The charging scenario is deployed in a diversified way to meet the charging needs of vehicles in different segments. Public charging stations mainly serve private cars and taxis/e-taxis, and the charging duration of vehicles in public charging stations is mainly within 1 h. Private cars are the main users of community charging stations, with the proportion of private cars charged in community charging stations being 90.4%, and the proportion of private cars which stay in community charging stations for more than 8 h up to being 37.2; and the charging in community charging stations generally occurs at 17:00–24:00. Among all vehicles charged in expressway charging stations, the private cars take the largest proportion, followed by taxis/e-taxis; the charging in expressway charging stations peaks at 8:00–9:00, 11:00–13:00 and 18:00–19:00, and most vehicles stay there for no more than 1 h after charging.

Battery swapping has become an important supplement to charging, and specific fields are the focus for the development of the battery swapping mode. Battery swapping can relieve the charging anxiety of users and improve the travel convenience of customers. At present, new energy vehicles of battery swap type are mainly concentrated in fields including taxis, e-taxis and other operating vehicles in China, and only a few of auto makers have developed private cars of battery swap type. Vehicles of battery swap type are mainly power supplemented by charging and battery swapping. However, the battery swapping station has not been widely applied due to a high construction cost; according to the operation frequency, the battery swapping times of taxis and private cars is relatively less than the charging times. The average mileage of single battery swapping changes season by season, and in winter and summer, it is heavily affected by the use of in-vehicle HVAC.

Charging infrastructure has been included as a "new infrastructure project", and has become an important force for driving the development of new energy vehicles, stimulating new consumer demands, and speeding up industrial transformation and upgrading. With the adoption of new policies, charging infrastructure embraces new development opportunities, but there is still a certain gap from the customer's expectations. At the present stage, the charging infrastructure industry is still facing prominent problems, such as difficult installation and construction of private charging piles, demand for improvement of public charging piles, and further increase of the operating efficiency of battery swapping stations. What we should do next is to speed up the improvement of the charging service experience, the digitalization of charging facilities and the deepening of V2G integration, which can be further broken down into the following actions: (1) Speed up the improvement of the integrated service network of comprehensive and diversified charging facilities based on different application scenarios to meet the user's needs for charging convenience; (2) Speed up the digital and intelligent layout of charging facilities to comprehensively optimize the user's charging service experience; In addition, electric vehicles, with the large-scale popularization of new energy vehicles in the future, can be used as not only flexible loads on the user side, but also the distributed power reserves, helping to adjust the power load of the power grid for peak shifting, consume renewable energies, and provide auxiliary services such as frequency modulation and backup for the power grid.

Chapter 6
Fuel Cell Electric Vehicles (FCEVs)

In the global context of transition to green and low-carbon economy, hydrogen energy is expected to become the direction of a new round of energy technology change by virtue of its cleanliness, high efficiency and rich reserve. Major countries and regions around the world are speeding up the layout of an industry chain around hydrogen energy, and their interests to hydrogen industry have been increasing. This chapter, from the perspective of fuel cell Electric vehicles (FCEVs), studies the development of China's fuel cell Electric vehicle (FCEV) industry, and the operation characteristics and hydrogen charging characteristics of FCEVs, providing a certain reference for evaluating the development achievements of China's FCEV industry and deploying development ideas in the future.

6.1 Development Status of Fuel Cell Electric Vehicle Industry

Fuel cell electric vehicles are in the scale promotion stage, and in the period covered by the 13th Five-Year Plan, where a total of 7345 FCEVs have been put into operation.

Driven by the subsidy policy and demonstration cluster effect, China's FCEV industry has moved from the industrial introduction stage to the scale promotion stage. In 2017, the development of FCEVs began to take wing, and the sales in that year exceeded 1000 units and was up to 1275, boasting a YoY increase of 102.70%. Since 2018, the sales of FCEVs have continued to increase. In 2019, in contrast to the overall decline of production and sales of NEVs under the effect of the reduction of NEV subsidies, the production and sales of FCEVs increased at a high speed with annual sales up to 2737 units, and scale demonstration and promotion achieving a significant effect (Fig. 6.1).

