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Abstract: In order to shorten the charging queue time and average charging distance, the paper designs a new energy charging pile installation layout method based on terminal load demand fusion processing. First, combined with the number of new energy vehicles and battery parameters, the terminal load demand is integrated, and the additional installation demand is calculated according to the charging power of the charging pile. Then, with the goal of the shortest charging queue time, the shortest average charging distance and the lowest running cost, the installation layout model is constructed. Finally, the sparrow search algorithm is introduced to obtain the optimal location of individual sparrows, and the optimal installation layout scheme is obtained. After applying this method, the queuing time of the user for charging is less than 25 min, and the maximum average charging distance of the user to drive is only 0.86 km, indicating that the method is effective.

Keywords: new energy vehicles; charging pile; charging power; retrofitting demand; charging queue time; charging distance; sparrow search algorithm.

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1 Introduction

New energy charging pile refers to the equipment and devices that provide charging services for new energy vehicles, which are usually installed in public places such as public buildings, parking lots, shopping malls, charging stations for operating vehicles, and private places such as residential areas (Qie et al., 2023). The new energy charging pile is the infrastructure for the popularisation and development of new energy vehicles, which provides reliable charging services for new energy vehicles, guarantees the normal operation of new energy vehicles, and is of great significance for promoting the popularisation and development of new energy vehicles.

With the continuous expansion of the new energy vehicle market, the demand for charging piles is also growing (Arzu et al., 2022). Reasonable layout of charging piles can not only meet the charging needs of new energy vehicle users, improve the utilisation rate of charging facilities, but also promote the popularisation and application of new energy vehicles, and promote the development of urban transportation in the green, low-carbon and sustainable direction. Therefore, it is of great practical significance to design a scientific and reasonable charging pile installation layout method (Wang et al., 2022).

The scientific and reasonable installation layout can not only make the charging pile evenly distributed, cover more areas, and provide users with more convenient charging services, but also predict the market demand, ensure that the number and distribution of charging piles meet the actual charging needs of users, avoid the imbalance between supply and demand leading to charging congestion or insufficient situation, and improve the efficiency and convenience of urban traffic (Mortimer et al., 2022). Secondly, by studying the installation layout, the maximum resource utilisation efficiency can be achieved under limited resources, avoiding resource waste and reducing the construction cost of charging facilities.

Therefore, an EV charging pile layout method based on particle swarm simulation is designed in Liu et al. (2021a). Taking the total toll station construction cost as the objective function, the method is divided into three levels, and MIP is used for conditional constraints, and an improved particle swarm optimisation algorithm is used to simulate electric vehicles by generating demand points in the area, and the optimal position of the charging pile is obtained. Yao et al. (2023) designed a charging facility layout optimisation method using multi-source data. This method comprehensively analyses the data such as user demand location and charging demand preference, and constructs the two-layer layout model of charging pile by collecting these data from multiple sources. Among them, the upper layer of the model takes the running cost of the charging pile as the objective function to achieve the best setting position of the charging pile, and the lower layer of the model takes the charging time and the waiting time of the

charging queue as constraints to achieve the best choice of the user. On this basis, the optimal selection of genetic algorithm is used to solve the two-layer model, and the best result of charging pile layout is obtained. In Wang and Gao (2023), based on the optimised particle swarm optimisation algorithm, a layout optimisation method of fast and slow charging station is designed. Firstly, the inertia weight factor and scaling factor of particle swarm in the iterative updating process are optimised to improve the optimisation performance of particle swarm, and the elite selection algorithm is added in the optimisation process to increase the scope of optimisation. After that, according to the optimised algorithm, the lowest charging pile layout cost and the highest charging efficiency are taken as multi-objectives, and the fast and slow charging pile layout is realised by solving the algorithm.

However, in practical applications, it is found that after the application of the traditional method, the user's charging queue time is longer, the average charging distance is longer, and the actual application performance is not good. The installation layout of new energy charging piles is a complex issue involving many factors, which needs to consider the traffic situation and demand of different cities, power supply and supporting facilities, charging standards and technical requirements, and the cooperation of relevant enterprises in the industrial chain (Fan et al., 2023). Therefore, in view of the shortcomings of traditional methods, this study designed a new layout method for the installation of new energy charging piles on the basis of fusion treatment of terminal load demand. The main design ideas are as follows:

- 1 According to the initial charging time and charging state, calculate the total charging power of the new energy charging pile.
- 2 After estimating the number of new energy vehicles, according to the vehicle battery capacity parameters, the load demand of the charging terminal is integrated, and the total charging power calculated in step 1 is calculated.
- 3 Aiming at the shortest charging queue time, the shortest average charging distance and the lowest operating cost, the new energy charging pile installation layout model is constructed, and the installation demand obtained in Step 2 and the demand satisfaction rate of charging pile are taken as the constraint conditions of the model.
- 4 The sparrow search algorithm is introduced to obtain the optimal scheme of the new energy charging pile installation layout model by iteratively updating the optimal position of individual sparrows.

