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

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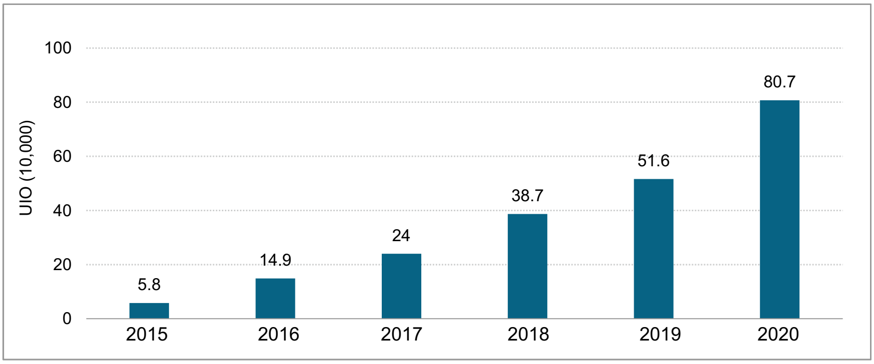


Fig. 5.1 UIO of public charging piles in China over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

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.

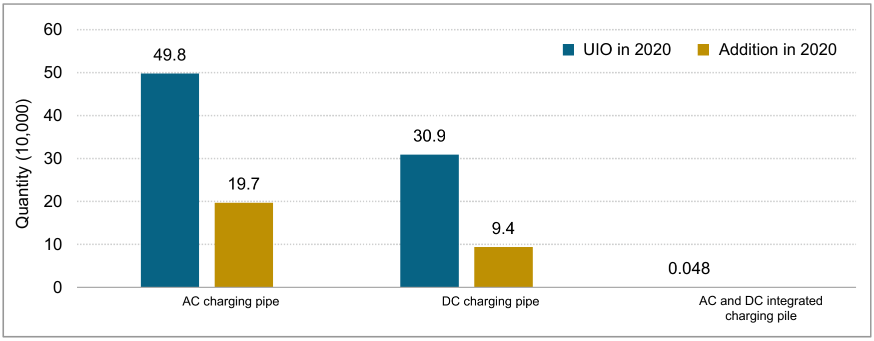


Fig. 5.2 UIO and new additions of public charging piles in China. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

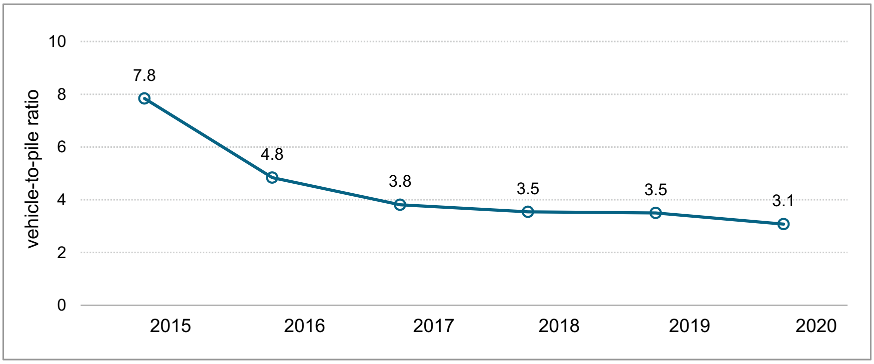


Fig. 5.3 Vehicle-to-pile ratio of NEVs in China over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

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).

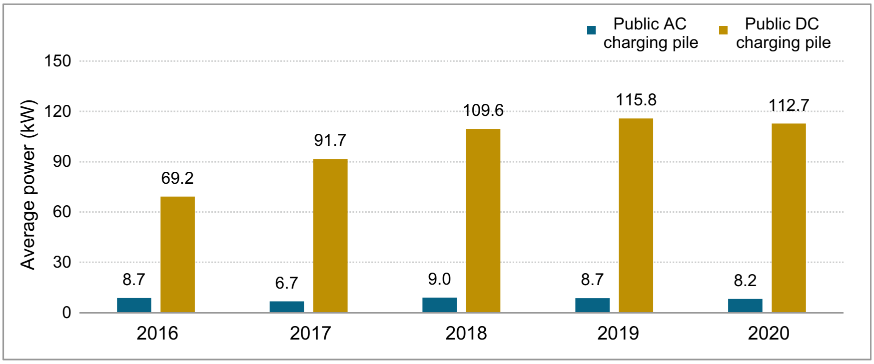


Fig. 5.4 Changes in average power of public charging piles over the years. *Source* China Electric Vehicle Charging Infrastructure Promotion Alliance (EVCIPA)

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

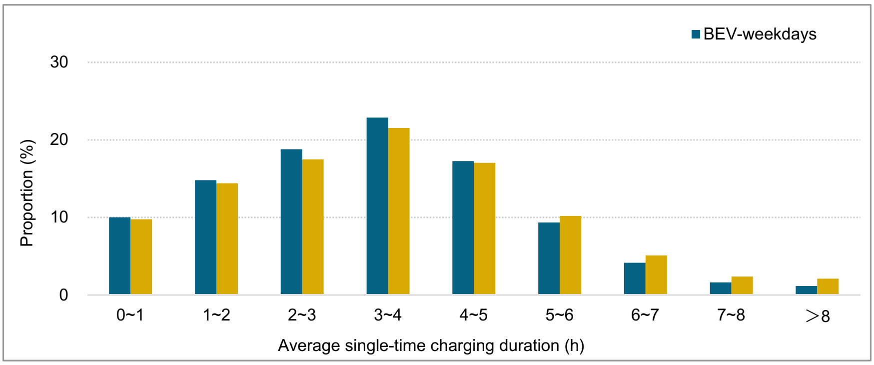


Fig. 5.5 Distribution of average single-time charging duration of BEV private cars in 2020-by weekday and weekend

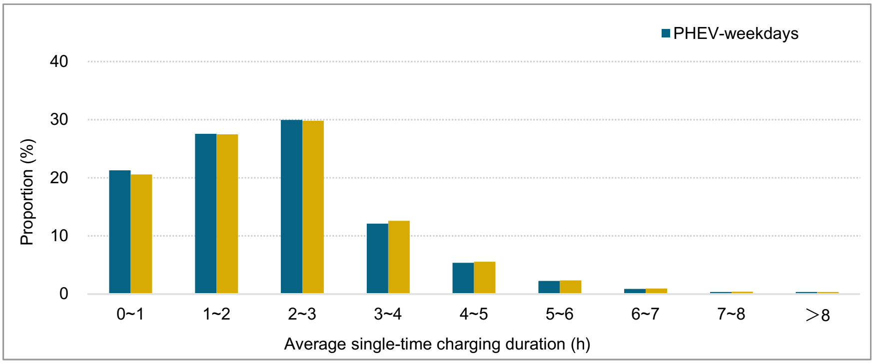


Fig. 5.6 Distribution of average single-time charging duration of FCEV private cars in 2020-by weekday and weekend

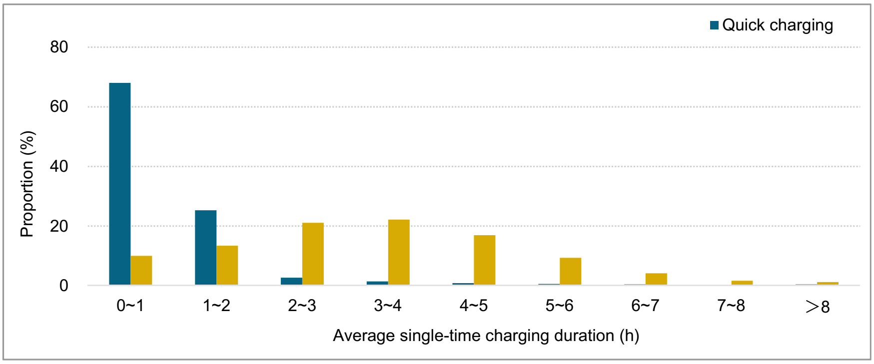


Fig. 5.7 Distribution of average single-time charging duration of BEV private cars in 2020-by quick charging and slow charging

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

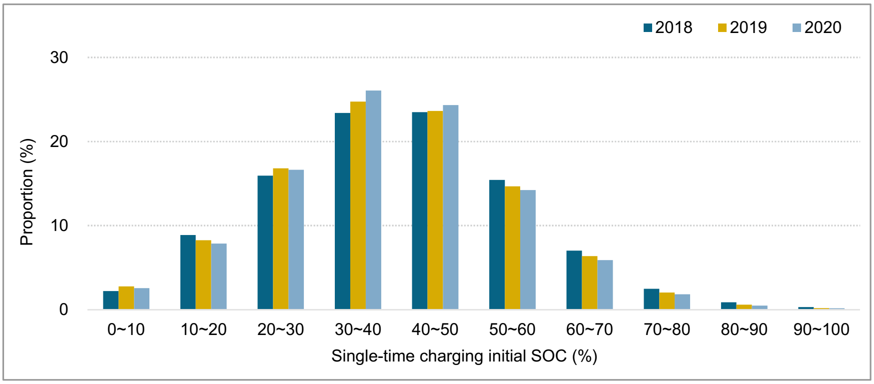


Fig. 5.8 Distribution of single-time charging initial charging SOC of new energy private cars-by year

(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).

