Journal of Computing and Electronic Information Management

ISSN: 2413-1660

Study on Site Selection of Electric Vehicle Charging Station Based on Improved Matter Element

Jie Ding [1, a], Jian Guo [1, b], Yuanyuan Xiong [2, c]
[1]Inner Mongolia Power (Group)CO., LTD, Inner Mongolia

[2]Department of Business and Administration Management, North China Electric Power University, Beijing

[a]djmx_1558@163.com, [b]ljhxm_1969@yeah.com,[c]whh397611892@163.com

Abstract: Charging stations and other supporting facilities directly affect the construction and development of electric vehicles. And the location of the charging station directly affects the latter part of the operation and quality of service, it must use a scientific approach to evaluate decision making. On the basis of taking into account the multiple factors influencing the site selection of electric vehicle charging stations, this paper chooses five elements of power grid, economy, environment, transportation and planning, then constructs the evaluation index system of charging station location and adopts improved material element extension model to solve the various levels of each index, the phase of incompatible contradictions, to maximize the location system to meet the balance of the various factors, and to be satisfied with the program. Finally, an example is given to demonstrate the rationality and validity of the evaluation system and model which can provide reference for the charging station.

Keywords: Electric vehicle charging station; Improved matter element extension; Location evaluation.

1. Introduction

The large-scale development of electric vehicles plays an important roles in improving the environment, realizing "energy saving and emission reduction" and alleviating the oil energy crisis. However, one of the important factors restricting the large-scale development of electric vehicles is the lagging and imperfection in the construction of charging and switching facilities. These factors not only reduce the promotion of electric vehicles greatly, but also affect the willingness of consumers to buy seriously. Therefore, it’s of great significance for the promotion and popularization of electric vehicles to construct charging stations and other supporting facilities rapidly. At the same time, for the construction of electric vehicle charging station, the rationality of the early location directly affects the operation efficiency and service quality of the charging station in the later period. China fully attaches importance to the promotion and development of electric vehicles. Since 2015, especially, in order to encourage the rapid development of the electric vehicle industry, the relevant departments of the country have issued preferential policies such as unlimited accesses, unlimited purchases and so on. The production and sales of electric vehicles in China has become the largest new energy vehicle market in the world. Yet the scale and quantity of charging stations and charging piles in China are far from satisfying the demand of electric vehicles. In addition, there are still some problems in the construction of charging stations in China, such as inadequate standards and norms, imperfect supporting policies, poor coordination and unity, etc. Hence, it is necessary to construct a reasonable evaluation index system and scientific evaluation methods to help the government to make decisions.

In recent years, the influence and planning of electric vehicle charging station on power grid has become a hot spot in the field of distribution network development and energy saving and emission reduction technology, which has achieved important fundamental achievements. Phonrattanasak.P and Leeprechanon.N analyzed that the calculation and optimization model of the fast charging station in residential areas must obey the minimum constraints of distribution circuits and traffic conditions, which came to a conclusion that, the most preferred location for a fast charging station should ensure a minimum total cost or total loss under technical and geographical constraints [1]. Wagner Sebastian et al. studied the optimal location of smart city charging stations based on the point of interest method, and evaluated the actual charging time and the destinations of the city owners [2]. Meysam Hosseini et al. analyzed the charging station location model and queue recognition ability considering the limitation of charging station capacity, and also proposed the concepts of charging time and waiting time [3]. Liu Bailiang et al. established the electric vehicle charging station and the sizing and location of distributed power model with the lowest total cost, the lowest network loss and the highest traffic satisfaction by study the timing and complementarity of distributed power supplies [4]. Jia Long et al. studied the charging demand distribution of electric vehicles in high-speed road networks, and determined the charging station planning scheme by two-stage method [5]. Liu Liang et al. constructed a comprehensive evaluation index system considering the needs of the government, power supply companies and charging users comprehensively, and verify the rationality combining with the analytic hierarchy process and gray evaluation [6]. The location of charging facilities not only needs to consider economic factors, but also is closely related to urban planning and power grid planning. Thus, it is necessary to consider the influence of various factors on the location of charging stations from the perspective of system.

This paper synthesizes the previous research, systematically considers the impact of charging station construction on power grid, environment, urban planning, etc. It constructs the evaluation indicator system of charging station location involving in five factor layers and fifteen sub-indicators, which including power grid impact, environmental factors, economic factors, traffic factors and urban planning. Based on the improved matter element extension means, the paper evaluates and selects the location planning indicators, and applies them to specific cases to verify the practicability and rationality of the evaluation system.

