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Joint optimization of bow-type fast charger locations and battery capacity for electric buses

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Abstract: The transition from fossil fuel-powered buses to battery electric buses (BEBs) is occurring gradually; however, BEBs encounter challenges such as limited driving range and extended charging durations, which highlight the need for the development of optimized charging solutions. The bow-type fast charger, characterized by its high charging power and capability for unmanned operation, presents a viable option. These chargers can be strategically installed at terminals or intermediate stops, enabling BEBs to leverage their dwell time for charging purposes. This study formulates a mixed integer programming model aimed at jointly optimizing the locations of bow-type fast chargers, the battery capacity of the buses, and the bus schedule for a specific bus line. The primary objective is to minimize the combined costs associated with the construction of chargers and the acquisition of vehicles. Empirical data from an operational BEB line in Meihekou City, China, is employed to validate the model. Additionally, the study examines the sensitivity of three critical parameters and the impact of random disturbance factors. The optimization outcomes in scenarios that do not account for charging time limitations at intermediate stops are also evaluated. Findings indicate that the service time utilization rate at intermediate stops equipped with charging bows exceeds 90%. This suggests that BEBs can effectively utilize their dwell time for charging, thereby facilitating the synchronization of BEB charging with the bus schedule.

Keywords: automotive engineering; battery electric bus; bow-type fast charger; charger location; battery capacity; bus schedule

1 Introduction

To achieve the carbon nutrition goals and improve the air quality in urban areas, it is important to consider low-carbon public transport solutions. In the public transportation system, the battery electric bus (BEB) together with renewable energy has the advantage of zero emissions and high energy efficiency. Therefore, BEBs are gradually replacing diesel buses in many countries. The penetration rate of new energy buses has increased from 10.8% in 2012 to 98.8% in Shanghai, China by 2022. As of 2022, the length of new energy bus lines has exceeded 10 million kilometers, and the cumulative number of passengers transported by them has exceeded 500 billion.

However, BEB has the limitation of short driving range and long charging time which requires careful charging-related decisions. The layout of charging facilities is the key factor that affects the operational effectiveness of BEBs. The distribution and type of charging facilities determine where and how the BEBs get charged. At present, there are three types of charging facilities: the station-based charger, the wireless lane-based charger, and battery swapping[1]. The bow-type fast charger is a new type of charging facility, that has been used in some cities in China, such as Shanghai, Qingdao, and Chengdu. Simply by pressing one button, the charging bow will drop to connect with the vehicle. After the vehicle completes charging, it will be automatically powered off and put away. The charging power of it can reach up to 1 000 kw. It can charge the BEB for 40 s and last for 10 km[2]. Because of its low carbon footprint, it can be installed not only at terminal stations but also at interme-

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diate stops, which enables the BEBs to get charged while serving passengers. Above all, the bow-type fast charger has the advantage of being unmanned, intelligent, efficient, and land-saving. It can provide frequent and short-time charging for BEBs, which can alleviate the mileage anxiety of BEBs and improve charging efficiency.

At present, many researches have studied the optimization for station-based regular charging, station-based fast charging, and wireless lane-based chargers. Regular charging stations are often set up in depots or bus terminals. Buses always have deadhead mileage when going to charge. Considering the BEBs queue at the charging station, Uslu, et al.[3] optimized the positions and capacities of conventional charging stations for the intercity routes. Considering the random fluctuations of charging demand and the influence of time-of-use electricity price, An[4] optimized the number of BEBs and the location of conventional charging stations. Zhang, et al.[5] used the grid affinity propagation clustering algorithm to optimize the layout position and capacity of conventional charging stations. Hsu, et al.[6] established a location and capacity optimization model for the hybrid public transport network system including BEBs and diesel buses. Jia, et al.[7] focused on addressing the strategic level problem in a bus depot open charger project by determining the number of chargers and maximum charging power for public use.