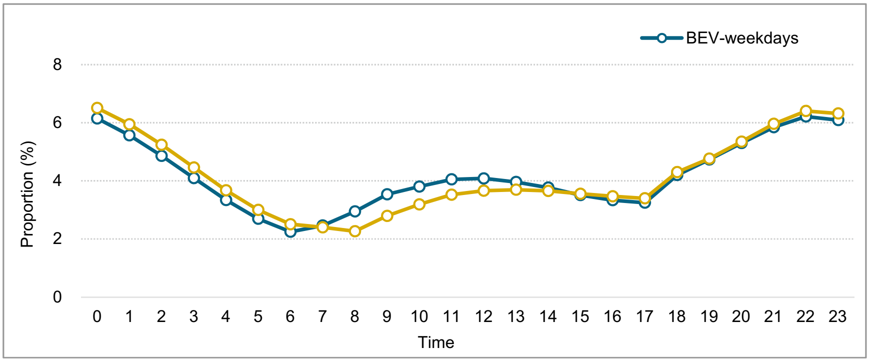


Fig. 5.9 Distribution of charging time of BEV private cars in 2020-by weekday and weekend

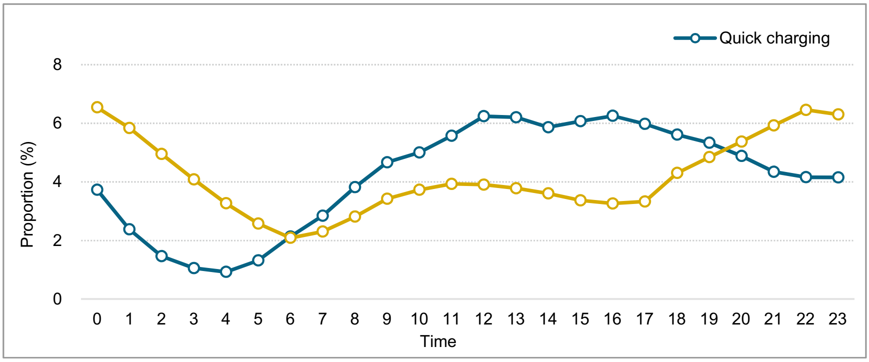


Fig. 5.10 Distribution of charging time of BEV private cars in 2020-by quick charging and slow charging

(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

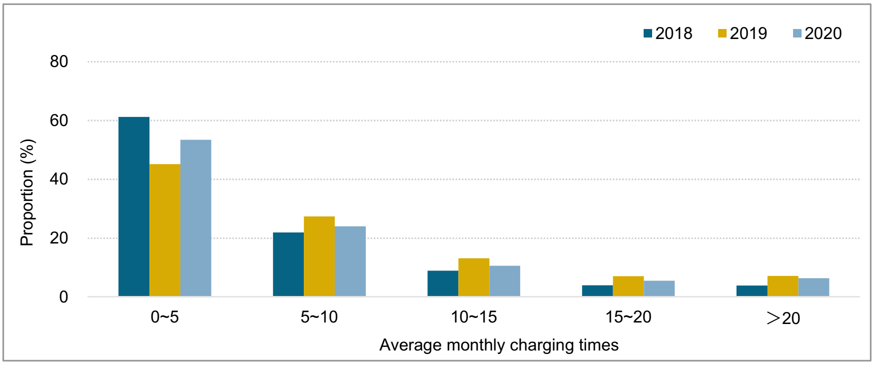


Fig. 5.11 Distribution of average monthly charging times of new energy private cars-by year

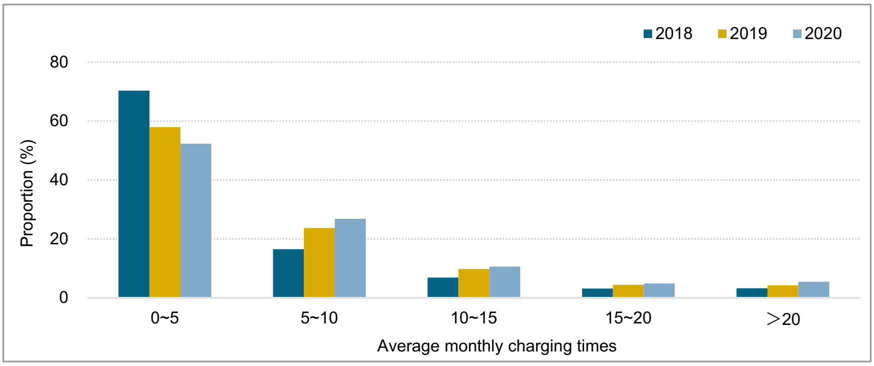


Fig. 5.12 Distribution of average monthly charging times of BEV private cars-by year

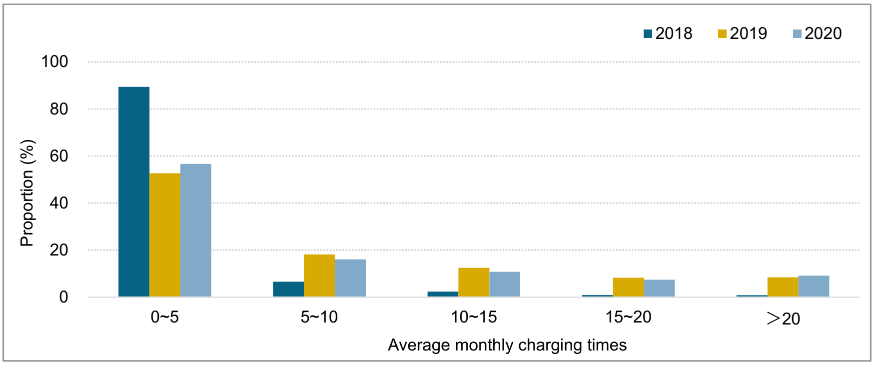


Fig. 5.13 Distribution of average monthly charging times of PHEV private cars-by year

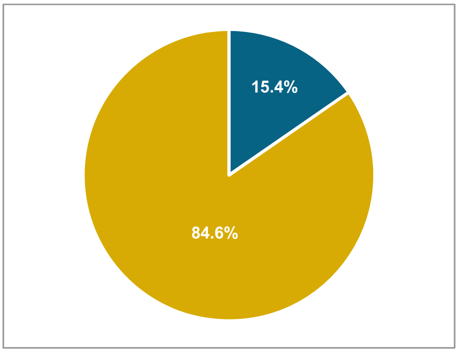


Fig. 5.14 Proportion of fast charging and slow charging in average monthly charging times of new energy private cars in 2020

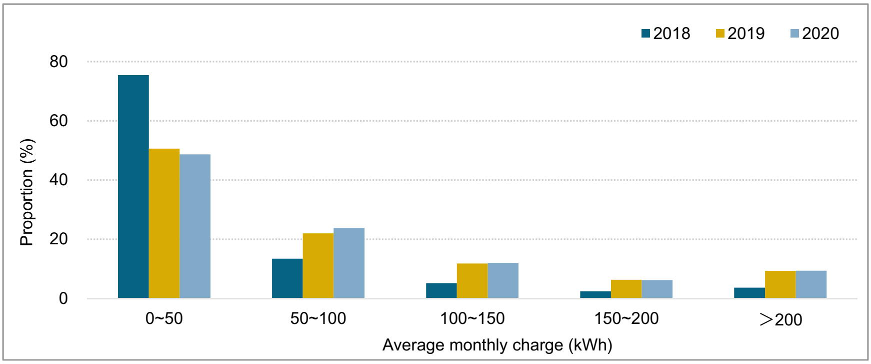


Fig. 5.15 Distribution of average monthly charge of new energy private cars-by year

