Distribution Network Island Partition and Black Start Based on Distributed Generation

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Abstract. In order to reduce the power outage loss of the grid after a large area power failure in the regional power system, it is necessary to start the black power grid as soon as possible. For distribution networks with distributed generation (DG), it is of great significance to determine the partition scheme of islands and put forward the black start strategy of DG to continue to supply power to the loads, so as to reduce the power outage loss. Fully considering the importance of loads and their controllability, an island partition scheme of two steps are proposed based on the established mathematical model. The primary island is formed by using the dynamic programming algorithm, and then, the secondary island is formed by modifying primary island according to certain rules, thus obtaining the optimal island. Then the starting sequence of the black start power supply in the island is determined by Analytic Hierarchy Process (AHP) and the black start strategy is obtained. The effectiveness of the proposed island partition and black start strategy is verified by using the example of PG&E69-node system.

1. Introduction
Distribution network undertakes an important task of power distribution [1-2]. The huge distribution system will inevitably fail [3], which has a series of impact on people's life. The main goal of traditional distribution network fault recovery is to recover the loads in the fault areas as soon as possible through network reconfiguration [4-5]. In recent years, all kinds of distributed generation technologies are developing rapidly, and the application of DG in the actual power grid has become more convenient [6-7], which makes the application of DG in fault recovery more feasible.

Many experts and scholars have conducted in-depth research on the restoration of power supply after the failure of distribution network. In terms of island division strategy, reference [8] updates the island partition strategy by combining DG and critical load with optimization algorithm, so that more important loads can be incorporated into the islands after division. Reference [9] proposes a dynamic island partition strategy for the imbalance between supply and demand of islands caused by the dual time-varying of clean energy and load power in the restoration process, as well as the problem of ignoring the regulatory potential of flexible loads. In [10], the problem of island partition is transformed into the problem of obtaining the minimum spanning tree of connected graph, and the reasonable island range is obtained by solving the problem with PRIM algorithm. However, this method may eventually form a large island, which makes it impossible to carry out parallel recovery and more time-consuming. The
research on black start mainly focuses on the formulation of black start scheme of transmission network and the establishment of evaluation model [11-12]. At present, there are few studies on the black start of distribution network, and few achievements have been published on the development of the island black start scheme of distribution network or the operation of the island black start scheme [13].

Combined with the status quo of the distribution network [14-15], this paper adopts the dynamic programming method to prioritize the important loads to form the primary island first, then the primary island is modified according to certain rules and the secondary island is obtained. Under the premise of satisfying the DG capacity constraint, the recovery load reaches the maximum. Next, the black start ability of DG was evaluated by Analytic Hierarchy Process (AHP) to obtain the black start strategy within the island [16]. Finally, an example is given to verify the rationality of the proposed strategy.

2. Island partition

2.1. Primary island formation scheme

The actual DG power access to the distribution network is generally small, providing continuous power supply for the surrounding loads. It is impossible for the load in blackout areas to rely on DG fully to restore power supply. Therefore, the load beyond the power supply range of DG should be eliminated, so as to improve the efficiency of the algorithm.

The maximum power supply range of DG represented by $D_{\text{max}}$ is the connected region consisting of loads that can be contained along each non-branching path starting from DG without breaking the DG capacity constraints. DG is taken as the root node to conduct depth-first search, and the capacity constraint of DG is checked while searching. Take the area of power loss shown in figure 1 as an example. In figure 1, the load of each node and the maximum power generation of DG are marked on the left side of the node, and the unit is kW. When searching to node 4 along the path DG-0-1-2, since the power required by the load after adding node 4 has exceeded the maximum output of DG, it searches node 3 up to the next level. After adding node 3, it meets the capacity constraint of DG, so DG-0-1-3 is determined. $D_{\text{max}}$ is finally determined as the region connected by solid lines as shown in figure 1.