2 New energy charging pile installation layout method design

2.1 Calculation of electric load of new energy charging pile

According to the charging power of the new energy charging pile, it can be divided into three levels, which are:

- a low power slow charging pile s_1
- b medium power slow charging pile s_2
- c high power fast charging pile s_3 .

After determining the initial charging time and initial state of charge, the total charging power of the new energy charging pile is calculated using the following formula:

$$P_i = \sum_{i=1}^n (s_{1i} + s_{2i} + s_{3i}) \quad (1)$$

In formula (1), P_i represents the total power of new energy charging piles, i represents the serial number of new energy charging piles, and n represents the total number of new energy charging piles. According to the calculation results of formula (1), the power load data of new energy vehicles in the region is analysed. Calculate the electric load of charging pile according to the change law of charging power consumption, as shown in formula (2):

$$L_i = \frac{C'}{C_0} \times P_i \quad (2)$$

In formula (2), L_i represents the electric load of the charging pile, C' represents the remaining electricity in the charging pile after unit time, and C_0 represents the initial electricity of the charging pile.

2.2 *Based on the fusion processing result of terminal load demand, the additional installation demand is calculated*

In practical applications, charging piles may serve different types of new energy vehicles, and different types of vehicles may have different needs for charging power and current (Zhou et al., 2021). Therefore, in order to ensure that charging piles can meet the charging needs of various types of vehicles, it is necessary to comprehensively consider the load requirements of different charging terminals (Zhou et al., 2021). The fusion processing of terminal load demand refers to the comprehensive analysis and processing of the power load required by the terminals (i.e., charging piles) for charging new energy vehicles. To this end, after calculating the electric load of the new energy charging pile above, the load demand of different charging terminals is integrated, and the additional demand of the charging pile is calculated according to the processing results.

First of all, according to the flow value of new energy vehicles in the planned area to be distributed, the number of new energy vehicles is estimated as follows:

$$Q = Q_e + Q_0 \times p \quad (3)$$

In formula (3), Q represents the number of new energy vehicles, Q_e represents the number of foreign new energy vehicles, Q_0 represents the number of registered new energy vehicles in the planned area, and p represents the probability of foreign new energy vehicles staying in the area, which is calculated as follows:

$$p = \frac{1}{2} + \frac{1}{2} \sin \left(\frac{\pi}{d_1 - d_2} \times \frac{d_1 + d_2}{2} \right) \quad (4)$$

In formula (4), d_1 represents the average daily mileage of the vehicle, and d_2 represents the average mileage of the vehicle.

The battery capacity of different brands of new energy vehicles is different to a certain extent (Xing et al., 2024). Therefore, this study collected the battery capacity data

of several mainstream new energy vehicles to analyse the load demand of charging terminals, and determined the relevant parameters of new energy cars and SUVs according to the battery capacity parameters of vehicles, as shown in Table 1.

Table 1 Battery parameters of new energy vehicles participating in the test

Parameter	Vehicle model	
	Car	SUV
Conversion efficiency of batteries (%)	> 92.5%	> 92.5%
Mass of the car (kg)	1,900–2,000	2,000–2,200
Windward area (m ²)	2.34	2.68
Air resistance coefficient	0.35	0.35
Acceleration power coefficient	1.2	1.2
Attachment loss (W)	895	948

Based on the data collected in Table 1, combined with the number of new energy vehicles and battery parameters, calculate the demand for charging terminals in the area. The process is as follows:

$$D = \frac{Q \times S \sqrt{\alpha^\beta \times p}}{\eta \times m} \quad (5)$$

In formula (5), D represents the terminal charging demand, m represents the body mass, S represents the windward area of the vehicle, η represents the conversion efficiency of the battery, α represents the acceleration power coefficient, and β represents the accessory loss (Zhang et al., 2023).

