Evaluation Method of DG Black Start of Distribution Network

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Abstract—*In the power system after the power failure accident, the DG connected in the distribution network is used to cooperate with large units to restore the system black start, which has a higher success rate than the traditional black start method.It is necessary to evaluate the black start performance of multiple DG connected in the system and select the DG with the best performance as the black start power.In this paper, the advantages and disadvantages of DG black startup are evaluated by combining fuzzy AHP and extended grey correlation method. It is proved that multiple DG in a system can be evaluated effectively, and more reliable results can be obtained compared with the traditional strategy of single method.*

Keywords—Black start;Distributed power supply;Evaluation of advantages and disadvantages;Fuzzy AHP;Grey correlation method

I. INTRODUCTION

In recent years, although the security and stability of the power grid have been greatly improved and power failure incidents are rare, major power failure incidents are still likely to occur in the face of severe natural disasters and other strong irresistible factors [1-3].The primary task after the blackout is to restore power supply to the grid as soon as possible, especially to ensure the power supply of important loads.

Traditional black start refers to the use of units with black start capability to drive units without black start capability to form a small island network capable of stable operation, gradually expand the scope of power supply, and finally restore the power supply of the entire grid by combining network reconstruction, load transfer and other methods [4].But when it comes to generating set as a black start power supply scheme has some disadvantages [5] : (1) the large generator is usually physical distance from the end of the power grid load, from unit to load power should be based on the complex, power transmission and distribution network is difficult to determine the optimal transmission path, unable to ensure timely and accurately to the target load power supply;(2) the black start units in the power plant are usually in idle standby state, which may temporarily fail to realize self-start;(3) the load rising speed of large generator sets is slow, which requires more recovery time;(4) the traditional "top-down" black start scheme with generator sets as black start power is aimed at restoring power supply to the entire grid. In such a recovery scheme, the key and important loads may not be guaranteed the fastest power supply.Therefore, this paper proposes that the Distributed Generarion (Distributed power supply) is used as the black start power for black start in the distribution network, so as to guarantee power supply for important loads in the first time [6-9].The scheme with DG as black starting power has the following advantages :(1) the DG is usually connected to the distribution network and is close to the load, so it is easy to plan the best power supply path and realize accurate and fast power supply to the target load;(2) DG has stable start-up performance, short start-up time and fast load lifting speed, which can save valuable recovery time;(3) to DG as a black start power supply, directly go to the power supply to the important loads, rather than put recovery goals in the power grid, so even if DG capacity is small (usually a 10 KW - 50 MW), also can form stable operation of the small island, both guarantee the important load in the first time, and can further cooperate with power grid restoration strategies, compared with the traditional method of only a single black start power supply, is a more reasonable choice.In the black start of distribution network, not only should power supply be restored at the fastest speed, but also the small island system formed can be ensured to run stably, and at the same time, the target load should be ensured to have the corresponding importance.Therefore, it is necessary to evaluate the advantages and disadvantages of a certain number of DG connected in a distribution network and determine the starting sequence of DG, so as to ensure that the black start scheme formulated subsequently can achieve the expected recovery effect [10-14].

There are two main parts to evaluate the merits and demerits :(1) select evaluation indicators and determine the weight value of each indicator;(2) make multi-attribute decision and determine the advantages and disadvantages of DG according to the attribute values of each DG in different

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indicators.In the existing studies, ahp is used to obtain the index weight in literature [4], literature [15] and literature [16], and then the membership degree of each DG in the index is calculated roughly, and then the ranking of the advantages and disadvantages of DG is conducted.Literature [17] used the weight estimation results to make the final multi-attribute decision, and obtained the ranking of the advantages and disadvantages of DG.In either case, the whole assessment process cannot be considered comprehensively, and the final result is easily affected by uncertainties.In view of this problem, this paper proposes to use the improved analytic hierarchy process (ahp) and grey correlation method to calculate the index weight and multi-attribute decision making process, so that both parts can get precise calculation results and ensure the accuracy of the final evaluation results.