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

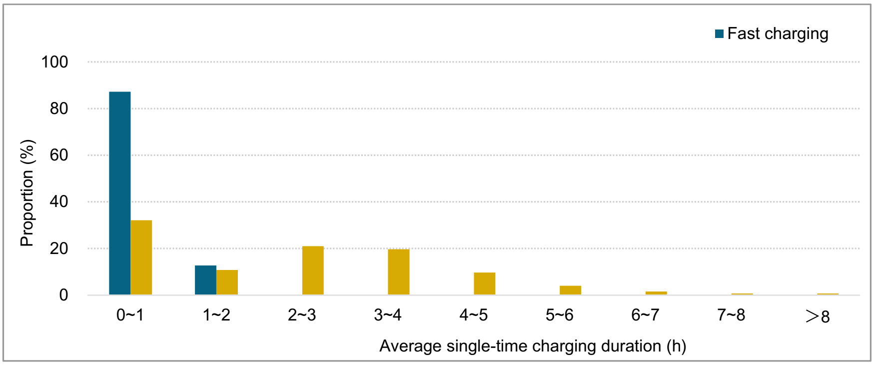


Fig. 5.16 Distribution of average single-time charging duration of BEV E-taxis in 2020-by fast charging and slow charging

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

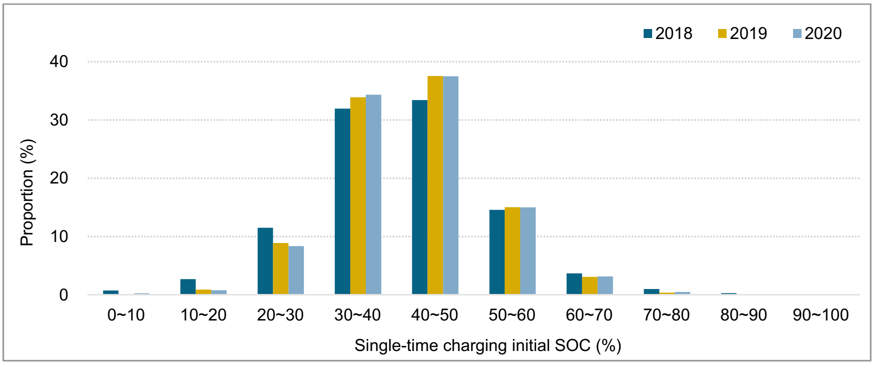


Fig. 5.17 Distribution of single-time charging initial SOC of BEV E-taxis-by year

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).

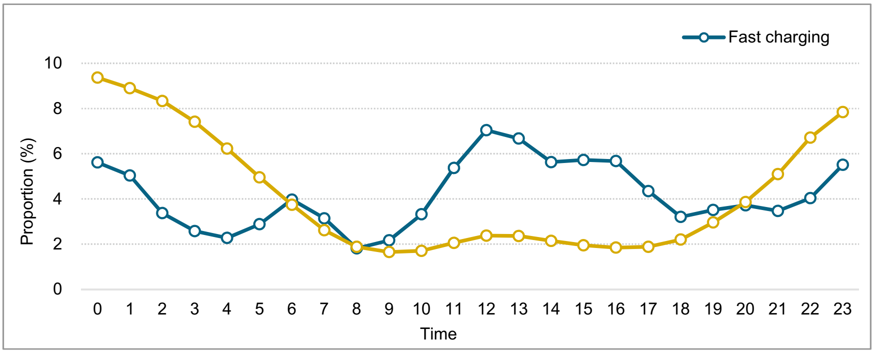


Fig. 5.18 Distribution of charging time of BEV E-taxis in 2020-by fast charging and slow charging

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

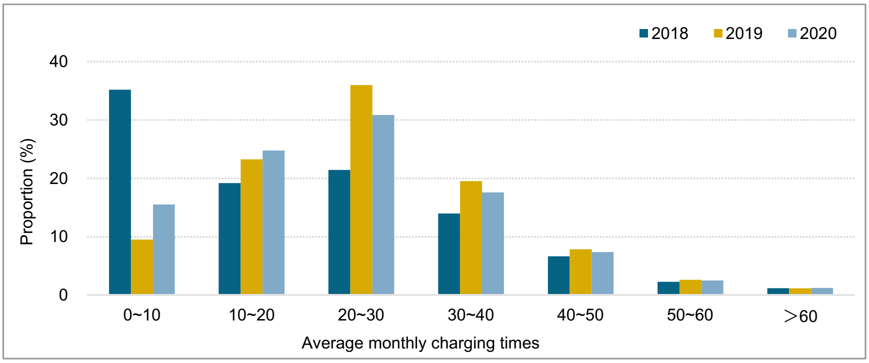
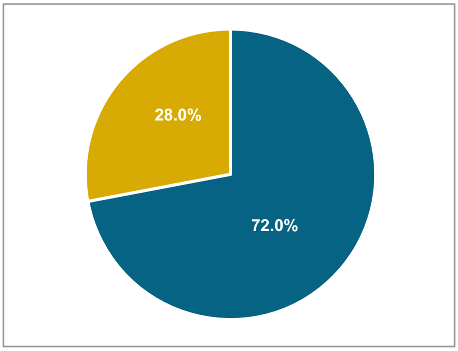


Fig. 5.19 Distribution of average monthly charging times of BEV E-taxis-by year

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

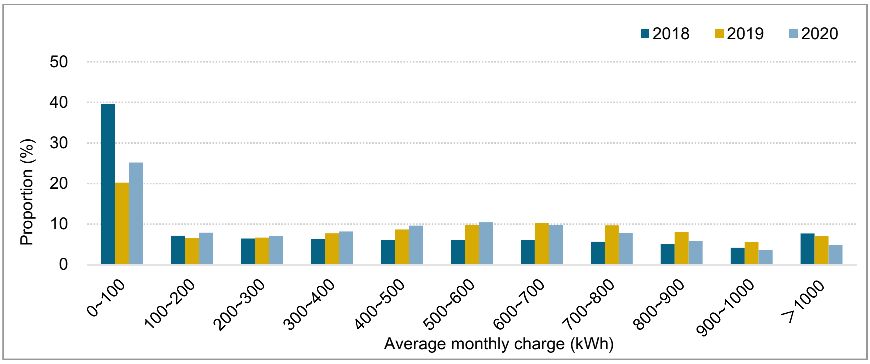


Fig. 5.21 Distribution of average monthly charge of BEV E-taxis-by year for fast charging

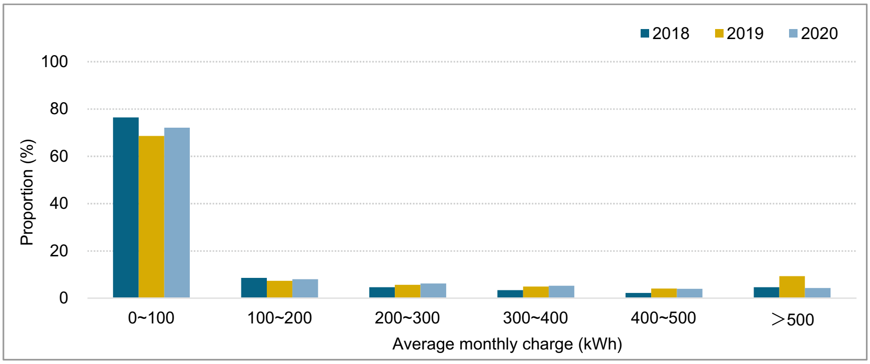


Fig. 5.22 Distribution of average monthly charge of BEV E-taxis-by year for slow charging

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

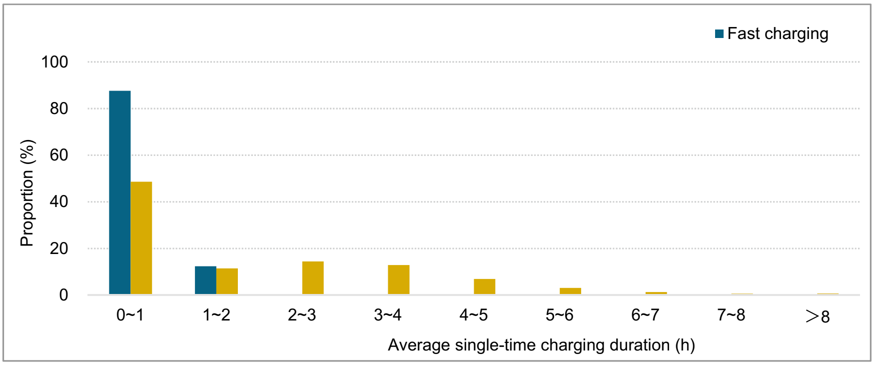


Fig. 5.23 Distribution of average single-time charging duration of BEV taxis in 2020-by fast charging and slow charging

