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The Optimal Configuration of Charging Piles for New Energy Vehicles in Shizong County: An Investigation

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The purpose of this study was 1)Based on the existing number and location of public charging piles in Shizong County, this study explores the problems existing in the configuration of public charging piles in Shizong County,2)Explore the views of residents in Shizong County on new energy vehicles, so as to determine the demand for public charging piles,3)Combined with the local traffic situation and urban development planning, explore the optimal configuration scheme of public charging piles in Shizong County, and obtain suggestions on the reasonable setting of public charging piles.This research tool is a paper survey questionnaire. A after-sales service interview survey was conducted on 250 new energy vehicle owners in Shizong County through a new energy vehicle sales terminal (4S store). Starting from the actual use scenarios of new energy vehicles, the interests of both charging station operators and new energy vehicle users were considered, including construction costs, operation and maintenance costs, network loss costs, user consumption costs, user loss costs, and land use costs, We constructed a goal programming model that minimizes the total social cost and used an improved particle swarm optimization algorithm to solve it.
The results indicate that the optimal layout plan for public charging piles for new energy vehicles in Shizong County. On the one hand, this plan demonstrates the reliability and rationality of the constructed model system theory, and on the other hand, the research results provide reference for the development decision-making of the new energy vehicle industry in Shizong County, assisting in the construction of new energy charging facilities, thereby promoting the development of the new energy vehicle industry in Shizong County, making the research both theoretical value and practical significance.

Keywords: New energy vehicles, Public charging station, optimized layout, Particle Swarm Optimization.

1. Introduction

With the continuous deepening of the "sustainable development" strategy, environmental and resource protection has become a key focus that countries are committed to maintaining. Faced with the energy crisis and environmental degradation, seeking environmentally friendly new energy has become an important issue for national development.

Electric vehicles, also known as new energy vehicles, can effectively solve problems such as oil shortages and environmental pollution by converting all electrical energy into mechanical energy through the use of electric motors to provide power for vehicles. In 2020, renowned German automotive industry expert Dudenhoff pointed out in a report from the German Automotive Research Center that due to Tesla's reasons, China may once again become the leader in the electric vehicle market by the end of this year. According to our prediction, this trend will not change in the next 50 years. Meanwhile, Dudenhoe believes that by 2025, the total number of electric vehicles in China will reach 6 million, while the European Union will still rank second.

In order to achieve rapid development in the electric vehicle industry, the Chinese government has successively introduced multiple policies. For example, in 2007, the country issued the "Regulations on the Administration of Production Access for New Energy Vehicles", which standardized the definition and industry standards of new energy vehicles; In 2014, the announcement on the new exemption stipulated that the purchase tax on energy vehicles was exempted from the purchase fee for new energy vehicles; In 2017, the Ministry of Industry and Information Technology and other departments issued the "Parallel Management Measures for Average Fuel Consumption and New Energy Vehicle Credit of Passenger Vehicle Enterprises" and the "New Energy Vehicle Carbon Quota Management Measures", indicating the promotion of the development of the new energy vehicle industry in a market-oriented manner, replacing previous financial and tax subsidies.

Despite the dual driving forces of trends and policies, there are still some problems in the development of the electric vehicle industry. For example, due to immature research technology, the scope of electric vehicles is relatively short and only suitable for daily commuting. Secondly, there are also problems such as unreasonable layout of public toll facilities, difficulty in building piles in some residential areas, non-standard operation of toll markets, and insufficient maintenance of facilities. As of the end of 2020, China had a total of 1.681 million charging infrastructure, including 807000 public charging stations, a year-on-year increase of 56.4%; The number of private charging stations (equipped with charging facilities) reached 874000, a year-on-year increase of 24.3%

2. Research objectives:

1. Based on the existing number and location of public charging piles in Shizong County, this study explores the problems existing in the configuration of public charging piles in Shizong County;

2. Explore the views of residents in Shizong County on new energy vehicles, so as to determine the demand for public charging piles;

3. Combined with the local traffic situation and urban development planning, explore the optimal configuration scheme of public charging piles in Shizong County, and obtain suggestions on the reasonable setting of public charging piles.