2. Evaluation indicator system for electric vehicle charging station location

2.1 Construction of the indicator system

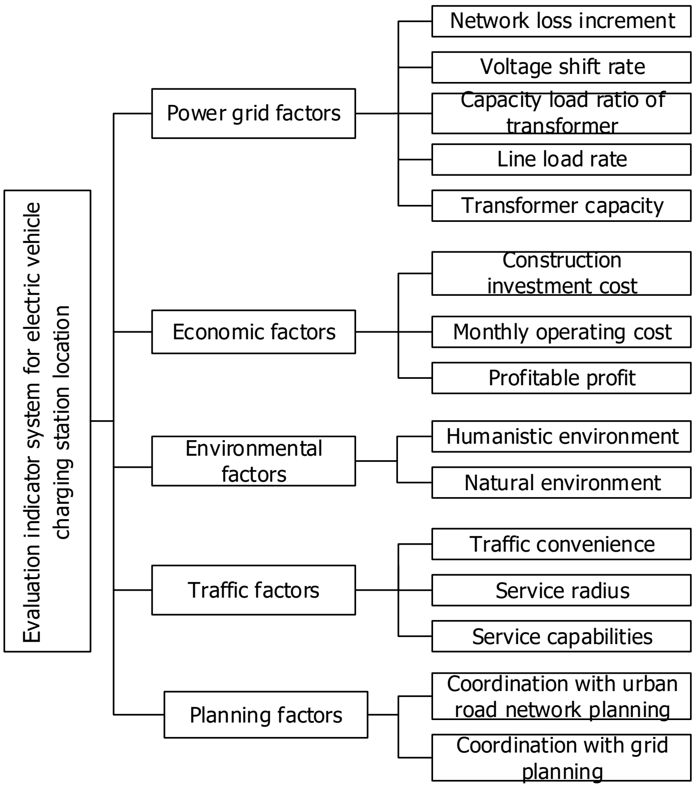

Fig.1 Location Index System of Electric Vehicle Charging Station

The evaluation index system for electric vehicle charging station has a wide range of factors and many influencing factors, so it is necessary to consider the objective differences of different location areas to make the evaluation meet the rationality and comparability [7-9]. This paper constructs the indicator system involving in five factor layers and fifteen sub-indicators, which including power grid factors, environmental factors, economic factors, traffic factors and urban planning combining with the relevant technical specifications for the construction of electric vehicle charging stations and the impact on the power grid system, urban planning system, etc., as shown in Fig.1.

2.2 Description of indicator system

Power network factors:

Network loss increment. The network loss after charging station connected increment is generally considered ;

2) Voltage shift rate. It refers to the shift rate of the 10KV bus voltage at the charging station access.

3) Capacity load ratio of transformer. The calculation formula is as follows: $R_S = \frac{S_N}{P}$, S_N refers to the transformer capacity. P refers to the actual load of transformer under typical operation mode. Generally, the higher the index value is, the smaller the proportion of load to capacity is, the less the transformer will be overloaded and the safer the voltage generator will be.

4) Line load rate. The calculation formula is as follows: $\delta = \frac{\sum_{i=1}^{n} \frac{\overline{P_i}}{S_i^N}}{n} \times 100\%$, $\overline{P_i}$ refers to the average load of line i, S_i^N refers to the maximum load capacity of line i. It mainly measures the difference degree between average load and maximum load.

5) Transformer capacity. It refers to the ability of a transformer to transmit electricity. The larger the capacity is, the stronger the power transmission capacity is.

Economic factors:

1) Construction investment cost. It mainly includes the cost of infrastructure construction and purchase of distribution facilities, etc.

2) Monthly operating cost. It includes charging station workers' wage, electricity bills, financial expenses, business taxes, battery amortization cost, etc.

3) Profitable profit. The calculation formula:

$$Monthly\ profit(I) = Monthly\ operating\ income(Z) - Monthly\ operating\ expenses(W)$$

3 Environmental factors:

1) The impact on the humanistic environment. It mainly examines whether the construction of charging station have an impact on the non-natural environment such as the original humanistic landscape.

2) The impact on the natural environment. It refers to whether the construction of the charging station affects the local environment (construction, noise, etc.).

