Research on Evaluation Method of First-class City Distribution Network

Qiang Sun *, Xiang Liu a, Xiangdong Li b, Fang Lv c and Jing Lv d
State Grid, State Grid Xi'an Power Supply Company, Xi'an, 710000, China

* Corresponding author email:404663641@qq.com, a liuxiang800108@163.com,
b lixiangdong8112@163.com, c 350645673@qq.com, d 38055552@qq.com

Abstract. The first-class urban distribution network is the key content of our country's current construction. In order to obtain accurate evaluation results, a first-class urban distribution network evaluation index system is constructed from four aspects of reliability, economy, low carbon and intelligence, and a decision-making method based on cloud model and probability analysis is proposed. The cloud model is used to express and process the linguistic evaluation information of qualitative attributes given by experts. The 3En criterion is utilized to convert the cloud model to the interval value, thereby reducing the impact of randomness on distribution network evaluation results. The probability method is used to process the interval value and obtain the comprehensive evaluation results. The proposed method can effectively solve the randomness and fuzziness of qualitative indicators in the evaluation process. Finally, the method is used to evaluate and sort 11 regional distribution networks in Xi'an jurisdiction, and the effectiveness of the proposed method is demonstrated according to the actual situation.

Keywords: First-class city distribution network; Evaluation; Cloud model; Possibility analysis

1. introduction
With the continuous development of the State Grid's work on "first-class urban distribution network" and the proposal of "Ubiquitous in the power Internet of things" in NPC & CPPCC this year, China's distribution network has ushered in a new round of development opportunities. In order to further respond to the strategic goal and vision of building "ubiquitous power Internet of things", power enterprises shall evaluate the distribution network within their jurisdiction. The traditional first-class urban distribution network evaluation system briefly evaluates the distribution network by extracting relevant operational data, lacking the consideration of economy, low carbon and intelligence in the development process of the distribution network, resulting in the incomplete first-class urban distribution network evaluation system. In addition, the traditional evaluation technology is difficult to adapt to the rapid development of distribution network, so the formulation of the corresponding first-class urban distribution network evaluation strategy has become one of the hot issues in the current research.
At present, there have been many achievements in the research of first-class urban distribution network. Literature [1] proposes the main idea of building a first-class urban distribution network, which improves the reliability of power supply of the distribution network by improving grid structure, control technology, lean operation and intelligent interactive service level. Literature [2] elaborates on TongShan power Supply Company’s construction of first-class urban distribution network. Literature [3] takes the construction of distribution network in PuDong, ShangHai as an example, and puts forward the preliminary conception of world-class urban distribution network. Literature [4] deeply excavates the problems in the construction of first-class urban power grid by benchmarking the construction of first-class urban power grid, and explores the construction of first-class urban power distribution network in the future. Literature [5] constructs the sub-system of annual overall evaluation and individual project evaluation of distribution network from four aspects: implementation process, grid performance, environmental and social impact, and investment benefit. Most of the above researches are about the exploration of the construction of first-class urban distribution network, while the evaluation of first-class urban distribution network is rarely involved. Although literature [5] involves the evaluation of distribution network, the fuzziness and randomness of qualitative indicators are not well dealt with. In addition, in current evaluation studies, the loss of original information is often caused to some extent in the process of processing different forms of information, which affects the accuracy of decision results. Especially for the evaluation of the first-class urban distribution network, since there are many indexes involved and the types of indexes are rather tedious, how to adopt a reasonable and effective method to achieve the evaluation of the first-class urban distribution network is the focus and difficulty of the current research.

With the continuous deepening of scholars' evaluation research, existing evaluation methods such as analytic hierarchy process, fault tree analysis, fuzzy comprehensive evaluation method, and grey fuzzy theory method are gradually mature [6]. However, the above methods cannot well solve the fuzziness and randomness in the evaluation process of first-class urban distribution network, and there is also a lack of effective methods to deal with the mutual transformation between qualitative and quantitative [7-9]. Based on probability theory and fuzzy mathematical theory, cloud model emphasizes the characteristics of data distribution, and can perfectly realize the mutual conversion between qualitative and quantitative information, and effectively deal with the randomness, fuzziness and relevance of evaluation information.