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https://doi.org/10.1007/978-981-19-5508-2_6

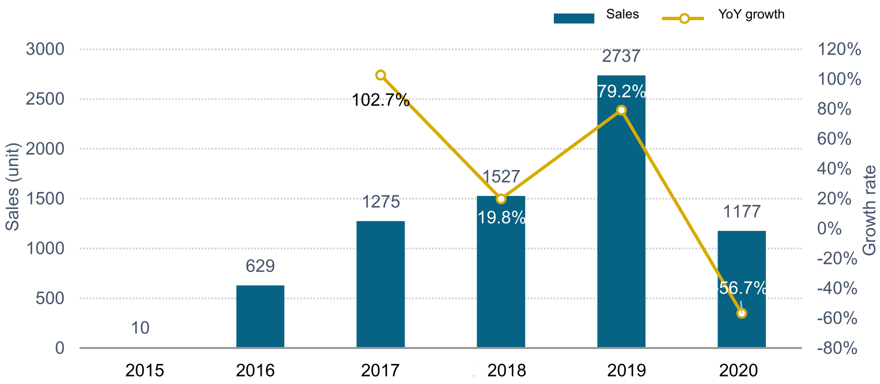


Fig. 6.1 Sales growth of FCEVs in China over the years. *Source* China Association of Automobile Manufacturers (CAAM)

In the first half of 2020, due to the superimposed effect of multiple factors including the COVID-19 outbreak, the reduction of subsidies and the cyclic fluctuation of market, the sales of FCEVs dropped heavily. Then, after the epidemic was quickly controlled, the market was gradually recovered, and throughout 2020, the sales of FCEVs reached 1177. In the period covered by the 13th Five-Year Plan, the total number of FCEVs put into operation was above 7000, laying a solid foundation for the scale promotion of NEV industry in the period of the 14th Five-Year Plan.

By the end of 2021, more than 120 hydrogen charging infrastructures have been constructed.

With the promotion of fuel cell electric vehicles, the market demand for hydrogen energy is increasing, and the construction of hydrogen charging stations has achieved remarkable results. On the one hand, the unit hydrogen charging capacity of the hydrogen charging station has increased significantly, with the daily hydrogen charging capacity gradually being increased from 200 kg/day to 500 kg/day or even 1000 kg/day; On the other hand, the construction of hydrogen charging infrastructure has accelerated, and as of December 31, 2020, more than 128 hydrogen charging stations have been constructed, in which 96 hydrogen charging stations have been put into operation. The development of hydrogen energy facilities in China varies from region to region. Currently, the hydrogen energy is mainly sourced from industrial by-product hydrogen, and considering this, the eastern coastal region, where the technical background and regional economy are strong, has obvious advantages, and is expected to achieve rapid growth in the scale of hydrogen charging stations and then promote the "point-to-surface" linked development of the region.

6.2 Analysis of FCEV Operation Characteristics

The National Monitoring and Management Platform can monitor the operation of FCEVs in real time, and ensure the operation safety of FCEVs through the analysis and diagnosis of their operation data. This section analyzes the operation characteristics of FCEVs from such dimensions as online rate and travel characteristics, with an aim to guiding the operation of FCEVs around China and, therefore, providing importance reference for the market-based promotion of the FCEV industry.

6.2.1 Access Characteristics

The cumulative access of FCEVs has exceeded 6000, consisting mainly of operating vehicles.

As of December 31, 2020, a total of 6002 FCEVs have been accessed to the National Monitoring and Management Platform, including 2222 FCEV buses (37.02%) and 3153 FCEV logistics vehicles (52.53%) (Fig. 6.2), which indicates that the demonstration and promotion of FCEV commercial vehicles have achieved a significant effect.

The promotion of FCEVs is mainly implemented in the eastern developed provinces, with the promotion in TOP10 provinces accounting for 95.7%.

As of December 31, 2020, the FCEV access in TOP10 provinces was 5744, accounting for 95.7% of the total FCEV access in China (Fig. 6.3). Among those provinces, Guangdong ranked first with an access of 2415 vehicles and a proportion of up to 40.2% in total FCEV access, followed by Shanghai, with an access of 1376 vehicles and a proportion of 22.9% in total FCEV access.