![Figure 1. Connected areas including DG.](image)

After determining $D_{\text{max}}$, if not all loads within this range can be restored to power supply, it is necessary to select and restore critical loads to maximize the importance value of load restoration, that is, maximizing the objective function value. The objective function takes the total recovery loads and loads priority into account.

$$f = \max \sum_{i=1}^{n} \epsilon_{i} x_{i}$$  \hspace{1cm} (1)

where $\epsilon_{i}$ is the importance value of the $i$th load, and $x_{i}$ represents whether the load $i$ is within the island. If it is selected into the island, then $x_{i}=1$; otherwise, $x_{i}=0$; $n$ is the number of loads in the island. Only the active power balance within the island needs to be considered when dividing the island. The constraints of load recovery model include voltage constraints, DG capacity constraints, and power balance constraints.
\[ U_i^{\text{min}} \leq U_i \leq U_i^{\text{max}}, i \in H \]  
(2)

\[ S_{iH, i}^{\text{min}} \leq S_{iH, i} \leq S_{iH, i}^{\text{max}}, i \in H \]  
(3)

\[ \sum_{i \in H} L_i \leq \sum_{i \in H} |s_i| \]  
(4)

where \( H \) is the node set within the island, \( L_i \) is the load value of the \( i \)th node selected into the island, and \( s_i \) is the capacity value of the \( i \)th DG within the island. \( U_i \), \( U_i^{\text{min}} \) and \( U_i^{\text{max}} \) are respectively the voltage level of node \( i \), its lower and upper limits; \( S_{iH, i} \), \( S_{iH, i}^{\text{min}} \) and \( S_{iH, i}^{\text{max}} \) are the actual power output of the \( i \)th DG, its minimum and maximum output power.

The importance degree of power outage load is changed from qualitative value to quantitative value in (5):

\[ k_i = w_i L_i \]  
(5)

where \( k_i \) is the importance degree value of the \( i \)th load; \( L_i \) is the \( i \)th load value; \( s_i \) is the importance grade index of the \( i \)th load. According to the degree of emergency, the loads can be divided into class 1, 2 and 3, and corresponding values are given.

According to the optimality theory of dynamic programming algorithms, an optimal strategy has the property that no matter what the past states and decisions are, the remaining decisions must constitute the optimal strategy for the states formed by the previous decisions. Assuming that the DG capacity in the island is \( G \) and contains \( R \) outage loads, the maximum load importance value that the island can recover is denoted as \( p[R][G] \). The core idea of dynamic programming algorithm is as follows:

\[ p[i][G] = \max \left\{ p[i-1][G], \frac{p[i-1][G - L(i)]}{G - L(i)} + k(i) \right\} \]  
(6)

where \( p[i][G] \) represents the maximum load importance value that can be realized in the \( (i-1) \)th power outage load with the DG capacity in the island is \( G \); \( p[i-1][G - L(i)] \) represents the maximum importance value that can be realized in the \( (i-1) \)th power outage load with the DG capacity of \( G - L(i) \) in the island. \( L(i) \) represents the \( i \)th load value; \( k(i) \) represents the importance value of the \( i \)th load. When \( p[i][G] = p[i-1][G] \), it indicates that the \( i \)th load is not divided into the island; \( p[i][G] = p[i-1][G - L(i)] \), indicating that the \( i \)th load is divided into the island.

### 2.2. Forming secondary islands

After forming primary islands, the existence of controllable loads in the island's boundary and the outer boundary of island makes primary island structure may not be optimal. Take figure 1 as an example to illustrate briefly, assuming that the island node 10 is 100% controllable load and its priority is lower than node 12, then the 16kW load on node 10 is removed and node 12 is included in the island. In this way, the constraint conditions are not violated, but the objective function value is increased and the island scheme is optimized. Whether the primary island can be optimized depends on whether there is controllable load in the island or outside the island boundary, and it is related to the size and grade of controllable load.

The concrete steps of primary island optimization to form secondary island are as follows: first, search the island on the border if there is a controllable load, this is because the maximum active DG output in practical engineering is often greater than the island's total power demand. In other words, the power surplus of DG can be reduced by accessing the controllable load on the outer boundary of the island. The nodes of the outer island boundary are successively compared with the nodes of the controllable load within the island. Firstly, starting from the first load node on the island's outer boundary, the importance level of controllable loads in the island is successively compared with it, and all the island's controllable loads whose load importance level is less than that of the node on the island's outer boundary are selected. The load amount of all selected controllable loads on the island is added to the remaining capacity of the primary island to restore the additional edge nodes. If the total amount of these
loads is greater than or equal to the outer boundary load of the island, the load can be completely restored. But if the total amount of these loads is less than the outer boundary load of the island and the load is controllable, part of the load can be restored. Continue to search for the next off-island boundary load node and repeat the above steps until all the off-island boundary load nodes have been searched, then it will be done.