3. Research significance:

1. This research can provide a theoretical basis for the promotion of "carbon peaking", "carbon neutrality" and "New Energy Vehicle Industry Development Plan". The development of the new energy vehicle industry requires not only the production of a large number of new energy vehicles, but also the manufacturing of corresponding supporting equipment and the construction of corresponding supporting facilities. Due to the fact that the construction of supporting facilities and equipment is not only a matter of quantity supply, but also a problem of optimizing configuration schemes, this study focuses on optimizing infrastructure configuration, which can provide a reference for corresponding practices.

2. This study can provide valuable solutions for the problems faced in the charging process of new energy vehicles. Provide a scientific optimization plan for the planning and layout of new energy vehicle charging facilities in Shizong County, which can promote the landing and implementation of new energy vehicle charging facility projects.

3. This study will build a new mathematical model and design corresponding solving algorithms for the layout optimization problem of new energy vehicle charging stations based on existing research. Provide a specific theoretical basis for research in the field of location selection and planning of new energy vehicle charging facilities.

4. Literature review:

This study identified five relevant variables: 1) Public charging stations for new energy vehicles, 2) Location of charging stations, 3) Overview of charging station development in different countries, 4) Factors affecting the location of public charging stations, and 5) Principles of public charging station layout.

1. Public charging stations for new energy vehicles

New energy vehicles are a concept that corresponds to traditional energy vehicles. New energy vehicles refer to new structures and technologies formed using advanced automotive technologies such as unconventional automotive fuels (including natural gas, liquefied petroleum gas, methanol, ethanol, and bio liquid fuels) as power sources.

New energy vehicles are mainly divided into pure electric vehicles (BEVs), hybrid electric vehicles (HEVs), fuel cell electric vehicles (FCEVs), hydrogen powered vehicles (HPVs), etc. The biggest difference between new energy vehicles and traditional vehicles is that new energy electric vehicles mainly rely on electricity, while traditional vehicles rely on gasoline combustion for operation.

The new energy vehicle charging station is a supporting facility that provides electricity for new energy vehicles. As a fuel distributor, it can charge various types of new energy vehicles. According to the installation method, installation location, number of charging interfaces, charging method and speed, it can be divided into floor mounted charging stations, wall mounted charging stations, public charging stations, dedicated charging stations, self fusing charging stations, etc.

2. Location of charging stations

Faced with the severe situation of global shortage of traditional fossil energy supply and the deterioration of ecological environment quality caused by excessive use of energy, exploring the development of new energy vehicles has gradually become a focus of attention for the automotive industry in various countries around the world. The location selection of new energy vehicle charging stations has also become a hot topic of research for many scholars. For example, Hua C et al. [1](2014) studied a series of strategic goals and policy regulations formulated by the German government by combining EU policies, and obtained a comprehensive coordination layout strategy for charging stations. MirHassani S.A. et al.[2] (2013) analyzed the construction investment cost, operating cost, maintenance cost, and network loss cost of toll pile charging piles, adopted the planning model with the minimum total cost, and combined with the user's travel situation, determined the location and hijack of the parking lot, and constructed a mixed integer programming model to solve the layout problem of charging piles; Of course, there are also spatiotemporal models constructed using Markov chain transportation models and remote transmission methods to predict the electricity demand for charging new energy vehicles in urban centers and explore the location planning of charging facilities (Mariz B. Arias, 2017)[3]

3. Overview of charging station development in different countries

The promotion and application of new energy vehicles are mainly concentrated in the four major automotive markets of China, Europe, the United States, and Japan. This industry started early abroad and has accumulated rich experience within the industry.[4] In foreign markets, the promotion and development models of various countries have their own characteristics, and relevant models are worth learning from.

(1) United States. Actively promote the development of charging stations and adopt the following positive measures to optimize the layout of charging stations: firstly, based on the overall deployment of smart grid development, combine the construction of toll facilities network with new energy vehicle network interconnection technology; The second is to implement subsidy policies for charging facilities, advocate for enterprises, and encourage individuals to participate in the construction of charging stations together. If each charging station is built, individuals or businesses will receive different tax credits.