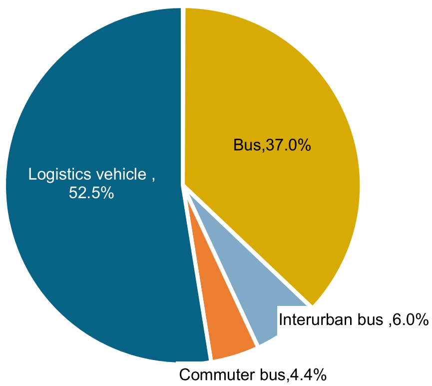


Fig. 6.2 Distribution of FCEVs in different application scenarios

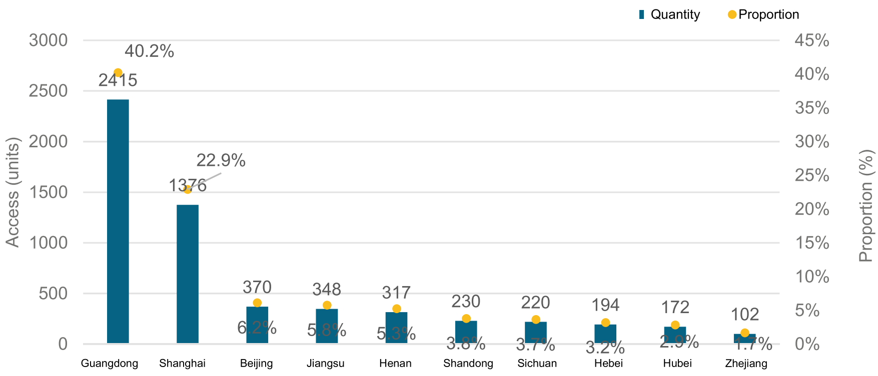


Fig. 6.3 TOP10 provinces in FCEV access in 2020

6.2.2 Online Rate Characteristics

The overall online rate of FCEVs is increasing steadily year by year.

As shown in Fig. 6.4, the average monthly online rate of FCEVs is increasing year by year, and in 2020, it was 75.00%, with an increase of 11% compared with 2019. However, the FCEV industry is still in demonstration and promotion stage, and the overall online rate of FCEVs is lower than the overall online rate of NEVs, which is closely related to factors such as the maturity of infrastructure and the convenience of use in the initial stage of industrial development.

As the curve shows (Fig. 6.5), the online rate of FCEVs in 2020 was stable, except for January and February when the online rate dropped below 60%. After March, as the epidemic eased and the subsidy policy of FCEVs of "replacing subsidies with

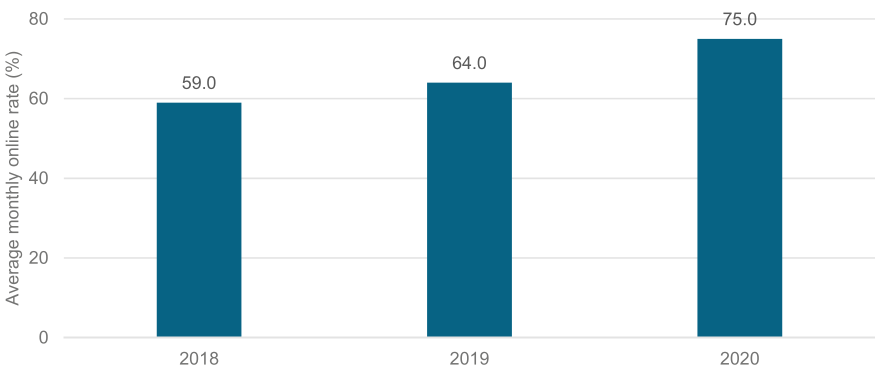


Fig. 6.4 Average monthly online rate of FCEVs

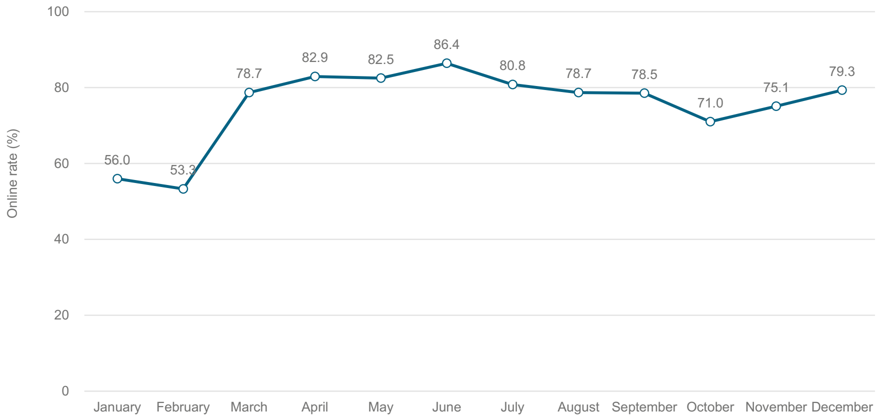


Fig. 6.5 Monthly online rate of FCEVs in 2020

rewards" was adopted, the monthly online rate of FCEVs rose continuously, and peaked in June and July with a value of 86.40%.

To sum up, with the continuous advancement of FCEV demonstration zones in various regions, the improvement of the overall industrial chain of hydrogen fuel cells, and the improvement of the industrial supporting environment, it is expected that the operation intensity of FCEVs will continue to increase, and the monthly online rate will rise steadily.

The online rate of FCEV buses is higher than that of FCEV logistics vehicles.

From the respective of application scenarios, FCEV buses and FCEV logistics vehicles, as the two main application scenarios of FCEVs, have become the "test field" of FCEVs in China due to their advantages including fixed operating routes and easy layout of industrial chain. According to the data over the years, the online rate of FCEV buses and logistics vehicles in 2020 increased at different rates compared with 2019 (Fig. 6.6). Specifically in 2020, the average monthly online rate of FCEV buses was 87.00% with an increase of 3% compared with 2019; the online rate of FCEV logistics vehicles increased quickly to 69.00% with an increase of 12% compared with 2019; according to the online rate in different application scenarios, the online rate of FCEV buses was generally higher than that of FCEV logistics vehicles.

