Decisions on Power Emergency Supplies Based on Confidence Criterion

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ABSTRACT: This paper presents a new model of standardized matching for supplies due to the lack of timeliness, validity and pertinence in deployment of emergency supplies and lack of complete sets of supplies. On this basis, this paper puts forward a decision-making method for power emergency supplies based on confidence criterion. This method divides the configuration packages of the emergency supplies required by different types of accidents into different levels through four indicators – disaster type, disaster degree, number of victims and number of commanders and rescuers. When a new accident occurs, as long as the corresponding index parameters are input, the level of configuration package of the emergency supplies required can be quickly acquired. Such a method is in line with the model of standardized matching for emergency supplies presented in this paper. The experimental results show that, the evaluation results of this evaluation model have a high precision. To divide the configuration demand for the emergency supplies required by different types of accidents by the level based on confidence criterion is more scientific, intuitive and feasible than the traditional fuzzy evaluation method.

Keywords: emergency supplies management; integrated management system of attribute; confidence criterion

1 INTRODUCTION

In recent years, due to frequent natural disasters, especially floods, snowstorms, earthquakes and other natural disasters, the power facilities in South China were damaged and destroyed, and power supply was interrupted, seriously affecting the local economic development, and bringing a huge impact on people’s daily life and the normal production of enterprises. These large-scale power outages make us recognize the significance of power stability on the society. The power system is characterized by the vulnerability. In the event of an accident, it will bring a serious threat to the security and reliability of the power system. To maintain the stability of the power system is an essential guarantee for social development. With the continuous development of the times and the continuous improvement of the system, the emergency supplies management is particularly important in the event of disasters.

At present, the research of the power emergency supplies management is only involved in the conceptual narration and general description, which is not deep into the specific operational implementation level. Wang Zhifa [1] proposed the emergency, unconventionality, uncertainty, social welfare and weak economy of the power logistics, and summarized the particularity of emergency supplies management as following issues: an urgent demand for supplies, a large quantity demanded, many varieties, a limited warehouse storage capacity and so on; Zhang Xiaohua [2] gave necessary description of the characteristics and operational processes of power emergency logistics and put forward the pertinent suggestions on the management of the supplies procurement, transportation and reserve from the perspective of logistics; Chen Xi [3] elaborated the problems in the emergency supplies management and put forward solutions to the

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corresponding problems, proposed to establish the emergency supplies reserve management system, and also gave a detail description of the process of system operation; Liu CC\footnote{61}, Rachel A Davidson\footnote{5} believed that the emergency extent of the power emergency events is very high, which should be coordinated and managed by the relevant department in a unified way; Zhang Yongling\footnote{6} combined the natural attributes and social attributes of the emergency supplies with the reality; the literature \cite{7} proposed the concept of demand for emergency supplies based on the analysis of existing emergency supplies classification methods; Johansen and Thorstenson\footnote{8} researched the supplier warehouse inventory management strategy. The literature \cite{9} researched the market changes and the impact of supply chain in the event of emergency events; Thomas\footnote{10} researched various problems that may be encountered in the process of supplying emergency supplies; Beamon B M\footnote{11} pointed out the characteristic of the emergency supplies under the environment of sudden-onset disaster, namely, uncertainty of the quantity demanded; Rosenshine M\footnote{12} researched how to manage and control the emergency supplies by using the inventory management strategy in the event of disasters. According to the existing researches, the current management status of the emergency supplies is mostly the traditional model, of which the supplies are stored according to the classification of a single supply. When an emergency occurs, this model will lengthen the supplies deployment time, and some important supplies after deployment fail to be deployed with the supplies to be matched, resulting in failure to directly put into use after the supplies being delivered to the scene. Therefore, the model of standardized matching for supplies becomes a key research object.