(2) Germany. Germany was the first technology to propose installing charging points on street lights, integrating charging devices into traditional devices to reduce charging costs. This is one of the methods that countries around the world are trying to reduce the cost of public charging facilities for new energy vehicles.

(3) France. The French government and businesses have adopted a dual approach. On the one hand, the government strongly supports and encourages enterprises to invest in the construction of toll piles through tax reduction measures; On the other hand, automotive companies are also continuing to promote the field of new energy, accelerating the construction of charging stations, and continuously expanding the coverage of charging

stations.

(4) Japan. Four well-known local car manufacturers (Toyota, Nissan, Honda, and Mitsubishi) have partnered with Japan Policy Investment Bank to establish a charging company that provides various services such as charging station installation and after-sales warranty.[5]

4. Factors affecting the location of public charging stations

The sales growth of new energy vehicles is stable and orderly, entering a new stage of development. There is an urgent need to further improve public toll facilities to meet the electricity needs of users for travel. On the basis of studying a large number of literature on the optimization of the layout of new energy vehicle public charging stations, this article summarizes that the influencing factors of the usage location of new energy public charging stations mainly include cost, user requirements, social factors, and grid factors.[6]

5. Principles of public charging station layout

Among numerous consumers, whether the number of charging stations is sufficient, whether they are convenient to use, whether costs can be reduced, and whether the location layout meets their expectations have become important decision-making factors for whether to purchase new energy vehicles.[7] Therefore, when optimizing the layout of public charging stations, the following principles should be considered:

- The principle of easy promotion and effective use
- Conforming to the principles of urban planning
- The principle of being forward-looking and able to cater to the development trend of new energy vehicles
- Practical
- Meeting actual needs

5. Research methodology:

The research design and its methods are introduced. The research design can be developed on the basis of the research objectives.

1. Population and Sample

The researchers conducted interviews and surveys with car owners who visited multiple new energy vehicle sales terminals (4S stores) in Shizong County for after-sales service between June 1 and July 30, 2023. A total of 250 valid survey questionnaires were completed; The survey mainly focuses on several dimensions such as charging time selection, charging time consumption, charging location selection, charging price, charging experience satisfaction, and charging problems faced during charging.

2. Model construction

Based on the analysis of the influencing factors and layout principles of new energy charging in the previous text, the planning and construction of new energy public charging piles should not only consider construction and operating costs, but also explore the social benefits after completion.[8][9] When optimizing the layout plan of public charging stations, this article takes into account the interests of charging station operators and users, and minimizes the total social cost, including six elements: enterprise cost and user cost (Table 1), as the objective function of the plan optimization. At the same time, land use costs were introduced because the construction of public charging stations requires a certain amount of land resources, namely land use costs. Especially due to the scarcity and preciousness of urban land resources, land use prices have been increasing year by year. Therefore, this is one of the factors that needs to be considered in this study.

The mathematical description is as follows:

$$\mathrm{minC} = \sum_{i}^{n} (C_{1i} + C_{2i} + C_{3i} + C_{4i} + C_{5i} + C_{6i} \tag{1}$$

In the formula : n is the number of public charging station stations.

Table 1 Main Cost Composition

Serial number	Character	Mean
1	C_{1i}	Represents the construction cost of public charging station i
2	C_{2i}	Represents the annual operation and maintenance cost of public charging station i
3	C_{3i}	Represents the average annual network loss cost of public charging station i
4	C_{4i}	Represents the annual charging cost of users within the service area of public charging station i
5	C_{5i}	Indicates the average annual loss cost incurred by the user during charging
6	C_{6i}	Represents the land use cost of public charging station stations

Construction cost of public charging station i:

$$C_{1i} = (e_i a + m_i b + c_i)\left(\frac{r_0(1+r_0)^z}{(1+r_0)^z - 1}\right) \tag{2}$$

In the formula : e_i is the number of transformers

a is the unit price of the transformer

m_i is the number of charging stations

b is the unit price of the charging station

c_i is the construction cost of public charging station i

Annual operation and maintenance costs for public charging station i:

$$C_{2i} = (e_i a + m_i b + c_i)\mu \tag{3}$$

In the formula : μ is the discount rate

The operation and maintenance costs of public charging station stations mainly consist of daily maintenance and repair of charging stations, depreciation costs, and labor expenses. Usually, the cost value of various expenses is not very clear. Generally speaking, the annual operation and maintenance costs of public charging station stations are calculated as a percentage of the initial input cost (i.e. considered as a discount rate).