3. Black start strategy
According to the black start ability of DG, the starting sequence of power supply can be determined. Considering various influencing factors, the evaluation indexes are stratified by the Analytic Hierarchy Process (AHP) and the units are comprehensively evaluated so as to obtain the black start strategy.

3.1. Establishment of DG characteristic evaluation hierarchy model
Considering that the goal of black start is to restore power to the grid as quickly as possible, the criterion layer of evaluating the characteristics should be power generation criterion, time criterion and reliability criterion. The analytic hierarchy model is shown in figure 2.

![Analytic hierarchy model of DG characteristics](image)

Figure 2. The analytic hierarchy model of DG characteristics.

In this paper, triangular fuzzy number is used to deal with indicators, which can be given by experts in the form of linguistic variables according to the pre-designed language comment set, and then the linguistic variables can be converted into corresponding triangular fuzzy number according to certain rules, as shown in table 1.

| Serial Number | The Degree Representation of Evaluation Index | Triangular Fuzzy Number |
|---------------|---------------------------------------------|-------------------------|
| 1             | Quite good/Crucial                          | (0.9, 1, 1)             |
| 2             | Good/Critical                               | (0.7, 0.9, 1)           |
| 3             | Somewhat important                          | (0.5, 0.7, 0.9)         |
| 4             | Ordinary                                    | (0.3, 0.5, 0.7)         |
| 5             | A little bad                                | (0.1, 0.3, 0.5)         |
| 6             | Bad/Unimportant                             | (0, 0.1, 0.3)           |

3.2. Determination of fuzzy weights
In this paper, the weight determination method based on the trapezoidal fuzzy number complementary judgment matrix is adopted to obtain the weight of each index. If m indexes are considered, the trapezoidal fuzzy number complementary judgment matrix $\tilde{F} = (\tilde{f}_{ij})_{m \times m}$ can be obtained by comparing
these m indexes pair-wise, where \( \tilde{f}_{ij} = (p_{ij}, q_{ij}, r_{ij}, s_{ij}) \) is the trapezoidal fuzzy number, indicating the degree to which index \( z_i \) is more important than index \( z_j \). 0 \leq p_{ij} \leq q_{ij} \leq r_{ij} \leq s_{ij} \leq 1 \) and they satisfy:

\[
p_{ij} = 0.5, q_{ij} = 0.5, r_{ij} = 0.5, s_{ij} = 0.5
\]

\[
p_{ij} + s_{ij} = 1, q_{ij} + r_{ij} = 1, r_{ij} + q_{ij} = 1, s_{ij} + p_{ij} = 1, i \neq j
\]

This method assumes that M (M\geq 1) experts are employed at the same time, and the status of all experts is equal. Pair comparisons and judgments are made for the indexes in the same index set \( Z \), and the trapezoidal fuzzy number complementary judgment matrices are given respectively. Let the judgment matrix given by the \( g \)th expert be \( F^{(g)}_{ij} = (f^{(g)}_{ij})_{m \times m} \), where \( f^{(g)}_{ij} = (p^{(g)}_{ij}, q^{(g)}_{ij}, r^{(g)}_{ij}, s^{(g)}_{ij}) \) and \( (g = 1, 2, \ldots, M) \). The kernel matrix of \( f^{(g)}_{ij} \) is calculated, and whether the complementary judgment matrix conforms to the consistency is determined by judging whether the additive consistency index of the kernel matrix is within the set critical value of the consistency index. If not, the complementary judgment matrix is adjusted until it meets the consistency. The complementary judgment matrix is used to determine the weight of each index. The specific steps are as follows:

- The complementary judgment matrix given by M experts hired is synthesized, and the calculation formula is:

\[
\tilde{f}_{ij} = (p_{ij}, q_{ij}, r_{ij}, s_{ij}) = \left( \frac{1}{M} \sum_{g=1}^{M} p^{(g)}_{ij}, \frac{1}{M} \sum_{g=1}^{M} q^{(g)}_{ij}, \frac{1}{M} \sum_{g=1}^{M} r^{(g)}_{ij}, \frac{1}{M} \sum_{g=1}^{M} s^{(g)}_{ij} \right)
\]

