COMPREHENSIVE EVALUATION ON RELIABILITY MANAGEMENT OF POWER SUPPLY ENTERPRISES

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ABSTRACT: *To raise the reliability management of power supply enterprises is very important for the modernization management of the enterprises. This paper analyzed the factors that influenced the reliability management level of the enterprises from different visual angles and set up evaluation index system of three levels. On the basis of traditional qualitative analysis and integration stage-analyzing method with fuzzy mathematics, this paper successfully applied the method of quantitative calculation to the comprehensive evaluation on the reliability management of power supply enterprises, and analyzed an example. Its analyzing philosophy and method also have some consult value for the study of the similar problems.*

Key word: *evaluation stage-analyzing quantitative reliability enterprises*

1.INTRODUCTION

As the impetus of modernization construction, electric power is connected more and more with people's routine activities and culture life. Today the power has been used in various fields of world. Power industry is one of the main impetuses and energies, and should go ahead of other industries. Only when power system works safely, reliably and economically, the other industries can work normally and national economy can develop continuously and normally. It is important to study and evaluate the reliability management situation of power supply enterprises, correctly evaluate the reliability management level of the enterprises, and make the best use of the present facility ability in order to improve the economic benefit of the enterprises and bring about a normal and continuous development of the national economy.

The reliability management of power supply enterprises is a system engineering and interacted by many factors. The reliability management of the enterprises has been evaluated with the qualitative methods for a long time. It is not easy to quantize evaluation indexes, determine evaluation standards and put forward the measures of improving the reliability management level. It is necessary to analyze various factors that influence the reliability management level of power supply enterprises, establish the system of evaluation indexes and the mathematical model of evaluation, analyze the reliability management using quantitative methods other than only qualitative methods, and find more scientific evaluation methods through applying quantitative and qualitative methods together, this paper did some useful exploration in these fields.

2.ANALYSIS ON FACTORS THAT INFLUENCE RELIABILITY LEVEL

After studying comprehensively, deeply and systemly the effect of production management and technological conditions of power supply enterprises, social environment and natural situation on reliability management of power supply, we have found that the main factors affecting the reliability management level of power supply enterprises are as follows:

2.1 **Modern management level**

When leaders of power supply enterprises draw up macroscopic industrial policies, such as utilizing resources rationally, optimizing distribution network structure, advancing technical level and improving economic indexes, in some productive processes, such as making system programs, plans, productions, constructions and economical management's, their abilities of scientific decision-making are a little lower. In the operational management of distribution network, such as production, overhaul, minor-overhaul, precautionary test, check of protective device etc., their arrangements lack rationality and flexibility so that the chances of repeating outage increase and the qualities of power projects can not meet the requirements of safety and reliability for power supply. The organization for reliability management is not perfect and lacks qualified management personnel in middle and high classes. All mentioned above restrict the raise of the reliability level.

2.2 **Technical support**

In planning and designing the distribution network, the analysis and evaluation on stability and reliability of the network remain in the primary stage of qualitative analysis lacking advanced scientific and systematic methods. In the project design of power engineering, the reliability can not match economy perfectly, so that the design scheme can not be scientific, rational and reliable. The step of technical advance, innovation and transformation for the distribution network are slow. The quality of staff in the enterprises is a little low, The number of talents is insufficient, and the specialized composition is not reasonable. These do not satisfy the requirements of power supply enterprise characterized by knowledge intensity and advanced techniques. The delay of technical support restricts the improvement of the reliability level.

2.3 Social environment

Power engineering design is separated from the electric equipment design and manufacture. The units are diveded by different authorities lacking the exchange for the information, so that the serialization, the degree of complete sets and the reliability of electric equipment are not high. The material for manufacturing the equipment is in low quality, weak wearability and a short life. The technical levels of power equipment factories are low. Their products are rough and have many quality defects. Manufactures of equipment are insufficient with competition, whose worker's technical qualities are low, and provide electric equipment not satisfying the requirement for the reliability of distribution network. The customers of power supply enterprises are large in number, and the technical and management qualities of their staff are irregular, so that there is a wide gap in the management of using power correctly and safely. The undesirable social environment influences the improvement of reliability level in the power system.

2.4 Natural environment

Unpredicted natural environment, such as natural calamities, various odious meteorological conditions, environmental pollution and damages by external force, is the another important factor influencing the improvement of the reliability of the power system. The damages bringing to the distribution network are random and huge, not being easy to prevent.