Characteristics of demand for power emergency supplies and existing problems:

(1) Lack of timeliness, validity and pertinence in deployment of emergency supplies: The grid company compiles the production equipment management department. It carries out classification according to all kinds of emergency events and natural disasters, stipulates the provisions and responsibilities of the units and departments in response to various types of emergency events and describes the process and grade of emergency response. However, in the process of emergency response, the deployment of emergency supplies is unable to be accurately oriented and deployed according to the emergency events, which is lack of timeliness, validity and pertinence.

(2) Lack of complete sets of emergency supplies: Now, the emergency supplies have begun to preliminarily establish complete sets of storage of some important facilities. For example, the emergency generator equipment has been gradually classified according to the generator power and model, and equipped with the appropriate cable, plug and other accessory equipment. A lot of emergency supplies do not need to be divided according to the usage of equipment to finish complete sets of configuration, so as to be easy to find and deploy the emergency supplies.

(3) Configuration of complete sets to be more refined: For the current situation of the existing equipment that has been configured in complete sets, the professional staff manages the materials import and export according to their own experience and business reasoning, without forming quantitative standards or enough support on the management of the entire emergency supplies, so it does not have a guiding significance of practical operability on the practical application for the emergency supplies.

In view of the above characteristics and problems, this paper designs a new model of standardized matching for emergency supplies, that is, to pack the previously scattered materials in accordance with the usage, in order to timely, effectively and pertinently use the power materials, and strengthen complete sets of the power emergency supplies. The power emergency supplies are divided into the following types in accordance with the usage: basic configuration package for emergency lighting, medical kit, standard configuration package, emergency equipment package and so on. For example, for the medical kit, the bandage, hemostasis, detumescence and protection types of supplies can be packaged together as a standardized configuration package, so there is only a need to deploy the medical kit in the process of deployment of materials, without need to deploy every material in the kit. On this basis, this paper proposes to divide supporting emergency supplies into different levels for varying degrees of disaster according to its degree of damage based on confidence criterion\footnote{13}, in order to avoid not to configure the supplies to be matched, resulting in failure to directly put into use the supplies after being delivered to the scene. That is, according to the disaster type, disaster degree, affected area, number of commanders and rescuers, temperature, humidity, elevation, topography, number of damaged routes, length of damaged routes, number of damaged substations, capacity of damaged main transformer and so on, each type of disaster and the number of standard configuration package for various types of emergency supplies to be equipped for different levels are calculated, in order to achieve overall deployment, and effectively solve the problems, such as lack of timeliness in deployment of emergency supplies and lack of complete sets of emergency supplies.

2 COMPREHENSIVE EVALUATION MODEL OF ATTRIBUTE MATHEMATICS

Based on the theory of attribute mathematics, this paper selects four indicators -- disaster type, disaster degree, number of victims and number of commanders and rescuers as the criteria of attribute comprehensive evaluation method. The configuration packages of the
emergency supplies is set up with three evaluation levels, namely, V=\{V_1, V_2, V_3, V_4\}=\{level I, level II, level III\}, of which the parameters of the configuration package of the emergency supplies at the level I are shown in Table 1.

The number of standard configuration package varies with different levels, of which level I is the lowest level, and level IV is the highest level. Assuming that X is a space of evaluation object, a certain type of elements in X is evaluated as the attribute space or evaluation space, and recorded as F, then the evaluation level V = \{V_1, V_2, V_3, V_4\} becomes the partition of the attribute space F. For (1<k<n) is called as an attribute set, the element in X, namely, the evaluated object x has the degree of attribute Vk, which is expressed by the attribute measure, \_xk=x \_Vk (x∈V_k).