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

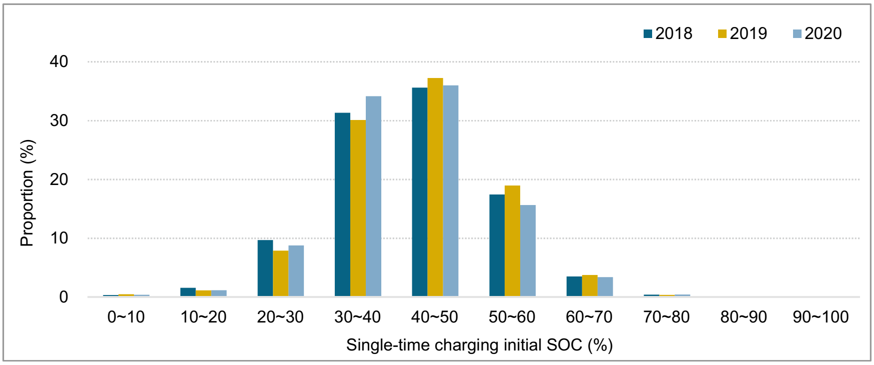


Fig. 5.24 Distribution of single-time charging initial SOC of BEV taxis-by year

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.

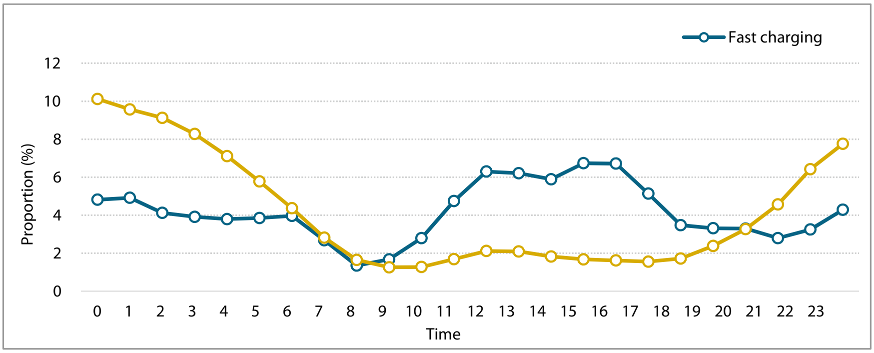


Fig. 5.25 Distribution of charging time of BEV taxis in 2020-by fast charging and slow charging

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

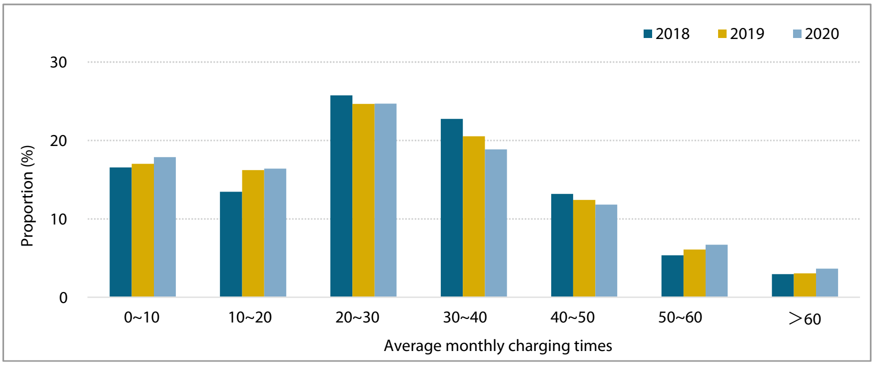
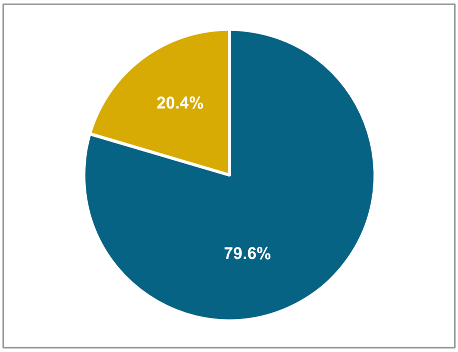


Fig. 5.26 Distribution of average monthly charging times of BEV taxis-by year

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

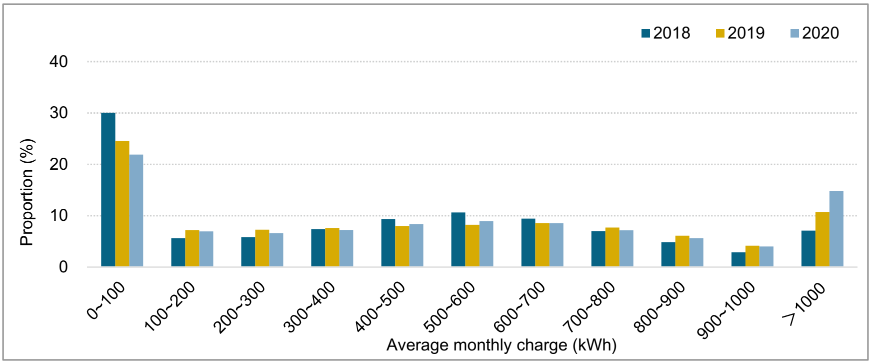


Fig. 5.28 Distribution of average monthly charge of BEV taxis-by year for fast charging

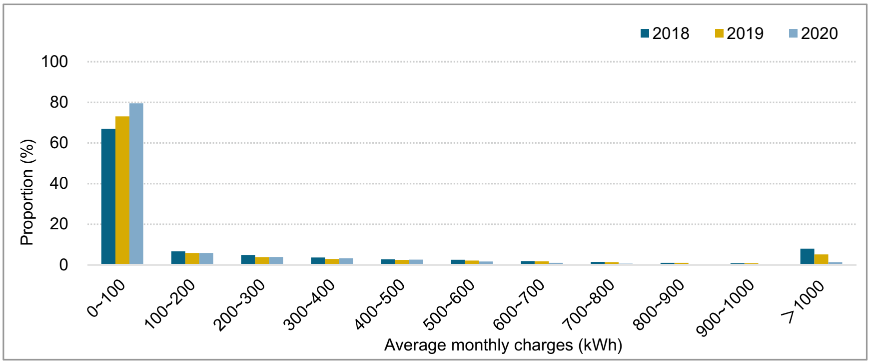


Fig. 5.29 Distribution of average monthly charge of BEV taxis-by year for slow charging

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

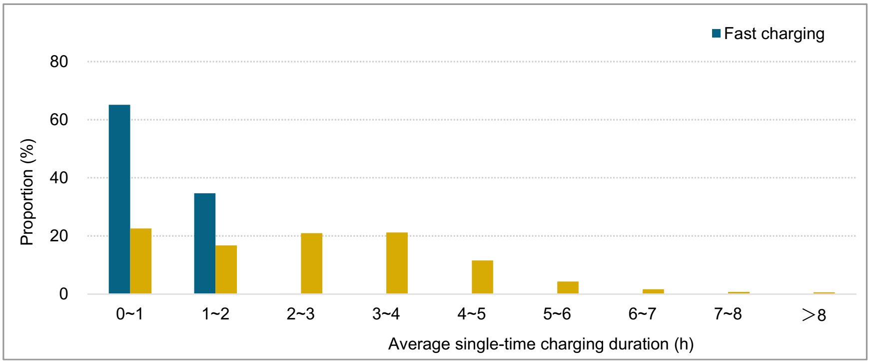


Fig. 5.30 Distribution of average single-time charging duration of BEV cars for sharing in 2020-by fast charging and slow charging

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

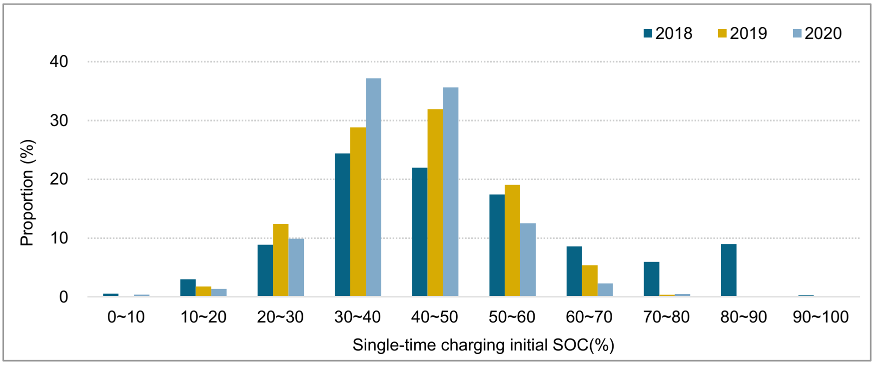


Fig. 5.31 Distribution of average single-time charging initial of BEV cars for sharing-by year