3.ESTABLISHMENT OF EVALUATION INDEX SYSTEM

We can know that the reliability management of power supply enterprises is a system problem with multistage and multifactor. From above analysis on factors that influence the reliability management level of power supply enterprises, an evaluation index system of the reliability management can be established. We set up a single factor evaluation aggregate of three level indexes as following chart--1, through analyzing, arranging and comparing various factors.

4.ESTABLISHMENT OF EVALUATION MODEL

Reliability management has advantages of systematism, stage and fuzziness. It is a complicate system with multistage and multifactor according to the above system of evaluation index. It must be evaluated one level by one level and calculated through recursion one stage by one stage.

4.1 Determination of weight ratio

4.1.1 Multi-level hierarchical structural model is built up by the key elements, such as evaluation aims and items (criterions), etc., which the evaluation system is made of.

4.1.2 The key elements belonging to the same level are compared with one another on the basis of using former level factors (H_s) as criterion. The relative important degree is determined according to the evaluation standard, then the evaluation matrix is built.

H_s	A_1	A_2	…	A_j	…	A_n
A_1	a_{11}	a_{12}	…	a_{1j}	…	a_{1n}
A_2	a_{21}	a_{22}	…	a_{2j}	…	a_{2n}
.	.	.		.		.
.	.	.		.		.
A_i	a_{i1}	a_{i2}	…	a_{ij}	…	a_{in}
.	.	.		.		.
.	.	.		.		.
A_n	a_{n1}	a_{n2}	…	a_{nj}	…	a_{nn}

$a_{ij}=A_i / A_j$ is the relative important degree between two elements.

In the matrix the scales of all elements that obtained through comparing all elements with one another, which indicate the relative scale of the relative important degree for element A_i to A_j, are given according to the scale of the evaluation level. Table—1 shows:

Table—1 the definition table of the evaluation scale

Evaluation scale	Definition
1	To H_s , A_i is the same important as A_j
3	To H_s , A_i is a little more important than A_j
5	To H_s , A_i is more important than A_j
7	To H_s , A_i is much more important than A_j
9	To H_s , A_i is much much more important than A_j
2 4 6 8	Locate between two adjacent evaluation scales

4.1.3 The determination of relative importance degree W_i for every factor means to calculate the relative important degree of the key element A_i to the former level H_s, in other words weight ratio W_i of A_i to H_s .

(1) Calculation of the weight vector

Weight vector: $$\overline{W_i} = \left[\prod_{j=1}^{n} a_{ij}\right]^{\frac{1}{n}} \quad (i=1,2,\cdots n) \qquad (1)$$

Normalization: $$W_A = \sum_{i=1}^{n} \overline{W_i} \qquad (2)$$

Relative important degree:

$$W_i = \frac{\overline{W_i}}{W_A} \qquad (3)$$

Result:

$$W = [W_1 \; W_2 \; \cdots \; W_n]^T$$

means the weight rector we want.