2.3 Construct the new energy charging pile installation layout model

In this study, the purpose of the new energy charging pile installation layout is not only to save the user's charging queue time for a long time, but also to shorten the average charging distance as much as possible, and consider the operating cost of the charging pile. Therefore, aiming at the shortest charging queue time $\min F_1$, the shortest average charging distance $\min F_2$ and the lowest running cost $\min F_3$, this study builds the new energy charging pile installation layout model as follows:

$$M = \min F_1 + \min F_2 + \min F_3 \quad (6)$$

The following is a detailed analysis of the three objective functions in the model:

1 Minimum charging queue time $\min F_1$

When the user uses the charging pile, if the queuing time is too long, it will directly affect the user experience and the efficiency of the charging pile (Yi et al., 2022). Therefore, by optimising the layout model to reduce the charging queue time, user satisfaction and the efficiency of the charging pile can be improved.

In the area to be distributed, assuming that the number of charging piles to be installed is N , the charging demand of each charging pile in the time period t is D_t ,

and the time when users arrive at the charging pile follows the Poisson distribution, the charging queue time can be expressed in the following form:

$$F_1 = \frac{D_t \times P_i}{N \times t \times (1 + \delta)} \quad (7)$$

In formula (7), δ represents the utilisation coefficient of the charging pile.

2 Minimum average charging distance $\min F_2$

The average charging distance reflects the user's convenience when using the charging pile. If the layout of the charging pile is not reasonable, the user may need to drive a long distance to reach the charging pile, which not only increases the inconvenience of the user, but also may reduce the user's willingness to use (El Halim et al., 2023). Therefore, by optimising the layout model and reducing the average charging distance, the user experience and charging efficiency can be improved.

Assume that the coordinate of the i -th charging pile is (x_i, y_i) , and the set of demand points that charging pile i can provide services is U_i , where the minimum subset number is u_i , which represents the number of demand points of charging pile i . The coordinate of the demand point j is (x_j, y_j) , then the charging distance of the user to the charging pile i is:

$$d_i = \frac{\sum_{j=1}^{U_i} \sqrt{((x_i - x_j) + (y_i - y_j))^2}}{n_c} \quad (8)$$

In formula (8), n_c represents the number of new energy vehicles in the area to be distributed. From this, the average charging distance can be calculated as follows:

$$F_2 = \frac{\sum_i^N d_i}{N} \quad (9)$$

3 Minimum operating cost $\min F_3$

Running cost is an important index to evaluate the economic benefit of charging pile. If the operating cost is too high, it may lead to a decline in the profitability of charging facilities, or even unable to maintain normal operations (Li and Pei, 2023). Therefore, by optimising the layout model and reducing operating costs, the profitability and sustainability of charging facilities can be improved. The operating cost is calculated as follows:

$$F_3 = z_1 + z_2 \quad (10)$$

In formula (10), z_1 represents the annual construction, operation and maintenance cost of charging pile, and z_2 represents the annual economic loss. The calculation methods of the two are as follows:

$$\begin{cases} z_1 = \sum_i^N \left(\frac{\bar{\mu} \times (1 + \bar{\mu}) \times y_{\max}}{\bar{\mu} \times (1 + \bar{\mu}) \times y_s - 1} \times \sigma \right) + \sum_i^N z_{yi} \\ z_2 = \sum_i^N ((z_{wi} + z_{mi} + z_{ei}) \times t_a) \end{cases} \quad (11)$$

In formula (11), $\bar{\mu}$ represents the depreciation rate of the charging pile, z_{yi} represents the annual operation and maintenance cost of the charging pile i , σ represents the construction cost of the charging pile, $y_{\max}$ represents the longest service life of the charging pile, t_a represents the driving time of electric vehicles, z_{wi} represents the time cost of the vehicle driving to the charging pile i , z_{mi} represents the time cost of the waiting process, z_{ei} represents the cost of power loss in the z_{wi} process.