Based on the above analysis, this paper firstly constructs the evaluation index system of first-class urban distribution network, proposes an analysis method based on cloud model and probability, and applies this method to the evaluation of first-class urban distribution network. This method uses cloud model to express and process uncertainty assessment information, and uses probability method to sort distribution network. Finally, the effectiveness of the proposed method is verified by taking Xi 'an regional distribution network evaluation as an example.

2. First-class urban distribution network evaluation index system

2.1. Construction of evaluation index system

The construction of evaluation index system of first-class urban distribution network plays a vital role in evaluating the advanced level of regional distribution network reasonably and effectively. It can be seen from the research of the existing literature that domestic and foreign scholars have established the evaluation index system for distribution network mostly around the perspectives of reliability, equipment safety and grid risk [10-13]. The evaluation of first-class urban distribution network is rarely involved in China. And the electric power enterprise will consider the actual situation, through delimits the concrete index to complete the assessment of the first-class city distribution network. However, in the concrete evaluation process of the first-class urban distribution network, due to the inherent ambiguity of the evaluation information and the uncertainty of the environment, the evaluation system is not perfect and it is difficult to evaluate the first-class urban distribution network comprehensively and reasonably. Based on the evaluation index of current first-class urban distribution network and
adding the semantic evaluation information of experts, this paper builds a comprehensive and reasonable evaluation index system of first-class urban distribution network.

The historical evaluation system of the first-class city distribution network mainly involves the reliability, economy and low-carbon of the distribution network. With the "ubiquitous power Internet of things" proposed in the State Grid Conference in 2019, the intelligence of the power grid has been highlighted. To realize the ubiquitous interconnection of power grid and deeply explore the value behind power grid data, the intelligence of power grid will be the key direction of future development. Therefore, this paper constructs the evaluation index of first-class urban distribution network from four aspects of reliability, economy, cleanness and intelligence. The specific index system is shown in table 1.

| Table 1. First-class city distribution network evaluation index system |
|--------------------------|--------------------------|--------------------------|
| **Target Layer** | **Rule Layer** | **Index Layer** |
| First-class urban distribution network evaluation index system | Power supply reliability (A1) |  |
| Reliability | Average number of system blackouts (A2) |  |
|  | 10 (20) kV line overload ratio (A3) |  |
|  | Strong degree of gird (A4) |  |
| Economy | High-loss distribution transformer ratio (B1) |  |
|  | Electricity sold per unit asset (B2) |  |
|  | Unit investment increase supply load (B3) |  |
|  | Annual revenue growth (B4) |  |
| Low-carbon | Coal to electricity load ratio (C1) |  |
|  | Absorption rate of clean energy (C2) |  |
| Intelligence | Coverage of distribution automation (D1) |  |
|  | coverage of distribution transformer information acquisition (D2) |  |
|  | coverage of smart grid dispatching system (D3) |  |
|  | coverage of communication optical fiber (D4) |  |

2.2. Evaluation index system analysis

2.2.1. Reliability index. Reliability is the basic index and the most important index of first-class urban distribution network evaluation. Considering that current power companies generally control the reliability of distribution network from the perspective of load, power failure, voltage and equipment, this paper selects representative indicators to evaluate the reliability of the network.

(1) Power supply reliability. Specifically, it refers to the ratio of the cumulative operating time of the actual operating voltage within the allowable voltage deviation range to the total actual operating time of the grid.

(2) Average number of system blackouts. This index mainly reflects the ratio of the total number of power outages to the total number of power outages in each power failure accident, and is an important index to reflect the power outage information of power grid.