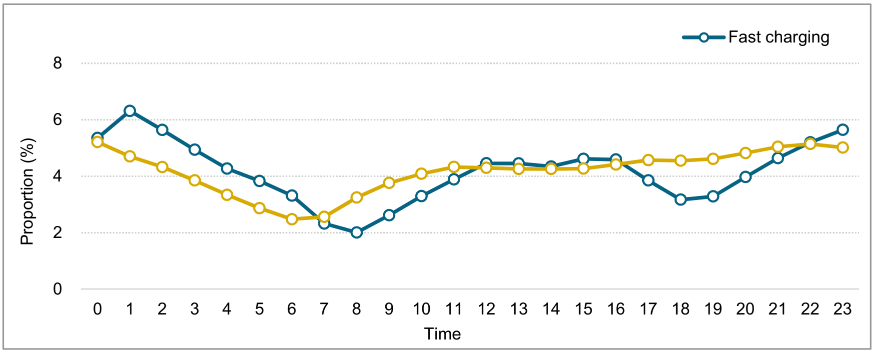


Fig. 5.32 Distribution of charging time of BEV cars for sharing in 2020-by fast charging and slow charging

(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

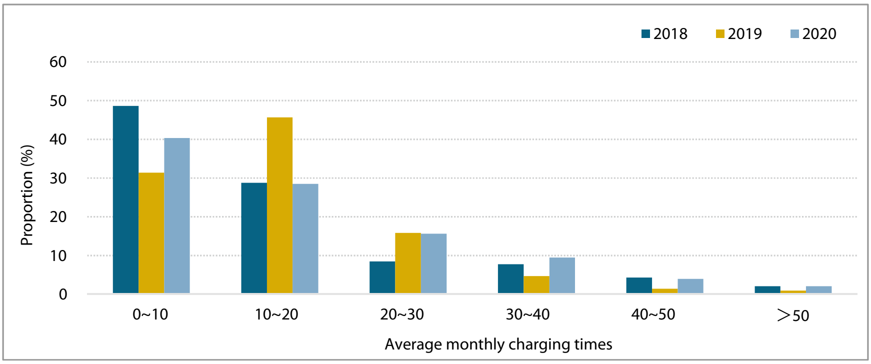
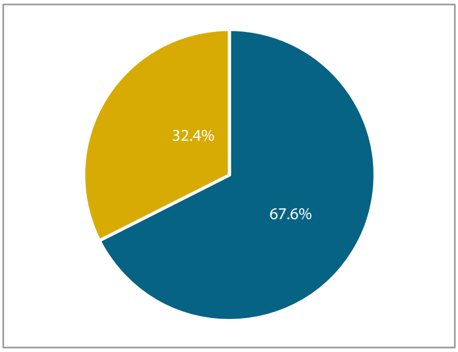


Fig. 5.33 Distribution of average monthly charging times of BEV cars for sharing-by year

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

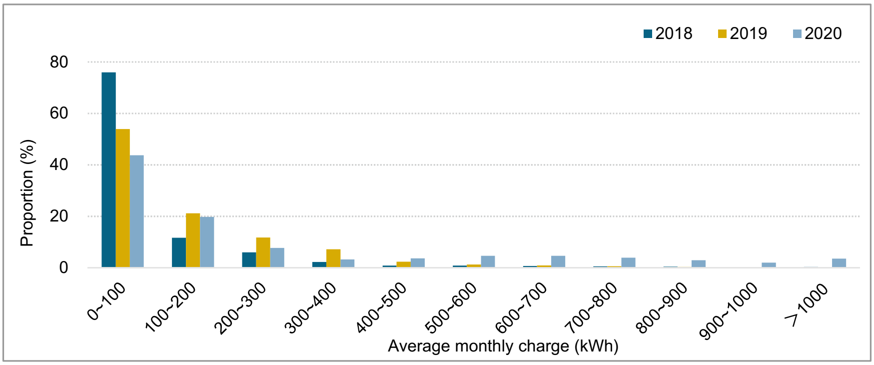


Fig. 5.35 Distribution of average monthly charge of BEV cars for sharing-by year for fast charging

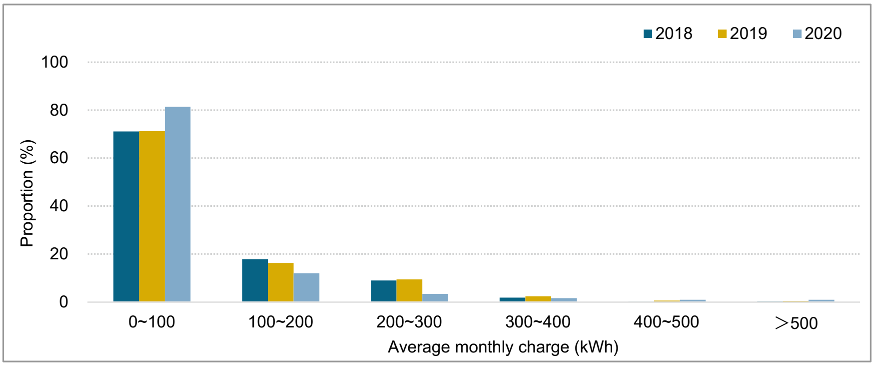


Fig. 5.36 Distribution of average monthly charge of BEV cars for sharing-by year for slow charging

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

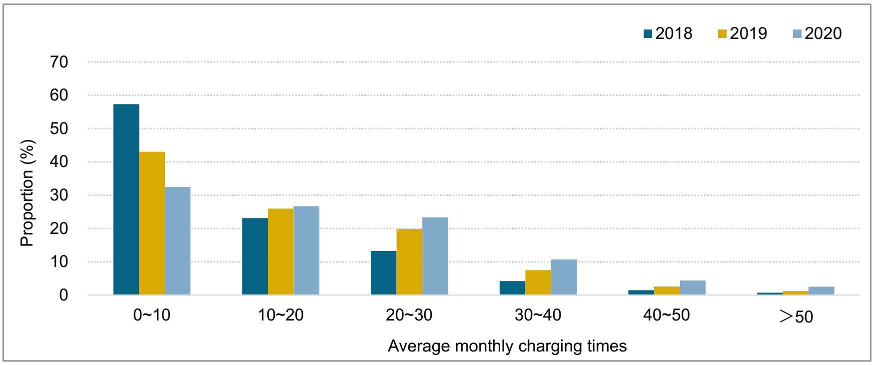
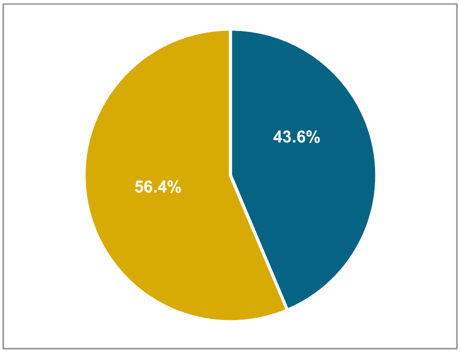


Fig. 5.37 Distribution of average monthly charging times of BEV logistics vehicles-by year

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).