For fast charging and wireless lane-based chargers, many studies have jointly optimized the layout of charging facilities and the battery capacity. Because of these two charging facilities' high charging power, BEBs can quickly charge in time, so there is no need to equip large-capacity batteries. A battery pack can account for 26% of the total bus weight and 39% of the total cost[8]. Heavy and costly battery packs will reduce BEBs' electricity efficiency. Hence, it's important to determine the minimum necessary battery capacity for the normal operation of BEBs. The battery capacity is determined by the charging demand of BEBs, which is affected by the layout of charging facilities[9]. Thus, the above two factors are jointly optimized in many researches. Zhang et al.[10] proposed a double-layer frame model to design bus lines and optimize the fast charging facilities and bus batteries. Considering the influence of energy consumption and battery aging, Teichert, et al.[11] optimized the battery capacity, quancity, and charging power of charging stations for a bus line. Considering the influence of battery life, discharge depth, and weight, Chen, et al.[12] optimized the position of the wireless charging board of BEBs and the size of the bus battery capacity in a multi-line bus network. Liu, et al.[13] addressed the problem of simultaneously selecting the optimal locations for the wireless charging facilities and the battery size for an electric bus system.

Although all the above studies have optimized the location of charging facilities, most of them only allowed the charging stations to be set at the terminal stations or the depots, and not considered the intermediate stops. Kunith, et al.[14] and He et al.[15] allowed the fast charging stations to be located at intermediate stops and optimized the battery capacity. They also considered the construction cost of the substation and optimized the capacity for the energy storage system. However, these two studies did not consider the impact of BEB charging on the bus schedule. Compared to traditional buses, BEBs not only need to execute bus trips in sequence but also need to meet the minimum electricity requirements during operation. After completing a certain number of trips, BEBs must have the opportunity to charge. Thus, some researches optimize the BEBs' charging scheduling to improve the charge efficiency and reduce the negative impact of mileage anxiety[16-18]. However, the scheduling of traditional fuel buses may not be applicable for BEBs. When the BEB executes too many trips in a day, it may not guarantee the minimum electricity requirements and meet the charging demand. Some researches jointly optimized bus scheduling and charging scheduling[19-21].

Based on the above analysis, it can be found that the number of trips executed by each BEB determines its electricity consumption. The electricity replenishment is determined by the layout of charging facilities and battery capacity, and there is also a mutual influence relationship between them. Therefore, the layout of charging facilities, battery capacity of BEBs, and BEB scheduling are closely related. Some articles have optimized these three aspects in the scenario of terminal charging[22-23], but there is currently no research considering charging at intermediate stops. Thus, to minimize the electrification cost of public transportation companies, we choose the bow-type fast charger as the charging facility and establish a mixed integer programming model to jointly optimize the location of the charging bow, battery capacity, and bus schedule for a bus line.

2 Methodology

2.1 Problem description

Let d be the running direction of a BEB route. $d = 1$ refers to the inbound trip, while $d = 0$ refers to the outbound trip. The route consists of $2N$ stops, of which $N-1$ stops belong to the inbound direction. Stop 1 and Stop $N+1$ are the terminal stations. The other stops are intermediate stops. Bow-type fast chargers can be installed at any stop to provide charging services for BEBs. There are V types of BEB batteries available for this route, and only one type will be selected to purchase. K BEBs can be deployed at most on this route under the procurement budget. One bus running from stop 1 to stop $N+1$ (inbound) or from stop $N+1$ to stop 1 (outbound) is defined as one complete trip. There are I inbound trips and J outbound trips during all-day operation time. After completing the trip in a certain direction, the BEB needs to carry out the trip in the opposite direction. It should be noted that $X_{0j} = 1$ represents trip j is the first trip carried out by the BEB, and $X_{i0} = 1$ represents that the BEB finishes the operation of the day after carrying out trip i. Figure 1 is a schematic diagram of the described line.

During operation hours, BEBs can be charged at the intermediate stops when serving passengers. It can also be charged at terminal stations by using the departure interval. During non-operation hours, BEBs will return to the bus depots to get fully charged. To ensure the normal operation of BEBs, the state of charge (SOC) value of the bus battery cannot be lower than a minimum value $SOC_{\min}$[24]. The following part will only focus on the inbound direction. The rule is also applicable to the outbound direction. Schematic diagram of the described line is shown in Figure 1, the variables and parameters in the model are shown in Table 1.