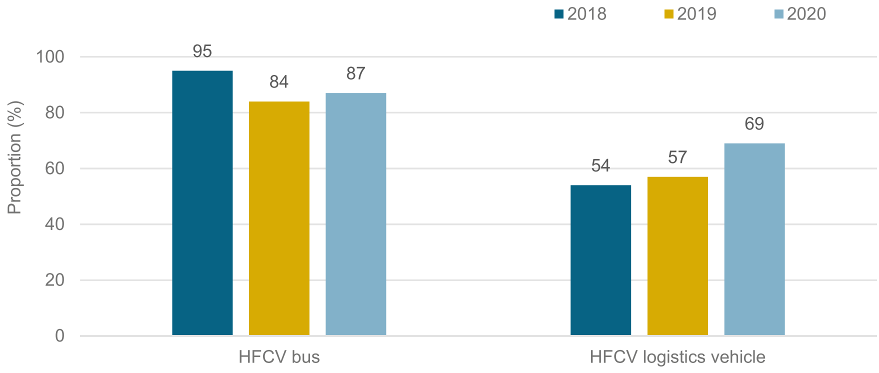


Fig. 6.6 Average monthly online rate of FCEV buses and logistics vehicles over the years

6.2.3 Travel Characteristics

(1) Mileage

As of December 31, 2020, the cumulative mileage of FCEVs has exceeded 100,000,000 km.

As of December 31, 2020, the cumulative mileage of FCEVs has reached 106,420,000 km. In 2020, the cumulative mileage of FCEVs was 75,770,000 km, increasing by 176.5% compared with last year. It can then be concluded that the annual mileage of FCEVs takes off exponentially.

Considering from the application scenarios, the mileage of FCEVs is mainly contributed by FCEV buses and logistics vehicles (Fig. 6.7). As of December 31, 2020, the cumulative mileage of FCEV buses and FCEV logistics vehicles has reached 56,758,000 km and 42,290,000 km, accounting for 53.3% and 39.7% of the total mileage of FCEVs, respectively.

In 2020, the single-vehicle daily mileage of FCEVs was mainly 0–40 km and 120–200 km, and the distribution of FCEVs with high mileage shows an obvious "migration" trend.

As the distribution shows, the single-vehicle daily mileage of FCEVs was mainly 0–40 km in 2018 and 2019, with the FCEVs in such single-vehicle daily mileage section accounting for about 45% (Fig. 6.8). The distribution of FCEVs with a single-vehicle daily mileage of 40–200 km is relatively even, which indicates that FCEVs play a certain role in short-distance logistics transportation; in 2020, the proportion of FCEVs with a high single-vehicle daily mileage increased significantly, and specifically, the proportion of FCEVs with a single-vehicle daily mileage of 120–200 km was 36.2%, which is significantly higher than that in the previous two years mainly due to the layout optimization of the hydrogen charging infrastructure and the improvement of the performance of the on-board hydrogen charging system.

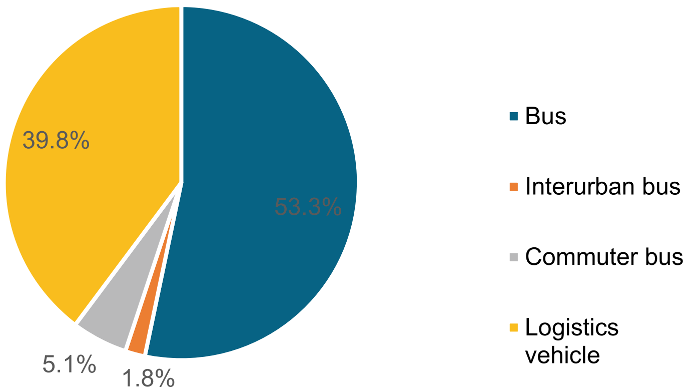


Fig. 6.7 Distribution of single-vehicle daily mileage of FCEVs in different application scenarios