Average annual network loss cost of public charging station i:

$$C_{3i} = e_i(c_{Fe} + c_{Cu}) \cdot T_v \cdot 365 \cdot pc + m_i(c_L + c_D) \cdot k_i \cdot T_v \cdot 365 \cdot pc \qquad (4)$$

In the formula : c_{Fe} is the iron loss rate of the transformer

c_{Cu} is the copper loss rate of the transformer

T_v is the effective daily charging time of the charging station

pc is the electricity price paid by the charging station to the power company

c_L is the loss value of each charging station in the charging station

c_D is the charging loss of a single charging station

k_i is the simultaneous rate of multiple charging stations in the charging station

The average annual charging cost of users within the service area of public charging station i:

$$C_{4i} = pQ_i \cdot 365 \qquad (5)$$

In the formula : Q_i is the daily average charging demand of users within the service area of public charging station i

p is the charging cost for the user

The average annual loss cost incurred by users during the charging process mainly considers two types of loss costs, namely the cost caused by the idle driving electricity generated by users during the charging process and the indirect loss cost .

The function is: $C_{5i} = h_1 + h_2 \qquad (6)$

Annual idle power consumption cost:

$$h_1 = \frac{\sum L_i}{g} p \cdot 365 \qquad (7)$$

In the formula : $\sum L_i$ is the comprehensive distance from all charging demand points in the service area of public charging station i to the public charging station site;

g is the unit electricity consumption of a new energy vehicle (calculated by dividing the range of the new energy vehicle by the vehicle's battery capacity, which is simplified as the distance that the vehicle can travel per kilowatt hour of electricity).

Annual indirect consumption expenses:

$$h_2 = \frac{\sum L_i}{v} k \cdot 365 \qquad (8)$$

In the formula :k is the cost of driving time for users, which can be estimated by the average wage income of residents within the layout range;

v is the average speed of new energy vehicles.

The comprehensive distance from all charging demand points within the service area of public charging station i to the public charging station site is:

$\sum L_i = \sum_{j=1}^{n_{um}} d_{ij} q_j$ (9)

In the formula : d_{ij} is the distance between charging demand point j and public charging station i;

q_j is the average number of new energy vehicles that need to be charged per day at the charging demand point j;

n_{um} is the number of charging demand points within the service area of public charging station i.

Substituting (7)(8)(9) into equation (6), after sorting, it can be concluded that:

$C_{5i} = \sum_{j=1}^{n_{um}} d_{ij} q_j (\frac{p}{g} + \frac{k}{v}) \cdot 365$ (10)

In the formula : d_{ij} is the distance from the charging demand point j to the public charging station i;

q_j is the daily average number of new energy vehicles that need to be charged at the charging demand point ;

n_{um} is the number of charging demand points in the service area of public charging station i;

p is the user's charging cost;

g is the unit electricity consumption of new energy vehicles;

k is the cost of driving time for users, which can be estimated by the average wage income of residents within the layout range;

v is the average speed of new energy vehicles.

Land use cost of public charging station sites:

$C_{6i} = \sum_{i=1}^{m_i} S_i \cdot (C_t \cdot \lambda_i)$ (11)

In the formula : S_i is the floor area of each public charging station,

C_t is the highest land use cost in the region,

λ_i is the comprehensive factor of each public charging station (including distance from the city center, location, etc.). Generally, the closer the geographical location is to the city center, the higher the cost of using the site.

The consideration of fixed capacity is mainly to determine the number of charging stations required within each public charging station. Because the traffic flow on any road segment is generally bidirectional and asymmetric, it is necessary to use the same flow direction to calculate the traffic flow density at each node of the road segment. In other words, the number of vehicle traffic flowing into or out of nodes should be uniformly used.

The charging demand for intersection node j during the T time period is:

$q_j = \int_0^T p_t^j \cdot \alpha \cdot \beta \cdot p_v d_t$ (12)

In the formula : α is the proportion of new energy vehicles;

β is the proportion of new energy vehicles that need to be charged;

p_v is the average capacity of new energy vehicles.