- The fuzzy evaluation value of each index \( z_i \) in the obtained trapezoidal fuzzy complementary judgment matrix is calculated:

\[
\tilde{u}_i = \left[ \frac{\sum_{j=1}^{m} p_{ij}}{\sum_{j=1}^{m} \sum_{j=1}^{m} s_{ij}}, \frac{\sum_{j=1}^{m} q_{ij}}{\sum_{j=1}^{m} \sum_{j=1}^{m} q_{ij}}, \frac{\sum_{j=1}^{m} r_{ij}}{\sum_{j=1}^{m} \sum_{j=1}^{m} r_{ij}}, \frac{\sum_{j=1}^{m} s_{ij}}{\sum_{j=1}^{m} \sum_{j=1}^{m} s_{ij}} \right]
\]

- According to the fuzzy evaluation value of each indicator, the expectation is calculated as follows:

\[
y_i = O(\tilde{u}_i) = \frac{p_i + q_i + r_i + s_i}{4}
\]

where \( y_i \) is the weight of index \( z_i \); the weight of each factor to the total target is \( W = y_CY_1 \).

### 3.3. Steps to determine the DG starting sequence

Assume that the evaluation index of DG characteristics is \( I = \{I_1, I_2, \ldots, I_6\} \), all the DGs that need to be evaluated are \( G = \{G_1, G_2, \ldots, G_6\} \), then the steps to evaluate DG are as follows:

- According to the given index attribute value matrix, the evaluation matrix is expressed by triangular fuzzy number as \( \tilde{Z} = (\tilde{z}_{ij})_{6 \times 6} \). Where \( \tilde{z}_{ij} = (\tilde{z}_{ij}, \tilde{z}_{ij}, \tilde{z}_{ij}) \) is the triangular fuzzy number of \( G_i \) for index \( I_j \);

- The evaluation matrix is transformed into a normative matrix \( \tilde{H} = (\tilde{h}_{ij})_{6 \times 6} \), where \( \tilde{h}_{ij} = (\tilde{h}_{ij}^p, \tilde{h}_{ij}^q, \tilde{h}_{ij}^r, \tilde{h}_{ij}^s) \), the evaluation index is divided into positive index and negative index;

\[
h_{ij}^a = \begin{cases} \frac{z_{ij}^a}{z_{ij}^a}, & z_{ij}^a = \max\{z_{ij}^a, z_{ij}^a, \ldots, z_{ij}^a\}, h_{ij}^a = \frac{z_{ij}^a}{z_{ij}^a}, & z_{ij}^a = \min\{z_{ij}^a, z_{ij}^a, \ldots, z_{ij}^a\} \end{cases}, (a = J, K, L)
\]

- For the canonical matrix obtained in the previous step, calculate the expected value of each element;
\[ \tilde{h}_{ij} = \frac{(1-b)h'_{ij} + h''_{ij} + bh'''_{ij}}{2} \quad (i = 1, 2, \ldots, 6; j = 1, 2, \ldots, 6) \]  

In (13), \( b \) can be any value between 0 and 1, which is determined by the evaluator’s attitude. In this paper, \( b \) is set to 0.5.

- Calculate the weight \( W \);
- According to \( d^{(b)}_j = \sum_{i=1}^{6} \tilde{h}^{(b)}_{ij}W_i \), the comprehensive evaluation value of each unit is obtained, and then the advantages and disadvantages of DG characteristics are ranked according to \( d^{(b)}_j \). Thus, the evaluation results of DG black start ability are obtained and the black start strategy is determined.

4. Analysis of examples

PG&E69 node system was used to test the proposed island division and black start strategy. The node system diagram is shown in Fig.2, DG1–DG4 are connected to the system through bus 6, 10, 24 and 53 respectively, and their maximum output active power is 100kW, 130kW, 100kW and 150kW respectively. The importance level of distribution network load is divided into level 1, 2 and 3, and the corresponding \( e_i \) values are set as 100, 10 and 1.

![Figure 3. PG&E69-node system.](image)

The loads attached to node 6, 9, 12, 18, 35, 37, 42, 51, 57 and 62 are class I loads; The loads attached to node 1–5, 8, 14, 15, 17, 19–21, 23–27 and 29–34, 36, 38–41, 44, 49, 50, 52–56, 58, 61, 64–69 are class II loads. The rest of the loads are class III loads. The loads connected to node 11, 12, 17, 19, 21, 23, 26, 29, 32, 47–49, 58, 63 and 66 are 100% controllable loads, while the loads carried by other nodes are uncontrollable loads.

