ABSTRACT

A new method is presented for power grid planning evaluation index system based on the analysis of minimum distance cluster, considering reliability, safety, economy, efficiency of power grid planning. The method could analyze the correlation among power grid planning index and provide beneficial guidance for the future constructing the index system of assessment power grid planning. The proposed method in the paper is validated by evaluating the power grid planning in some area.

INTRODUCTIONS

In order to make the power grid planning and management to keep pace with The Times, it is very urgent that establish a scientific and objective evaluation index system of power grid planning, to protect the power grid planning [1], multilevel coordination work can be put in place seriously. Reasonable power grid planning,
the national resources can be saved, however, due to the diversity of the various levels of power grid planning indicators, the evaluation of the power grid planning index system [2], is endless. At present, the evaluation of power grid information mainly found in reports of power system operation and power system planning and the paper. In these papers, mainly is to evaluate a certain or some aspect of the grid. In the traditional power grid planning project, security, reliability, economy are compared and evaluated in three aspects.

In the paper, correlation analyzing between indicators is based on the shortest distance clustering theory methods [3], with this method, the multilevel coordination index system [4], of power network planning is studied. It makes the index system has the characteristics of comprehensive, objective, systematic, and reflect the correlation between every index comprehensively and intuitively by the pedigree chart.

**PRINCIPLE AND STEPS**

**Clustering Principle**

The collection of physical or abstract objects can be divided into multiple classes of similar objects, it is known as clustering. Clustering analysis is a statistical analysis method to study the classification problem. The distance between the sample \(x_i\) and \(x_j\) was denoted \(d_{ij}\). \(D_{ij}\) denote the distance between the class \(G_i\) and \(G_j\). Definition the distance between the class \(G_i\) and \(G_j\) as closest distance of samples of two classes, namely:

\[
D_{ij} = \min_{x_i \in G_i, x_j \in G_j} d_{ij}
\]  

(1)

Assuming that class \(G_p\) and \(G_q\) merged into a new class to sign \(G_r\), the distance between any class \(G_k\) and \(G_r\) is:

\[
D_{kr} = \min_{x_i \in G_k, x_j \in G_r} d_{ij} = \min \left\{ \min_{x_i \in G_k, x_j \in G_p} d_{ij}, \min_{x_i \in G_k, x_j \in G_q} d_{ij} \right\} = \min \{D_{kp}, D_{dq}\}
\]  

(2)

**The Shortest Distance Clustering Method Steps**

1. Calculating the distance between two samples. The distance between sample \(i\) to sample \(j\) and sample \(j\) to sample \(i\) is equal, so only need to calculate one of them. Get the distance matrix for \(D(0)\), at this time \(D_{ij} = d_{ij}\).
2. Find out the minimum non diagonal elements in the \(D(0)\), set it to \(D_{pq}\). The \(G_p\) and \(G_q\) merged into a new class, denoted as \(G_r\), namely \(G_r = \{G_p, G_q\}\).
3. The formula for calculating the distance between the new class and other classes is given: \(D_{kr} = \min \{G_{kp}, G_{kq}\}\). The \(P, Q\) row and \(P, Q\) column by the above formula
merged into a new row column in the $D_{(0)}$, the new row and column corresponds to
$G_{r}$, get a new matrix called $D_{(1)}$.

(4) The above for $D_{(0)}$ to $D_{(1)}$, repeat (2), (3) steps and conclude $D_{(2)}$, so the cycle
continues until all elements merged into a class. If more than one of the minimum
non diagonal elements in the $D_{(k)}$, corresponding to these minimum element classes
can be combined.

**BULDING ALGORITHM MODEL**

Through the shortest distance clustering method to analyzed and evaluated
multilevel coordination index system of power grid. The correlation between
indicators was comprehensive, clear, objective reflects to the pedigree chart.
Through the analysis of the original data, the correlation between the indexes can be
obtained correctly and realized by programming.

**The Selection of Evaluation Index and Standardized Data Processing**

According to the characteristics of power grid development, the influencing
factors are analyzed to find out the intrinsic coupling relationship of various
indicators and form the index system. Based on the reliability, safety, economy and
other aspects of the consideration, the selection of quantitative indicators are as
follows: maximum load regulation $c_1$, 220$kV$ substation power supply load $c_2$,
220$kV$ capacity load ratio $c_3$, 220$kV$ variable 10$kV$ direct load $c_4$, 110$kV$ capacity load
ratio $c_5$, 110$kV$ sensitive load capacity load ratio $c_6$, total electricity consumption $c_7$,
power supply forecast $c_8$, maximum load forecasting $c_9$, 110$kV$ planning for the
capacity of the public substation $c_{10}$, 110$kV$ substation power supply load $c_{11}$, 220$kV$
planning for the capacity of the public substation $c_{12}$, average load rate of 110$kV$
substation $c_{13}$, average load rate of 220$kV$ substation $c_{14}$, daily maximum load $c_{15}$,
maximum load ratio of 110$kV$ main transformer $c_{16}$, maximum load ratio of 220$kV$
main transformer $c_{17}$, N-1 pass rate $c_{18}$, the utilization rate of annual maximum load
$c_{19}$, annual average load of last year $c_{20}$.