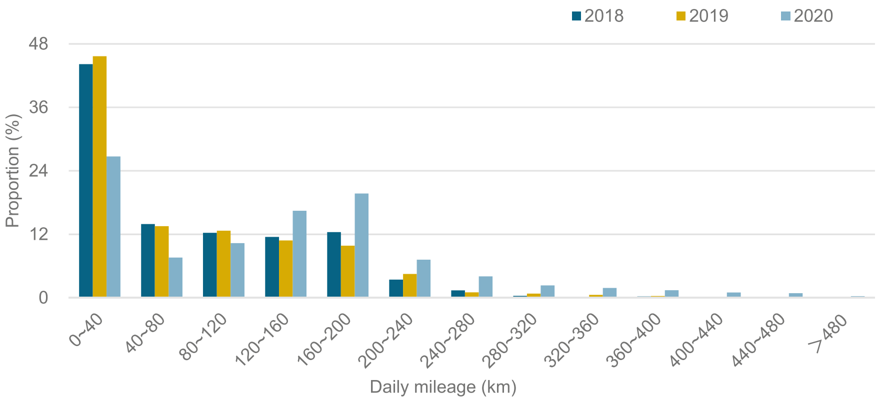


Fig. 6.8 Distribution of single-vehicle daily mileage of FCEVs

However, FCEVs are still in the operation demonstration stage at present, and are mainly applied in urban transportation.

The single-vehicle daily mileage of FCEV buses is mainly within 200 km, and the proportion of FCEV logistics vehicles with a single-vehicle daily mileage above 200 km is higher than that of FCEV buses.

Considering from the application scenarios, the single-vehicle daily mileage of FCEV buses in 2020 was mainly below 200 km, with the proportion of FCEV buses with such a single-vehicle daily mileage up to 95.41% (Fig. 6.9), and among them, the FCEV buses with a mileage of 80–200 km accounted for 58.04%; most of the FCEV buses are applied in urban public transportation.

The distribution of single-vehicle daily mileage of FCEV logistics vehicles is relatively discrete. Compared with FCEV buses, the proportion of FCEV logistics vehicles with a single-vehicle daily mileage above 200 km is much higher, and among

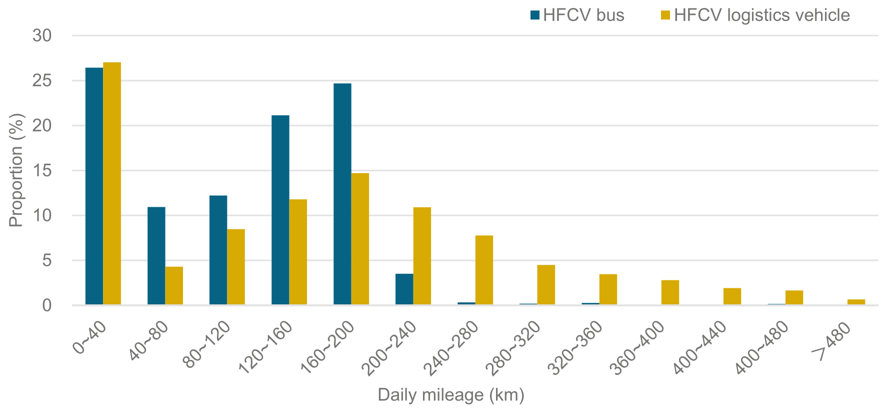


Fig. 6.9 Distribution of single-vehicle daily mileage of FCEV buses and logistics vehicles in 2020

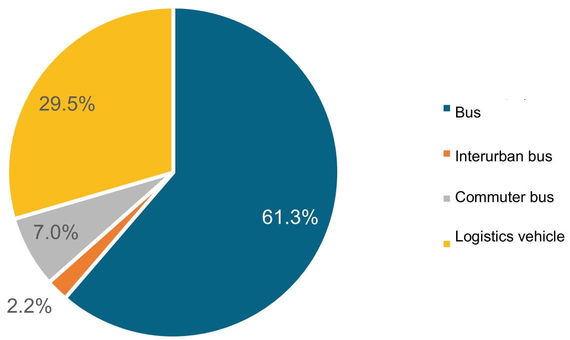
them, the FCEV logistics vehicles with a single-vehicle daily mileage above 400 km account for 4.23%, indicating that FCEV logistics vehicles have gradually shown their potential in cross-city transportation.

(2) Travel duration

As of December 31, 2020, the cumulative travel duration of FCEVs has exceeded 3,880,000 h.

As of December 31, 2020, the cumulative travel duration of FCEVs has reached 3,884,000 h (Fig. 6.10), and in 2020, it was 2,722,000 h, increasing by 1,722,000 h (i.e., 171.2%) compared with 2019. Considering from the application scenarios, the cumulative travel duration of FCEVs is mainly contributed by FCEV buses and logistics vehicles. As of December 31, 2020, the cumulative travel duration of FCEV buses and FCEV logistics vehicles have reached 2,381,000 h and 1,147,000 h, accounting for 61.3% and 29.5% of the total cumulative travel duration of FCEVs, respectively.