II. CALCULATION OF INDEX WEIGHT

A. *The selection of DG evaluation indicators*

In the assessment of DG's advantages and disadvantages, the following indicators are selected:

(1) start time.Power start time is related to the time of the whole black start process, which is an important indicator of the merits and demerits of DG black start.

(2) speed of liter load.The DG should have a good load raising speed and bear more load in a short time after being started.

(3) black start ability.DG is divided into black-started DG and non-black-started DG according to whether it has black-started capability, and black-started DG is arranged to start first in the starting sequence.

(4) DG capacity.The larger capacity DG can restore more load power.

(5) importance of nearby load.DG with important loads nearby should be started first to ensure that important loads are supplied first.

(6) running state.Since the power output state of some DG is not stable, the operation state needs to be included in the assessment of the advantages and disadvantages of DG.

B. *Introduction to FAHP (fuzzy analytic hierarchy process)*

AHP (analytic hierarchy process) for the first time by the operational research professor home Saaty, through hierarchical analysis model is set up, all the elements in each level are compared, and two, respectively calculate all elements of an element in a level weight sorting, eventually available solution (bottom) elements on the target layer (top) weight sorting [18-19].

Considering the actual evaluation expert comments influenced by subjective factors, in the process of a certain ambiguity, quantificating introduced on the basis of the traditional AHP and fuzzy mathematics to construct judgment matrix with fuzzy number, instead of the scale of 1 to 9 number classic "nine scaling", may carry on the mathematical description of subjective factors, make up the mathematical model and the actual situation of deviation [20].

C. *Index weights were calculated using FAHP*

Step 1. Establish the hierarchical analysis model of advantages and disadvantages of DG black startup as shown in figure 1.

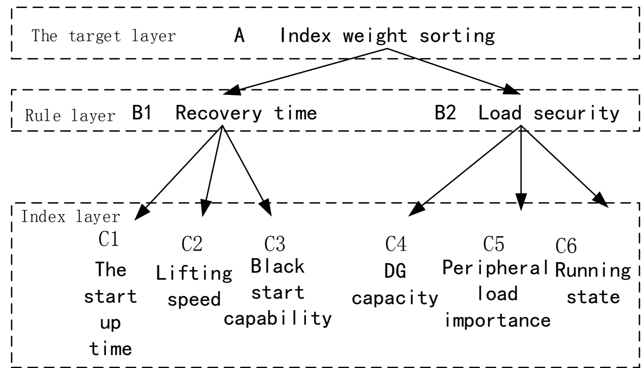

Figure1. Hierarchical analysis model of DG's advantages and disadvantages

In the figure, the target layer is the index weight ordering that needs to be calculated finally, and the recovery time and load guarantee are set in the criterion layer.The three indexes of start time, load speed and black start ability are subordinated to the recovery time criterion, and the three indexes of DG capacity, importance of surrounding load and running state are subordinated to the load guarantee criterion.

Step 2.construct the judgment matrix of triangular fuzzy number.

Invite a number of experts to make pairwise comparison of several elements belonging to a certain element in the upper level, and get the relative importance between the two, forming a judgment matrix.

Let the judgment matrix be R, and R can be expressed as:

$$R_{n\times n}=\begin{bmatrix} r_{1,1} & \cdots & r_{1,n} \\ \vdots & \ddots & \vdots \\ r_{n,1} & \cdots & r_{n,n} \end{bmatrix} \qquad (1)$$

Trigonometric fuzzy number $r_{ij}=(l_{ij}, m_{ij}, h_{ij})$ is an element of the matrix, then the median m_{ij} of r_{ij} represents the priority degree of element I relative to element j.L and h are upper and lower bounds of triangular fuzzy Numbers respectively, representing the degree of fuzzy evaluation by experts.The larger h-l is, the vaguer the expert evaluation is; the smaller h-l is, the clearer the expert evaluation is.As for the comments given by s-bit experts, they are unified according to the following formula to obtain the judgment matrix:

$$r_{ij}=(r^2{}_{ij(1)}+r^2{}_{ij(2)}+\cdots+r^2{}_{ij(t)})^{\frac{1}{2}} \qquad (2)$$

Referring to the traditional 9 scale method of real number field, when the median value m is 1, it is defined as both are equally important, and the value is gradually increasing from 1 to 9. When the value is 9, it means that element I is more important than element j, and the inverse represents the opposite definition.