If there are n_i intersection nodes in the service area of public charging station , the charging requirements that should meet during the T period are:

$$Q_i = \sum_{j=1}^{n_i} q_j \qquad (13)$$

Number of charging stations to be equipped for public charging station i:

$$m_i = \left[Q_i\ (\rho + 1)\ /Pk_x + T_v k_t\right] + 1 \qquad (14)$$

In the formula : m_i is the number of charging stations to be equipped at public charging station ;

ρ is the charging capacity margin of the public charging station;

P is the charging power of a single charging station;

k_x is the efficiency of the charging station;

Formula (13) The main consideration is to meet the daily maximum flow demand in the service area of public charging station , in order to configure the number of charging stations at public charging station .

3. Research Tools

(1) Particle Swarm Optimization

This article uses an improved particle swarm optimization algorithm to solve the objective function, and uses particle swarm optimization (PSO) to optimize the objective function.[10] The introduction of particle swarm optimization algorithm is as follows:

The PSO algorithm is initialized as a group of random particles, and then the optimal solution is found through multiple iterations. During each iteration, the particle updates itself by finding its own optimal solution (referred to as individual extremum) and the current optimal solution found by the entire population (referred to as global extremum). It can also use the extremum of its own neighbor (referred to as local extremum) to update its own speed and new position.[11]

In the group bird foraging model, each individual can be seen as a particle, while the bird flock is seen as a particle swarm.Set in a D-dimensional target space, consisting of a group of m particles, where the position of the i-th particle is represented as , i.e. the position of the i-th particle in the D-dimensional search space is.[12] In other words, the position of each particle is a potential solution. By bringing into the objective function, its fitness value can be calculated, and its pros and cons can be measured based on the size of the fitness value. The best position experienced by an individual particle is denoted as , and the best position experienced by all particles in the entire population is denoted as . The velocity of particle i is denoted as.[13]

The particle swarm algorithm uses the following formula to continuously update the position of particles (unit time is 1):

$$v_i = w \cdot v_i + c_1 \cdot r_1 \cdot (p_i - x_i) + c_2 \cdot r_2 \cdot (p_g - x_i) \quad (15)$$

$$x_i = x_i + a \cdot v_i \quad (16)$$

w is a non negative number called the inertia factor

c_1 and c_2 are called acceleration constants.

c_1 is a constant that is determined based on the individual's own experience;

c_2 Based on the group's experience;

a is called a constraint factor, which aims to control the weight of speed.

The flying speed v_i of particle i is limited by a maximum velocity v_{max}. If the particle's velocity v_i in a certain dimension exceeds the maximum flying speed v_{max} of that dimension at the current time, then that dimension is limited to v_{max}.

The iteration termination condition is set according to the specific problem, usually to reach the predetermined number of iterations or the minimum allowable error of the particle swarm searching to the most favorable position that satisfies the objective function so far.

(2) Parameter selection

Parameter 1: Number of particles

The number of particles is generally between 20 and 40, and experiments have shown that for most 30 particles, it is sufficient. The more particles there are, the larger the search range, and the easier it is to find the global optimal solution, but the longer the program runs.

Parameter 2: Inertia factor

The inertia factor w plays a significant role in the convergence of particle swarm optimization algorithms. The larger the value of , the greater the flight amplitude of particles, and it is easy to miss out on local optimization ability, while the stronger the global search ability; On the contrary, the stronger the local capability, the weaker the global capability. The usual approach is to set the inertia factor higher at the beginning of the iteration and gradually reduce it during the iteration process.The value of is [0 1]. If is taken as a fixed value, it is recommended to take 0.6-0.75.

Parameter 3: Acceleration constants c_1 and c_2

In general, c_1=c_2=2.0. At present, there is significant disagreement in the academic community regarding the exact values of the acceleration constants c_1 and . Typically, c_1 is equal to and the range is between 0 and 4.

Among them, c_1 represents one's own experience; c_2 represents group experience.