When the data unit of the sample measurement is different or the difference of
each variable is very big, should carry on the standardized processing to the data,
then carries on the calculation sample distance.

**Euclidean Distance Calculation**

In the research of classification, we often use several kinds of distance to
calculate and contrast, it is concluded that a more appropriate distance clustering,
this article adoptive the Euclidean distance. Because the Euclidean distance is
suitable for clustering index. As shown in type (3).
\[ d_{ij} = \sqrt{\sum_{k=1}^{n}(x_{ik} - x_{jk})^2} (i, j = 1, 2, \ldots, n) \] (3)

**EXAMPLE ANALYSES**

The index system is built on the basis of original data of a certain area and its power grids planning during 2015-2020, through putting forward the shortest distance clustering to analyze the relevance of multifaceted coordination of grid planning. According to the power grid planning, choose the index data and establish the sample information sheet. The selected date is about 6 regions of 6 years. For example, analyzing the correlation between different areas indexes in 2015. The region power grid planning coordination index in 2015 is shown in table I:

### Table I. Planning Indexes Data of Area in 2015.

<table>
<thead>
<tr>
<th>Index C</th>
<th>Area</th>
<th>( c_1 )</th>
<th>( c_2 )</th>
<th>( c_3 )</th>
<th>( c_4 )</th>
<th>( c_5 )</th>
<th>( c_6 )</th>
<th>( c_7 )</th>
<th>( c_8 )</th>
<th>( c_9 )</th>
<th>( c_{10} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>222</td>
<td>192</td>
<td>2.2</td>
<td>24.5</td>
<td>0.479</td>
<td>0.543</td>
<td>0.81</td>
<td>0.649</td>
<td>18.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>311</td>
<td>191</td>
<td>3.6</td>
<td>18.3</td>
<td>0.553</td>
<td>0.464</td>
<td>0.79</td>
<td>0.643</td>
<td>24.33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>127</td>
<td>107</td>
<td>1.7</td>
<td>13.1</td>
<td>0.645</td>
<td>0.728</td>
<td>0.82</td>
<td>0.619</td>
<td>4.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>134</td>
<td>134</td>
<td>2.2</td>
<td>14.5</td>
<td>0.466</td>
<td>0.46</td>
<td>0.80</td>
<td>0.577</td>
<td>9.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>155</td>
<td>155</td>
<td>1.7</td>
<td>18.6</td>
<td>0.621</td>
<td>0.589</td>
<td>0.81</td>
<td>0.578</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>194</td>
<td>184</td>
<td>1.8</td>
<td>15.1</td>
<td>0.488</td>
<td>0.597</td>
<td>0.82</td>
<td>0.649</td>
<td>9.66</td>
<td></td>
</tr>
</tbody>
</table>

1) Firstly all evaluation indexes have to be standardized for unified standard and 2) eliminated the dimension, transformed into a standard which is dimensionless and countless magnitude difference, then analysis and evaluation.

3) Using the method of Euclidean distance to calculate the distance between indexes.

4) By the clustering process analyzing step by step, pedigree chart can be obtained by the method of the shortest distance clustering, which can be clear and comprehensive reflection correlation of indexes. As is shown in figure 1, the distance of clustering is denoted by ordinate.
As you can see from figure 1 110kV substation average load rate c13, 110kV main transformer maximum load rate c16, 220kV Main Transformer maximum load rate c17, 220kV substation, the average load rate c14, these indexes are the most similarity, so they are most relevant. From the point of view of their physical significance is indeed related. According to the power grid planning project selecting 20 indicators from six

Figure 1. The chart of clustering analysis.

areas in 2015. As is shown figure 1, the indicators can be classified into eight categories by the shortest distance Method \{c13,c16,c17,c14,c19,c18,c5,c6\};\{c4,c7,c20,c8\};\{c1,c9\};\{c15\};\{c2\};\{c11\};\{c12\};\{c10\}. The similar indexes have a strong correlation; each two index correlations was gradually weakened, which provide the basis for the classification of evaluation indexes.

As is shown figure 1, the farther the distance between the indexes the less the relevance, for example,110kV planning for the capacity of the public substation c10 and 220kV planning for the capacity of the public substation c12 are obviously uncorrelated, on the clustering tree can also showed no correlation between them. In real power system, the load rate of transmission line and the whole society power consumption is uncorrelated; with the shortest distance method of clustering analysis also show its irrelevance. This proves, we can use the shortest distance clustering methods to analyze the relevance of various indexes and build a multilevel index system of coordination of power grid with a small amount of calculation, and the problem is simplified.

CONCLUSIONS

The evaluation method of multilevel coordination index system of power grid is discussed in the paper, according to Euclidean distance to calculate the distance between the indicators, through the shortest distance clustering method to research
on the correlation between the indicators in the index system, constructing evaluation index system of power network planning, finally, the cluster pedigree chart is comprehensive, which directly reflects the correlation between the indicators. Finally, the rationality and practicality of the algorithm is verified through the concrete example. Exploring new ideas of hierarchical classification of index system based on the shortest distance cluster analysis. It is not only favor to a certain application value for the multilevel coordination index of power grid planning, but also has a certain reference value for the future power grid planning.

**REFERENCE**