(3) 10 (20) kV line overload ratio. This index mainly reflects the situation of distribution network lines, and the level of this index directly determines the reliability coefficient of distribution network lines. The lower load ratio can leave enough margin for the power grid dispatching and ensure the safe operation of the power grid.

(4) Strong degree of gird. Since it is difficult to describe the strength of distribution network frame with specific figures, this paper obtains the final evaluation result according to the evaluation of dispatching experts on this index.

2.2.2. Economic index. Economical is the basis of the development of distribution network. This paper extracts the economic index of distribution network from the perspective of equipment, investment and income growth.
(1) High-loss distribution transformer ratio. Considering factors such as asset investment, many old transformers will remain in the grid. Due to the backwardness of technology, the loss of the old transformer will be much larger than the current running transformer, which brings great difficulties to the economic operation of the distribution network.

(2) Electricity sold per unit asset. This index represents the relationship between power grid investment and income. The higher the index is, the higher the income of current power grid investment is, and it is an important index reflecting the efficient investment of power grid.

(3) Unit investment increase supply load. This index can effectively reflect the efficiency of power grid investment. The higher the unit investment supply load is, the more power enterprises can meet the maximum power supply demand with the minimum investment, and it is an important index to evaluate the efficiency of power grid ontology.

(4) Annual revenue growth. The index relates to the specific profit of the power grid, which is a commercial secret in the current social environment and inconvenient to announce the specific amount, however it is also an irreplaceable index for evaluating the first-class urban distribution network. Therefore, this paper collects semantic evaluation of relevant experts to obtain evaluation information for this index.

2.2.3. Low-carbon index. Low-carbon is the trend of distribution network development. As clean energy continues to access the distribution network, the requirements for cleanliness of first-class urban distribution networks are gradually increasing. According to local characteristics, this paper extracts the low-carbon index of distribution network from the relevant assessment index of State Grid.

(1) Coal to electricity load ratio. In northern cities, due to winter heating caused a certain degree of pollution to the environment, so many cities have implemented the coal-to-electricity project. Under the government subsidies, electric heating is used uniformly in winter to reduce the pollution caused by coal combustion. The ratio of coal to electricity load has become an important aspect of the evaluation of distribution network in the first-class cities in northern China.

(2) Absorption rate of clean energy. Clean energy such as photovoltaic and wind turbines are continuously connected to the distribution network, which has caused a certain impact on the distribution network. During operation, the distribution network will conduct wind and light abandoning operations for clean energy to a certain extent according to its own reliability. Clean energy cannot guarantee its full consumption, the high clean energy consumption rate can not only reflect the strength of the distribution network itself, but also reflect the low carbon level of the current distribution network. Therefore, this paper takes the clean energy absorption rate as an important indicator to reflect the low-carbon power grid.

2.2.4. Intelligence index. The intelligence of the distribution network refers to the communication and automation level of the distribution network. In particular, this year's State Grid "two sessions" proposed to strengthen the construction of three types of two networks, and the realization of ubiquitous power Internet of Things requires the distribution network to have extremely high intelligence. This paper refines the intelligence indicators from the automation level and communication level of the distribution network.

(1) Coverage of distribution automation. This index specifically refers to the ratio between the number of medium-voltage lines meeting terminal configuration requirements and the total number of medium-voltage lines in the region, reflecting the level of distribution automation in the region.

(2) Coverage of distribution transformer information acquisition. The index characterizes the extent to which the dispatching department can observe the transformer data, and the visualization of the transformer data is the basis for the intelligence of the distribution network.

(3) Coverage of smart grid dispatching system. This index reflects the degree of intelligent dispatching of the distribution network. The higher the index is, the higher the operability of the regional distribution network is, and can cope with some unexpected situations.
(4) Coverage of communication optical fiber. The realization of smart distribution network is closely related to its high-speed communication. Meanwhile, the ubiquitous Internet of things requires the grid to realize the interconnection of everything. Therefore, the coverage of communication fiber directly determines the future development potential of the power grid.