Parameter 4: Maximum flying speed v_{max}

The particle swarm optimization algorithm is achieved by adjusting the distance each particle moves on each dimension during each iteration, with a random change in speed. It does not want uncontrolled particle search trajectories to be extended to increasingly wide distances in the problem space and reach infinity. If particles are to be effectively searched, the parameter v_{max} must be restricted. The parameter v_{max} helps to prevent meaningless divergence of the search range. The determination of v_{max} requires a certain prior knowledge. In order to pick out the local optimum, a larger optimization compensation is required, and it is better to use a smaller step size when approaching the optimal value. If v_{max} remains unchanged, it is usually set to 10% -20% of the variation range per dimension.

The above is the standard particle swarm optimization (PSO) algorithm.

Index	2022
Car ownership	54326
Year-on-year growth	8.7%
Fuel powered vehicle ownership	49535
Growth in fuel vehicles	9.75%
New energy vehicle ownership	4791

6. Research results:

1. Basic information

Shizong County is located in the southeast of Yunnan Province and belongs to Qujing City. It consists of Danfeng Street, Yangyue Street, Datong Street, Xiongbi Town, Kuishan Town, Caixi Town, Zhuji Town, Longqing Township, Gaoliang Township, Wulong Township, and other areas. The purchase and use of automobiles in Shizong County in 2022 are as follows:

Table 2 Purchase and Use of Automobiles in Shizong County in 2022

Index	2022
Car ownership	54326
Year-on-year growth	8.7%
Fuel powered vehicle ownership	49535
Growth in fuel vehicles	9.75%
New energy vehicle ownership	4791
Growth of new energy vehicles	54.3%

Source: Shizong County Traffic Police Detachment

In recent years, Shizong County has taken various measures to promote new energy vehicles, and the government has intensively introduced relevant policies, such as reducing the purchase tax of new energy vehicles, providing subsidies for consumers to purchase cars, and establishing green new energy special license plates. At the same time, the planning department and automobile transportation management department of Shizong County have also set up targeted distribution points for public charging stations in the urban renovation process according to local conditions. As of December 2022, there are 7 registered charging construction and operation enterprises in Shizong County, and 12 public charging stations have been built, including 4 DC charging stations and 8 AC charging stations, which can generally meet the current urban vehicle charging needs. However, due to the overly centralized or scattered layout of charging stations, the overall layout is unreasonable, resulting in an overall utilization rate of only 5.68% for public charging stations. Overall, there is still significant room for improvement in the operation of public charging stations in

Shizong County.

2. Instance solving

This article will consider and explore the reasonable layout and site selection of newly added charging stations in the local area based on the actual situation, in order to bring practical convenience to local car owners. For example, a certain charging station construction and operation company plans to install a new energy vehicle public charging station in a designated area of Shizong County urban area. The planned layout area of the charging station is 25k square meters. Within the planned construction area, there are a total of 18 road sections and 12 intersection nodes. The proportion of new energy vehicles is 8%, and the proportion of new energy vehicles that need to be charged is 20%; According to the relevant regulations of Shizong County on new energy vehicles and charging piles, the calculation parameters, intersection coordinates, and traffic flow values are shown in Table 3.

Table 3 Relevant Calculation Parameter Values

Index	Value
The power of the charging station	96kW
The average capacity of energy vehicles	50kWh/unit
Minimum capacity configuration of charging stations within the site	5 unit
Maximum capacity configuration of charging stations within the site	20 unit
Unit price of charging station	¥72500
Effective charging time of public charging stations	16 h
Charging capacity margin	20%
Charging efficiency of charging stations	0.9
Discount rate	0.8
Loss rate	0.2
Iron loss rate	0.3
Copper loss rate	0.3
Coefficient of simultaneous operation of charging stations	0.8
Operators pay electricity prices	¥1 / (kW·h)
Unit electricity consumption of new energy vehicles	7 km / (kW·h)
User pays the charging price	¥1.8 / (kW·h)
The average speed of the vehicle	32km/h
Value of user travel time	¥17/h
The service life of the charging station	10 years

(1) Location and traffic flow of 12 nodes

Table 4 Coordinates of 12 Node Positions

12 node position coordinates (X, Y)			
(1,1)	(2,1)	(3,1)	(4,1)
(1,2)	(2,2)	(3,2)	(4,2)
（1,3）	（2,3）	（3,3）	（4,3）