Assuming that there is a fault between bus 1 and bus 2, using the algorithm in this paper, the island formation process is as follows. The primary islands are: island 1, \{DG1, DG2, DG3, 6, 9, 12, 14, 22, 24, 33, 35, 37, 57\}. Island 2, \{DG4, 47–49, 51–53, 55\}. The primary islands are the areas within the dashed lines shown in figure 4, and the active power surplus in the island is 51.88kW and 14.8kW respectively. There is a controllable load 21 on the outer boundary of island 1, so the remaining 51.88kW load in the primary island can be used to partially restore load 21 and form a new island. After inspection, this island is the secondary island. For the correction of island 2, the 14.8kW load on node 11 is connected to make the remaining capacity of DG4 0kW. There are controllable loads inside and outside the island. According to the revised rules, the 54kW load on node 47 and 48 is disconnected, and the remaining load on node 11 continues to be accessed. After the modification, there is no controllable load on the outer edge of the new island. Eventually the secondary island is formed. The secondary islands formed are the areas circled by the solid red lines. The DG residual capacities of the modified secondary
islands are respectively 0 and 0, which indicates that when the controllable loads are considered, the utilization rate of DG can reach 100%.

![Diagram of primary and secondary islands.](image)

**Figure 4. Diagram of primary and secondary islands.**

After obtaining the range of each island, the black start scheme is determined by AHP. In this paper, four DGs in the PG&E 69-node system are evaluated for black start capability, and the power starting sequence is determined by the weights of each unit. The parameters of DG are shown in table 2.

### Table 2. Characteristic parameters of DG.

| DG serial number | DG1   | DG2   | DG3   | DG4   |
|------------------|-------|-------|-------|-------|
| Type             | Micro-gas turbine | PV    | Wind turbines | Micro-gas turbine |
| Capacity (kW)    | 100   | 130   | 150   | 100   |
| Startup time (min) | 1     | 3     | 5     | 1.5   |
| Load-lifting speed (kW/min) | 5     | 15    | 30    | 8     |
| Operation capability | Ordinary | Good | Ordinary | Quite good |
| Importance of surrounding loads | Crucial | Somewhat important | Ordinary | Somewhat important |

The fuzzy matrix of the attribute value of the generator set is:

\[
Z = \begin{pmatrix}
(100,100,100) & (1.0,1.0,1.0) & (5,5,5) & (0.3,0.5,0.7) & (0.9,1.0,1.0) \\
(130,130,130) & (3.0,3.0,3.0) & (15,15,15) & (0.7,0.9,1.0) & (0.5,0.7,0.9) \\
(100,100,100) & (5.0,5.0,5.0) & (30,30,30) & (0.3,0.5,0.7) & (0.3,0.5,0.7) \\
(150,150,150) & (1.5,1.5,1.5) & (8,8,8) & (0.9,1.0,1.0) & (0.5,0.7,0.9)
\end{pmatrix}
\]

The expected value of the elements in the canonical matrix is:

\[
H = \begin{pmatrix}
0.67 & 1.00 & 0.17 & 0.51 & 1.00 \\
0.87 & 0.33 & 0.50 & 0.90 & 0.72 \\
0.67 & 0.20 & 1.00 & 0.51 & 0.51 \\
1.00 & 0.67 & 0.27 & 1.00 & 0.72
\end{pmatrix}
\]

According to the weight calculation method of trapezoidal fuzzy number complementary judgment matrix in 3.2, the weight of each index relative to the overall target is determined. The specific calculation process is as follows:

Three experts were hired to judge the related attributes, then transform the qualitative evaluation language into a trapezoidal fuzzy number complementary judgment matrix as follows:

The judgment matrix of criterion layer relative to index layer:
The judgment matrix of index layer $I_1$, $I_2$ relative to criterion layer $C_1$:

\[
R_{cl}^1 = \begin{bmatrix}
0.5,0.5,0.5,0.5 & 0.4,0.5,0.6,0.6 \\
0.4,0.4,0.5,0.6 & 0.5,0.5,0.5,0.5 \\
0.5,0.6,0.6,0.6 & 0.5,0.5,0.5,0.5
\end{bmatrix}
\]

(16)

Since $C_2$ is only related to one criterion, there is no need to give an expert judgment matrix.