3. First-class urban distribution network evaluation model

Due to the particularity of the evaluation object, an evaluation model is needed to distinguish the degree of first-class urban distribution network in each region. The evaluation model used in this paper mainly includes three parts. The first part uses the cloud model to transform the expert semantic information and obtain the cloud model of the corresponding indicator. The second part uses the method described in literature [10] to fuse the cloud model generated by data indicators and semantic indicators to generate a comprehensive cloud model. The third part uses the method of probability to evaluate the first-class degree of regional distribution network.

3.1. Cloud model

Cloud model is a model used to deal with qualitative and quantitative concepts. This model can accurately reflect the fuzziness of human thinking and the uncertainty of things in the decision-making process. Since it was proposed by Li Deyi, academician of Chinese academy of engineering in 1995, the model has been widely used in prediction, evaluation, analysis and decision making. Cloud model can be represented by expected value Ex, entropy En and excess entropy He. Ex is used to represent the center value of cloud model, En is used to reflect the range that can be accepted by the linguistic value in the quantified domain. It appears as the span of the cloud in the cloud image, meanwhile En also reflects the probability that the point in the quantified domain can represent the linguistic value. The excess-entropy He reflects the cohesiveness of the uncertainty representing all points in the quantization space, which is shown as cloud thickness in the cloud image.

3.2. Translation of linguistic evaluation value into cloud model

This paper uses the method proposed in [13] to transform the expert language evaluation into five one-dimensional normal clouds in theory [0, 1]. The evaluation scale of 5 uncertain languages is {very low, low, medium, high, very high}, denoting as {VL, L, M, H, VH}. The language interval set in reference [14] is adopted, and the specific parameters of one-dimensional normal cloud corresponding to each evaluation language are obtained according to the calculation method in reference [11], as shown in table 2.

| Semantic Variable | Cloud Model |
|-------------------|-------------|
| Very low (VL)     | (0.165, 0.055, 0.0262) |
| Low (L)           | (0.335, 0.055, 0.0162) |
| Medium (M)        | (0.5, 0.0567, 0.01) |
| High (H)          | (0.665, 0.055, 0.0162) |
| Very high (VH)    | (0.835, 0.055, 0.0262) |

Considering the accuracy of the evaluation of first-class urban distribution network, this paper obtains semantic descriptive information based on the evaluation of experts in different fields, and obtains the final evaluation result by synthesizing the generated cloud. The process of cloud synthesis is as follows:

Let \( C_1 = (E_{x_1}, E_{n_1}, H_{e_1}) \), \( C_2 = (E_{x_2}, E_{n_2}, H_{e_2}) \) are two cloud models, \( a \) and \( b \) are two constants, satisfying \( a + b = 1 \). According to the independent normal distribution algorithm, the cloud synthesis result is:
Equation (1) is the composite cloud model. If multiple cloud models are synthesized, the method is similar, and it will not be described in this paper.

3.3. Transformation of cloud model and interval value

In the generation of cloud model, each cloud droplet has a different contribution value to the qualitative concept, and the droplet with a high contribution value will generally gather in the interval \([Ex - 3En, Ex + 3En]\). The cloud droplets in this area can characterize the described information in detail, so the above characteristics of the cloud model are also called the normal cloud \(3En\) criteria, as shown in Figure 1. According to the method proposed in literature [12] and combined with the \(3En\) criteria, the interval number transformation is carried out for the normal cloud model. Considering that the excess entropy in the cloud model will have certain influence on the results, it is taken into account in the transformation process. The specific transformation formula is as follows:

\[
C = aC_1 + bC_2 = a\left(Ex_1, En_1, He_1\right) + b\left(Ex_2, En_2, He_2\right) = \left(aEx_1 + bEx_2, \sqrt{\left(aEn_1\right)^2 + \left(bEn_2\right)^2}, \sqrt{\left(aHe_1\right)^2 + \left(bHe_2\right)^2}\right)
\]

