Risk Assessment Model and Method of Urban Distribution Network Considering Real-time and Potential Factors

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Abstract: In order to make accurate assessment of the risk level of urban distribution network, this paper establishes the risk assessment model of distribution network and proposes a risk assessment method. The risk assessment model of distribution network is established in two aspects, which are operation risk and grid risk. Operation risk reflects the risk level of the current operation state of the distribution network, while grid risk reflects the potential risks resulting from defects of the grid structure. Then the corresponding risk assessment index system of distribution network is established, and the risk quantized values and risk rating are calculated according to the index values. The comprehensive risk level of distribution network is figured out based on the above calculation results, and variable weights and logarithm compound method are used in the process of calculation. Finally, a numerical example shows that the proposed risk assessment model is feasible and the risk assessment method is effective. The proposed risk assessment model has been adopted by Shenzhen Power Supply Bureau of China Southern Power Grid, and the application effect is good.

Key words: distribution network; risk assessment; operation risk; grid risk; risk quantized value.

I. Introduction

Risk assessment, a concept of economics at the earliest, is applied to each field in power industry in recent decades, including reliability quantitative evaluation, economics benefits evaluation, operation risk monitoring, device management policy, power loss assessment and so on, as risk theory is put forward and developed in the power system and practiced in the engineering applications. Risk assessment is also used in the power systems containing distributed generations and active distribution networks. Early researches focus on constructing the equipment outage model and failure risk assessment based on Markov Chain and Monte Carlo Simulation. As multiple large-scale blackout events occurred in multiple countries in recent decades, the risk assessment of distribution network gets more and more attention.

The risk assessment of distribution network mainly contains operation risk assessment and grid structure risk assessment. In terms of operation risk assessment, [1] simulates the failure of distribution network operation by state continuous sampling method. [2] constructs risk indicators based on Utility theory and makes weighed calculation on operation risk by Analytic Hierarchy Process(AHP). [3] constructs operation risk indicators from probability and consequence of the failure and gives out the level of failure risks. [4] puts forward operation risk assessment method taking grid change process which considers relay protection, prepared from the cast and load shedding. In terms of grid structure risk assessment, [5] constructs structure model of distribution network based on Symbolic dynamics. [6] and [7] conduct a comprehensive analysis of structure risk assessment of distribution network from the Network topology aspect and implement the planning and optimization of the network structure. To conduct risk assessment of the distribution network more comprehensively from operation risk and grid structure risk, [8] use distribution network partition method combined with fault weight to assess the anti-catastrophic ability of the distribution network. [9] constructs model of equipment, operation of distribution network and network structure risk and assess the complex risk by Information Entropy Theory. [10] calculates the grid structure risk by considering the number of accident reassignment programs and the operation risk. After that, [10] determines the overall risk by the way of multiplying the operation risk and structure risk.

However, the risk assessment method mentioned above can only be used in offline analysis, so it's difficult to be used in engineering practice. In addition, because of the fast-changing operating status of distribution network, it's necessary to conduct real-time and online risk assessment. However, because the calculation of the offline analysis method is too large, so currently simplifying equipment model, calculating risk indexes and giving out the level of the accident consequence are used to conduct online risk assessment. But the risk factors mentioned above are not very comprehensive, so it's difficult to provide further support for risk warning, power dispatching and maintenance decision.

Based on the risk assessment method mentioned above, this paper proposes a new city distribution network risk assessment method which comprehensively consider the potential risks brought caused by real-time operation risk and grid structure risk. This paper constructs the risk assessment indicator system from real-time operation and grid structure of power system. Besides, this paper realizes the quantitative representation of risks and gives out the level of the risks during the risk assessment which is helpful to conduct intuitive analysis of the risk assessment result and provides reference for the reduction of the level of grid's risk level. Then this paper calculates the structure risks by multiplying the quantized value of probability and the consequence and calculates the quantized value of operation risk and structure risk by Variable Weight Formula and logarithmic synthesis. Above method which is more applicable to engineering practice can conduct the real-time evaluation and display of the risk level of the distribution network which is convenient for dispatching officer to conduct accurate operation by achieving risk information. At last, through practical example of Shenzhen power supply bureau, this paper proves the effectiveness and rationality of the risk assessment model and method.