Values of l and h are shown in table 1:

TABLE I. THE VALUES OF L AND H AND THEIR DEFINITIONS

The value of l	The value of h	The value of h-l	Define
l=max{m-0.5,1}	h=min{m+0.5,9}	h-l=1	The comments are clear
l=max{m-1.5,1}	h=min{m+1.5,9}	h-l=3	The comments are vague
l=max{m-2.5,1}	h=min{m+2.5,9}	h-l=5	The comments were very vague

Step 3: verify the consistency of R matrix.

Since the element rij in the judgment matrix is a subjective evaluation given by a number of experts based on their own knowledge and experience, there may be differences between individual opinions, which may lead to the deviation of the judgment matrix from the actual situation. Therefore, the consistency test of the judgment matrix is required.For the judgment matrix composed of fuzzy Numbers, the median matrix can be used for approximate test.

Define consistency indicator CI:

$$CI = \frac{\lambda_m - n}{n-1} \tag{3}$$

Where n is the order of the matrix, lambda m is the maximum eigenroot of the median matrix m.

In order to compare with CI, random coefficient RI is introduced:

$$RI = \frac{CI_1 + CI_2 + \cdots + CI_n}{n} \tag{4}$$

For matrices of different orders, the values of RI are usually shown in the table 2:

TABLE II. THE VALUES OF RI FOR MATRICES OF DIFFERENT ORDERS

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

The test coefficient CR was obtained by comparing CI with RI:

$$CR=\frac{CI}{RI} \tag{5}$$

When CR is less than 0.1, the judgment matrix is considered to meet the consistency requirement, otherwise the matrix needs to be adjusted.

Step 4. Monolayer weight calculation.

Construct the fuzzy degree measurement matrix En×n, whose diagonal element e_{ii}=1, and off-diagonal element:

$$e_{ij} = 1 - \frac{h_{ij} - l_{ij}}{2m_{ij}} \tag{6}$$

By multiplying the median matrix M with the fuzzy degree measurement matrix E, the correction judgment matrix C can be obtained:

$$C=M\times E \tag{7}$$

It can be seen from the construction form of e_{ij} that h_{ij}-l_{ij} reflects the degree of fuzziness, so the m-matrix multiplied by e-matrix is used to obtain c-matrix, which can effectively remove the influence of fuzziness on the judgment result.The ith element of the correction matrix C is divided by c_{ii}, and the diagonal element is 1.Weight calculated by Q:

First calculate the NTH square root of each row element of Q, then normalize the result, that is, get the weight vector of the current level.The specific calculation is as follows:

$$\varpi_i = \frac{\sum_{i=1}^{n} q_{ij}}{n}, \qquad i = 1, 2, \cdots n \tag{8}$$

$$\tilde{\varpi}_i = \frac{\varpi_i}{\sum_{i=1}^{n} \varpi_i}, \qquad i = 1, 2, \cdots n \tag{9}$$

Step 5. Comprehensive weight calculation.

After calculating the single-layer weight of each layer element to the upper layer subordinate element, the comprehensive weight of the bottom layer element to the top layer element can be obtained from the recursive relation.