Fig. 6.10 Distribution of travel duration of FCEVs in different application scenarios



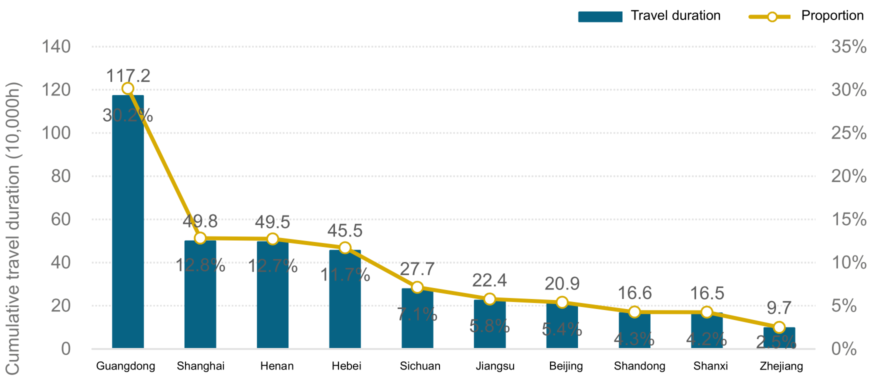


Fig. 6.11 Ranking of TOP10 provinces in cumulative travel duration of FCEVs

The cumulative travel duration of FCEVs in TOP10 provinces is 3,758,000 h, accounting for 96.7% of the total cumulative travel duration in China.

As the distribution in various provinces shows, by the end of 2020, the cumulative travel duration of FCEVs in TOP10 provinces was 3,758,000 h, accounting for 96.7% of the total cumulative travel duration of FCEVs in China (Fig. 6.11). Among those provinces, Guangdong ranked first with a cumulative travel duration of 1,172,000 h and a proportion of up to 30.2% in total cumulative travel duration of China; this is followed by Shanghai, Henan and Hebei with a cumulative travel duration of more than 450,000 h. These figures demonstrate that the FCEVs have achieved a good demonstration operation effect.

The proportion of FCEVs with long single-vehicle daily travel duration is increasing, indicating that the operation intensity of FCEVs has gradually increased.

The distribution of single-vehicle daily travel duration of FCEVs is relatively discrete, that is to say, there are FCEVs operating in each time period. Compared with 2018 and 2019, the proportion of FCEVs with long single-vehicle daily travel duration increased in 2020 (Fig. 6.12), especially the FCEVs with a single-vehicle daily travel duration of more than 6 h, indicating that the operation intensity of FCEVs has gradually increased.

The proportion of FCEV buses with a long daily travel duration is higher than that of FCEV logistics vehicles.

Overall, the proportion of FCEV buses with a long daily travel duration is higher than that of FCEV logistics vehicles (Fig. 6.13). Considering from the application scenarios, the single-vehicle daily travel duration of FCEV buses is mainly above 5 h, and those FCEV buses are mainly applied in urban public transportation; the distribution of single-vehicle daily travel duration of FCEV logistics vehicles is somehow polarized, and specifically, on the one hand, the FCEV logistics vehicles

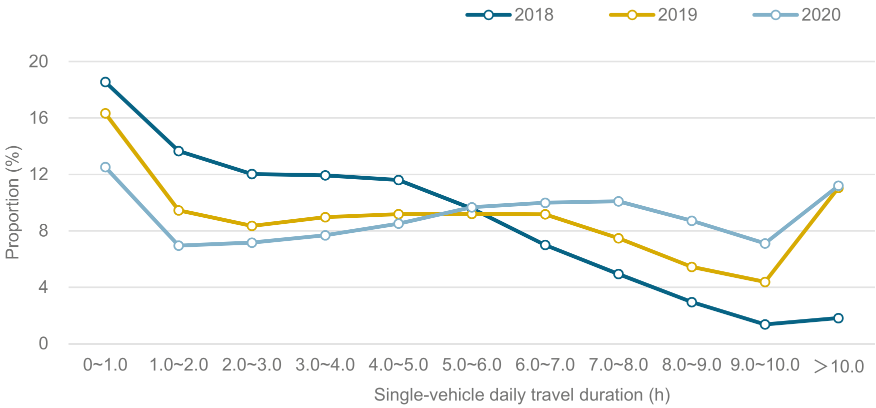


Fig. 6.12 Distribution of single-vehicle daily travel duration of FCEVs from 2018 to 2020