(1)

3.4. Transform of cloud model and interval value

Different presentation contents of indicators will lead to the occurrence in the process of indicator presentation that the higher the value of some indicators is, the better; while the smaller the value of some indicators is, the better. Therefore, formula (3) is firstly adopted in this paper to standardize the numerical indicators, so that the larger the value of all indicators, the better the response indicators will be.

\[
\tilde{r}_{\max,i} = \frac{c_i}{a_i}, i \in C
\]

(3)
Where, $C_i = \min_{i \in C} a_i$, $C$ means the smaller the index value, the better; $a_i$ is the corresponding specific index value.

As different evaluation indexes are composed in different ways, there will be a large gap between the values of each index interval, which will have a certain impact on the evaluation of the ultimate first-class urban distribution network. And normalizing the interval value can solve this problem well. This paper draws on the method proposed in [15], and uses the range conversion method to normalize the interval values. The range transformation method can normalize the optimal index to 1 and the worst index to 0 through the calculation of formula (4), and the other indexes can get the possible values of normalized indexes by adopting the linear interpolation method.

\[
\begin{align*}
\epsilon^e &= \frac{C_i - \min_{i=1,2,...,m} (C_i)}{\max_{i=1,2,...,m} (C_i) - \min_{i=1,2,...,m} (C_i)} \\
\epsilon^w &= \frac{C_i - \min_{i=1,2,...,m} (C_i)}{\max_{i=1,2,...,m} (C_i) - \min_{i=1,2,...,m} (C_i)}
\end{align*}
\]

Through the normalization of interval values, it is possible to solve the problem of excessively large individual indicator intervals and ensure the accuracy of the assessment of the first-class city distribution network.

3.5. Probability Method Interval Sorting

The method of interval ranking of probability degree starts from the fuzziness of interval number, defines a measure to describe the specific degree that one interval number exceeds another interval number, and sorts the interval number based on this criterion. This method can avoid the problem of information loss caused by the traditional method to quantify the interval number. The method of probability is as follows.

Suppose two interval Numbers $a$ and $b$ represent intervals respectively $[\bar{a}, \underline{a}]$, $[\bar{b}, \underline{b}]$, let $L(a) = \bar{a} - \underline{a}$, $L(b) = \bar{b} - \underline{b}$, then the probability of $a \geq b$ is:

\[
p(a \geq b) = \frac{\max \{0, L(a) + L(b) - \max (0, b - \bar{a})\}}{L(a) + L(b)}
\]

Where, $0 \leq p(a \geq b) \leq 1$, if and only if $\bar{a} \geq \bar{b}$, the right equal sign is established, $\bar{b} \geq \underline{a}$, the lift equal sign is established.

The formula (5) can be used to calculate the probability of a given set of intervals, and construct a probability matrix $P = \left(p_{ij}\right)_{n \times n}$, where $p_{ij} = p(a_i \geq a_j)$, $a_i$ and $a_j$ respectively represent two interval Numbers. After that, the interval is sorted by formula (6) to obtain the final evaluation result.

\[
v_i = \frac{1}{n(n-1)} \left( \sum_{j=1}^{n} p_{ij} + \frac{n(n-1)}{2} \right), i \in N
\]
4. Model solution

The specific process of solving the model is as follows:

Step1: Obtaining the evaluation value of qualitative index and the actual value of quantitative index.

Step2: Converting qualitative semantic evaluation value into normal cloud, and adding the normal cloud models generated by the different language evaluation values of the same indicator to obtain a comprehensive normal cloud model of different indicators, meanwhile, the evaluation value of data is standardized.