The measured value of the j-th index of X (l_j) has the degree of attribute (or level) V_k, which is expressed by the attribute measure, \_xjk=x \_jk (j∈V_k). According to the attribute set and the attribute measure theory, \_xk and \_xjk should satisfy:

\[ \_xk \geq 0, \sum_{k=1}^{n} \_xk = 1 \]  \hspace{1cm} (1)

\[ \_xjk \geq 0, \sum_{k=1}^{n} \_xjk = 1 \]  \hspace{1cm} (2)

The comprehensive evaluation system of the attribute is divided into three sub-systems: single-index performance function analysis subsystem, multi-index comprehensive performance function analysis subsystem and identification subsystem. In this paper, the performance function is the attribute test. The three sub-systems are discussed below.

2.1 Single-index performance function analysis subsystem

Now, considering the single index \_l_j, the actually measured value of the j-th index \_l_j of the sample x_i is \_t_j, and \_t_j has the attribute measure \_xjk=x \_jk (j∈V_k) of the attribute \_v_j, which needs to be determined according to the specific problem, experimental data, expert experience and certain mathematical processing method. A common way is to give an attribute test function, which is used to indicate the change in the attribute measure \_xjk=x \_jk (j∈V_k) when the measured value \_t_j of the index \_l_j changes.

For the special cases in Table 2, the attribute measure function is constructed for illustration, of which \_d_j satisfies \_d_j < \_a_1 < ... < \_a_k or \_a_1 > \_a_2 > ... > \_a_k. Here, in case of \_d_j < \_a_1 < ... < \_a_k, the single-index attribute measure function is constructed.

Table 2. Classification criteria of single-index attribute.

<table>
<thead>
<tr>
<th>Index</th>
<th>V_1</th>
<th>V_2</th>
<th>...</th>
<th>V_4</th>
</tr>
</thead>
<tbody>
<tr>
<td>t_1</td>
<td>a_{j1}^2</td>
<td>a_{j2}^2</td>
<td>...</td>
<td>a_{jk}^2</td>
</tr>
<tr>
<td>t_2</td>
<td>a_{j1}^2</td>
<td>a_{j2}^2</td>
<td>...</td>
<td>a_{jk}^2</td>
</tr>
<tr>
<td>t_n</td>
<td>a_{j1}^2</td>
<td>a_{j2}^2</td>
<td>...</td>
<td>a_{jk}^2</td>
</tr>
</tbody>
</table>

Let \_d_j = \frac{a_{j1}^2 - a_{jk}^2}{2}, k = 1, 2, ..., n - 1, \_d_j = a_{jk}^2, k = 1, 2, ..., n - 1.

The literature [14] constructed the attribute measure function method. Assuming that the j-th index of x is \_l_j, the single-index attribute measure function is constructed according to Table 2.

\[
\_xjk(l_j) = \begin{cases} 
1, & t < a_{j1} - d_j \\
\frac{t - a_{j1} + d_j}{2d_j}, & a_{j1} - d_j \leq t \leq a_{j1} + d_j \\
0, & a_{j1} + d_j < t 
\end{cases} \quad (3)
\]

\[
\_xjk(l_j) = \begin{cases} 
0, & t < a_{j-1} - d_j \\
\frac{t - a_{j-1} + d_j}{2d_j}, & a_{j-1} - d_j \leq t \leq a_{j-1} + d_j \\
1, & a_{j-1} + d_j < t \leq a_{j-1} - d_j \\
\frac{a_{j-1} + d_j - t}{2d_j}, & a_{j-1} - d_j \leq t \leq a_{j-1} + d_j \\
0, & a_{j-1} + d_j < t 
\end{cases} \quad (4)
\]

If \_d_j = a_{jk0} - b_{jk0}, \_k > 1, then:

\[
\_xjk0(l_j) = \begin{cases} 
0, & t < a_{jk0} - d_j \\
\frac{t - a_{jk0} + d_j}{2d_j}, & a_{jk0} - d_j \leq t \leq a_{jk0} + d_j \\
\frac{a_{jk0} + d_j - t}{2d_j}, & a_{jk0} + d_j < t \leq a_{jk0} + d_j \\
0, & a_{jk0} + d_j < t 
\end{cases} \quad (5)
\]
In this paper, the comprehensive attribute measure is obtained by weighted summation of single-index attribute measure. \( w_j \) in \( \sum_{j=1}^{n} x_j \) is the weight reflecting the importance of the \( j \)-th index \( l_j \), which can be determined by experts and experimental data. From (2), (5) and (6), we can get:

\[
\sum_{k=1}^{m} x_k = \sum_{k=1}^{m} w_{j-k} y_k = \sum_{j=1}^{n} w_j = 1
\]