Traffic factors:

1) Transportation convenience. It mainly investigates the traffic conditions of the main road the road conditions, the number of lanes of the road, the number of nearby intersections and the size of the intersection at the location of the charging station.
2) Service capabilities. It refers to the number of electric vehicles that can be charged by the electric vehicle charging station every day, of which includes the daily charging capacity, the maximum charging capacity of the charging station and other main factors.
3) Service radius. It refers to the distance of the chargeable area covered by the charging station, which can be calculated according to the local population density.
Planning factors:
1) Coordination with urban road network planning. It mainly considers the intersection of the city main trunk lines, the main entrance and exit roads of the city and the intersection of the highways, the important population residential areas and the main functional divisions of the urban planning.
2) Coordination with grid planning. It examines the impact of charging stations connected to the grid on the safety and reliability of power supply.

3. The matter element extension model

The matter element extension method is mainly applied in complex systems to solve the main contradictions and critical problems of the problem. According to the needs of incompatible contradictions generated at various levels and stages, it adopts the breaking through conventional and expansive methods and creative decision-making techniques, which grabs the pivotal strategy to the largest extent and satisfies the main system in an utmost way. Thus, the incompatible contradiction can be transformed into the compatible relation so as to achieve the optimal decision-making goal of global and unity.

3.1 Basic steps of matter element evaluation

The basic calculation steps of matter element evaluation:
Determination of classical domain, joint domain, and matter element.

$$R_j = \left(N_j, C_j, V_{ji}\right) = \begin{bmatrix} N_j & c_1 & v_{j1} \\ & c_2 & v_{j2} \\ & \cdots & \cdots \\ & c_n & v_{jn} \end{bmatrix} = \begin{bmatrix} N_j & c_1 & \langle a_{j1}, b_{j1} \rangle \\ & c_2 & \langle a_{j2}, b_{j2} \rangle \\ & \cdots & \cdots \\ & c_n & \langle a_{jn}, b_{jn} \rangle \end{bmatrix} \tag{1}$$

In formula (1): N_j represents the divided j levels; $c_1, c_2, \ldots c_n$ are n different characteristics of N_j; $v_{j1}, v_{j2}, \ldots v_{jn}$ are the range of N_j for $c_1, c_2, \ldots c_n$, which is classical domains.

$$R_p = \left(p, C_i, V_{pi}\right) = \begin{bmatrix} p & c_1 & v_{p1} \\ & c_2 & v_{p2} \\ & \cdots & \cdots \\ & c_n & v_{pn} \end{bmatrix} = \begin{bmatrix} N_j & c_1 & \langle a_{p1}, b_{p1} \rangle \\ & c_2 & \langle a_{p2}, b_{p2} \rangle \\ & \cdots & \cdots \\ & c_n & \langle a_{pn}, b_{pn} \rangle \end{bmatrix} \quad (2)$$

In formula (2): p indicates the total composition of the object to be evaluated; $v_{p1}, v_{p2}, \ldots v_{pn}$ are the range of p for $c_1, c_2, \ldots c_n$, which is the joint domain of p .

$$R_0 = \begin{bmatrix} p_0 & c_1 & v_1 \\ & c_2 & v_2 \\ & \cdots & \cdots \\ & c_n & v_n \end{bmatrix} \quad (3)$$

In formula (3): p_0 is the matter element to be evaluated; $v_1, v_2, \ldots v_n$ are specific data detected of p_0 for $c_1, c_2, \ldots c_n$.

Determining weight. There are many methods to determine the weight, such as Delphi method, analytic hierarchy process method [10], fuzzy comprehensive evaluation [11], etc. The choice of method directly affects the feasibility and quality of comprehensive evaluation. This paper uses the entropy weight method to determine the weight according to the characteristics of the indicators to be evaluated.

Calculating comprehensive correlation degree.

The correlation function value of each matter element to be evaluated and each indicator is calculated according to formula (4).

$$K_j\left(V_i\right) \begin{cases} \dfrac{-\rho\left(v_i, V_{ji}\right)}{\left|V_{ji}\right|} & \left(V_i \in i\right) \\ \dfrac{\rho\left(v_i, V_{ji}\right)}{\rho\left(v_i, V_{pi}\right) - \rho\left(v_i, V_{ji}\right)} & \left(V_i \notin V_{ji}\right) \end{cases} \quad (4)$$

In formula (4): $K_j\left(V_i\right)$ is the correlation function value of the indicator i for level j , $\left|V_{ji}\right|$ is the classical domain value of the indicator i for j , $\rho\left(v_i, V_{ji}\right)$ is the distance between the matter element value to be evaluated and its classical domain of i ; $\rho\left(v_i, V_{pi}\right)$ is the distance between the matter element value to be evaluated and its classical domain of i .