Step3: Criterion 3En is used to interval the standardized numerical index and the comprehensive normal cloud model, and record the interval value of the p-th distribution network with respect to the q-th indicator \([A_{pq}, B_{pq}]\), then the interval evaluation matrix is:

\[
C = \begin{bmatrix}
[A_{11}, B_{11}] & [A_{12}, B_{12}] & \cdots & [A_{1n}, B_{1n}] \\
\vdots & \vdots & \ddots & \vdots \\
[A_{m1}, B_{m1}] & [A_{m2}, B_{m2}] & \cdots & [A_{mn}, B_{mn}]
\end{bmatrix}
\] (7)

Where, \(m = 14\), \(n\) is the quantity of distribution network to be evaluated.

Step4: Each element in matrix \(C\) is normalized according to Eq. (3).

Step5: Using the formula (2) to generate the corresponding cloud model from the interval evaluation matrix, and take \(He = 0.005\) according to the literature [13].

Step6: The cloud models of the same distribution network under different indicators are synthesized to obtain the comprehensive cloud models of different distribution networks.

Step7: Internalizing the comprehensive cloud model in step6, and sorting different distribution networks with the probability method to obtain the final decision results.

5. Case Analysis

5.1. Case analysis of Xi’an

Taking Xi’an regional distribution network as an example, this paper evaluates the first-class urban distribution network of each district. In order to ensure the accuracy of the semantic evaluation indicators, relevant experts from the dispatching, marketing, and transportation supervision departments are invited to evaluate the indicators. Specific indicators collection results are shown in table 1.

The language evaluation value is converted into a cloud model, and the cloud models of experts from three departments are synthesized to obtain the comprehensive cloud model corresponding to the four indicators, as shown in table 3.
Table 3. Semantic evaluation into a comprehensive cloud model

| District | A4        | B2             | B4             | C1             |
|----------|-----------|----------------|----------------|----------------|
| Xincheng | (0.72, 0.032, 0.013) | (0.84, 0.032, 0.015) | (0.61, 0.032, 0.008) | (0.67, 0.032, 0.009) |
| Beilin   | (0.72, 0.032, 0.013) | (0.67, 0.032, 0.009) | (0.67, 0.032, 0.011) | (0.78, 0.032, 0.013) |
| Lianhu   | (0.67, 0.032, 0.011) | (0.78, 0.032, 0.013) | (0.61, 0.032, 0.008) | (0.72, 0.032, 0.012) |
| Yanta    | (0.50, 0.033, 0.0057) | (0.61, 0.032, 0.008) | (0.56, 0.032, 0.007) | (0.67, 0.032, 0.009) |
| Chang’an | (0.34, 0.032, 0.0093) | (0.17, 0.032, 0.015) | (0.39, 0.032, 0.012) | (0.22, 0.032, 0.013) |
| Baqiao   | (0.50, 0.032, 0.0083) | (0.45, 0.032, 0.007) | (0.50, 0.032, 0.008) | (0.56, 0.032, 0.007) |
| Yanliang | (0.28, 0.032, 0.012) | (0.28, 0.032, 0.012) | (0.39, 0.032, 0.010) | (0.50, 0.032, 0.006) |
| Weiyang  | (0.445, 0.032, 0.007) | (0.50, 0.032, 0.006) | (0.44, 0.032, 0.011) | (0.50, 0.032, 0.006) |
| Zhaoyi   | (0.165, 0.032, 0.011) | (0.39, 0.032, 0.008) | (0.50, 0.032, 0.006) | (0.45, 0.032, 0.007) |
| Lantian  | (0.005, 0.032, 0.013) | (0.50, 0.032, 0.006) | (0.39, 0.032, 0.008) | (0.45, 0.032, 0.007) |

In order to unify the expression of indicators, formula (3-4) is used to standardize the indicators. According to the actual situation, the higher indicators A1, A4, B2, B3, B4, C2, D1, D2, D3 and D4 are, the higher the degree of first-class cities in the distribution network is, while the lower the indexes A2, A3 and B1 are, the higher the first-class city degree of distribution network is. Therefore, data indicators need to be standardized, and the results are shown in table 4.