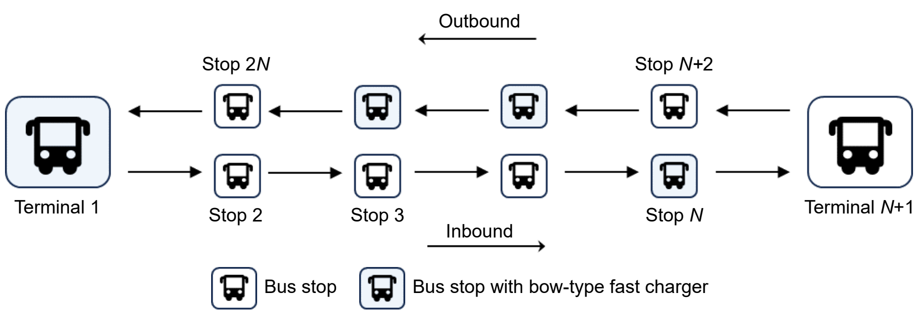

Fig. 1 Schematic diagram of the described line

Table 1 Notation

Parameters	$N = \{n\}$	Bus stop set, where n represents the stop number
	$V = \{v\}$	Set of battery types available for BEBs, where v represents the battery type index
	$I = \{i\}$	Inbound trip set, where i represents the inbound trip number
	$J = \{j\}$	Outbound trip set, where j represents the outbound trip number
	C	The construction cost of a bow-type fast charger (CNY)
	C_v^{b}	The purchase cost of a BEB with battery type v (CNY)
	C^{p}	The waiting cost per passenger per second (CNY)
	M	A sufficiently large number
	Z_v	The battery capacity of battery type v (kW·h)
	P	The charging power of the bow-type fast charger (kW)
	$SOC_{\min}$	The minimum state of charge (SOC) of the battery
	$t_{\min}^{\mathrm{c}}$	The minimum charging time at the intermediate stops (s)

Continued Table 1

Parameters	T_i^{s}	The departure time specified in the bus timetable of BEB in the trip i
	t_i	The travel time of trip i (min)
	$t_{n,i}^{p}$	Time to service passengers of the BEB at stop n if it carries out trip i (s)
	$p_{n,i}$	The number of passengers on the bus after the BEB serving i at stop n
Decision Variable	s_v	Binary variable, $s_v = 1$ if the battery type v is selected and $s_v = 0$ otherwise
	b_n	Binary variable, $b_n = 1$ if the bow-type fast charger is installed at the stop n, and $b_n = 0$ otherwise
	X_{ij}	Binary variable, $X_{ij} = 1$ if the BEB carries out the trip j after the trip i and $X_{ij} = 1$ otherwise
Other Variable	$y_{n,i}$	Binary variable, $y_{n,i} = 1$ if the BEB charges at the stop n when it carries out an inbound trip i and $y_{n,i} = 0$ otherwise
	$\hat{K}$	The number of BEBs utilized for operation
	$\hat{w}_{n,n+1,i}$	Estimated trip energy consumption for a BEB running from stop n to stop $n+1$ in trip i (kW·h)
	$e_{n,i}^{a}$	The remaining power of the BEB when it arrives at stop n if it carries out an inbound trip i (kW·h)
	$e_{n,i}^{d}$	The remaining power of the BEB when it leaves stop n if it carries out an inbound trip i (kW·h)
	$t_{n,i}^{c}$	Charging time of the BEB at stop n if it carries out trip i (s)
	$T_{n,i}^{a}$	The arrival time of the BEB at stop n if it carries out trip i
	$t_{n,i}^{w}$	The additional waiting time of passengers at stop n if the BEB carries out trip i (s)

2.2 Energy consumption estimation

Vehicle curb weight determines the driving force and the trip energy consumption[25]. Battery weight is an important component of the BEB curb weight and is affected by battery capacity. To describe the influence of battery capacity on BEBs' trip energy consumption, we adopt a multiple regression-based method in exiting studies[26]. In this method, line length, curb weight, travel time, and ambient temperature are considered. The BEB trip energy consumption consists of two parts, one is the traction and battery thermal management system energy consumption which exists in every trip, and the other is the air conditioning system energy consumption which is determined according to the actual operation situation.