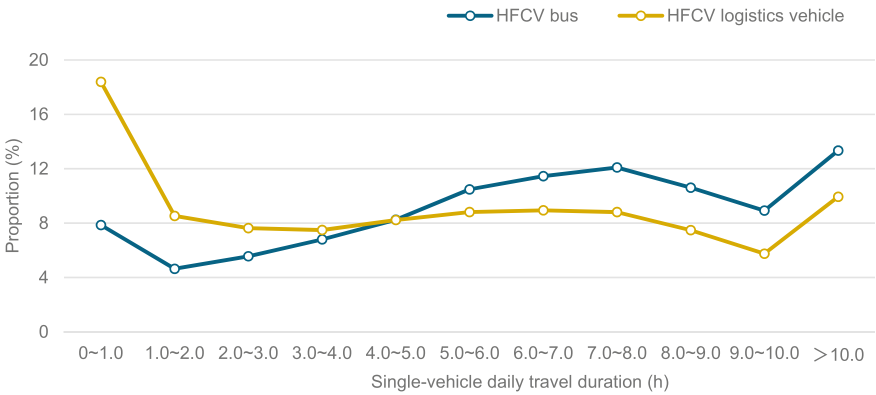


Fig. 6.13 Distribution of single-vehicle daily travel duration of FCEV buses and logistics vehicles in 2020

with a daily travel duration below 2 h take a large proportion, and are mainly applied in short-distance logistics transportation in the city; the FCEV logistics vehicles with a daily travel duration above 10 h account for 10%, indicating that some FCEV logistics vehicles are applied in cross-city transportation.

6.2.4 Hydrogen Charging Characteristics

The distribution of the hydrogen charging start time is discrete, and the proportion of FCEVs refueled intermittently during the operation is relatively high.

According to the data requirements for fuel cell in GB/T32960.3-2016 *Technical specifications of remote service and management system for electric vehicles—Part 3: Communication protocol and data format*, the “hydrogen maximum pressure” is defined as the basis for hydrogen charging. But for the purpose of this report, the maximum pressure difference of hydrogen fuel cell of ≥15 MPa is selected as the basis for hydrogen charging,[1] and based on it, the effective data of hydrogen charging duration can be calculated, and abnormality treatment, if necessary, can be made for hydrogen charging duration.

According to the operation data of FCEVs on the National Monitoring and Management Platform, the distribution of hydrogen charging start time is relatively discrete. As shown in Fig. 6.14, the hydrogen charging is concentrated at 10:00–11:00 and 16:00. The layout of the hydrogen charging stations directly affects the intermittent hydrogen charging of FCEVs during operation. In addition, we will also see a small peak of hydrogen charging around 20:00 at night.

The hydrogen charging duration of FCEVs is short, and FCEVs have advantage over electric vehicles in terms of energy supplement efficiency.

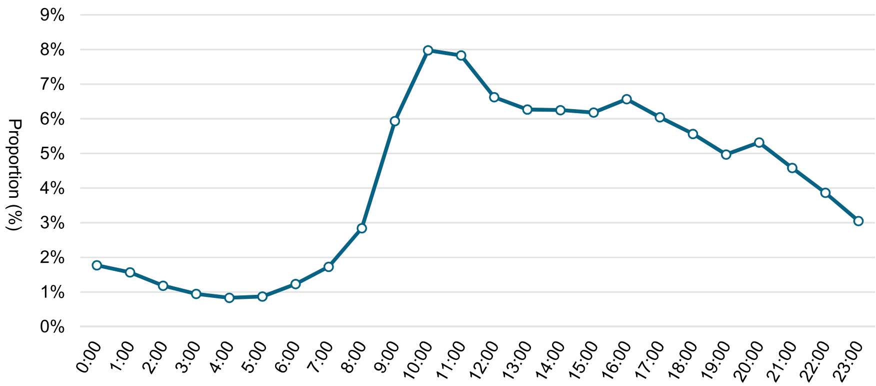


Fig. 6.14 Distribution of hydrogen charging start time of FCEVs in 2020

[1] Reason for selecting the maximum hydrogen pressure difference of ≥15 MPa as the basis for hydrogen charging: according to the probability distribution of the maximum hydrogen pressure difference of all hydrogen charging behaviors, the hydrogen pressure difference of more than 90% hydrogen charging behaviors is above 15 MPa, so this value is taken as the basis for calculating the effective hydrogen charging data.