Table 5 Traffic Flow at 12 Node Positions

X	Y	Traffic volume	X	Y	Traffic volume	X	Ys	Traffic volume
1	1	210	1	2	116	1	3	198
2	1	270	2	2	228	2	3	192
3	1	68	3	2	186	3	3	176

4	1	84	4	2	130	4	3	95

(2) Encoding particles：

1	2	3	4	1	5
4	3	3	5	1	2

As shown in the above figure, there are 12 nodes. Assuming there are 2 public charging station stations, randomly generate 1-5 values at these 1-12 positions, and the number of each value is also random. There are 20 particles, c_1=0.5, c_2=1.49, and the maximum number of iterations is 20.

The final output result is: the location of each public charging station and the node location served by each public charging station, the number of service nodes, the cost of each part, and the total number of public charging station stations. The cost and total cost of each type of charging station:

Table 6 Cost and total cost of using POS algorithm to solve the number of charging station points（Ten thousand yuan）

N/Number of charging stations	C1	C2	C3	C4	C5	C6	Total
1	39.37	28.71	1.43	19.32	3.13	26.45	118.41
2	38.65	21.92	1.69	19.62	3.06	25.72	110.66
3	38.61	24.82	1.85	19.18	3.08	26.03	113.57

Output the location of each public charging station and the corresponding service nodes of the public charging station, as shown in Table 7:

Table 7 Location of Public Charging Station Stations and Corresponding Service Nodes

	X	Y	X	Y
Charging station location	1.4	3.4	2.2	1.3
Service nodes	1	1	2	1
	1	2	3	1
	1	3	3	2
	2	2	4	1
	2	3	4	2
	3	3	4	3

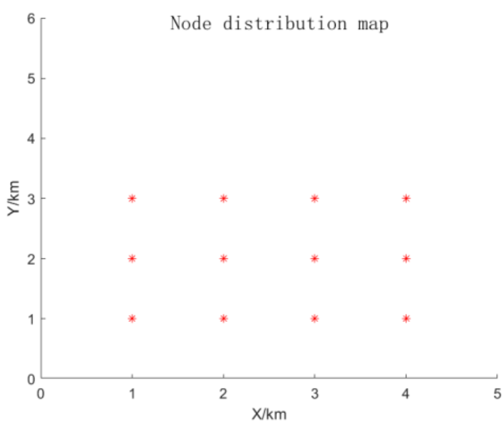


Figure 1. Node Distribution Map

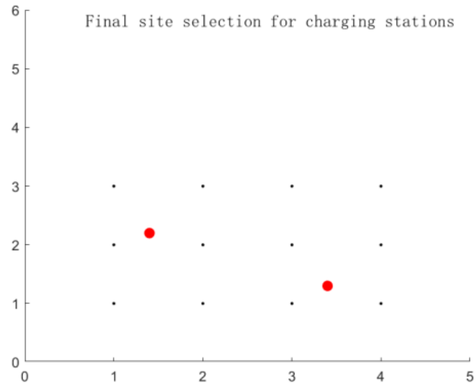
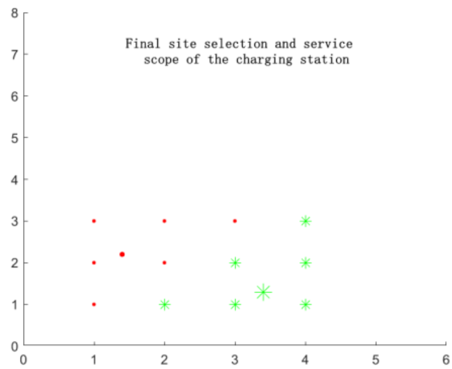


Figure 2 Final site selection for charging stations



(The same color and shape represent the nodes served by the charging station)

Figure 3 Distribution map of public charging station stations and corresponding service nodes