2.3 Joint optimization model

The optimization goal of the model is to minimize the total costs consisting of the construction cost of bow-type fast chargers, and the purchase cost of BEBs.

$$\min Z = \sum_{n=1}^{2N} b_n C + \sum_{v=1}^{V} s_v C_v^{b} \hat{K} \tag{1}$$

To ensure the normal operation of BEBs, we need to pay attention to the battery energy change of BEBs at each stop. Equation (2) assigns an initial value to the battery energy of the first trip. Equation (3) calculates the battery energy change between two adjacent stops. Equation (4) calculates the battery energy change at the same stops. Equation (5) indicates that the remaining energy of BEB when departing from the terminal stop of an inbound trip is equal to the remaining energy of BEB when arriving at the first stop of the following outbound trip. Equation (6) requires that the SOC of BEBs' battery cannot be lower than the minimum limit value. Equation (7) requires that the remaining energy of BEB cannot exceed the battery capacity.

$$\sum_{v=1}^{V} Z_v s_v - M(1-X_{0i}) \leqslant e_{1,i}^{d} \leqslant \sum_{v=1}^{V} Z_v s_v + M(1-X_{0i}), \forall i, \tag{2}$$

$$e_{n+1,i}^{a} = e_{n,i}^{d} - \hat{w}_{n,n+1,i},\ \forall i, n \neq N+1, \tag{3}$$

$$e_{n,i}^{d} = e_{n,i}^{a} + \frac{t_{n,i}^{c} P}{3{,}600},\ \forall i, n. \tag{4}$$

$$e_{N+1,i}^{d} - M(1-X_{ij}) \leqslant e_{N+2,j}^{d} \leqslant e_{N+1,i}^{d} + M(1-X_{ij}),\ \forall i, j, \tag{5}$$

$$e_{n,i}^{a} \geqslant \mathrm{SOC}_{\min} \sum_{v=1}^{V} Z_v s_v,\ \forall k, i, n, \tag{6}$$

$$e_{n,i}^{\mathrm{d}} \leqslant \sum_{v=1}^{V} Z_v s_v,\ \forall k,i,n. \tag{7}$$

For charging time, it is necessary to limit its maximum and minimum values. Equation (8) requires that the charging time of the BEB at each stop exists only if a bow-type fast charger is installed. Considering the operational feasibility of the charging bows, Equations (9) and (10) require that the charging time at the intermediate stops cannot be lower than a minimum limit value. Equations (11) requires that the charging time at the intermediate stops cannot exceed the service time for passengers boarding and alighting.

$$t_{n,i}^{\mathrm{c}} \leqslant b_n M,\ \forall i,n, \tag{8}$$

$$-M(1-y_{n,i}) \leqslant t_{n,i}^{\mathrm{p}} - t_{\min}^{\mathrm{c}} \leqslant y_{n,i} M,\ \forall i, n=2,\cdots,N, \tag{9}$$

$$t_{n,i}^{\mathrm{c}} \leqslant y_{n,i} M,\ \forall i, n=2,\cdots,N, \tag{10}$$

$$t_{n,i}^{\mathrm{c}} \leqslant t_{n,i}^{\mathrm{p}},\ \forall i, n=2,\cdots,N. \tag{11}$$

To optimize the bus schedule, we need to determine the time when BEBs complete the current trip. Equations (12) calculates the BEBs' arrival time at the terminal stop, which is equal to the sum of the departure time at the starting stop and the travel time. Equations (13) prevents the queuing of BEBs from adjacent trips at the same terminal stop. It requires that the departure time at the terminal stop of the current trip should not exceed the arrival time of the next trip.

$$T_{N+1,i}^{\mathrm{a}} = T_i^{\mathrm{s}} + t_i, \forall i, \tag{12}$$

$$T_{N+1,i}^{\mathrm{a}} + \frac{t_{N+1,i}^{\mathrm{c}}}{60} \leqslant T_{N+1,i+1}^{\mathrm{a}},\ \forall i \neq I\,. \tag{13}$$

The following are the constraints related to bus scheduling. Equations (14) and (15) ensure that each trip can only be carried out by one BEB at one time. Equations (16) and (17) are trip flow conservation constraints. Equation (18) enables the sum of the BEBs' arrival time at the starting stop and the charging time should be less than or equal to the departure time specified in the timetable. Equation (19) calculates the number of BEBs actually in operation. Equation (20) requires that the utilized BEBs cannot exceed the maximum number available. Equation (21) restricts that only one type of battery capacity can be selected for the BEB line.