On the basis of setting the above three objective functions, the installation demand and the demand satisfaction rate of charging pile obtained in Section 2.2 are taken as the constraint conditions. Among them:

- 1 The installation of demand constraints can ensure that the layout of charging piles can meet the charging demand in the future period of time, and avoid the situation of insufficient or excess supply of charging piles (Luo et al., 2022). At the same time, the installation of charging piles according to actual needs can reasonably allocate investment and avoid resource waste and poor economic benefits.
- 2 The demand satisfaction rate of charging piles refers to the ratio of the actual number of available charging piles to the number of charging piles required by users, reflecting the degree to which the layout and service capacity of charging piles meet user needs (Liu et al., 2021b). The constraint of the demand satisfaction rate of charging piles can ensure that the layout and configuration of charging piles can provide high-quality services, meet the charging needs of users, and improve user satisfaction (Yan et al., 2021). Through reasonable layout and configuration of charging piles, the utilisation efficiency of charging piles can be improved to avoid idle resources and waste.
- 3 The constraint condition of demand satisfaction rate of charging pile can be expressed in the following form:

$$\begin{cases} \lambda_i = \frac{\gamma_{i1}}{n_{i1}} \geq \chi_{\min} \\ \kappa_i = \frac{\gamma_{i2}}{n_{i2}} \geq \chi_{\min} \end{cases} \quad (12)$$

In formula (12), n_{i1} and n_{i2} respectively represent the number of electric vehicles in fast charge and slow charge demand, γ_{i1} and γ_{i2} respectively represent the number of fast charge and slow charge charging piles, λ_i and κ_i respectively represent the charging demand satisfaction rate of fast charge and slow charge and $\chi_{\min}$ represents the minimum charging demand satisfaction rate.

The above new energy charging pile installation layout mode first calculates the total charging power of the new energy charging pile, and combines the number of new energy vehicles and battery capacity parameters to integrate load demand. This processing method can ensure that the amount of charging stations installed matches the actual

charging needs, avoiding the problem of too many or too few charging stations, thereby improving resource utilisation efficiency. This layout pattern is constructed with the goal of minimising charging queue time, minimising average charging distance, and minimising operating costs. These three goals are all practical issues that users are most concerned. By optimising these goals, users can significantly improve their user experience, reduce charging costs, and improve the operational efficiency of the entire charging network.

2.4 The algorithm of sparrow search is used to solve the installation layout model

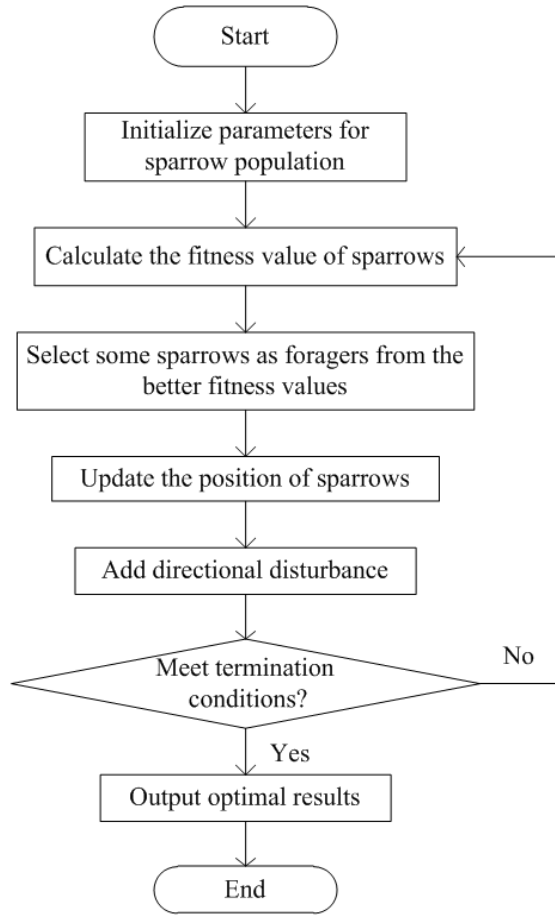
Aiming at the new energy charging pile installation layout model constructed in Section 2.3, the sparrow search algorithm is used to solve the model, and the final installation layout result can be obtained. The algorithm is an optimisation algorithm based on swarm intelligence, which seeks the optimal solution by simulating the foraging behaviour and social habits of sparrows (Zhou et al., 2024). The algorithm has the characteristics of strong global search ability, fast convergence speed and flexible parameter adjustment, and is suitable for solving various complex optimisation problems (Hu et al., 2022). The basic principle of the sparrow search algorithm is to transform the optimisation problem into a problem of finding the optimal solution in the solution space. In the layout problem of charging station installation, the algorithm first initialises a group of ‘sparrows’, each representing a possible charging station layout scheme. Then, the algorithm continuously iterates and optimises these layout schemes by simulating the behaviour of sparrows during food search, such as foraging, clustering, jumping, and evasion.