II. Calculation and Grading of the Urban Distribution Network's Risk Assessment Indicator System

A. Urban Distribution Network's Risk Assessment Indicator System

The security of the power system refers to the ability of the continuous power supply for the load when power failure happens in the power system, the same as the ability of avoiding extensive power failure, which involves the real-time status and sudden failure. Static security analysis (N-1) includes accident screening, predictive accident analysis and security control, the first two of which are the basis of the security analysis. The analysis process is conducted based on the accident consequence severity index. Simultaneously, N-1 is the basis of the distribution network's risk assessment. So the generalized risk assessment should take the current risk and the potential risk into account.

Based on the above analysis, to assess the urban distribution network's operation risk level, this paper selects risk indexes from the operation risk and grid structure risk and the risk assessment index system is shown in Figure 1.

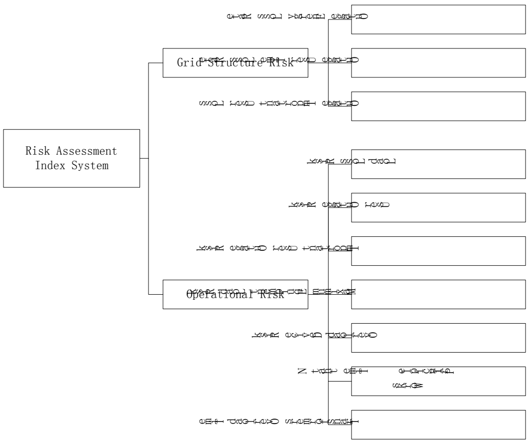

Fig. 1 Risk assessment index system of urban distribution network

1) Load Loss Risk

This index which reflects the load loss degree can be measured both by the percentage of the load loss in the total load and by the absolute value of the load loss. The index of load loss risk can be written as R_{sys1}.

2) User Outage Risk

This index which reflects the user outage condition can be measured both by the number of outage users and by the percentage of the number of outage users in all the users. The index of user outage risk can be written as R_{sys2}.

3) Important User Outage Risk

This index which reflects the important user outage condition can be measured by the number of the important outage users. The index of important user outage risk can be written as R_{sys3}.

4) Maximum Equipment Load Risk

This index which reflects the worst overload line condition can be measured by the maximum equipment load in all the lines or transformers. The index of maximum equipment load risk can be written as R_{sys4}.

5) Overload Device Risk

This index which reflects the lines and transformers overload condition can be measured both by the percentage of lines and transformers in all the devices and the number of lines and transformers. The index can be written as R_{sys5}. This paper defines the lines and transformers whose overload rate over 80% as the overload devices.

6) Time that N-1 Principle Works

This index which reflects the time that N-1 Principle is OK can be measured by the percentage of the time in all the statistics time. The index can be written as R_{sys6}. The statistics time can be adjusted according to demand and default is 24 hours.

7) Transformers Overload Time

This index reflects the condition of the overload transformers. This paper defines the transformers whose overload rate over 80% as the overload devices. The index can be written as R_{sys7}. If one transformer turn from overload to stable status, then this paper records the time and restarts timing.

8) Outage Energy Loss Rate

This index which reflects the energy loss condition of the distribution network after outage can be written as C_{FE}. The calculation process is shown as follow:

Use the following formula to calculate the outage load loss rate ρ_{FE}:

$$\rho_{FE} = \frac{S_{FL}}{S_{SL}} = \frac{\sum_{i=1}^{N_{FC}} (S_{FL}^{i} \gamma_{FL}^{i})}{\sum_{j=1}^{N_{SC}} (S_{SL}^{j} \gamma_{SL}^{j})} \tag{1}$$

In the above formula: ρ_{FE} is the outage load loss rate, S_{FL} is the outage load loss capacity, S_{SL} is the total capacity of the power system, N_{FC} is the number of outage loss users, N_{SC} is the number of total users in the system, S_{FL}^{i} is the loss capacity of user i, S_{SL}^{j} is the loss capacity of user j, γ_{FL}^{i} is the rating factor of the removed user i, γ_{SL}^{j} is the rating factor of the user j, rating factor ranges from 0 to 1. In addition, the more important the user is, the larger his rating factor is.