$$\sum_{i=0}^{I} X_{ij} = 1,\ \forall j, \tag{14}$$

$$\sum_{j=0}^{J} X_{ij} = 1,\ \forall i, \tag{15}$$

$$\sum_{i=0}^{I} X_{ji} = \sum_{i=0}^{I} X_{ij},\ \forall j, \tag{16}$$

$$\sum_{j=0}^{J} X_{ij} = \sum_{j=0}^{J} X_{ji},\ \forall i, \tag{17}$$

$$-M(1-X_{ij}) \leqslant T_j^{\mathrm{s}} - T_{N+1,i}^{\mathrm{a}} - \frac{t_{N+1,i}^{\mathrm{c}}}{60},\ \forall i,j, \tag{18}$$

$$\hat{K} = \sum_{k=i}^{I} X_{0i} + \sum_{k=j}^{J} X_{0j}, \tag{19}$$

$$\hat{K} \leqslant K, \tag{20}$$

$$\sum_{v=1}^{V} s_v = 1. \tag{21}$$

3 Results and discussion

3.1 Numerical example

To verify the performance of the model, we take an actual BEB line in Meihekou city, Jilin Province, China as an example. Line 108 of Meihekou is 8.5 km long and has two-way 48 stops in total. In this paper, we define Leibang Mansion Station to Building Materials City Station as the inbound trip. Figure 2 shows the satellite map of the line. The maximum number of BEBs that can be used is 14. There are a total of 170 trips, including 85 inbound trips and 85 outbound trips. The departure time of the first trip is 6:30, and the departure time of the last trip is 17:30. The departure intervals between trips are 5 or

Fig. 2 Satellite map of the line 108

10 min. In all trips, there is no energy consumption of the air conditioning system. There are 5 types of batteries available for BEBs, and their battery capacities are 30 kW·h, 45 kW·h, 60 kW·h, 75 kW·h, and 90 kW·h. The charging power of bow-type fast chargers is 360 kW, and SOC_{min} is 0.2. The operation data of all BEBs on a certain working day is selected as the input, and the proposed model is solved by the optimization software Gurobi.

3.2 Result analysis

The construction cost of bow-type fast chargers and the purchase cost of BEBs affect the selection results of the model. Since the bow-type fast charger is a new charging facility in recent years, the construction cost of it is still expensive and higher than the purchase cost of BEBs. When the cost structure is as follows, the model will only build the bow-type fast chargers at terminals and select the 75 kW·h battery. However, with the development of technology, the construction cost of the bow-type fast charger will continue to decrease. When the construction cost is lower than the purchase cost of BEBs, the model will also choose to build the bow-type fast charger at the intermediate stops and select a smaller capacity battery. Since this paper is dedicated to studying the impact of charging at intermediate stops on the operation of BEBs, the construction cost of bow-type fast chargers is set lower than the purchase cost of BEBs, and the results are as follows.

The optimization results show that the model chooses to build bow-type fast chargers at two bus terminals, as well as two intermediate stops which is the stop 12 and stop 38. The number of BEBs put into operation is 12, and a battery capacity of 45 kW·h is selected. Figure 3 shows the average charging time of all BEBs at each intermediate stop with bow-type fast chargers. The unused time is the service time of intermediate stops that is unused for charging. It can be seen that the utilization rate of service time at each intermediate stop is above 90%. BEBs can make full use of the dwell time to charge which will not cause delays or change the bus schedule. Setting the charging bows at intermediate stops can reduce the influence of BEBs' charging on the bus schedule. The charging frequency of BEBs at each stop are affected by the length of the service time. That means a shorter service time of the stop will lead to lower charging frequency.

Figure 4 shows the daily total energy consumption and total charging electricity of each BEB. Figure 5 shows the number of trips, the average charging frequency at intermediate stops, and the terminal stations for each BEB. It can be seen that when the BEB performs more trips, the total energy consumption and the total charging electricity increase. The total number of trips performed by each BEB is in the range of 12-17, which shows that the model can avoid large differences in the use intensity of BEBs. The charging frequency at the ter-

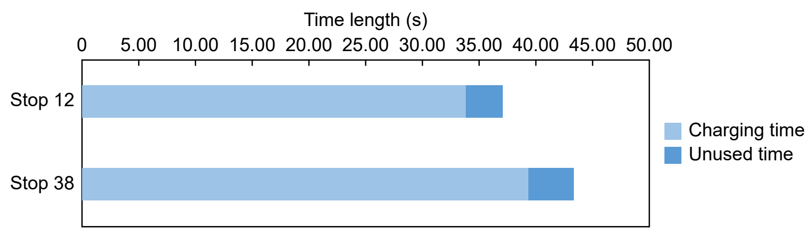

Fig. 3 The average charging time of all BEBs at intermediate stops with bow-type fast chargers