Let the weight of element B_i to element A at the highest level be I, and the weight of element C_j to element Bi be ij, then the weight of element C_j at the bottom level to element A at the highest level is:

$$\varpi_j = \varpi_i \cdot \varpi_{ij} \tag{10}$$

III. EVALUATION OF THE ADVANTAGES AND DISADVANTAGES OF DG

When the weight of each indicator is determined, it becomes a typical multi-attribute decision-making problem to evaluate the advantages and disadvantages of DG.The grey relation method is an effective method to solve the multi-attribute decision making problem, which is used to analyze the correlation between the reference sequence (the optimal sequence) and the comparison sequence.When making multi-attribute decision, the attribute value of the scheme cannot be characterized by a certain value, so the fuzzy number can be used to express the attribute value.When evaluating the merits and disadvantages of DG, the upper and lower bounds of fuzzy Numbers of attribute values are not easy to be determined. At this point, the upper and lower bounds of fuzzy Numbers can be expressed as interval Numbers, and the expanded interval fuzzy Numbers gray correlation method can minimize the loss of original information and ensure the accuracy of evaluation results [17].

A. The interval fuzzy number representation of the attribute value

The attribute value of DG can be divided into the definite value that can be measured and the value that can not be measured but can only be evaluated subjectively.If a certain attribute value is measured as a, the interval fuzzy number can be directly expressed as [(a,a);a;(a,a)], indicating that the fuzzy degree of the determined value is zero.According to the table 3, the evaluation statement can be converted into the interval fuzzy number expression:

TABLE III. THE INTERVAL FUZZY NUMBER EXPRESSION OF EVALUATION STATEMENT

Evaluation of the statement	**Corresponding interval fuzzy number**
Very good	[(8.5,9.5);10;(10,10)]
better	[(5.5,7.5);9;(9.5,10)]
good	[(4.5,5.5);7;(8,9.5)]
ordinary	[(2.5,3.5);5;(6.5,7.5)]
poor	[(0,1.5);3;(4.5,5.5)]
More poor	[(0,0.5);1;(2.5,3.5)]
Very poor	[(0,0);0;(1,1.5)]

B. The advantages and disadvantages of DG are evaluated by extended grey correlation method

Step 1: establish the canonical attribute value matrix.

For DGi (I = 1, 2,...,m) in the attribute Cj(j=1,2..., n) xij have attribute value = [(a, a '); b; (c, c)], composed of xij attribute value matrix can be obtained Xm * n.Since the measured value elements have different unit dimensions and value ranges, their values differ greatly, so the attribute value matrix needs to be normalized.All the properties of DG are divided into positive effect properties (the bigger the better) and negative effect properties (the smaller the better), and the normalization method is given respectively.

For positive benefit attributes:

$$\tilde{x}_{ij}=\left[\left(\frac{a_{ij}}{c_{\max}},\frac{a'_{ij}}{c_{\max}}\right);\frac{b_{ij}}{c_{\max}};\left(\frac{c'_{ij}}{c_{\max}},\frac{c_{ij}}{c_{\max}}\right)\right]\quad i=1,2,\cdots,n;\ j=1,2,\cdots,m \tag{11}$$

For negative benefit attributes:

$$\tilde{x}_{ij}=\left[\left(\frac{a_{\min}}{c_{ij}},\frac{a_{\min}}{c'_{ij}}\right);\frac{a_{\min}}{b_{ij}};\left(\frac{a_{\min}}{a'_{ij}},\frac{a_{\min}}{a_{ij}}\right)\right]\quad i=1,2,\cdots,n;\ j=1,2,\cdots,m \tag{12}$$

The attribute value after specification is denoted as:

$$\tilde{x}_{ij}=\left[\left(l_{ij},l'_{ij}\right);m_{ij};\left(h_{ij},h'_{ij}\right)\right] \tag{13}$$

Get the attribute value matrix of the specification:

$$X_{m\times n}=\begin{bmatrix} x_{1,1} & \cdots & x_{1,n} \\ \vdots & \ddots & \vdots \\ x_{m,1} & \cdots & x_{m,n} \end{bmatrix} \tag{14}$$

Step 2. Calculate the difference between the normative attribute value sequence and the reference sequence.