So this paper defines the outage energy loss rate with time characteristics as follow:

$$C_{FE} = \rho_{FE} T_{FL} = \frac{\sum_{i=1}^{N_{FC}} (S_{FL}^{i} \gamma_{FL}^{i})}{\sum_{j=1}^{N_{SC}} (S_{SL}^{j} \gamma_{SL}^{j})} T_{FL} \qquad (2)$$

In the above formula, T_{FL} is the outage recover time.

9) Outage User Time Loss Rate

This index reflects the users' loss condition in the distribution network, written as C_{FC}.

The calculation process is as follow:

First, this paper calculates the outage user loss rate:

$$\rho_{FC} = \frac{\sum_{i=1}^{N_{FC}} \gamma_{FL}^{i}}{\sum_{j=1}^{N_{SC}} \gamma_{SL}^{j}} \qquad (3)$$

So this paper define the outage user time loss rate index as follow:

$$C_{FC} = \rho_{FC} T_{FL} = \frac{\sum_{i=1}^{N_{FC}} \gamma_{FL}^{i}}{\sum_{j=1}^{N_{SC}} \gamma_{SL}^{j}} T_{FL} \qquad (4)$$

10) Outage Important User Loss

To the risk assessment of distribution network, the effects of the important users between the normal users are different, so the important user loss should be focused on. This paper take the important user loss as an index which can be measured by the important user loss condition, written as C_{FU}.

B. Risk Assessment Index Grading

Because the dimension and magnitude of each index are totally different, so this paper should determine a uniform standard for these indexes. This paper divide these indexes into five levels which are 'Over Level 1', 'Level 1', 'Level 2', 'Level 3' and 'Below Level 3'. In all the five levels, 'Over Level 1' risk means the largest risk and the 'Below Level 3' is the smallest risk.

Although through the risk level grading the level of each risk can be seen easily, it is not easy to calculate the comprehensive risk. So this paper should determine the quantized risk value for each risk level (Percentage System). Especially, For index R_{sys3} and C_{FU}, the quantized risk values of each risk level are 100, 80, 70, 60. For index, the quantized risk value of 'Below Level 3' is 100. For other indexes, the upper limit and lower limit of quantized risk value of all the risk level are 100 and 60.

III. Comprehensive Risk Calculation

This paper classifies distribution network risk into operation risk and structure risk and use the risk assessment index mentioned above to calculate the comprehensive risk and give out the risk level.

a) Operation Risk Calculation

Operation risk reflects the risk level of the current operating state of distribution network, so the probability of each risk is 1. The operation risk index is $R_{sys1} \to R_{sys7}$ in section A and this paper only considers value of the calculation result.

The calculation process of operation risk is as follow:

First, this paper calculates the quantized value of the risk index $R_{sys1} \to R_{sys7}$ respectively, written as $A_1 \to A_7$. This paper calculates the average operation risk as follow:

$$R_{SYSA} = \sum_{i=1}^{7} \alpha_i A_i \qquad (5)$$

In above formula, R_{SYSA} is the average risk value, A_i is the quantized value of the risk index R_{sysi}, α_i is the weight of the risk index R_{sysi}, and $\sum_{i=1}^{7} \alpha_i = 1$. This paper use the variable weight formula in [12] to calculate the weight, the calculation formula of α_i is as follow:

$$\alpha_i = \frac{\alpha_i' A_i^{\rho-1}}{\sum_{j=1}^{7} \alpha_j' A_j^{\rho-1}} \qquad (6)$$

In above formula, α_i' is the initial weight of the ith risk index which can be determined by Analytic Hierarchy Process(AHP) or given directly, α_i is the modified weight of the ith operation risk index, ρ is the coefficient of equilibrium and its value ranges from 0 to 1. In this paper, ρ is 0.5. Because the given initial weight will not change with the index value, so when one index value is abnormal, the calculation result through traditional method won't be ideal. So here this paper uses variable weight formula to make the index weight change with the index value.