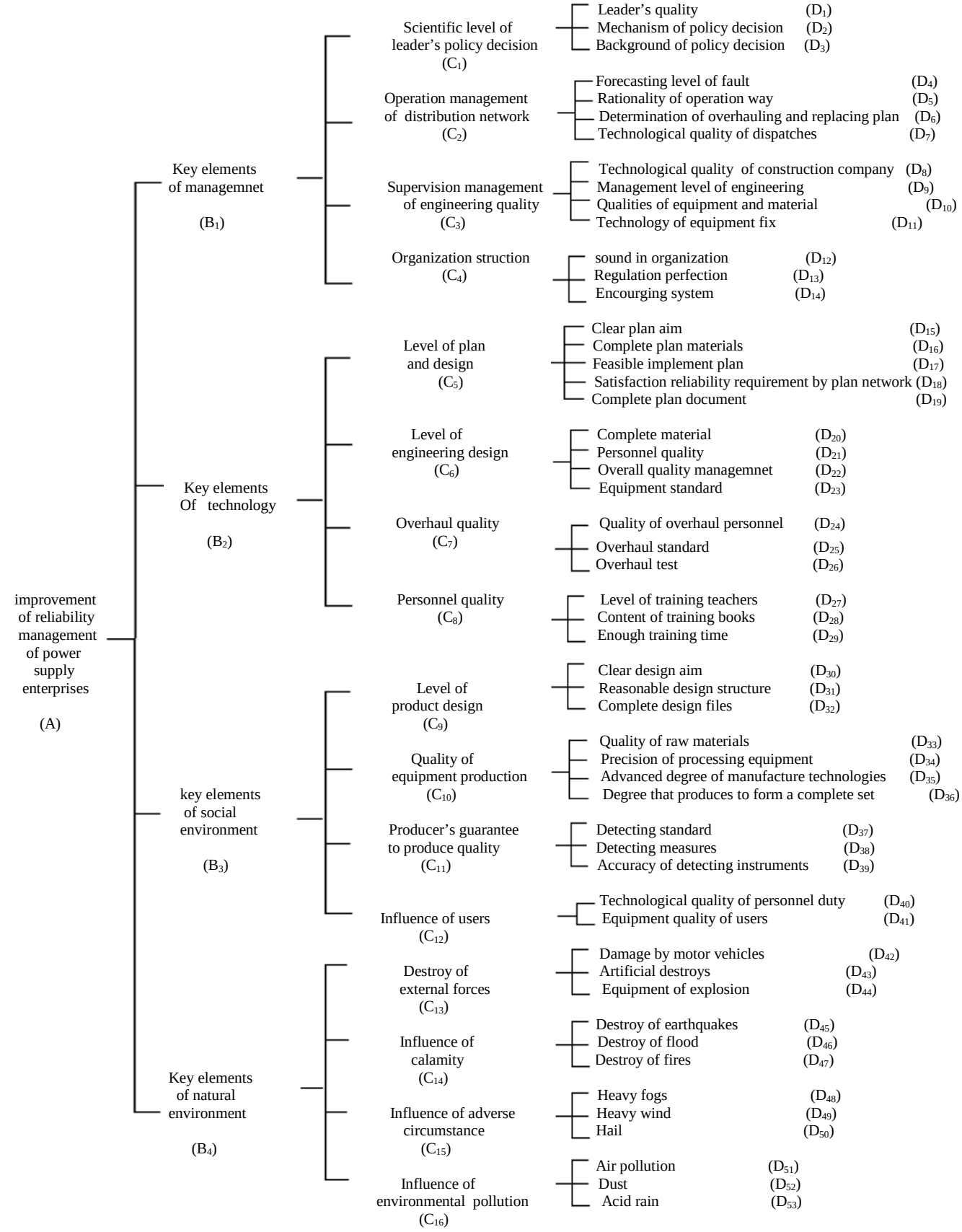

Chart--1
Single factor evaluation aggregate of three level indexes

(2) Calculation of the maximum latent root $\lambda_{\max}$

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{\left(\tilde{A}W\right)_i}{W_i} \tag{4}$$

in which $\left(\tilde{A}W\right)_i = \sum_{j=1}^{n} a_i w_j$ (i=1,2, ⋯n)

4.1.4 *Consistency check*

(1) Calculation of the consistency index

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{5}$$

(2) Calculation of the consistency of ratio

$$CR = CI / RI \tag{6}$$

When CR <0.1 it is thought that the evaluation matrix has satisfactory consistence. In this case, the corresponding weight vector can be regarded as the weight value of level sorting. Otherwise the evaluation matrix is needed to be adjusted.

RI is an average stochastic consistency index value. It is used to measure whether the evaluation matrixes with the different orders have satisfying consistence. The RI values of the evaluation matrixes are in the following table—2

Table—2 Order 1—9 evaluation matrixes

Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

4.2 Fuzzy comprehensive evaluation

In order to evaluate comprehensively reliability states, the following three key elements should first be determined.

(1) Evaluation factor collection U

$$U = \left(U_1, U_2, \cdots, U_n\right)$$

(2) Evaluation factor collection V

$$V = \left(V_1, V_2, \cdots, V_n\right)$$

(3) Single factor evaluation:

The evaluation matrix R^k *of single factor can be calculated:*

$$R^k = \left(r_{ij}^k\right)_{n\times p} \quad (k=1,2,\cdots m) \tag{7}$$

In the formula, r_{ij}^k expresses the evaluation level's degree of the ith factor belonged to the jth one $r_{ij}^k \in [0,1]$, so the general expression of single factor's fuzzy evaluation to the ith factor of aggregate U^k is

$$R_i^k = \left[r_{i1}^k, r_{i2}^k, \cdots r_{i3}^k\right] \tag{8}$$

If the single factor's evaluation on each factors is done in aggregate U^k, the evaluation matrix R^k with one factor will be obtained.