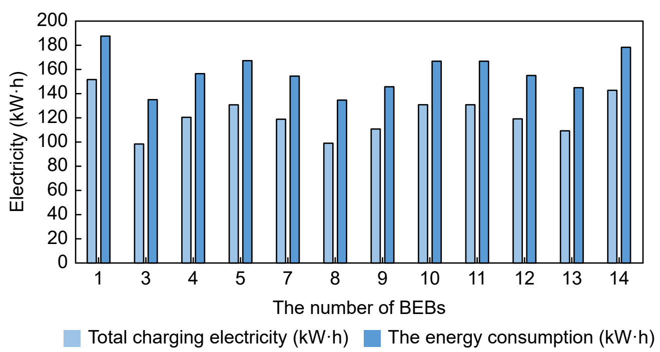

Fig. 4 The daily total energy consumption and total charging electricity of each BEB

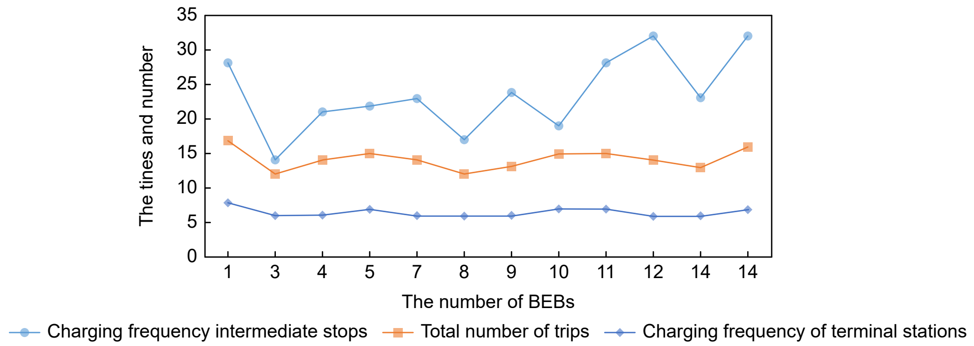

Fig. 5 The number of trips and the average charging frequency for each BEB

minal station affect the total number of trips. This is because the charging time at the terminal station will directly affect the time when the BEB can carry out the next trip. The charging frequency of each BEB at the terminal station is much less than that at intermediate stops. This is because the average charging time of BEBs at the terminal station is 150 s, and BEBs are almost fully charged with one single charge. However, the maximum allowable charging time of BEBs at the intermediate stops is only 43 s, and BEBs need multiple and short-time charging to ensure normal operation. The charging at intermediate stops will not cause extra waiting time for BEBs. Thus, the high charging frequency of intermediate stops will help to coordinate the charging schedule with the bus schedule.

3.3 Sensitivity analysis

We carry out a sensitivity analysis on the charging power of charging bows, the minimum value of SOC, and the departure interval in the timetable. The optimization costs of different scenarios are shown in Figure 6. It can be seen that high charging power will increase charging efficiency, which can reduce the number of charging bows and BEBs, but the cost will not reduce when the power exceeds 360 kW. Therefore, high charging power is the advantage of the bow-type fast charger, but it makes no sense to increase power blindly. With the increase of SOC_{min}, the charging demand of BEBs increases. That leads to increase in the number of charging bows and BEBs. The SOC_{min} affects the battery state which determines the battery aging and damage. Bus companies need to make a trade-off between long-range battery maintenance costs and line construction costs. With the increase of the departure interval, the number of charging bows declines. This is because BEBs can have more charging time at the terminal stations and will not delay the departure time of the next trip, so the intermediate stops do not need to build charging bows. However, the loose scheduling scheme will reduce service efficiency.