The judgment matrix of index layer $I_3$, $I_4$, $I_5$ relative to criterion layer $C_3$:

\[
R_{cl}^3 = \begin{bmatrix}
0.5,0.5,0.5,0.5 & 0.3,0.4,0.4,0.5 \\
0.3,0.3,0.4,0.6 & 0.5,0.5,0.5,0.5 \\
0.5,0.6,0.6,0.7 & 0.5,0.5,0.5,0.5
\end{bmatrix}
\]

(17)

\[
R_{cl}^2 = \begin{bmatrix}
0.5,0.5,0.5,0.5 & 0.3,0.4,0.4,0.5 \\
0.3,0.3,0.4,0.6 & 0.5,0.5,0.5,0.5 \\
0.5,0.6,0.6,0.7 & 0.5,0.5,0.5,0.5
\end{bmatrix}
\]

(18)

The trapezoidal fuzzy complementary judgment matrix of the three experts was synthesized:

\[
R_{ci} = \begin{bmatrix}
0.5,0.5,0.5,0.5 & 0.4,0.5,0.6,0.6 & 0.3,0.4,0.4,0.5 \\
0.4,0.4,0.5,0.6 & 0.5,0.5,0.5,0.5 & 0.1,0.2,0.3,0.4 \\
0.5,0.6,0.6,0.6 & 0.6,0.7,0.8,0.9 & 0.5,0.5,0.5,0.5
\end{bmatrix}
\]

(25)

Calculate the indexes of each index layer and criterion layer, and get the fuzzy evaluation value:

\[
v = \begin{bmatrix}
0.22 & 0.29 & 0.34 & 0.43 \\
0.21 & 0.24 & 0.29 & 0.39 \\
0.35 & 0.39 & 0.45 & 0.46
\end{bmatrix}
\]

(28)

\[
v_{Cl} = \begin{bmatrix}
0.29 & 0.34 & 0.37 & 0.46 \\
0.53 & 0.63 & 0.66 & 0.76
\end{bmatrix}
\]

(29)
Calculate the expectation of each fuzzy evaluation value:

\[ I(v) = \begin{pmatrix} 0.32 & 0.28 & 0.40 \end{pmatrix} \]

\[ I(v_{C}) = \begin{pmatrix} 0.36 & 0.64 \end{pmatrix} \]  

\[ I(v_{C2}) = 1 \]  

\[ I(v_{C3}) = \begin{pmatrix} 0.35 & 0.65 \end{pmatrix} \]  

Calculate the weight of each index to the overall goal:

\[ W = \begin{pmatrix} 0.12 & 0.2 & 0.28 & 0.14 & 0.26 \end{pmatrix} \]  

The comprehensive fuzzy utility of each index \( d_{j}^{(b)} (b=0.5) \) is determined according to the calculated weight of each index: \( d_{j}^{(b)} = \begin{pmatrix} 0.66 & 0.62 & 0.60 & 0.65 \end{pmatrix} \). It can be seen from the results that the black start capability of distributed power supply is sorted as: DG1 > DG4 > DG2 > DG3. Therefore, the power starting sequence for island 1 is DG1-DG2-DG3, and start DG4 for island 2.

5. Conclusion

In this paper, the island-partition process is divided into two steps, and the fuzzy analytic hierarchy process is used to determine the black start sequence of distributed power supply within the island. The power supply of distribution network can be restored through the above strategy. In the case that DG can’t restore all the outage loads, the dynamic programming algorithm is adopted to restore the important loads first to form primary islands. Then, secondary islands are obtained according to a series of detailed revision rules. The modified islands can recover more critical loads. When the number of controllable loads is enough, the distributed power supply can be fully utilized. Then, within the range of islands, the fuzzy analytic hierarchy process is adopted to evaluate the capability of distributed power supply as black start power supply, and five evaluation indicators are selected from three aspects of power generation. There are both qualitative and quantitative indexes. Finally, the black start strategy within the island is obtained, which can not only restore the power supply rapidly but also ensure the reliability of the island operation. The example of PG&E69 nodes proves the effectiveness of the proposed island division and black start strategy.

The research of power supply recovery strategy based on distributed power supply island operation is of great significance. With the development of smart power grid, how to use the online decision division method to guarantee the critical load after the failure of DG and micro grid within the distribution network will be the next research content.

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