Then this paper uses the following formula to calculate the highest operation risk value (the quantized risk value of the operation risk index whose risk is highest):

$$R_{SYSM} = \min_{i=1,2,3,4,5,6,7} (R_{sysi}) \qquad (7)$$

In the above formula, R_{SYSM} is the highest risk value.

Although the average operation risk can reflect the operation risk level to a certain degree, it will have a great impact on operation risk and won't be reflected from the average operation risk if one operation risk is very high. So this paper should calculate the quantized operation risk value combine with the highest operation risk value. [13] points out that traditional method of weighted sum doesn't consider the effects of relationship between indexes on the assessment result. In fact, there is a certain relationship between the average operation risk value and the highest operation risk value, so the additive synthesis is not applicable. Under this circumstance, multiplication synthesis is a feasible method because the multiplication of the indexes shows the comprehensive level of the indexes, but the amplification effect of the multiplication will make the result different from people's thinking habits. The logarithmic synthesis shorten the difference between the indexes which can overcome the shortcoming of multiplication synthesis, so this paper use logarithmic synthesis to calculate the operation risk value:

$$R_{SYS} = \exp(\gamma_1 \ln R_{SYSA} + \gamma_2 \ln R_{SYSM}) \qquad (8)$$

In the above formula, R_{SYS} is the quantized value of the operation risk, γ_1 is the weight of average operation risk, γ_2 is the weight of highest operation risk, and $\gamma_1 + \gamma_2 = 1$. The weights can be determined by Analytic Hierarchy Process(AHP) or given directly. Different with the traditional weight in weighted sum, the weight γ_1 and γ_2 are coefficient of elasticity actually. When R_{SYSA} increases 1%, R_{SYS} will increase $\gamma_1\%$, which makes the difference smaller and the calculation more practical in the engineering.

b) Grid Structure Risk Calculation

If a system can conduct the safe transfer of lost load in all the non-fault areas and satisfy the system constraint at the same time after every possible accident happens, then this paper thinks the system has a strong grid structure [11]. This paper only considers that there are only line outages and the line outage probability will be modified according to its current operation status. The line outage probability P_F calculation is as follow:

$$P_F = \sigma \frac{\lambda}{\lambda + \mu} \tag{9}$$

In above formula, P_F is the line outage probability, λ is the line outage rate, μ is the line repair rate, σ is the outage probability modifying factor.

Assume that the outage is caused by the ith line in the distribution network, then the outage probability P_E is as follow:

$$P_E = P_{Fi} \prod_{j \neq i} (1 - P_{Fj}) \tag{10}$$

Similarly, this paper conduct risk level division and quantized of the outage probability whose quantized value can be written as L_P.

The grid structure risk indexes are C_{FE}, C_{FC} and C_{FU} in section 2.1. The quantized value of three indexes are written as L_{FE}, L_{FC} and L_{FU}. The average outage risk consequence quantized value L_{FA} can be calculated as follow:

$$L_{FA} = \beta_1 L_{FE} + \beta_2 L_{FC} + \beta_3 L_{FU} \tag{11}$$

In the above formula, L_{FA} is the average outage risk consequence quantized value, L_{FE}, L_{FC} and L_{FU} are the risk quantized values of the index C_{FE}, C_{FC} and C_{FU}. β_1, β_2, β_3 are their weights and $\beta_1 + \beta_2 + \beta_3 = 1$. This paper still uses variable weight formula to calculate and use the following formula to calculate the risk consequence quantized value:

$$L_F = \exp(\sigma_1 \ln L_{FA} + \sigma_2 \ln L_{FM}) \tag{12}$$

In above formula, L_F is the outage risk consequence quantized value, L_{FA} is the average outage risk consequence quantized value, L_{FM} is the outage highest risk consequence quantized value and $L_{FM} = \min(L_{FE}, L_{FC}, L_{FU})$. σ_1 and σ_2 are their weights and $\sigma_1 + \sigma_2 = 1$ which can be determined by AHP or given directly.