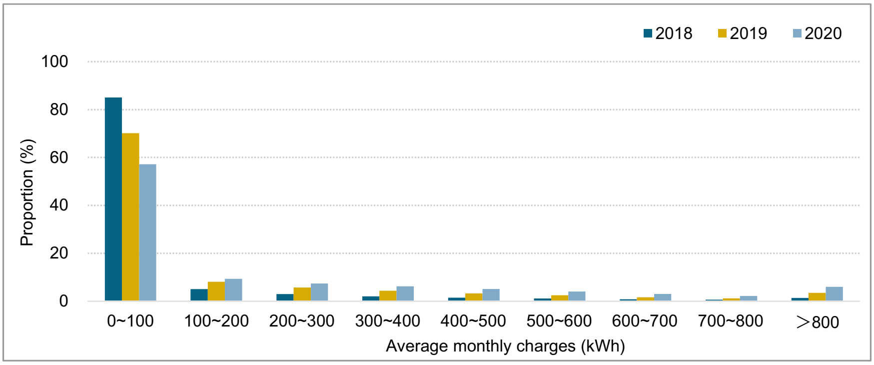


Fig. 5.39 Distribution of average monthly charge of BEV logistics vehicles-by year for fast charging

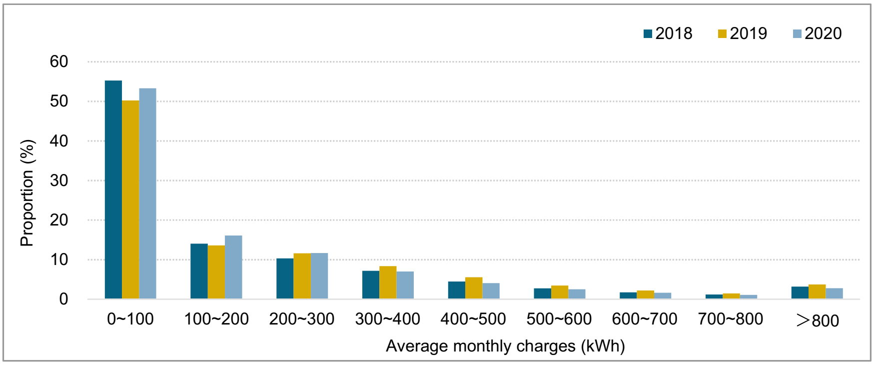


Fig. 5.40 Distribution of average monthly charge of BEV logistics vehicles-by year for slow charging

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

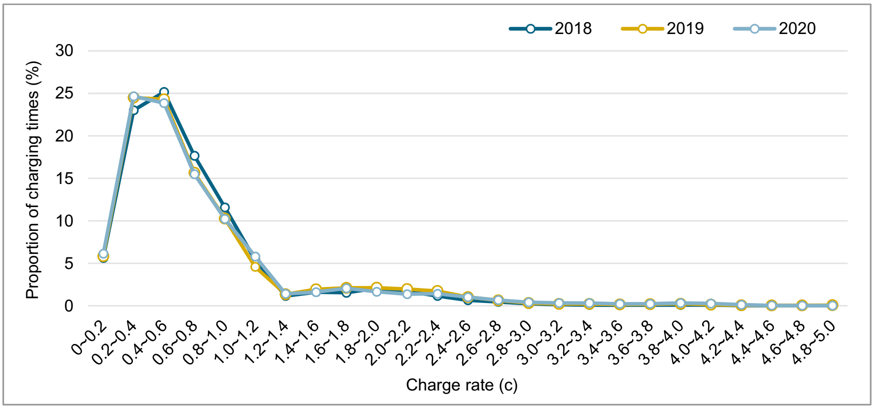


Fig. 5.41 Distribution of charging times of BEV buses under different charge rates

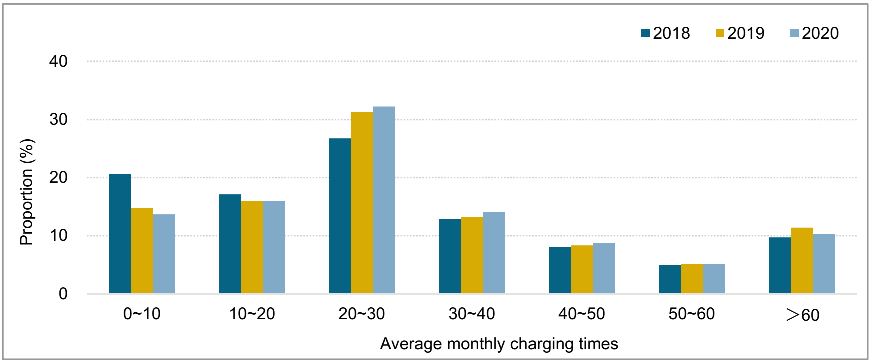


Fig. 5.42 Distribution of average monthly charging times of BEV buses-by year

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.

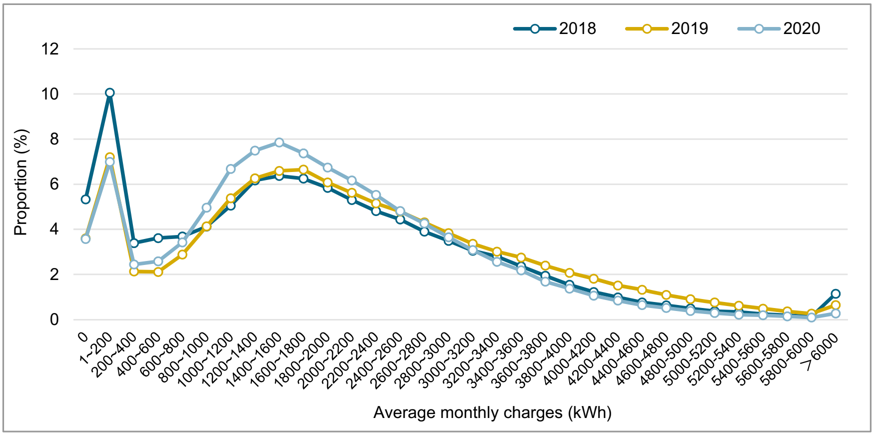


Fig. 5.43 Distribution of average monthly charge of BEV buses

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.

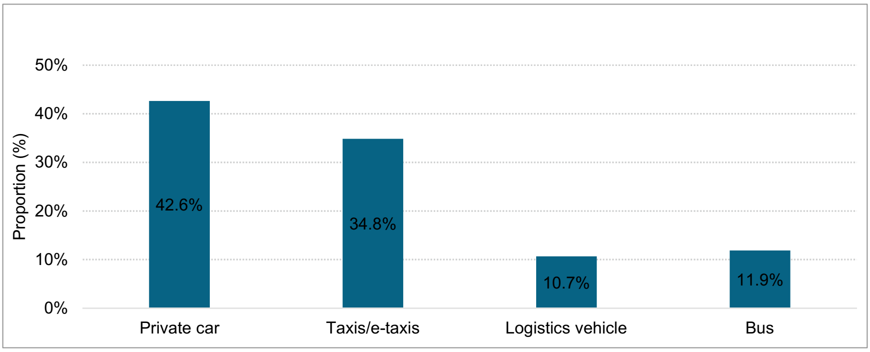


Fig. 5.44 Difference in distribution of vehicles charged in public charging stations-by key segments

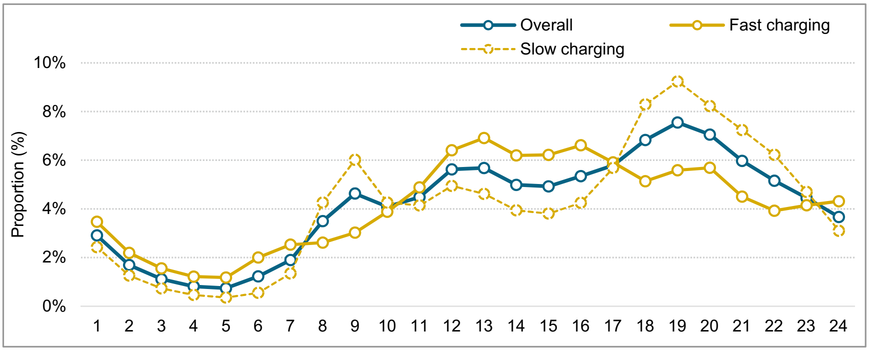


Fig. 5.45 Distribution of vehicle charging time in public charging stations-by fast charging and slow charging

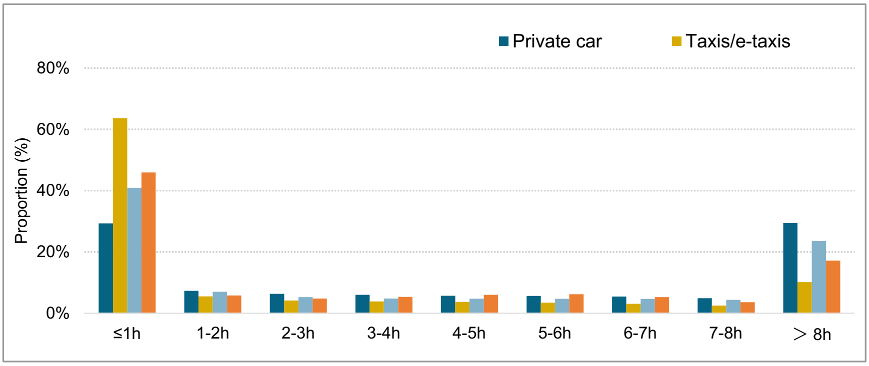


Fig. 5.46 Distribution of single-time charging staying duration of vehicles in public charging stations-by key segments

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.