Table 4. Data indicator standardization

| District | A2        | A3      | B1      |
|----------|-----------|---------|---------|
| Xincheng | 0.4483    | 0.6250  | 0.0625  |
| Beilin   | 1.0000    | 1.0000  | 1.0000  |
| Lianhu   | 0.4643    | 0.5000  | 0.3333  |
| Yanta    | 0.2321    | 0.5556  | 0.0500  |
| Chang’an | 0.2241    | 0.3846  | 0.0198  |
| Baqiao   | 0.2131    | 0.4545  | 0.5000  |
| Yanliang | 0.0514    | 0.4032  | 0.0408  |
| Weiyang  | 0.1781    | 0.5000  | 0.8333  |
| Zhaoyi   | 0.0553    | 0.3906  | 0.2381  |
| Lantian  | 0.1140    | 0.4000  | 0.0065  |

Eq. (2) is used to interval the comprehensive cloud model generated by semantic evaluation, and the results are shown in table 5.

Table 5. Integrated cloud model interval

| District | A4       | B2             | B4             | C1             |
|----------|----------|----------------|----------------|----------------|
| Xincheng | [0.512, 0.935] | [0.604, 1.066] | [0.439, 0.781] | [0.486, 0.844] |
| Beilin   | [0.512, 0.935] | [0.486, 0.844] | [0.439, 0.781] | [0.562, 0.995] |
| Lianhu   | [0.473, 0.860] | [0.562, 0.995] | [0.439, 0.781] | [0.522, 0.921] |
| Yanta    | [0.350, 0.650] | [0.439, 0.781] | [0.393, 0.717] | [0.486, 0.844] |
| Chang’an | [0.156, 0.514] | [-0.066, 0.396] | [0.189, 0.588] | [0.005, 0.438] |
| Baqiao   | [0.329, 0.671] | [0.283, 0.607] | [0.329, 0.671] | [0.393, 0.717] |
| Yanliang | [0.079, 0.478] | [0.079, 0.478] | [0.202, 0.575] | [0.350, 0.650] |
| Weiyang  | [0.283, 0.607] | [0.350, 0.650] | [0.250, 0.637] | [0.350, 0.650] |
| Zhaoyi   | [-0.066, 0.396] | [-0.066, 0.396] | [0.140, 0.527] | [0.140, 0.527] |
| Lantian  | [0.140, 0.527] | [0.219, 0.561] | [0.350, 0.650] | [0.283, 0.607] |

Data indicators can be converted into interval values corresponding to their data. For example, A1 of the Xincheng district can be written as [99.99, 99.99]. Therefore, the interval value is normalized according to equation (5). The final result is shown in table 5. The cloud model is generated according to the interval values in attached list 5. Finally, formula (1) is used to synthesize the cloud model of each indicator to generate the comprehensive cloud model of each region, as shown in table 6.
Table 6. Integrated cloud model for each region

| District   | Integrated cloud model       |
|------------|------------------------------|
| Xincheng   | (0.7262, 0.0035, 0.0050)     |
| Beilin     | (0.6416, 0.0032, 0.0050)     |
| Lianhu     | (0.5697, 0.0035, 0.0050)     |
| Yanta      | (0.5777, 0.0050, 0.0050)     |
| Chang’an   | (0.3159, 0.0032, 0.0050)     |
| Baqiao     | (0.5287, 0.0048, 0.0050)     |
| Yanliang   | (0.2547, 0.0042, 0.0050)     |
| Weiyan     | (0.3753, 0.0050, 0.0050)     |
| Zhaoyi     | (0.3042, 0.0029, 0.0050)     |
| Lantong    | (0.4130, 0.0050, 0.0050)     |
| Lintong    | (0.4308, 0.0046, 0.0050)     |

Internalizing the above results and use the method proposed in this paper to evaluate the distribution networks of first-class cities in various regions. Obtain the final interval value, and obtain the probability matrix according to formula (6), as shown in table 7. Formula (7) is used to obtain the final evaluation results of first-class urban distribution network, as shown in table 8.