Traditional risk assessment methods usually calculate the risk value by multiplying the risk probability and consequence. This paper uses the risk calculation method in [13] by adding probability and consequence. Combining the calculating outage risk consequence quantized value and the risk probability quantized value, this paper calculates the risk value as follow:

$$L_R = \omega_1 L_P + \omega_2 L_F \tag{13}$$

In above formula, L_R is the outage risk value, L_P is the outage probability quantized value, L_F is the outage consequence quantized value. ω_1, ω_2 are their weights and $\omega_1 + \omega_2 = 1$ which can be determined by AHP or given directly.

To assess the strength of the grid structure comprehensively and practically, this paper should consider both the number of the outage transferring programming K and the severity of the outage consequence. Generally speaking, the larger the number of the outage transferring programming K is, the consequence is smaller and the grid structure risk is smaller. However, some special cases should be considered: 1) System can’t conduct the outage transferring for the load, then $K = 0$. 2) System can conduct the outage transferring for the load, but the consequence of the outage is very severe. 3) Suppose there are two distribution networks A and B, A conforms to the first case and B conforms to the second case. Then this paper can't judge the grid structure strength of A and B. Based on above analysis, to consider the number of outage transferring programming K and the consequence of the outage comprehensively, this paper uses penalty factor ε and defines the grid structure risk is calculated as follow:

$$L_G = \frac{\sum_{i=1}^{N_B}[\sum_{j=1}^{N_{Si}} L_{Ri}^{(j)}]}{\sum_{i=1}^{N_B}[\varepsilon_i \overline{L_{Ri}^{(j)}}]} \qquad (14)$$

In above formula, L_G is the grid structure risk value, N_B is the number of the lines in the distribution network, N_{Si} is the number of the line i's transferring programming whose value is 0, 1 ,2, 3. When N_{Si} is over 3, N_{Si} is the three programming whose $L_{Ri}^{(j)}$ is the largest. $L_{Ri}^{(j)}$ is the outage risk value of transferring programming j when the line i outages. When $N_{Si} = 0$, $L_{Ri}^{(j)}$ is the outage risk value under the case of line i is outage loss of load. When $N_{Si} \neq 0$, then $\overline{L_{Ri}^{(j)}} = \max_{j=1,2,\cdots,N_{Si}} (L_{Ri}^{(j)})$. When $N_{Si} = 0$, $\overline{L_{Ri}^{(j)}} = L_{Ri}^{(j)}$. ε_i is the grid structure penalty factor when line i outages.

From Formula (12), we can see that when the outage consequence is very severe, then the transferring load still caused large loss and $L_{Ri}^{(j)}$, L_G will be small and ε_i will be large. Similarly, when the number of transferring is little even zero, the numerator of Formula (12) is small and so is L_G. Through above analysis, the small L_G means the high grid structure risk. So this paper defines the grid structure risk level and quantized value which written as R_{GRI}.

c) Comprehensive Risk Calculation

This paper calculates the comprehensive risk quantized value through operation risk value and grid structure risk value. Because the operation risk value and the grid structure risk value are relevant to the same distribution network, so this paper still uses logarithmic synthesis.

$$R_{COM} = \exp(\theta_1 \ln R_{SYS} + \theta_2 \ln R_{GRI}) \qquad (15)$$

In above formula, R_{COM} is the comprehensive risk quantized value, R_{SYS} is the operation risk quantized value, R_{GRI} is the grid structure risk quantized value. θ_1 and θ_2 are their weights and $\theta_1 + \theta_2 = 1$ which can be determined by AHP or given directly.