According to the normalization method defined in equations 13 and 14, the reference sequence can be defined as:

$$\tilde{X}_0=(x_0^{(1)},x_0^{(2)},\cdots,x_0^{(n)})=([(1,1);1;(1,1)],\cdots,[(1,1);1;(1,1)]) \tag{15}$$

When calculating the difference between the sequence of attribute values and the sequence of reference values, the upper and lower bounds of the interval fuzzy Numbers are separated to ensure the accuracy of the results.

Define interval fuzzy number difference:

$$\begin{cases}\tau_{ij}^{(1)}=\sqrt{(l_{ij}-1)^2+\left(m_{ij}-1\right)^2+\left(h_{ij}-1\right)^2} \\ \tau_{ij}^{(2)}=\sqrt{(l'_{ij}-1)^2+\left(m_{ij}-1\right)^2+\left(h'_{ij}-1\right)^2}\end{cases} \tag{16}$$

From the above equation, we can see that the difference between each attribute value and the reference sequence element is an interval number $\tau_{ij}=(\tau_{ij}^{(1)},\tau_{ij}^{(2)})$.

Step 3. calculate the grey relational degree.

$$\begin{cases}\gamma_i^{(1)}=\sum_{j=1}^{n}\varpi_j\cdot\xi_{ij}^{(1)} \\ \gamma_i^{(2)}=\sum_{j=1}^{n}\varpi_j\cdot\xi_{ij}^{(2)}\end{cases} \tag{17}$$

Which surrounded the ζ_{ij} as grey correlation coefficient, defined as follows:

$$\begin{cases}\xi_{ij}^{(1)}=\dfrac{\tau_{\min}^{(1)}+\rho\cdot\tau_{\max}^{(1)}}{\tau_{ij}^{(1)}+\rho\cdot\tau_{\max}^{(1)}} \\ \xi_{ij}^{(2)}=\dfrac{\tau_{\min}^{(2)}+\rho\cdot\tau_{\max}^{(2)}}{\tau_{ij}^{(2)}+\rho\cdot\tau_{\max}^{(2)}}\end{cases} \tag{18}$$

Where ρ is the resolution coefficient, generally 0.5.

According to formula (18), the interval number of gray correlation degree of DG_i is:

$$\gamma_i=(\gamma_i^{(1)},\gamma_i^{(2)}) \tag{19}$$

Step 4. Rank the advantages and disadvantages of DG.

According to the analysis in the third section, the principle of grey correlation method is to analyze and calculate the degree of correlation between the existing comparison sequence and the ideal reference sequence. The higher the degree of correlation, the closer the two are.The optimal sequence in the comparison sequence should have the maximum correlation with the reference sequence, that is, the maximum grey correlation.In this paper, the calculation result of grey relational degree is an interval number, so in the comparison between two DG's, it is necessary to calculate the possibility that one DG is better than the other.

Let $P(DG_a \succeq DG_b)$ represent the possibility that DGa is better than DGb, and introduce the concept of possibility degree of interval number. The calculation formula is as follows:

$$\begin{aligned} P_{ab} &= P(DG_a \succeq DG_b) = P(\gamma_a \succeq \gamma_b) \\ &= \max\left\{1-\max\left\{\frac{\gamma_b^{(2)}-\gamma_a^{(1)}}{\gamma_a^{(2)}+\gamma_b^{(2)}-\gamma_a^{(1)}-\gamma_b^{(1)}},0\right\},0\right\} \end{aligned} \tag{20}$$

By pairwise comparison of m DG, the possibility matrix $P_{m\times m}$ can be obtained:

$$P_{m\times m} = \begin{bmatrix} P_{11} & \cdots & P_{1m} \\ \vdots & \ddots & \vdots \\ P_{m1} & \cdots & P_{mm} \end{bmatrix} \tag{21}$$

The final evaluation value V_i of DG_i can be calculated from the possibility matrix of equation (21) :

$$V_i = \frac{1}{m(m-1)}\left(\sum_{j=1}^{m} P_{ij} + \frac{m}{2} - 1\right) \tag{22}$$

The ranking of the good and bad of DG is determined by the value of Vi. The larger the value of Vi, the better the black start performance of DG is.

