

# Analysis of Repairing Efficiency Enhancement for Distribution Network Fault Based on the Data of Work Orders

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**Abstract.** In a certain power supply company, its repairing time for distribution network fault declined sharply in the year of 2017. Based on the data of work orders, this paper uses approaches, such as cluster analysis, comparison and trend analysis, to analyze the monthly trend, regional distribution and fault type with regard to repairing time of distribution network fault. The analysis has shown that there are problems like low resistance of distribution network equipment to lightning, weakness in the structure of rural grid, long repairing time for low-voltage fault and low level of automation for distribution lines. In the meantime, this paper provides advice accordingly, aiming to serve as reference for repairing efficiency enhancement regarding distribution network fault in the company.

## 1. Preface

If a power failure caused by distribution network fault is not repaired timely, electricity customers tend to make a complaint. Therefore, the repairing efficiency of distribution network fault may directly impact on electricity customers' evaluation of electricity services. In general cases, the repairing efficiency of distribution network fault is measured by the repairing time of distribution network fault (hereinafter referred to as "repairing time for the fault") <sup>[1]</sup>. Existing literature mostly focuses on common faults of distribution network and precautionary measures, management models for the repairing of distribution network fault and the influence of strategies and management systems on the repairing efficiency for distribution network fault <sup>[2-6]</sup>, and the papers that use the data of work orders to analyze and research the repairing efficiency for distribution network fault are relatively rare. This paper focuses on the fact that the repairing time for the fault in a certain company (hereinafter referred to as "the company") in 2017 decreased drastically by 66.02% year-on-year. Based on the data of work orders, this paper analyzes the repairing time for the fault, providing reference for repairing efficiency enhancement regarding distribution network fault.

## 2. Case introduction

### 2.1 Monthly analysis

In the company, the average monthly repairing time for the fault was 141.85 minutes in the year of 2017, which plummeted by 66.02% year-on-year, and the figures of the repairing time for the fault in



January, February and March were bigger than the average. Amongst the data lower than the average value, the figures of the repairing time for the fault in June and July exceeded 100 minutes. The monthly repairing time for the fault in the company can be seen in Table 1.

Table 1 Figures of the Monthly Repairing Time for the Fault in the Company

| Month     | Repairing time for the fault (min) |                    |             |                    |
|-----------|------------------------------------|--------------------|-------------|--------------------|
|           | 2016                               |                    | 2017        |                    |
|           | The company                        | Provincial average | The company | Provincial average |
| January   | 333.99                             | 286.75             | 384.59      | 225.54             |
| February  | 298.99                             | 305.08             | 328.48      | 200.80             |
| March     | 403.40                             | 339.31             | 172.77      | 169.16             |
| April     | 472.38                             | 360.35             | 74.93       | 193.24             |
| May       | 354.41                             | 382.86             | 88.34       | 200.24             |
| June      | 353.42                             | 366.93             | 125.23      | 206.94             |
| July      | 443.57                             | 472.80             | 101.04      | 176.26             |
| August    | 636.92                             | 432.47             | 79.21       | 173.91             |
| September | 402.95                             | 390.75             | 66.90       | 153.04             |
| October   | 433.56                             | 307.76             | 73.21       | 136.29             |
| November  | 457.74                             | 317.53             | 65.63       | 101.04             |
| December  | 409.18                             | 278.06             | 82.08       | 101.74             |

It can be seen from Table 1 that there was a noticeable decrease in monthly repairing time for the fault in the company, but the time in January, February, March, June and July were supposed to be reduced. When analyzing the data of work orders for the five months mentioned before, the author has found that the work orders regarding the repairing of the fault in January and February mainly concerned the overload of distribution lines and distribution transformers. This was because the Spring Festival fell in January and February, the supporting facilities in some parts of the area could not satisfy the surging electricity utilization, so the problems like unstable voltage and transformer overload frequently occurred, which caused the increase in the number of orders for repair work. Nevertheless, repair resources were relatively limited<sup>[7]</sup>, which caused the extension of repairing time for some work orders. The work orders regarding the repairing of the fault in June and July mostly concerned the damage of equipment arising from lightning strike, which was because there were many thunderstorms during the period from June to July. However, the fault that caused by lightning strike were normally located at remote areas, so the repairing time of the fault would be extended if the factors of weather and location were taken into consideration. The data of work orders for January and February reflect that the company needs to improve its solution to the high electricity demand during the Spring Festival, and the grid of the company is inadequate to handle severe weather.

For the frequent occurrence of distribution network fault during the Spring Festival, it is suggested that the company should conduct load forecast beforehand, place special workers in key areas, and carry out real-time monitoring for the operation of power supply equipment. To solve the problem of the vulnerability of the grid to lightning strike, it is advised that the company should install specific lightning-proof hardware in places like switches and line taps that are vulnerable to lightning strike, and reducing the frequency of line fault caused by lightning strike.

## 2.2 Regional analysis

According to the regional division principle, the repairing time of the company in the urban area in 2017 was 128.40 minutes, declining by 72.39% compared with the year earlier; the time for the rural area was 164.85 minutes, falling by 62.07% compared with the year earlier. The repairing time of the

company for the fault in different areas can be seen in Table 2.