The larger the comprehensive risk quantized value is, the less the risk is.

IV. Case Study

The risk assessment model and method of urban distribution network considering real-time and potential factors have been was initially applied in China Southern Power Grid Shenzhen Power Supply Bureau. Shenzhen Power Supply Bureau is the oversized power supply bureau in China Southern Power Grid, whose areas of jurisdiction are Futian administrative district, Luohu Administrative district, Nanshan Administrative district, Yantian Administrative district, Baoan Administrative district, Longgang Administrative district, Guangming new district, Longhua district, Pengshan district and Dapeng district. The number of feeders and transformers in Shenzhen distribution network are 6114 and 70000. Here we take Futian district as the case study. Futian district owns 596 feeders, 6038 transformers and 55 110KV transformers. Next this paper takes one running section in 2016 as an example to prove the effectiveness and practicality of the model and method in this paper.

Step one, calculate the operation risk. The index value and quantized value of each operation risk in initial state is shown in table 1.

Table 1 Operation risk assessment results in original state

Operation Risk Index	Value	Quantized Value
Load Loss Risk	0MW	100
User Outage Risk	0	100
Important User- Outage Risk	None	100
Maximum Equipment- Load Risk	68.75%	91.41
Overload Device Risk	0	100
Time that N-1 Principle- Works	100%	100
Transformers Overload- Time	0minute	100

From table 1, we can see that because there are no outages at first, so the Load Loss Risk, User Outage Risk and Important User- Outage Risk quantized value are all 100. Here this paper sets each operation risk index weight are 1/7, and modified the weights through Formula (6) 0.1419, 0.1419, 0.1484, 0.1419, 0.1419, 0.1419. According to the engineering demands, this paper sets $\gamma_1 = 0.2$ and $\gamma_2 = 0.8$ in Formula (8), and calculates the operation risk quantized value of initial state is 92.83.

Step 2, calculate the grid structure risk. According to the practical engineering demand, because all the feeders in Shenzhen Grid are cables, so this paper neglects the effect of weather. In the practice, historical tripping information is usually used to calculate the device outage probability and modified it through considering equipment load operating life. When calculating outage quantized value using Formula (11) and (12), this paper sets the initial weights of grid structure risk indexes as 1/3, and modifies them similar as Formula (6). And this paper sets $\sigma_1 = 0.2$ and $\sigma_2 = 0.8$ in Formula (12). Finally this paper uses Formula (14) to get the grid structure risk value 1.98 and quantized value 94.22.

Table2 gives four typical lines' outage risk value according to Formula (13). From table 2, we can see that under current load and grid structure, there are outage transferring programming without load loss, so the current risk is 'Below 3 Level'.

Table 2 Accident risk values of 4 typical branches in original state

Line Number	Line Description	K	Transferring Description	Risk Consequence Quantized Value	Risk Probability	Risk probability Quantized Value	Risk Quantized Value
1	Tianmian Station F63 Huangxin Line	1	Closing Yitian Station F05 Line Jinqiang Switch Jinqiang #1	100 100 100	3.42×10^{-5}	87.31	94.92
2	Xinghe Station F18 Jingdao Line 1	1	Closing Shaoniangong Station F16 Line Jinjia Jindao Public Housing Switch #5	100 100 100	1.14×10^{-5}	89.80	95.94
3	Zhuzilin Station F10 Hulian Line 2	1	Closing Zhuzilin Station F10 Line Hulian 2 Dianxinshahe Room three-High - voltage cabinet Swithch #1	100 100 100	1.14×10^{-5}	89.80	95.94
4	Gangsha Station F08 Line Damengang	1	Closing Tianmian Station F20 Line Tianmian Futian Village Cultural Square Switch #2	100 100 100	3.42×10^{-5}	87.31	94.92

	2	Closing Gangsha Station F08 Line Damenfang Switch #3	100,100,100	3.42×10^{-5}	87.31	94.92

Step 3, calculate the comprehensive risk. After calculating operation risk and grid structure risk through Formula (8) and (13), this paper uses Formula (15) to calculate the comprehensive risk value. Set $\theta_1=\theta_2=0.5$ and this paper calculates the grid structure quantized value in the initial state is 94.22 which basically reflects the ability of resisting risk when no outage. The operation risk quantized value is 92.83 and the comprehensive risk quantized value is 92.84 which is ‘Below Level 3’ risk.