Specifically, the foraging behaviour in the algorithm means that each sparrow will, with a certain probability, choose its current optimal solution or the optimal solution of its neighbors as the next search direction to find a more suitable charging station layout. Crowding behaviour refers to sparrows considering the optimal solution of their neighbors and moving towards their positions with a certain probability, in order to jointly search for better layout solutions. Jumping behaviour allows sparrows to randomly jump within a certain distance range with a certain probability, centred around the current optimal solution, in order to increase search diversity. The avoidance behaviour is to prevent the algorithm from falling into local optima, allowing ‘sparrows’ to randomly perturb their positions with a certain probability.

By continuously iterating these behavioural strategies, the sparrow search algorithm can gradually approach the optimal charging station installation layout scheme in the solution space. When the preset stop condition is reached, the algorithm will output the currently found optimal layout solution.

The application of sparrow search algorithm in the layout method of new energy charging piles fully utilises its strong global search ability and fast convergence speed, which can quickly find high-quality solutions in complex problem spaces. At the same time, by combining or improving with other optimisation algorithms, the efficiency and performance of the algorithm can be further improved, providing more scientific and reasonable decision support for the installation and layout of new energy charging piles.

The optimal installation layout process based on the sparrow search algorithm is shown in Figure 1.

Figure 1 The flow chart of optimal installation layout based on sparrow search algorithm

As can be seen from Figure 1, this study mainly iteratively updates the optimal position of individual sparrows, so as to find the optimal solution of the new energy charging pile installation layout model. Among them, the optimal position updating process of individual sparrows is shown as follows:

$$X_{i,j}^{T+1} = \frac{r_1 \times X_{best}}{r_2 \times (1 - \omega) \times X_{i,j}^T} \quad (13)$$

In formula (13), r_1 and r_2 represent the learning factor, $X_{i,j}^T$ represents the current position of individual sparrows, X_{best} represents the historical optimal position of individual sparrows, and ω represents the inertia weight.

During the sparrow search, first, the sparrow search algorithm initialises a group of sparrows to represent different charging pile placement schemes. The position and speed of each sparrow represent a specific number of charging piles, location, power and other parameters.

Then, the algorithm evaluates the advantages and disadvantages of each layout scheme through the fitness function, which comprehensively considers the three elements of the objective function (charging queue time, average charging distance and running cost), assigns a weight to each objective, and calculates the weighted sum as the fitness value. In this way, the algorithm is able to optimise all three objectives at the same time, not just one of them. In the iterative process of the algorithm, the position and speed of each sparrow will be updated according to certain rules. These rules usually include strategies such as individual search, group search, and random search, and are designed to balance the ability of local search and global search. Through continuous iterative updating, the sparrow population will gradually approach the optimal solution.

On this basis, the algorithm considers the influence of constraints when updating the sparrow position and speed. For example, the requirement constraint requires the algorithm to keep the number of charging piles reasonable during the search process and avoid too many or too few additions. The constraint on the requirement satisfaction rate of charging piles requires the algorithm to ensure that the layout of charging piles can meet the charging needs of users and avoid insufficient or excess service capacity.

Finally, when the algorithm reaches the maximum number of iterations, the final layout of the charging pile will be output. The result will be an optimal layout scheme based on the consideration of multiple objectives such as the shortest charging queue time, the shortest average charging distance and the lowest running cost under the premise of meeting the constraints.

The above process selects some sparrows as foragers from the individual sparrows with high fitness value, updates the position of the sparrow population, and stops the iterative operation of the algorithm by judging whether the current state reaches the best state. At this time, the optimal output value of the algorithm is the optimal solution of the objective function, and the optimal processing of the installation layout of the new energy charging pile can be completed by taking the optimal solution as the goal.