IV. THE EXAMPLE ANALYSIS

Evaluate the advantages and disadvantages of black start for 6 DG connected in a certain power grid. DG parameters are shown in table 4:

TABLE IV. DG IN A DISTRIBUTION NETWORK

	The form of DG	**The startup time(min)**	**Lifting speed(kw/min)**	**Black start capability**	**DG generating capacity(kw)**	**Load importance**	**Running state**
DG1	Micro gas turbine	4	15	yes	200	very important	Very good
DG2	wind	2	24	no	350	important	poor
DG3	Photovoltaic (pv)	1.5	18	no	100	not important	ordinary
DG4	Photovoltaic (pv)	2.5	21	no	600	more important	ordinary
DG5	Energy storage	3	12	yes	400	very important	good
DG6	Small hydropower	2	30	yes	1000	important	better

A. *Weight calculation*

First, calculate the weight of B1 and B2 index to target A.Establish the fuzzy number evaluation matrix:

$$M = \begin{bmatrix} (1,1,1) & (1.5,2,2.5) \\ (0.4,0.5,0.667) & (1,1,1) \end{bmatrix}$$

The test coefficient CR=0 is obtained, and the matrix is completely consistent.

The E matrix calculated is:

$$E = \begin{bmatrix} 1 & 0.75 \\ 0.73 & 1 \end{bmatrix}$$

From equation (9), the C matrix is:

$$C = \begin{bmatrix} 1 & 1.5 \\ 0.365 & 1 \end{bmatrix}$$

Finally, it was calculated that $\tilde{\omega}_1$ =0.6468 , $\tilde{\omega}_2$ =0.3532。

The weights of C1, C2, C3 to B1 and C4, C5 and C6 to B2 are calculated in the same way, and the results are shown in table 5 and table 6.

TABLE V. THE WEIGHTS OF C1, C2 AND C3 TO B1 AND A

Judgment matrix				Weights of B1	Weights of A
	C1 Black start time	C2 Lifting speed	C3 Black start capability		
C1	(1,1,1)	(1.5,2,2.5)	(1.5,3,4.5)	0.4739	$\tilde{\omega}_{11}$ =0.3110
C2	(1/2.5,1/2,1/1.5)	(1,1,1)	(1.5,2,2.5)	0.3436	$\tilde{\omega}_{12}$ =0.2222
C3	(1/4.5,1/3,1/1.5)	(1/2.5,1/2,1/1.5)	(1,1,1)	0.1771	$\tilde{\omega}_{13}$ =0.1145

TABLE VI. THE WEIGHT OF C4, C5 AND C6 TO B2 AND A

Judgment matrix				Weights of B2	Weights of A
	C4 Generating capacity	C5 Peripheral load importance	C6 Running state		
C4	(1,1,1)	(1/2.5,1/2,1/1.5)	(1.5,2,2.5)	0.3015	$\tilde{\omega}_{24}$ =0.1056
C5	(1.5,2,2.5)	(1,1,1)	(2.5,3,3.5)	0.5257	$\tilde{\omega}_{25}$ =0.1857
C6	(1/2.5,1/2,1/1.5)	(1/3.5,1/3,1/2.5)	(1,1,1)	0.1728	$\tilde{\omega}_{26}$ =0.0610

B. Evaluation of the advantages and disadvantages of DG

According to the actual attribute value of each DG, the interval fuzzy number attribute value matrix is established and normalized as table 7 and table 8 :