(4) Level evaluation.

If $K_j\left(p_0\right) = \max\left\{K_j\left(p_0\right)\right\}\left(j = 1, 2, \ldots, m\right)$, the matter element to be evaluated p_0 belongs to level j .

$$\overline{K_j}\left(p_0\right) = \frac{K_j\left(p_0\right) - \min K\left(p_0\right)}{\max K\left(p_0\right) - \min K\left(p_0\right)} \quad (5)$$

$$j^* = \frac{\Sigma_{j=1}^{m} j\overline{K_j}(p_0)}{\Sigma_{j=1}^{m} \overline{K_j}(p_0)} \tag{6}$$

In formula (6), j^* is the risk level variable eigenvalues of p_0 .According to the size of the value, the degree to which the matter element to be evaluated is biased towards the adjacent level can be judged.

3.2 Improved matter element extension model

In the traditional matter element extension model, it is easy to find that the indicator value exceeds the joint domain association function, which makes it impossible to calculate. Therefore, on the basis of the original matter element, the value of each classical domain and the matter element to be evaluated carries out special processing. The processing method is as follows: The above values are all divided by the value b_{pi} of the right endpoint of the joint domain V_P , and then obtains a new matter element classic domain and the matter element to be evaluated as shown in formula (7).

$$R_j^{'} = \left(N_j, C_j, V_{ji}^{'}\right) = \begin{bmatrix} N_j & c_1 & \left\langle \frac{a_{j1}}{b_{p1}}, \frac{b_{j1}}{b_{p1}} \right\rangle \\ & c_2 & \left\langle \frac{a_{j2}}{b_{p2}}, \frac{b_{j2}}{b_{p2}} \right\rangle \\ & \dots & \dots \\ & c_n & \left\langle \frac{a_{jn}}{b_{pn}}, \frac{b_{jn}}{b_{pn}} \right\rangle \end{bmatrix} \tag{7}$$

$$R_0^{'} = \begin{bmatrix} p_0 & c_1 & \frac{v_1}{b_{p1}} \\ & c_2 & \frac{v_2}{b_{p2}} \\ & \dots & \dots \\ & c_n & \frac{v_n}{b_{pn}} \end{bmatrix} 93.8 \tag{8}$$

For the new matter element to be evaluated, use the formula (9) to calculate the distance D about the magnitude range of the new classical domain.

$$D\left(v, V_{ji}^{'}\right) = \left| v - \frac{a+b}{2} \right| - \frac{b-a}{2} \tag{9}$$

In the formula (9), v is the point value; a and b a are the values of the left and right endpoints of the interval, respectively.

Calculation of correlation degree: As formula (10), replace the association degree function $K_j(V_i)$ with D_{ij} to calculate the comprehensive correlation degree.

4. Example analysis

4.1 Data preprocessing and weight determination

This example is based on the actual monitoring and survey data of a certain region, as shown in Tab.1. The data of quantitative indicators in the table are obtained through actual monitoring and investigation, and the description of qualitative indicators is evaluated by Delphi method.

Firstly, the corresponding basis that the qualitative data of Table 2 is quantified to obtain each score are mainly:

The quantitative data table corresponding to each qualitative data of substation capacity is as follows: {not at all, basic match, poor conformance, match, complete match}={0, 0.25, 0.5, 0.75, 1};

The quantitative data table corresponding to each qualitative data of the human environment is as follows: {great affect; some affect; little affect; less affect; no affect}={0.2, 0.4, 0.6, 0.8, 1};

The quantitative data table corresponding to each qualitative data of the natural environment is as follows: {great affect; some affect; little affect; less affect; no affect}={0.2, 0.4, 0.6, 0.8, 1};

The quantitative data table corresponding to each qualitative data of traffic convenience is as follows: {poor(E), relatively poor(D), general(C), good(B) , excellent(A)}={0.2, 0.4, 0.6, 0.8, 1};

The quantitative data table corresponding to the qualitative data of urban road network planning coordination is as follows: {poor, relatively poor, general, good, excellent}={0.2, 0.4, 0.6, 0.8, 1};