The weight of the \( j \)-th index \( l_j \) satisfies \( w_j \geq 0 \), \( \sum_{j=1}^{n} w_j = 1 \),

\[
\sum_{k=1}^{m} x_k = \sum_{k=1}^{m} w_{j-k} y_k = \sum_{j=1}^{n} w_j = 1
\]

Namely, \( x_k \) satisfies the equation (1), so it is the attribute measure.

2.3 Identification subsystem

After solving the attribute measure \( x_{jk} \) of the object \( x_j \), 1 < \( k \) < \( n \), how to identify the evaluation type \( \nu_j \) of \( x_j \)? We know that many evaluation issues are related to degree evaluation, for example, the degree of atmospheric pollution, slag-bonding degree of coal ash, degree of customer satisfaction with products and knowledge mastery degree for students. It divides into different levels according to different degrees of demand. For example, the degree of atmospheric pollution is divided into five levels or five categories: \( C_1 \)={clean}, \( C_2 \)={light pollution}, \( C_3 \)={moderate pollution}, \( C_4 \)={heavy pollution}, \( C_5 \)={serious pollution}. These levels can be compared. For example, the lower the pollution level is, the better is. Therefore, “strong” or “weaker” order relations can be established for some attribute sets.

When the attribute set \( A \) is “stronger” than the attribute set \( B \), it is recorded as \( A \succ B \). When the attribute set \( A \) is “weaker” than \( B \), it is recorded as \( A \prec B \). For “strong” or “weak” orderly transitivity, if \( A \succ B \) and \( B \succ C \), then \( A \succ C \); if \( A \prec B \) and \( B \prec C \), then \( A \prec C \). Whether there is a strong and weak relation is determined by the specific issues. If \( (C_i, \ldots, C_k) \) is the partition of the attribute space \( F \), and \( C_1 \succ \ldots \succ C_k \) or \( C_i \prec \ldots \prec C_k \), then \( (C_i, \ldots, C_k) \) is called as orderly partition. In the above issue of atmospheric pollution, \( F \) is the pollution level, which is divided into five categories - (\( C_1 \), \( C_2 \), \( C_3 \), \( C_4 \), \( C_5 \)) and \( C_1 \succ C_2 \succ C_3 \succ C_4 \succ C_5 \). The confidence degree criterion: the evaluation category \( (C_1, C_2, \ldots, C_n) \) is the orderly partition \( (C_1 \succ C_2 \succ \ldots \succ C_n) \) or \( (C_1 \prec C_2 \prec \ldots \prec C_n) \), \( \lambda \) is the confidence degree.

The above criterion requires that “strong” category occupies a large proportion. The confidence degree \( \lambda \) is generally between 0.6 and 0.7.

3 APPLICATION INSTANCES

This paper researches the standard emergency supplies configuration method based on confidence criterion. According to the disaster type, disaster degree, affected area, number of commanders and rescuers, temperature, humidity, elevation, topography, number of damaged routes, length of damaged routes, number of damaged substations, capacity of damaged main transformer and so on, each type of disaster and the number of standard configuration package for various types of emergency supplies to be equipped for different levels are calculated.