Table 2 The Repairing Time of the Company for the Fault in Different Areas

| Region     | Repairing time for the fault (min) |                    |             |                    |
|------------|------------------------------------|--------------------|-------------|--------------------|
|            | 2016                               |                    | 2017        |                    |
|            | The company                        | Provincial average | The company | Provincial average |
| Urban area | 465.10                             | 323.65             | 128.40      | 147.65             |
| Rural area | 434.57                             | 408.37             | 164.85      | 191.21             |

From the figures in Table 2, we can see that the repairing time of the company for the fault in urban and rural areas were both decreased to different degrees, with the time for the rural area being longer. When analyzing the data of work orders in urban and rural areas, the author has found that there were huge changes in approval procedures and processes regarding work orders in the urban area in 2017 if compared with the procedures and processes in 2016, and there were some changes in approval procedures regarding work orders in the rural area. In April 2017, the company launched the construction of a power supply service command centers, aiming to centralize the work of inspection, dispatch and marketing, coordinate the resources regarding the repairing of the fault, so as to effectively shorten the repairing time for the fault. However, there was a huge gap between rural and urban areas when it came to electricity infrastructure, so the construction of the command centers in the rural area still stagnated at the stage of structure building, failing to come into play as expected. The data of work orders in urban and rural areas reflect that the company's strategy of building a power supply service command centers can effectively reduce the repairing time for the fault.

To solve the problem that the power supply service command centers in the rural area are not effective enough, the company is suggested to selectively promote city construction experience in the rural area, to realize the integration of the repairing work in urban and rural areas. Meanwhile, the company is supposed to advance the development regarding the functions of the existing power supply service command centers and to integrate the functions of inspection, dispatch and marketing, realizing the command over the on-site repairing of the fault and shortening the repairing time for the fault.

### 2.3 Fault type analysis

According to the first-class classification for distribution network fault types<sup>[1]</sup>, the repairing time for the six types of faults in 2017 showed a downward trend. Amongst the six types, the repairing time for low-voltage fault was higher the average level in the province. The figures with regard to the repairing time of the company for the fault were shown in Table 3 as per first-class classification. The figures regarding the repairing time for low-voltage fault were shown in Table 4 as per second-class classification.

Table 3 The Repairing Time of the Company for the Fault as per First-class Classification

| Fault type              | Repairing time for the fault (min) |                    |             |                    |
|-------------------------|------------------------------------|--------------------|-------------|--------------------|
|                         | 2016                               |                    | 2017        |                    |
|                         | The company                        | Provincial average | The company | Provincial average |
| High-voltage fault      | 401.30                             | 401.23             | 286.75      | 342.08             |
| Low-voltage fault       | 460.32                             | 321.45             | 203.32      | 172.29             |
| Power-quality fault     | 782.15                             | 2713.22            | 241.96      | 675.38             |
| Customer internal fault | 259.28                             | 204.30             | 80.73       | 92.67              |
| Non-electric fault      | 751.01                             | 515.37             | 170.76      | 266.17             |
| Measurement fault       | 447.64                             | 407.15             | 112.27      | 201.82             |

**Table 4 The Repairing Time of the Company for Low-voltage Fault as per Second-class Classification**

| First-class classification | Second-class classification | Repairing time for the fault (min) |                    |
|----------------------------|-----------------------------|------------------------------------|--------------------|
|                            |                             | The company                        | Provincial average |
| Low-voltage fault          | Low-voltage overhead line   | 223.88                             | 207.21             |
|                            | Low-voltage cable line      | 311.29                             | 355.09             |
|                            | Low-voltage equipment       | 115.01                             | 117.82             |

It can be seen from Table 3 and Table 4 that the repairing time for low-voltage fault was relatively long, especially for low-voltage overhead line fault. When analyzing the data of work orders regarding low-voltage fault, the author has found that the work orders regarding the repairing of line fault mostly concerned short circuit and trip-out caused by ground fault, which were mainly due to natural disasters and external damages. After the short circuit of overhead lines and cable lines occurred, because the automation level of distribution lines was relatively low in the company, so the identification of equipment fault and the locating of fault took a long time, which largely extended the repairing time of the fault. The work orders regarding the repairing of low-voltage equipment fault mainly concerned the ageing of equipment and the quality problem. Several common fault types were the faults caused by burning of a switching connector, and severe oxidation and corrosion of equipment. The figures from the work orders regarding low-voltage failure reflect that the automation level of distribution lines is relatively low in the company, and operation management for low-voltage equipment needs to be improved.

For the low-voltage line fault triggered by external damages, it is suggested that the company should send out leaflets to improve the publicity and education regarding power facilities protection, and improve the test and management regarding underground cables in the urban area, save the information and drawings with regard to cable construction, and make up damaged cable posts. As to the frequent occurrence of low-voltage equipment fault, it is advised that the company should place special workers to regularly inspect the switches in cable branch boxes and the ageing level of wires in accident-prone areas, and fix the problems of equipment in time after identification. To solve the problem of relatively low automation level in distribution lines, the company is suggested to accelerate the update regarding distribution line automation, to realize remote measuring, controlling and communicating for key equipment and lines as soon as possible.

### 3. Conclusion

Based on the data of work orders, this paper analyzes the repairing time of a certain company for distribution network fault in 2017 from various perspectives, and it has been found that the dramatic reduction of repairing time of the company was mainly due to the construction of power supply service command centers. On the other hand, the analysis reflects that there are several problems in the company, such as low resistance of distribution network equipment to lightning, unsatisfying construction of power supply service command centers in the rural area, long repairing time for low-voltage fault and low automation level for distribution lines. According to these problems, the paper gives corresponding suggestions, aiming to provide the company with some support and reference for repairing efficiency enhancement for distribution network fault.

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