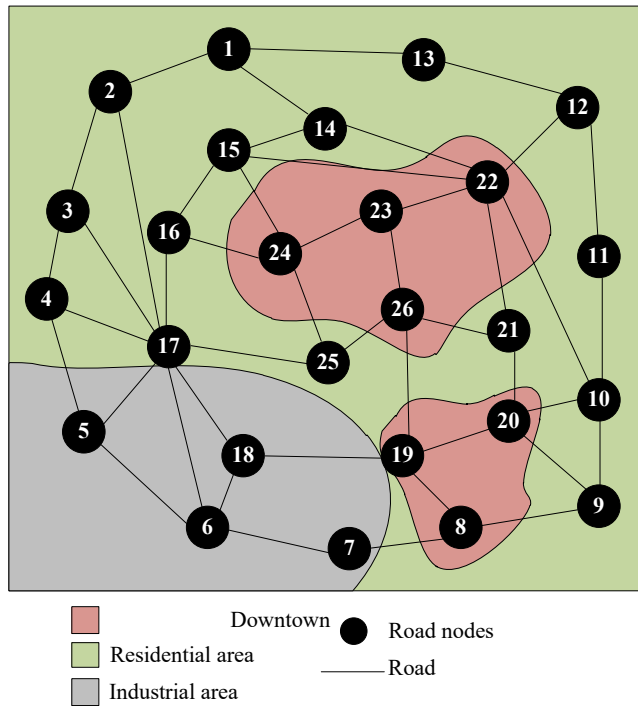
3 Experiment and result analysis

In order to verify the application effect of the new energy charging pile installation layout method based on terminal load demand fusion processing designed above in practical work, the following experiments are designed. In order to enhance the contrast of the experiment, method of Liu et al. (2021b) and method of Yao et al. (2023) were used as controls respectively.

3.1 Experimental design and environment

The experiment takes the main road in city M as the planning area, which involves three main parts: residential area, commercial area and industrial area. The method of this paper is used to install new energy charging piles in this area. The schematic diagram of the main road in area M is shown in Figure 2.

In region M, there are 26 road nodes and 45 roads. Charging piles in the area need to provide charging services for more than 5,000 new energy vehicles. Charging piles in the area are divided into two specifications: fast charging and slow charging. Relevant parameters are shown in Table 2.

Figure 2 Diagram of the main road in the area to be laid out (see online version for colours)**Table 2** Related parameters of charging piles in the area

<i>Parameters of charging stations</i>	<i>Fast charging</i>	<i>Slow charging</i>
Single charging station price / yuan	7,895	3,570
Charging time / min	50	150
Service life / year	10	10
Discount rate / %	5.0	4.2
Charging power / kW	38	5
Charging method	DC charging	AC charging

In the process of experiment, the application performance of different methods is verified by taking the queuing time and the average charging distance of users as indicators. Among them:

The queuing time refers to the time that the user needs to wait before arriving at the charging pile. In the peak period of charging demand, if the number of charging piles is insufficient or the location layout is unreasonable, the user will queue for a long time, affecting the user experience and charging efficiency. Therefore, when evaluating the application performance of the installation layout method, it is necessary to consider whether the layout of charging piles can effectively reduce the queuing time of users.

The average charging distance refers to the average distance that the user needs to travel when using the charging pile. The charging pile with reasonable layout can better meet the charging needs of users, reduce the driving distance of users, and improve the

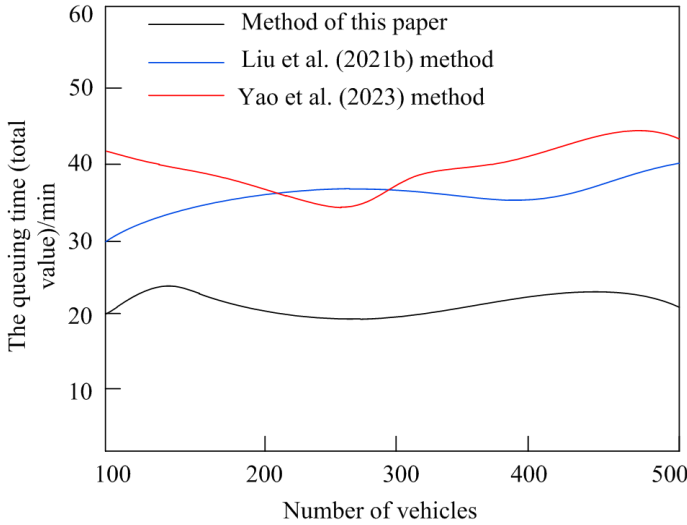
charging efficiency. If the charging pile is not evenly distributed or far away from the user, the user may need to spend longer time and mileage in the process of finding the charging pile, which reduces the availability and charging efficiency of the system.

In order to reduce the experimental error, the experiment should be carried out several times, and the vehicle information set for different methods in each round of experiment should be completely consistent with the new energy charging pile parameters, regional information and other data. The average value of multiple experimental results should be taken as the final result for horizontal comparative analysis.