(4)Evaluation model is established and the consequent collection B^k *of fuzzy comprehensive evaluation is calculated:*

$$B^k = A^k \circ R^k \tag{9}$$

In the formula, $A^k = \left(a_1^k, a_2^k, \cdots a_n^k\right)$ is the weight ratio distribution of evaluation factors. It shows the important degree of every evaluation factor to the evaluation level. It is the weight ratio that the ith subfactor corresponds to in aggregate U^k, $0 \le a_i^k \le 1$, and $\sum_{i=1}^{n} a_i^k = 1$, B^k is a fuzzy aggregate of the level collection V. It is also called the consequent aggregate of fuzzy comprehensive evaluation. $B^k = \left(b_1^k, b_2^k, \cdots b_n^k\right)$ is a vector. $\sum_{j=1}^{n} b_j^k$ should commonly be 1, otherwise it is needed to be normalized.

When evaluating the complicate system with more factors, we often divide evaluation factors into many levels according to the reality, and evaluate them level by level and from down to top using above evaluation model.

5.EXAMPLE ANALYSIS

5.1 Zhengzhou electric power bureau was taken as an example. By checking and analyzing concerned materials of the reliability management, inquiring the departments concerned and some specialists concerned, we set up an evaluation index system of the reliability management level, the single factor's evaluation collection of three level indexes, by using the fuzzy comprehensive evaluation model with multistage and multifactor.

With the stage-analyzing method, the weight ratio coefficient of the first level was determined.

A	B_1	B_2	B_3	B_4	W_i	λ_{max}	CR
B_1	1	1	2	3	0.35		
B_2	1	1	2	3	0.35	4.009	0.0003
B_3	1/2	1/2	1	3/2	0.8		
B_4	1/3	1/3	2/3	1	0.12		

The rest may be deduced by analogy. Table—3 is the order for the calculated result of each level's weight ratio.

Table—3 Table for order of weight ratio

A	0.35	0.35	0.18	0.12	
B1	0.11	0.53	0.28	0.08	
B2	0.47	0.34	0.07	0.12	
B3	0.31	0.50	0.12	0.07	
B4	0.13	0.08	0.31	0.49	
C1	0.26	0.57	0.16		
C2	0.24	0.45	0.24	0.08	
C3	0.20	0.40	0.20		
C4	0.46	0.27	0.27		
C5	0.15	0.27	0.12	0.38	0.09
C6	0.34	0.34	0.18	0.15	
C7	0.27	0.46	0.27		
C8	0.27	0.39	0.22		
C9	0.27	0.46	0.27		
C10	0.26	0.14	0.45	0.14	
C11	0.39	0.39	0.22		
C12	0.41	0.59			
C13	0.20	0.60	0.20		
C14	0.07	0.28	0.64		
C15	0.43	0.43	0.13		
C16	0.43	0.43	0.13		

Fuzzy comprehensive evaluation:

V=(excellent, good, general, bad)

was chosen as the comment grade.
By calculating with recursion step by step single factor's evaluation collection of three level indexes from down to top, we got the final result of evaluation as follows:

$$A=W\circ B=\begin{bmatrix}0.35 & 0.35 & 0.18 & 0.12\end{bmatrix}\begin{bmatrix}0.14 & 0.33 & 0.42 & 0.18\\ 0.14 & 0.32 & 0.38 & 0.15\\ 0.12 & 0.24 & 0.41 & 0.26\\ 0.15 & 0.25 & 0.33 & 0.28\end{bmatrix}$$

$$=\begin{bmatrix}0.14 & 0.30 & 0.39 & 0.19\end{bmatrix}$$

Total evaluation result V=0.39. It belonged to general level and conformed with reality.

6.CONCLUSION

Reliability management is an important part of modern management for power supply enterprise. On the basis of traditional qualitative analysis, this paper employs the quantitative calculation to comprehensively evaluate the reliability management of power supply enterprise by combining the stage analyzing method with fuzzy mathematics, so that the evaluation is quantitative, audio-visual as well as more scientific. This paper has important value for improving the reliability management of power supply enterprise and enhance their reliability management level. The analyzing philosophy and method in this paper also possess some reference value for the study of the similar problems.

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