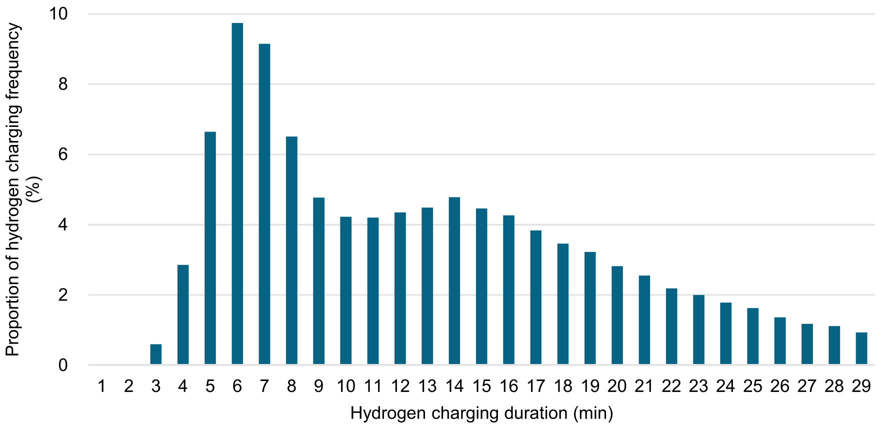


Fig. 6.15 Distribution of hydrogen charging duration of FCEVs in 2020

This report, through the statistics of hydrogen charging duration of FCEVs on the National Monitoring and Management Platform in 2020, selects the FCEVs with a hydrogen charging duration of less than 30 min as valid calculation samples, and calculates based on an interval of 1 min to generate the distribution of hydrogen charging duration of FCEVs. As shown in Fig. 6.15, the hydrogen charging duration of some vehicles is 4–5 min, and 13–15 min for other vehicles. These figures tell that the hydrogen charging duration of FCEVs is short, and FCEVs have advantages over BEVs in terms of energy supplement efficiency.

6.3 Summary

Hydrogen energy, as an ideal link medium for the efficient use of traditional petrochemical energy and the large-scale development of renewable energies, is an ideal choice for large-scale and deep decarbonization of transportation sector. In recent years, the central and local governments have continuously strengthened their support and guidance for the hydrogen energy industry. As the main force driving the growth of the downstream application market, FCEVs have achieved remarkable results in demonstration and application in recent years. This chapter, based on the big data of operation of FCEVs on the National Monitoring and Management Platform, makes the following conclusions:

The promotion and application of FCEV commercial vehicles has achieved remarkable results. The development and application of hydrogen energy industry in China follows the principle of "FCEV commercial vehicles first FCEV passenger cars followed". With the continuous support of national research plans and demonstration programs, the technical reliability, durability and maturity of some FCEV buses and logistics vehicles meet the actual operational needs, and FCEV technology has achieved good operation results in fields of buses and logistics. As of December 31, 2020, the access of FCEVs to National Monitoring and Management Platform has exceeded 6000, of which 5375 are FCEV buses and logistics vehicles, accounting for 89.55% of the total FCEV access in China; from the perspective of mileage, the cumulative mileage of FCEVs in China has exceeded 100,000,000 km and the cumulative travel duration has exceeded 3,880,000 h, among which, the contributions of FCEV buses and logistics vehicles to cumulative mileage and cumulative travel duration of FCEVs are more than 99,048,000 km and 3,528,000 h, respectively.

The promotion of FCEVs is mainly implemented in the developed eastern coastal region. According to the regional distribution of complete vehicles, Jiangsu, Shandong, Zhejiang, Guangdong and other provinces in developed coastal region have adopted a large number of policies for fuel cell industry at a high density, and the hydrogen energy industry there enjoys a high development fever; according to the regional distribution of promotion, the promotion of FCEVs takes place more in developed eastern provinces, with the FCEVs promoted in Guangdong and Shanghai, as of December 31, 2020, accounting for 40.2% and 22.9% of the total FCEVs promotion in China.

FCEVs have significant advantages in mileage and energy supplement efficiency. With the advancement of fuel cell technology and hydrogen storage system technology, FCEVs have strong advantages in the fields of long-distance buses, and urban/intercity medium-/long-distance freight transportation. According to the operation data of FCEVs in Foshan on the National Monitoring and Management Platform, the average daily mileage of FCEV buses is above 200 km, and that of FCEV logistics vehicles is above 400 km; as for the hydrogen charging behavior, the FCEVs in China have a shorter hydrogen charging duration (specifically, the hydrogen charging duration is 4 ~ 5 min for some vehicles, and 13 ~ 15 min for other vehicles), and thus they have advantage over electric vehicles in terms of energy supplement efficiency. In the medium and long term, FCEVs are expected to be promoted and applied in the fields of heavy-duty trucks, buses, and long-distance logistics vehicles. To make full use of the complementary relationship between FCEVs and electric vehicles, promotion mode and market cultivation mode should be explored based on different application scenarios to give full play to the potential of FCEVs in long range and energy supplement efficiency.

The number and layout rationality of hydrogen charging stations are important for the promotion and application of FCEVs. Through the statistics of hydrogen charging duration of FCEVs on the National Monitoring and Management Platform, the hydrogen charging duration is mainly 4–5 min and 13–5 min. At present, the market scale of hydrogen charging station in China is small due to high construction cost and small profit margin, and the operation of hydrogen charging stations mainly depends on the government subsidies, and in view of this, the advantage of some FCEV commercial vehicles in long range has not been effectively unleashed. Therefore, it is necessary to expand a stable hydrogen energy supply system according to local conditions to ensure and promote the sound operation of the FCEV industry.