Table 7. Final interval number of each region

| District   | Integrated cloud model       | District   | Integrated cloud model       |
|------------|------------------------------|------------|------------------------------|
| Xincheng   | [0.671,0.782]               | Yanliang   | [0.197,0.312]               |
| Beilin     | [0.587,0.696]               | Weiyan     | [0.315,0.435]               |
| Lianhu     | [0.514,0.625]               | Zhaoyi     | [0.250,0.358]               |
| Yanta      | [0.518,0.638]               | Lantong    | [0.353,0.473]               |
| Chang’an   | [0.261,0.371]               | Lantian    | [0.372,0.490]               |
| Baqiao     | [0.469,0.588]               |            |                             |

Table 8. Final evaluation result

| District   | Assessed value | District   | Assessed value |
|------------|---------------|------------|---------------|
| Xincheng   | 0.135         | Yanliang   | 0.050         |
| Beilin     | 0.125         | Weiyan     | 0.074         |
| Lianhu     | 0.112         | Zhaoyi     | 0.058         |
| Yanta      | 0.113         | Lantong    | 0.082         |
| Chang’an   | 0.060         | Lantian    | 0.085         |
| Baqiao     | 0.105         |            |               |

Therefore, the final assessment results of first-class urban distribution network are as follows: Xincheng>Beilin>Yanta>Lianhu>Baqiao>Lantian>Lintong>Weiyan>Chang’an>Zhaoyi>Yanliang.

5.2. Analysis of evaluation results

Due to the late construction of Xincheng district, the investment in the construction of the distribution network in the region was relatively large. Beilin District and Yanta District are economically developed areas. Therefore, the level of the first-class cities in the distribution network is second, which is in line with the current development trend of the power grid. In addition, Baqiao district is under construction, so the level of first-class urban distribution network in the region is still improving. However, it can be seen from the evaluation results that it has a small gap with the previous regions. In the distribution network of several regions at the bottom of the ranking, due to the incoordination between urban construction and local power development level, there are certain demolition work in each region. Therefore the degree of first-class cities in distribution networks in these regions has a relatively large gap with Xincheng district. Low-ranking Zhaoyi and Yanliang district have more of the old city and town, power grid are in urgent need of upgrading. By comparing the actual situation, it proves that the evaluation method proposed in this paper is highly feasible.

In addition, this paper adopts the method proposed in literature [16] to evaluate and analyze the first-class urban distribution network, and the results are consistent with the method proposed in this paper.
However, in terms of multi-expert semantic processing, this document is not covered and lacks the breadth of evaluation. The literature [16] is evaluated by constructing the evaluation matrix. The randomness and ambiguity of the qualitative indicators are not well considered, so the evaluation results are very close. As can be seen from the results in table 7, the method proposed in this paper can well evaluate the first-class urban distribution network in each region, and the evaluation value has a strong degree of discrimination.

6. Conclusion.
This paper studies the evaluation of first-class urban distribution network, including 14 indexes from four aspects to form the evaluation system of first-class urban distribution network, and evaluates the first-class urban distribution network by combining cloud model and probability method. According to the results of case analysis, the following conclusions can be drawn:

1. The method proposed in this paper can comprehensively evaluate and sort multiple distribution networks, so that staff can be informed of the first-class level of regional distribution networks in time.
2. The results show that the results obtained in this paper are consistent with the current development of Xi'an Power Grid, and the evaluation is reliable.
3. It can be seen from the comparison of methods that the evaluation method proposed in this paper has better discrimination.

In addition, the method combining cloud model and probability can effectively deal with mixed multi-attribute decision making, providing scientific and reasonable decision basis for the evaluation of first-class urban distribution network, and providing a new idea for mixed multi-attribute decision making.

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