The quantitative data table corresponding to the qualitative data of grid planning coordination is as follows: {poor, relatively poor, general, good, excellent}={0.2, 0.4, 0.6, 0.8, 1};

In order to avoid the unable direct comparison of the indicators data due to the dimensional constraints, the data needs to normalized. In the process of conversion to quantitative data, qualitative data has been normalized for convenience. In the following, only the quantitative data in Table 2 needs to be normalized. The specific normalization method is as follows:

For indicators with larger values, the better, such as profitable profit and other profitability indicators, the normalization method is as shown in formula (11):

$$x_i = \begin{cases} 0 & x_i < x_{i\min} \\ \dfrac{x_i - x_{i\min}}{x_{i\max} - x_{i\min}} & x_{i\min} < x_i < x_{i\max} \\ 1 & x_i < x_{i\max} \end{cases} \quad (11)$$

For indicators with smaller values, the better, such as construction investment cost, operating cost and other indicators, the normalization method is as shown in formula (12).The results obtained by quantifying and normalizing the qualitative indicators are shown in Table 2.

$$x_i = \begin{cases} 0 & x_i < x_{i\min} \\ \dfrac{x_{i\max} - x_i}{x_{i\max} - x_{i\min}} & x_{i\min} < x_i < x_{i\max} \\ 1 & x_i < x_{i\max} \end{cases} \quad (12)$$

Tab.1 Alternate 10 measured data for the charging station

	1	2	3	4	5	6	7	8	9	10
Network loss increment (c1)	90.6	91.3	92.8	51	58.5	93.8	46.2	92.9	94.8	96.4
Voltage offset ratio (c2)	66.86	98.44	99.86	71.33	99.78	99.09	64.64	99.54	66.82	98.91
Transformer capacity ratio (c3)	52.17	72.15	87.69	57.25	29.97	45.51	100	64.38	55.52	71.04
Line load rate (c4)	43.75	96	69.75	38.25	96	97.75	87.75	64	99.75	51
Transformer capacity（c5）	Completely suitable	Poor compliance	suitable	Completely suitable	Poor compliance	Completely suitable	Poor compliance	Completely suitable	Basic match	Completely suitable
Construction investment cost (c6)	25.96	42.29	77.36	97.37	100	50.2	32.06	100	57.21	100
Monthly operation cost (c7)	79.94	58.5	52.82	71.12	100	70.52	35.28	75.8	84.94	74.2
Profits (c8)	76	100	52	90	64	56	60	74	38	82
Cultural environment（c9）	no affect	Less affect	Less affect	no affect	Less affect	no affect	Greater affect	no affect	Less affect	Less affect
Natural environment（c10）	no affect	Less affect	Less affect	no affect	Less affect	no affect	Greater affect	no affect	Make a difference	Less affect
Transportation convenience (c11)	B	D	B	A	D	A	E	A	E	D
Service capability (c12)	3460	3150	3200	3700	2400	4000	2300	4000	2800	2600
Service radius (c13)	11.5	10	10.5	14	7	15	6	15	9	8
Coordination with urban road network planning（c14）	B	D	B	B	D	A	E	A	E	C
Coordination with grid planning（c15)	B	D	C	B	D	A	E	A	C	C

Tab.2 The results of criteria normalized

	1	2	3	4	5	6	7	8	9	10
c1	0.116	0.102	0.0712	0.904	0.755	0.052	1	0.070	0.032	0
c2	0.937	0.040	0	0.810	0.002	0.022	1	0.009	0.938	0.027
c3	0.317	0.602	0.824	0.390	0	0.222	1	0.491	0.365	0.586
c4	0.089	0.939	0.512	0	0.939	0.967	0.8045	0.419	1	0.207
c5	1	0.25	0.75	1	0.25	1	0.25	1	0.5	1
c6	0.310	0.641	0.729	0.4463	0	0.456	1	0.374	0.233	0.399
c7	0.613	1	0.226	0.839	0.419	0.290	0.355	0.581	0	0.710
c8	0.613	1	0.226	0.839	0.419	0.290	0.355	0.581	0	0.710
c9	1	0.6	0.8	1	0.6	1	0.2	1	0.8	0.8
c10	1	0.6	0.6	1	0.8	1	0.2	1	0.4	0.6
c11	0.8	0.4	0.8	1	0.4	1	0.2	1	0.2	0.4
c12	0.73	0.575	0.6	0.85	0.2	1	0.15	1	0.4	0.3
c13	0.65	0.5	0.55	0.9	0.2	1	0.1	1	0.4	0.3
c14	0.8	0.4	0.8	0.8	0.4	1	0.2	1	0.2	0.6
c15	0.8	0.4	0.6	0.8	0.4	1	0.2	1	0.6	0.6

After normalization of the real-time monitoring data, such as power related data, profit, cost and other related data, we can obtain the total contribution e_j of the corresponding j indicator of 10 alternative sites based on the entropy method, the difference coefficient d_j and the weight corresponding to each indicator are shown in Tab.3.