7. Suggestions for optimizing the layout of public charging stations:

The example shows that the proposed method and model have certain feasibility and rationality in optimizing the layout of public charging stations.[14] This provides decision-making references for optimizing the layout of charging station construction operators. Based on relevant industry standards for new energy vehicles and charging stations, and with the advancement of new energy vehicle technology, various factors such as construction investment costs, user demand for new energy vehicles, and consumption costs are fully considered to construct an optimal charging station layout model.For the optimization of the layout of the construction of new energy vehicle charging stations, on the one hand, efforts should be made to meet the various indicators of the above model. On the other hand, if we want to better improve the popularity of new energy vehicles, we also need to consider the status of the power supply network in the planning and layout area. Before implementing the planning and layout, we should actively coordinate with the power supply departments, fully utilize and play to the relevant government guidance policies, In order to continuously reduce the construction and operation costs of charging stations, and reduce the situation of unreasonable construction of charging stations, we should pursue the service quality of charging stations more finely, improve user experience and recognition, rather than pursuing the expansion of the number of charging stations, and bring tangible convenience to the travel of new energy vehicle users, better serving users.[15]

At the same time, based on the analysis of population density in various regions of Shizong County, as well as the investigation of relevant new energy vehicle users, combined with the actual situation of charging piles and new energy vehicle ownership, the following strategies for optimizing the layout of public charging piles are proposed:

Table 7 Layout Strategy of Public Charging Stations in Various Regions of Shizong County

Region	Regional scope	Regionalism	Strategys
Class I region	Datong street Longqing street Danfeng street	①High density of permanent population ②Large ownership of new energy vehicles ③Most of the residential areas have been built ④High demand for public charging ⑤High land use prices	①Comprehensive coverage ②Strengthen maintenance ③Service improvement
Class II region	Yangyue street Xiongbi Town Caiyun Town	① High density of permanent population ② Large number of new energy vehicles in stock ③ Both completed and newly built communities ④ There is a high demand for public charging ⑤ Land use prices are relatively high	① Strengthen encryption ② Accelerate layout ③ Reasonably set up points
Class III region	Zhuji Town Kuishan Town Ggaoliang Town Wulong Town	① Low permanent population density ② The ownership of new energy vehicles is relatively small ③ Most newly built communities ④ Public charging demand is relatively small ⑤ Land use prices are relatively low	① Encourage and support ② Moderate increment ③ Improve publicity

8. Conclusion:

The automotive industry is a typical technology, talent, and capital intensive industry. It is not only a traditional industry, but also an important force in achieving the upgrading and transformation of new industries. With the continuous expansion of production and sales of new energy vehicles, the demand for charging is also increasing day by day.[16] The lag of charging stations has become one of the important factors restricting the development of new energy vehicles. Therefore, it is urgent to study and analyze the problems faced by charging stations in China, explore paths to solve the problems, and propose corresponding solutions.

On the basis of organizing relevant literature and drawing on the research ideas and models of scholars, this article explores a series of issues related to the layout of charging piles that have emerged in the current development of new energy vehicles. Starting from user satisfaction, the optimal planning model theory and particle swarm optimization algorithm are introduced to explore the optimization problem of charging station layout. The main conclusion is:

(1) The flourishing development of an industry depends on many related objects. The layout issue of charging stations is no exception, as it involves multiple objects such as government, automobile manufacturers, dealers, charging station operators, users, and venue suppliers. There are also various factors that can affect layout issues. This article focuses on selecting the charging cost and idle driving cost of users, and the investment cost of building charging piles includes indicators such as electricity bills, equipment purchase fees, installation fees, and operation and maintenance fees. In the model construction, land use costs were considered, and industry standards and relevant target planning were combined. The particle swarm optimization algorithm was used for instance verification to verify the feasibility of the algorithm.

(2) On the basis of summarizing the measures taken by countries that started early in the layout of charging stations abroad, this article hopes to stimulate people's thinking on the innovation of charging facility promotion methods and models, which has reference significance. In addition, this article also studied the current situation of the automobile related industry in Shizong County, with the aim of providing reference for the common progress of other regions through local active innovation measures and development experience.

(3) This article always adheres to the principles of easy promotion, operability, and practicality throughout the entire paper, abandoning overly complex and cumbersome layout and calculation modes, providing good solutions for practical problems, and making theoretical research better serve practical needs.

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