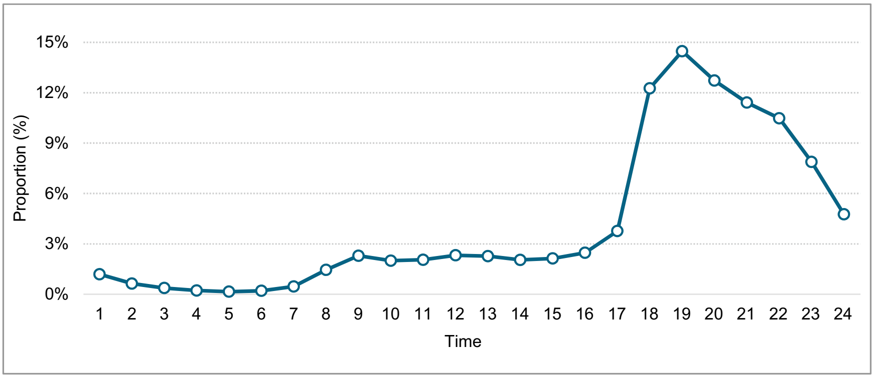


Fig. 5.47 Distribution of vehicle charging time in community charging stations

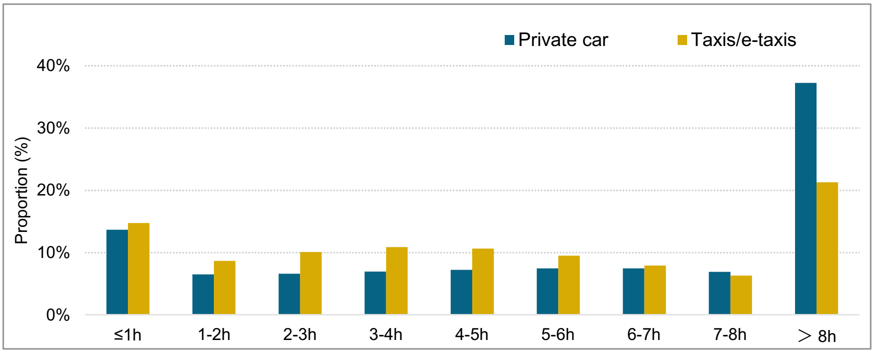


Fig. 5.48 Distribution of single-time charging staying duration of vehicles in community charging stations-by key segments

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.

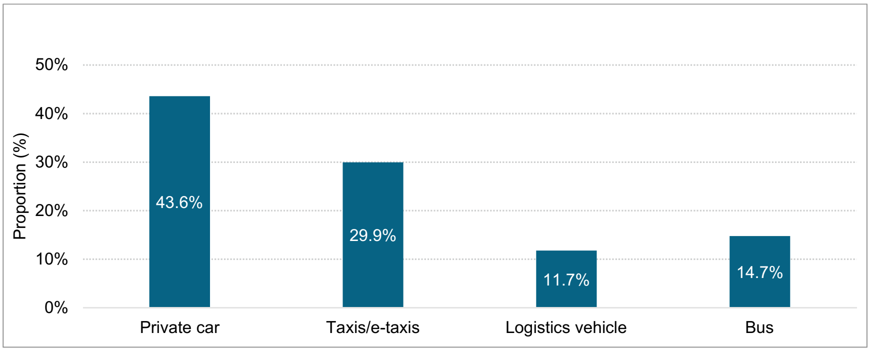


Fig. 5.49 Difference in distribution of vehicles charged in expressway charging stations-by key segments

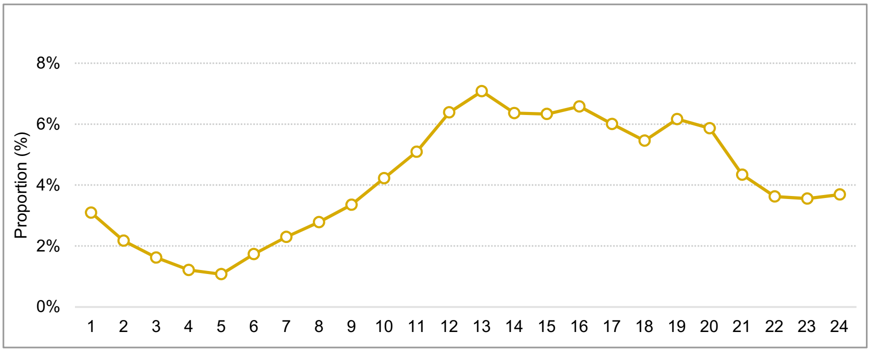


Fig. 5.50 Distribution of vehicle charging time in expressway charging stations

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.

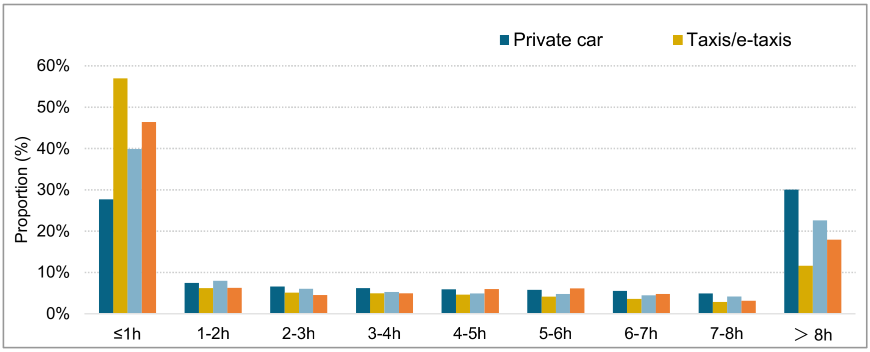


Fig. 5.51 Distribution of single-time charging staying duration of vehicles in expressway charging stations-by key segments

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

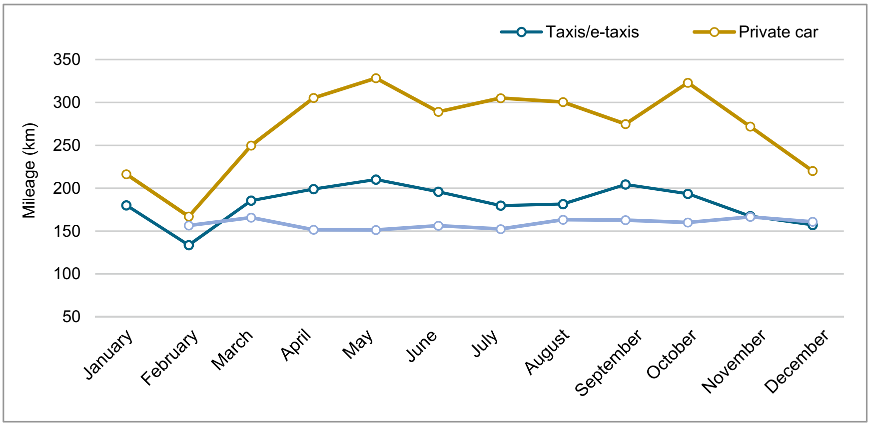


Fig. 5.52 Average mileage of single-time battery swapping of vehicles in different segments in 2020

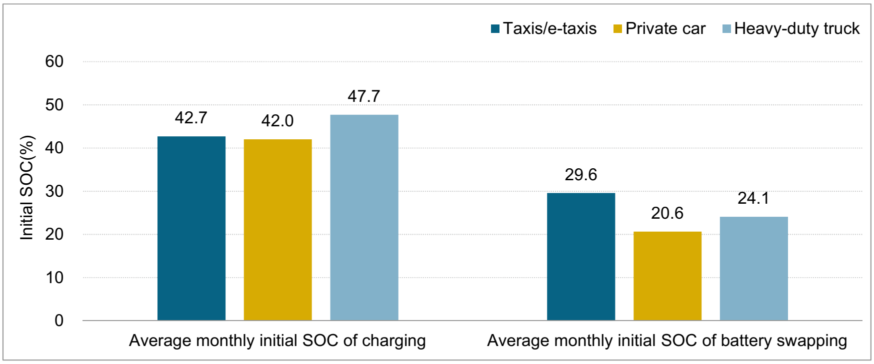


Fig. 5.53 Comparison of initial SOC of charging and initial SOC of battery swapping of vehicles in different segments in 2020