To further prove the effectiveness of the model and method, this paper simulates Xianghe Station F04 Hulian Line 1 outages on the basis of initial state (This line is the backup power of Zhuzilin Station F10 Hulian Line 2) and restart the calculation of each risk, the result is shown in table 3 and table 4.

Table 3 Operation risk assessment results in accident state

Operation Risk Index	Value	Quantized Value
Load Loss Risk	0MW	100
User Outage Risk	0	100
Important User- Outage Risk	None	100
Maximum Equipment- Load Risk	68.75	91.41
Overload Device Risk	0	100
Time that N-1 Principle- Works	95.83%	85.83
Transformers Overload- Time	0	100

Table 4 Accident risk values of 4 typical branches in accident state

Line Number	Line Description	K	Transferring Description	Risk Consequence Quantized Value	Risk Probability	Risk probability Quantized Value	Risk Quantized Value
1	Tianmian Station F63 Huangxin Line	1	Closing Yitian Station F05 Line Jinqiang Switch Jinqiang #1	100 100 100	3.42×10^{-5}	87.31	94.92
2	Xinghe Station F18 Jingdao Line 1	1	Closing Shaoniangong Station F16 Line Jinjia Jindao Public Housing Switch #5	100 100 100	1.14×10^{-5}	89.80	95.94
3	Zhuzilin Station F10 Hulian Line 2	0	—	96.1 80 100	1.14×10^{-5}	89.80	82.19
4	Gangsha Station F08 Line Damengang	1	Closing Tianmian Station F20 Line Tianmian Futian Village Cultural Square Switch #2	100	3.42×10^{-5}	87.31	94.92
		2	Closing Gangsha	100	3.42×10^{-5}	87.31	94.92

Station F08 Line Damenfang Switch #3

After simulating, the number of transferring in Zhuzizhan turns from 1 to zero, which results in energy loss and the outage risk consequence quantized value turns from 95.94 to 82.19. The grid structure risk turns into ‘Lever 3’ risk, at the same time the time percentage that N-1 principle works turns from 100 to 85.83, which turns the operation risk to ‘Level 3’ risk.

After line outage simulation, the comprehensive risk quantized value has significantly decreased because the decrease of the contacted switches results into the decrease of the lines which can transfer power. So under this circumstance, load shedding measures must be conducted whose loss is apparently larger than transferring. In the case study, the grid structure risk value calculated from Formula (14) turns from 1.98 to 0.55 and the quantized value turns from 94.22 to 86.44. Operation risk quantized value decreases to 87.89 and the comprehensive risk quantized value turns from 93.52 to 87.16 and the comprehensive risk level turns from ‘Below Level 3’ to ‘Level 3’. So this case study reflects clearly the change of system risk level which proves the risk model and method in the paper.

On the other hand, comparing the grid structure risk value, we can see that the size of network can’t affect the grid structure risk calculating and risk level grading through introducing penalty factoe.

V.Conclusion

In order to make accurate assessment of the risk level of urban distribution network, this paper establishes the risk assessment model of distribution network and proposes a risk assessment method. This paper uses risk level grading and quantized value to show the risk level which can show the risk level more intuitively and be convenient for dispatching officer to conduct accurate operation by achieving risk information. Currently, this risk model and method have been use in China Southern Power Grid Shenzhen Power Supply Bureau with a good effect.

Because the risk indexes proposed in this paper can’t cover all respects and the index synthesis method has room for improvement. In addition, only the risks in distribution network are considered, so the next work is to improve the risk indexes, index synthesis method research and the evaluation of the risk between the main grid and distribution network.

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