Tab.3 the weights of criteria based on entropy method

Index	e_j	d_j	Weight
c1	0.983	0.017	0.114
c2	0.978	0.022	0.145
c3	0.992	0.008	0.050
c4	0.988	0.0124	0.081
c5	0.991	0.009	0.056
c6	0.984	0.016	0.105
c7	0.993	0.007	0.046
c8	0.992	0.008	0.053
c9	0.995	0.005	0.030
c10	0.995	0.005	0.030
c11	0.992	0.008	0.055
c12	0.992	0.008	0.051
c13	0.992	0.008	0.056

c14	0.993	0.007	0.046
c15	0.994	0.006	0.040

4.2 Improvement of Matter-element extension Model

(1) Classification of matter-element extension system evaluation level. The alternative charging sites are divided into the following five levels according to their merits and demerits: Level 1, level 2, level 3, level 4 and level 5. Among them, the primary charging station can best meet the requirements of each indicator and determine the optimal charging station location. And so on.

(2) Establishing the matter-element extension evaluation model. Establish a matter-element extension evaluation model.

Due to space limitations, only the determination process of R_1 is given here.

$$R_1=(N_1,C_1,V_{1i})=\begin{bmatrix} N_1 & c_1 & v_{11} \\ & c_2 & v_{12} \\ & \cdots & \cdots \\ & c_n & v_{1n} \end{bmatrix}=\begin{bmatrix} N_1 & c_1 & (0,0.2) \\ & c_2 & (0,0.2) \\ & c_3 & (0,0.2) \\ & c_4 & (0,0.2) \\ & c_5 & (0,0.2) \\ & c_6 & (0,0.2) \\ & c_7 & (0,0.2) \\ & c_8 & (0.2,0.36) \\ & c_9 & (0.2,0.36) \\ & c_{10} & (0,0.2) \\ & c_{11} & (0,0.2) \\ & c_{12} & (0.2,0.36) \\ & c_{13} & (0.25,0.4) \\ & c_{14} & (0.25,0.4) \\ & c_{15} & (0.2,0.36) \end{bmatrix}$$

(3) Determination the distance of the index with respect to the classical domain. According to the Eq.(9), the distance between the indicators in each index system of 10 alternative charging station sites and the classical domains can be obtained. To save space, only the distance of the alternative site 1 is given here, as shown in Tab. 4.

Tab.4 Distance for the classic domain of alternative site 1

Index	Level 5	Level 4	Level 3	Level 2	Level 1
c1	-0.084	0.084	0.284	0.484	0.684
c2	0.737	0.537	0.337	0.137	-0.063
c3	0.117	-0.083	0.083	0.283	0.483
c4	-0.089	0.111	0.311	0.511	0.711

c5	0.8	0.6	0.4	0.2	0
c6	0.110	-0.09	0.090	0.290	0.490
c7	0.413	0.213	0.013	-0.013	0.187
c8	0.44	0.28	0.12	-0.04	0.04
C9	0.24	0.08	-0.08	0.08	0.24
c10	0.53	0.33	0.13	-0.07	0.07
c11	0.45	0.25	0.05	-0.05	0.15
c12	0.44	0.28	0.12	-0.04	0.04
c13	0.35	0.2	0.05	-0.05	0.1
c14	0.6	0.45	0.3	0.15	0
c15	0.44	0.28	0.12	-0.04	0.04

(5) Rating: According to the formula $K_j(p_0) = \max\{K_j(p_0)\}(j = 1, 2, ..., m)$, the rank of the websites are determined, and the obtained result is shown in Tab.6:

Tab.6 The rank of each site

Site	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Level	Level 2	Level 3	Level 3	Level 1	Level 5	Level 2	Level 1	Level 3	Level 4	Level 4

According to Tab.6, it can be seen that the site 4, 7 belongs to the first-level site; the site 1,6 belongs to the second-level; the site 2,3,8 belongs to the third-level; the site 9,10 belongs to the fourth-level; Site 5 belongs to the five-level.