We also analyze the influence of the travel time randomness on the model. The cost is shown in Figure 6. The result shows that the model chooses to equip the line with one more BEB after adding random disturbance factors. The number of charging bows did not increase, but their setting position was changed. Therefore, random disturbance factors will affect the optimization res-

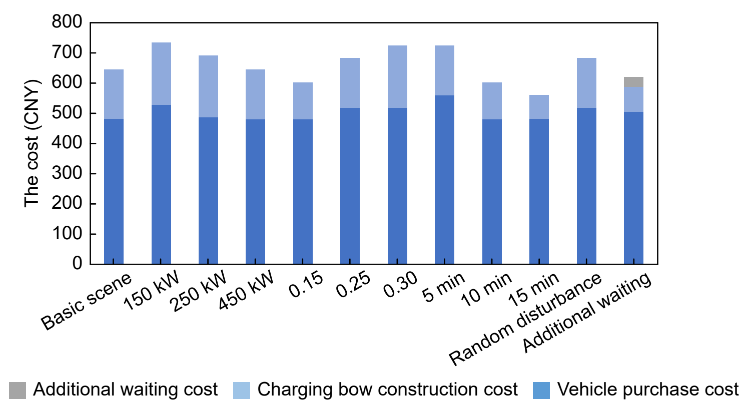

Fig. 6 The optimization costs of different scenarios

ult. This represents that the instability of traffic flow in the real environment will have an impact on the facility layout and bus schedule. Finally, we consider the expansion of the model function in the special situation. Due to technical and functional characteristics, the charging bow can be set at intermediate stops. However, the charging time is limited by the service time of intermediate stops in the basic scene. If the time limit is not considered, BEBs can supplement more electricity at intermediate stops and the battery capacity can be further reduced. When the charging time exceeds the service time, passengers will have extra waiting time and the additional waiting cost needs to be considered in the model. Therefore, we modify the original objective function as shown in Equation (22), and we calculate the extra waiting time for passengers as shown in Equation (23). The passengers' waiting costs are calculated as the city's per capita annual income divided by the total number of days in the year.

The modified model cost is shown in Figure 6. The results show that the model chooses to equip all BEBs with the smallest batteries. The number of charging bows is reduced and the average charging time of BEBs at the intermediate station increases. Passengers will have additional waiting costs, but the total cost is less than the basic scenario. However, if the charging time exceeds the service time, the BEBs will be delayed, which will affect the bus schedule and increase the number of BEBs in operation. Therefore, if the extra waiting cost for passengers is reasonable, the bus company can consider allowing passengers to have extra waiting time to reduce the total cost of the line.

$$\min Z = \sum_{n=1}^{N} b_n C + \sum_{v=1}^{V} s_v C_v^{\mathrm{b}} \hat{K} + \sum_{i=1}^{I} \sum_{n=2}^{N} t_{n,i}^{\mathrm{w}} p_{n,i} C^{\mathrm{p}} + \sum_{j=1}^{J} \sum_{n=N+2}^{2N} t_{n,j}^{w} p_{n,j} C^{\mathrm{p}}, \tag{22}$$

$$t_{n,i}^{\mathrm{w}} = \begin{cases} t_{n,i}^{\mathrm{c}} - t_{n,i}^{\mathrm{p}} & t_{n,i}^{\mathrm{c}} > t_{n,i}^{\mathrm{p}} \\ 0 & t_{n,i}^{\mathrm{c}} \leqslant t_{n,i}^{\mathrm{p}} \end{cases}, \forall i, n = 2, 3, \cdots, N. \tag{23}$$

4 Conclusions

This paper establishes a model to jointly optimize the position of bow-type fast chargers, BEB battery capacity, and bus schedule for one bus line. The result shows that the model can provide a low-cost electrification plan of BEBs for the bus line. At the intermediate stops, BEBs can use the service time to charge and reduce the time used for charging alone, which can improve charging efficiency and make the operation of BEBs more similar to that of diesel buses. At the terminal station, BEBs can get longer charging time, but may delay the departure time of the next trip and affect the bus schedule. Due to the high charging power and special position of the charging bow, the model can select a smaller-capacity battery for BEBs. Sensitivity analysis results show that higher charging power, lower $SOC_{\min}$ and larger departure interval are beneficial to reducing total cost. For the special scene, when the extra waiting cost of passengers is reasonable, passengers can be allowed to have extra waiting time to save total cost. This paper provides a new idea for the layout of new-type charging facilities and the selection of battery capacity. The influence of charging on the bus schedule is considered and the paper is committed to reducing the adverse effects of BEBs' charging on the application. However, the joint optimization model only optimizes one bus line, but not the whole bus network. In the future, the research scope will be expanded, and the practicability and integrity of the research will be improved.

Declaration of competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

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