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

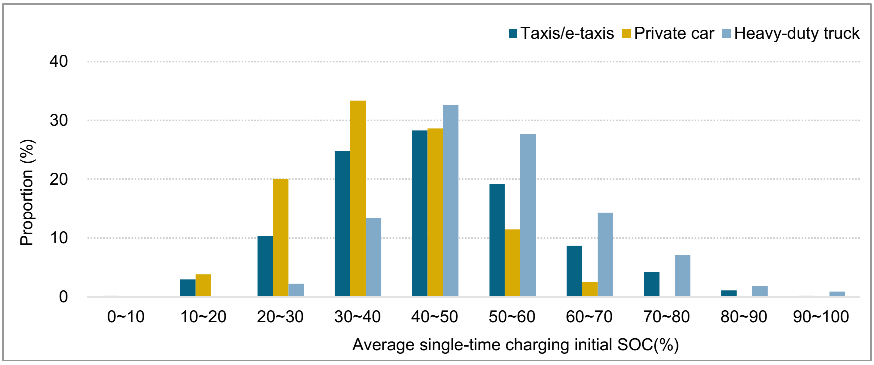


Fig. 5.54 Distribution of initial SOC of charging of vehicles in different segments in 2020

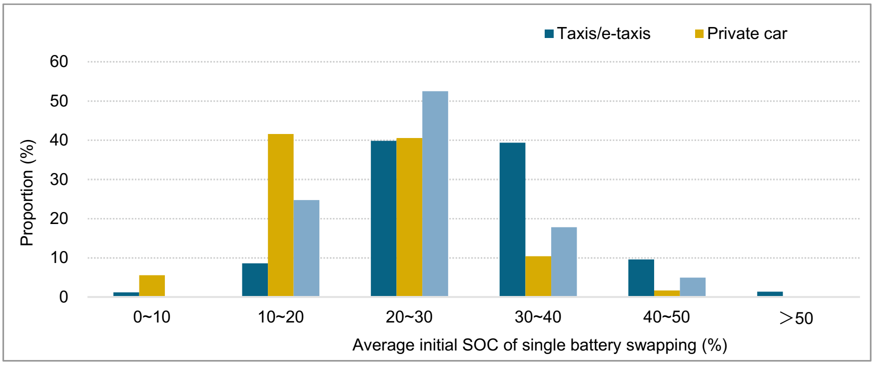


Fig. 5.55 Distribution of initial SOC of battery swapping of vehicles in different segments in 2020

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

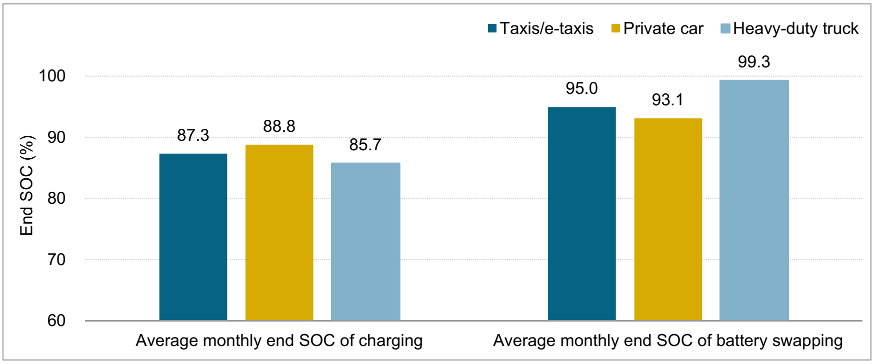


Fig. 5.56 Comparison of end SOC of charging and end SOC of battery swapping of vehicles in different segments in 2020

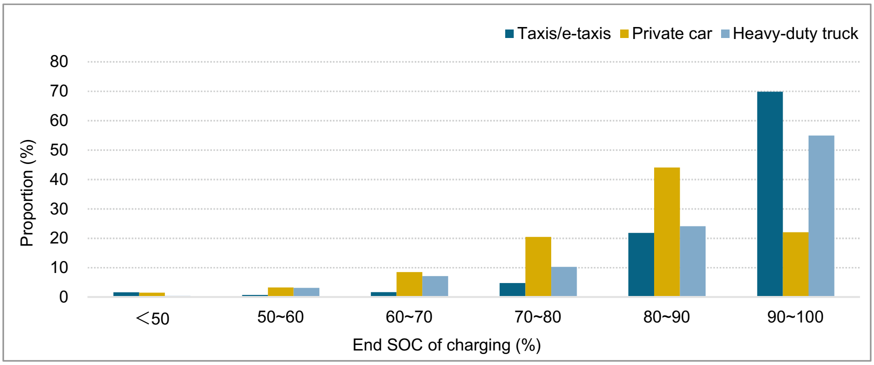


Fig. 5.57 Distribution of end SOC of charging of vehicles in different segments in 2020

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

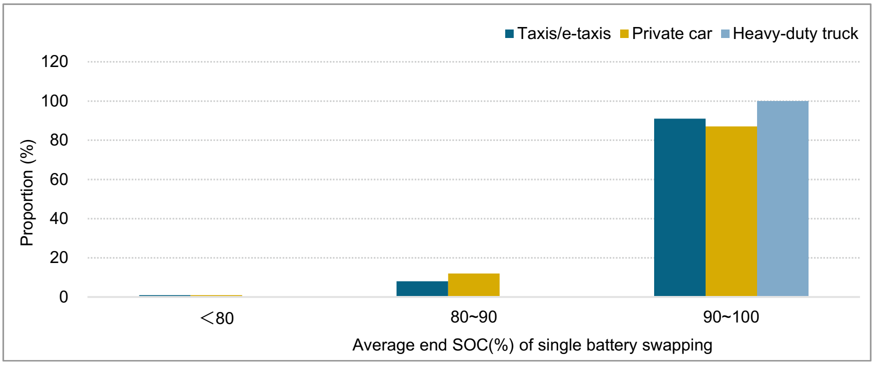


Fig. 5.58 Distribution of end SOCs of battery swapping of vehicles in different segments in 2020

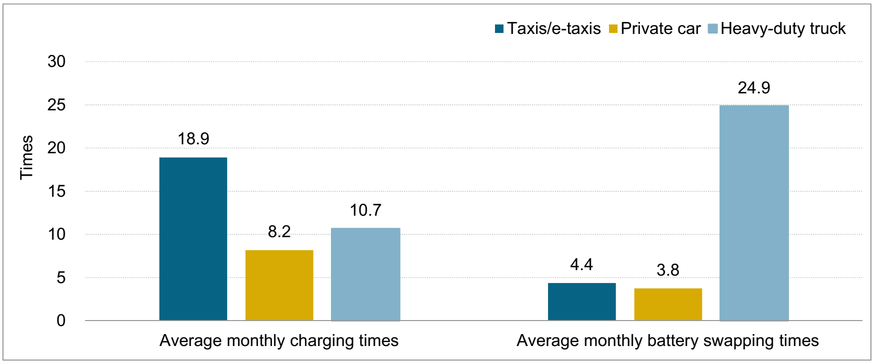


Fig. 5.59 Comparison of average monthly charging times and battery swapping times of vehicles in different segments in 2020

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.

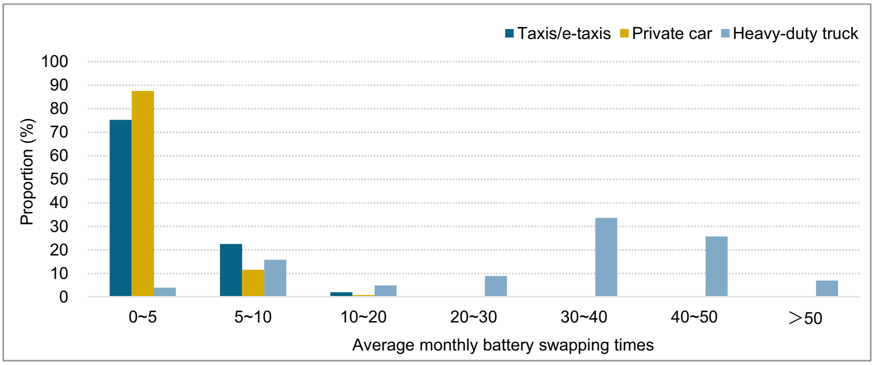


Fig. 5.60 Distribution of average monthly battery swapping times of vehicles in different segments in 2020

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.