According to formula (5), (6), the variable eigenvalues belonging to the same-level site can be calculated, and the degree of deviation of the evaluated matter elements to the adjacent level can be judged by the eigenvalues of variables obtained from calculation. The calculation results are shown in tab. 7.

Tab.7 The corresponding eigenvalues of each site

Site	Site 4	Site 7	Site 1	Site 6	Site 2	Site 3	Site 8	Site 9	Site 10	Site 5
Level	Level 1	Level 1	Level 2	Level 2	Level 3	Level 3	Level 3	Level 4	Level 4	Level 5
Eigenvalues	3.83	3.83	3.68	3.66	2.49	2.68	2.63	2.41	2.27	2.23

According to Tab.7, it can be concluded that the order of 10 alternative sites is as shown in Tab.8.

Tab.8 Each alternate site corresponds to the order

Site	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Sort	3	7	5	1	10	4	2	6	8	9

According to the order of Tab.8, we can see that using the improved matter-element extension model can solve the problem of charging station location well. In Tab.8, the site 4, 7 and 1 are all the better site selection schemes.

5. Conclusion

Reasonable planning of charging station nodes can provide better service for charging customers of electric vehicles, optimize the allocation of resources, and reduce the waste of public resources caused by human error in planning or improper selection methods. In order to avoid the situation that the correlation value cannot be calculated because the index value exceeds the section, the magnitude of each classical domain and the object to be evaluated is normalized, and the electric vehicle charging station based on the improved matter-element extension method is constructed, which comprehensively deals with the qualitative and quantitative indicators. Finally, an example verifies the feasibility and scientificity of the method, and gets the better location scheme and their respective ranking, which provides new ideas and methods for charging station location planning.

References

[1] Phonrattanasak.P, Leeprechanon.N. "Optimal Placement of EV Fast Charging Stations Considering the Impact on Electrical Distribution and Traffic Condition". International Conference and Utility Exhibition on Green Energy for Sustainable Development (ICUE), 2014, 6.

[2] Wagner,Sebastian, Götzinger, Markus, Neumann, Dirk. "Optimal Location of Charging Stations in Smart Cities: A Point of Interest Based Approach". International Conference on Information Systems, 2013, p2838-2855.

[3] Meysam Hosseini, S.A.MirHassani. "Selecting optimal location for electric recharging stations with queue". KSCE Journal of Civil Engineering, 2015, Vol.19 (7): p2271-80.

[4] Liu Biliang, Huangueliang, Li Jun, Qian Xin, Cheng Jun. "Multi-Objective Planning of Distribution Network Containing Distributed Generation and Electric Vehicle Charging Stations". Power System Technology，2015, Vol.39（2）：p450-456.

[5] Jia Long, Hu Chunze, Song Yonghua. " Planning of Electric Vehicle Charging Stations in Highway Network". Automation of Electric Power Systems, 2015, Vol. 39（15）：p82-89.

[6] Liu Liang, Zhou Yusheng, Zhou Wenqing, Jing Qunwei, Luo Yu, Qiu Qiangjie. " Research on siting planning evaluation system of electric vehicle charging station". Electrical measurement and instrumentation, 2016, Vol. (18): p1-5.

[7] Xiong Yuanyuan. "Research on Location Optimization Model of Electric Vehicle Charging Station under Energy Internet Environment". Beijing: North China Electric Power University, 2017, Vol.3.

[8] Cheng Hongbo, Xiao Yongle, Wang Xun, Lun Li, Li Minghui. "Site planning of electric vehicles charging station based on gravity model". Advanced Technology of Electrical Engineering and Energy, 2016, Vol.(05): p61-66.

[9] Peng Zejun, Lan Jian, Chen Yen, Zou Qin, Jia Legang, Yang Jun. ” EV Charging Station Sitting Method Based on Cloud Focus Theory”. Electric Power Construction, 2015, Vol.(04): p1-7.
[10] Suo Li, Tang Wei, Bai Muke, Zhang Lu. “Locating and Sizing of Centralized Charging Stations in Distribution Network Considering Load Shifting”. Proceedings of the CSEE, 2014, Vol.(07): p1052-1060.
[11] Zhang Guoliang, Li Bo, Wang Yunfa. ” Location and algorithm of multi-level electric vehicle charging stations”. Journal of Shandong University of Technology, 2011, Vol.(06): p136-142.