3.2 Result analysis

After applying different methods, the queuing time required by users to charge is calculated, and the result is shown in Figure 3.

Figure 3 Statistical result of user charging queue time (see online version for colours)



According to the analysis of the results shown in Figure 3, when the number of new energy vehicles to be charged changes, after the application of the method of this paper, the user's queuing time for charging is relatively small, which is never more than 25 min in numerical terms. However, after the application of the Liu et al. (2021b) and Yao et al. (2023) methods, The maximum waiting time for charging is 39 min and 44 min respectively. It can be seen that the method of this paper can more effectively save the user's charging queue time. This is because the method of this paper can accurately calculate the load demand of charging terminals and determine the installation demand of charging piles by integrating the ownership and battery capacity parameters of new energy vehicles. This practical demand based calculation method ensures that the layout and quantity of charging stations match the user's charging needs, avoiding situations where there are too many or too few charging stations, thereby reducing the waiting time for users to queue due to insufficient charging stations.

After applying different methods, the average charging distance that users need to travel is calculated, and the results are shown in Table 3.

Table 3 Statistical results of the average charging distance the user needs to drive

Number of vehicles	Average charging distance/km		
	Method of this paper	Method of Liu et al. (2021b)	Method of Yao et al. (2023)
100	0.64	1.17	1.54
200	0.68	1.28	1.50
300	0.60	1.35	1.47
400	0.71	1.32	1.66
500	0.86	1.22	1.39

According to the analysis of the results shown in Table 3, under the condition that the number of new energy vehicles to be charged changes, after applying the method of this paper, the average charging distance required by the user is relatively small, and the maximum value is only 0.86 km. However, after applying the methods of Liu et al. (2021b) and Yao et al. (2023), the average charging distance required by the user is only 0.86 km. The maximum average charging distance that users need to travel is 1.35 km and 1.66 km respectively. It can be seen that the method of this paper can reduce the user's driving distance and improve the charging efficiency. This is because the method of this paper aims to construct a layout model for the installation of new energy charging piles with the goals of shortest charging queue time, shortest average charging distance, and lowest operating cost. This multi-objective optimisation method can comprehensively consider the user's charging experience and economic costs, and find the optimal charging pile layout scheme through optimisation algorithms. Under this layout scheme, the distribution of charging stations is more reasonable, and users can easily find nearby charging stations, thereby reducing the driving distance.

4 Conclusions

As the infrastructure for the popularisation and development of new energy vehicles, new energy charging piles are of great significance for promoting the healthy development of the new energy vehicle industry and achieving urban sustainable development and energy transformation. The study of the new energy charging pile installation layout method can improve the utilisation rate of charging facilities, optimise the urban transportation environment, and promote energy transformation and clean development, which has important practical significance and long-term value.

Through the new energy charging pile installation layout method based on terminal load demand fusion processing, the research successfully shortened the charging queue time and average charging distance of new energy vehicles. The method firstly calculates the total power of the charging pile, synthesises the data of new energy vehicles and the terminal load demand to obtain the demand, and then establishes a model with the goal of the shortest queuing time, the shortest charging distance and the lowest cost, and optimises the layout scheme by using the sparrow search algorithm. The experimental results show that the queuing time of users is controlled within 25 min, and the average charging distance is less than 0.86 km.

In high-density urban areas, there are numerous new energy vehicles and a high demand for charging. This method can accurately calculate the installation demand

through refined load demand fusion processing, ensuring that the layout of charging piles can meet the charging needs during peak hours. Meanwhile, by optimising the layout model, the charging queue time is reduced and the charging efficiency is improved. In low-density cities or suburbs, the number of new energy vehicles is relatively small, but the layout of charging points still needs to be planned reasonably. This method can adjust the installation demand according to actual needs, ensuring that the layout of charging piles is neither too dense nor too sparse, while considering charging distance and operating costs, providing convenient charging services.

In addition, in areas with high density of new energy vehicles, there is a high demand for charging, and there are high requirements for the layout and quantity of charging piles. This method can accurately calculate the installation demand based on the number of new energy vehicles and battery capacity parameters, and find the optimal layout plan through optimisation algorithms to meet high-density charging needs. For areas with low density of new energy vehicles, this method can flexibly adjust the layout strategy, install charging piles according to actual needs, and avoid resource waste. Meanwhile, by optimising charging distance and operating costs, we provide cost-effective charging services.

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