The object space \( X = \{ \text{different types of accidents} \} \) and the attribute space \( F \) is the configuration package of emergency supplies. According to the type and size of accident, we divide \( F \) into three categories: \( V_1 = \{ \text{level I} \} \), \( V_2 = \{ \text{level II} \} \), \( V_3 = \{ \text{level III} \} \), and select four indicators – disaster type, disaster degree, number of victims and number of commanders and rescuers for each object. According to different size of accident, we select five accident samples \( x_i \), \( i = 1, 2, \ldots, 7 \). The package type of required emergency supplies is determined based on the measured values of four indicators \( (x_{11}, x_{12}, x_{13}, x_{14}) \). In the process of experiment, this paper develops a set of relevant standards for the disaster type and disaster level, and gives different weight ratios according to the size of damage. For example, for the disaster type, 8-class earthquake is classified as a catastrophe, so its weight ratio is about 9.0. Relatively speaking, 3-class earthquake has less degree of damage, so its weight ratio is about 1.7.
For other issues, the same method can be used to calculate its corresponding attribute measure of four indexes. Then, we need to calculate its multi-index comprehensive attribute measure. Taking an accident as an example, according to the equation (7), \( (-x_{11}, -x_{12}, -x_{13}) = (0.15, 0.23, 0.77) \). In the process of experiment, for the convenience in calculation, we assume that the weight \( w_i \) is equal.

The comprehensive attribute measure of each sample is shown in Table 4.

<table>
<thead>
<tr>
<th>Accident sample</th>
<th>( x_{11} )</th>
<th>( x_{12} )</th>
<th>( x_{13} )</th>
<th>Evaluation results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident 1</td>
<td>0.15</td>
<td>0.23</td>
<td>0.77</td>
<td>Level III</td>
</tr>
<tr>
<td>Accident 2</td>
<td>0.75</td>
<td>0.14</td>
<td>0.11</td>
<td>Level I</td>
</tr>
<tr>
<td>Accident 3</td>
<td>0.03</td>
<td>0.05</td>
<td>0.92</td>
<td>Level III</td>
</tr>
<tr>
<td>Accident 4</td>
<td>0.48</td>
<td>0.46</td>
<td>0.06</td>
<td>Level I</td>
</tr>
<tr>
<td>Accident 5</td>
<td>0.42</td>
<td>0.51</td>
<td>0.07</td>
<td>Level I</td>
</tr>
</tbody>
</table>

Finally, the evaluation analysis is conducted. If the level divided in the distribution of emergency supplies is higher, it indicates that the degree of damage caused by the accident is higher and the demand for the emergency supplies is also greater, so the evaluation categories of V1, V2 and V3 are orderly, \( V_3 > V_2 > V_1 \), that is, level III > level II > level I. According to the confidence criterion, taking \( \lambda > 0.6 \), the final evaluation results are shown in Table 4. Viewing from the final results, according to different degrees of disaster, the number of victims and other indicators, the corresponding results obtained are basically consistent with the actual requirements, proving that the algorithm is valid.

4 CONCLUSION

This paper aims at packaging materials according to the usage and standard configuration package, and managing the standard configuration package and disasters according to disaster type, degree and other factors, in order to correspond with the standard package of the emergency supplies and disasters, set up the specific standard package of the emergency supplies for each degree of disaster, and the required number of standard configuration. According to four indicators - disaster type, disaster degree, number of victims and number of commanders and rescuers, the configuration package of emergency supplies required for different types of accidents is divided into three levels by the method of confidence criterion, of which level III is the highest, and level I is the lowest. When a new accident occurs, we can input the corresponding indicator parameters to quickly get the level of the configuration package of the emergency supplies required, which is in line with the model of standardized matching for emergency supplies presented in this paper. This method solves the comprehensive evaluation issue of multiple fuzzy attributes, whose recognition criterion is the confidence criterion proposed based on the order of some evaluation categories. It requires that the “strong” category occupies a large proportion, which is scientific. Through the practical application, the evaluation results of this model have a high precision. The research of this decision-making system aims at practice, so this decision-making system can be improved only by a large number of engineering applications.

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