TABLE VII. NORMALIZED ATTRIBUTE VALUE MATRIX

	Black start time	Lifting speed	Black start capability
DG1	[(0.375,0.375);0.375;(0.375,0.375)]	[(0.5,0.5);0.5;(0.5,0.5)]	[(1,1);1;(1,1)]
DG2	[(0.75,0.75);0.75;(0.75,0.75)]	[(0.8,0.8);0.8;(0.8,0.8)]	[(0,0);0;(0,0)]
DG3	[(1,1);1;(1,1)]	[(0.6,0.6);0.6;(0.6,0.6)]	[(0,0);0;(0,0)]
DG4	[(0.6,0.6);0.6;(0.6,0.6)]	[(0.7,0.7);0.7;(0.7,0.7)]	[(0,0);0;(0,0)]
DG5	[(0.5,0.5);0.5;(0.5,0.5)]	[(0.4,0.4);0.4;(0.4,0.4)]	[(1,1);1;(1,1)]
DG6	[(0.75,0.75);0.75;(0.75,0.75)]	[(1,1);1;(1,1)]	[(1,1);1;(1,1)]

TABLE VIII. NORMALIZED ATTRIBUTE VALUE MATRIX

	Generating capacity	Peripheral load importance	Running state
DG1	[(0.2,0.2);0.2;(0.2,0.2)]	[(0.85,0.95);1;(1,1)]	[(0.85,0.95);1;(1,1)]
DG2	[(0.35,0.35);0.35;(0.35,0.35)]	[(0.55,0.75);0.9;(0.95,1)]	[(0,0.15);0.3;(0.45,0.55)]
DG3	[(0.1,0.1);0.1;(0.1,0.1)]	[(0,0.05);0.1;(0.25,0.35)]	[(0.25,0.35);0.5;(0.65,0.75)]
DG4	[(0.6,0.6);0.6;(0.6,0.6)]	[(0.45,0.55);0.7;(0.8,0.95)]	[(0.25,0.35);0.5;(0.65,0.75)]
DG5	[(0.4,0.4);0.4;(0.4,0.4)]	[(0.85,0.95);1;(1,1)]	[(0.55,0.75);0.9;(0.95,1)]
DG6	[(1,1);1;(1,1)]	[(0.55,0.75);0.9;(0.95,1)]	[(0.45,0.55);0.7;(0.8,0.95)]

The grey correlation degree of each DG is calculated which are shown in table 9:

TABLE IX. THE GRAY RELATION OF DG

DG number	Grey correlation
DG1	$(\gamma_1^{(1)},\gamma_1^{(2)})=(1.254,1.312)$
DG2	$(\gamma_2^{(1)},\gamma_2^{(2)})=(0.710,0.741)$
DG3	$(\gamma_3^{(1)},\gamma_3^{(2)})=(0.352,0.357)$
DG4	$(\gamma_4^{(1)},\gamma_4^{(2)})=(0.331,0.339)$
DG5	$(\gamma_5^{(1)},\gamma_5^{(2)})=(0.727,0.765)$
DG6	$(\gamma_6^{(1)},\gamma_6^{(2)})=(0.298,0.308)$

The probability matrix P and the comprehensive evaluation value of DG calculated from equations (20)-(22) are as shown in table 10:

TABLE X. DG POSSIBLE DEGREE MATRIX

	DG1	**DG2**	**DG3**	**DG4**	**DG5**	**DG6**
DG1	0.5	1	1	1	1	1
DG2	0	0.5	1	1	0.203	1
DG3	0	0	0.5	1	0	1
DG4	0	0	0	0.5	0	1
DG5	0	0.797	1	1	0.5	1
DG6	0	0	0	0	0	0.5

V1=0.25 ， V2=0.1901 ， V3=0.15 ， V4=0.117 ， V5=0.2099，V6=0.0833

According to the comprehensive evaluation value of each DG,V1>V5>V2>V3>V4>V6,So you get the order of DG plus or minus:DG1>DG5>DG2>DG3>DG4>DG6.

V. CONCLUSION

Aiming at DG in black start strategy and evaluation problems, this paper proposes a new method, in the traditional method is introduced on the basis of the triangular fuzzy number and interval fuzzy number, combined with analytic hierarchy process (AHP) and grey correlation method, weight calculation and evaluated respectively, at the same time ensure the accuracy and the precision of these two aspects, to avoid the traditional method of single cause of deviation.You can get more accurate results.

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