Research on pricing model of uninterrupted maintenance for distribution network project of power grid enterprise

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Abstract. Uninterrupted operation of distribution network engineering is an important means to ensure the safe and reliable operation of power supply equipment and improve the level of power supply reliability and quality service. In recent years, with the vigorous promotion of the power grid company, the uninterrupted operation of distribution network has a more rapid and standardized development. At present, the pricing basis of distribution network engineering has not included the content of uninterrupted power operation, which leads to the problems of unable to find the corresponding quota and unclear charging standard in the actual construction charging process. Therefore, it is urgent to study the pricing method of uninterrupted power operation, guide the uninterrupted power operation, standardize the charging, and promote the healthy development of power construction.

1. Introduction

The technology of uninterrupted power operation in distribution network of power supply enterprises is one of the important symbols to measure the management level of power enterprises and the construction level of power grid [1]. Uninterrupted power operation needs to be further studied, scientific management standards are formulated, the operation behavior of equipment is standardized, and the safety and reliability of urban power supply network system is guaranteed[2]. The service level of power supply needs to be continuously improved, so as to achieve the development goal of China's new urbanization faster and better.

The popularization and application of uninterrupted power operation in distribution network engineering needs continuous investment of personnel, equipment, tools and instruments. At present, there is no unified pricing basis for uninterrupted power operation, which leads to no corresponding quota in the preparation of estimation and budget estimate of uninterrupted power operation, and different construction cost standards, which affects the standardization and scientficity of work to a certain extent. At present, the research on uninterrupted maintenance of distribution network engineering focuses on improving the effect of power supply reliability [3,4]. There is less research on project charging, so it is urgent to study the pricing method of uninterrupted operation, so as to better guide the standardized charging of this operation and promote the healthy development of uninterrupted operation.

2. Contents and status quo of uninterrupted power supply operation

In 2016, power grid enterprise issued the specification for operation of 10kV distribution network without power outage, with a total of 33 items of operation without power outage, covering 10KV
overhead lines and cable lines[5]. According to the tools, equipment and operation methods used, the operation without power outage is divided into four categories, as follows:

The first type includes four simple insulation pole operation methods, including common defect elimination and removal of accessories, 10kV live line disconnection and connection of drainage line.

The second category includes 10 simple insulating glove operation methods, such as live replacement of fuse, 10kV live replacement of pole switch or disconnector.

The third category includes 13 complex insulating pole operation methods, such as 10kV on load replacement of pole switch or disconnector, changing loaded linear pole into tension pole, and complex insulating glove operation method.

The fourth category includes six comprehensive uninterrupted operation methods, such as replacing overhead lines by bypass operation and replacing post transformers without power failure.

3. Research on pricing method of uninterrupted power operation

Taking the overhead line overhauled by bypass operation as an example, this paper introduces the calculation method of the supplementary quota. According to the supplementary quota number standard, the quota number is bg-px7-1. The work contents of this item are: inspection of tools and equipment, overhead laying of bypass system, installation and removal of complete accessories, overhead laying and removal of bypass cable and bypass switch, insulation shielding and removal, phase verification, switching operation, live line disconnection and lead connection, live line operation measures and patrol inspection of bypass system Maintenance, completion cleaning, tools transportation, etc

3.1. Composition of fixed cost

According to relevant standards, technical regulations, construction scheme, human resources, machinery and survey data, the composition of labor, materials and machinery costs is determined, which is as shown in Table 1.

| Fee | type | Indicator unit | Fee | type | Indicator unit |
|-----|------|----------------|-----|------|----------------|
| **artificial** | Ordinary workers | Man days | Bypass load switch | A set |
| | Live mechanic | Man days | Bypass high voltage downlead cable | Item |
| | Rubber insulated gloves (10kV) | A pair | Bypass cable | Item |
| | Rubber insulated gloves (8kV) | A pair | T-head connecting cable | Item |
| | Sheepskin protective gloves | A pair | Complete set of accessories for overhead laying bypass operation system | A set |
| | Insulated safety protective gloves | A pair | Complete set of accessories for ground laying bypass operation system | A set |
| | Insulated safety protective gloves | A piece | Insulated discharge pole | Item |
| | Insulation blanket | A piece | Insulated transmission rope | kg |
| | Insulation blanket clip | Item | Insulated wire tightener | Item |
| | Wire shield | Item | Felt cloth 2m × 3m | A piece |
| | Jumper insulation shield | Item | Other tools and materials | Yuan |
| | Cross arm insulation shield | Item | Insulated boom truck | |
| | Pin insulator insulation shield | Item | Mobile box transformer | |
| | High voltage down cable support | A set | Cable car | |
| | Spare cable tools | A set | Bypass tool car | |
| | | | Generator car | |
| | | | Power engineering vehicle | |

Machine shift (one day's work for a car)
3.2. Measurement of human resource and machine consumption

Select the "bypass operation maintenance overhead line" (quota No. bg-px7-1) in the new quota. In order to increase the reliability and representativeness of engineering calculation results, this paper selects Sample 1, 2, 3, 4 typical bypass operation maintenance overhead line sample project to carry out field survey, and compiles the labor, material, mechanical shift quota consumption measurement table, as shown in Table 2, table 3, and table 4.

| Type of work | Indicator unit | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Quota labor consumption |
|--------------|----------------|----------|----------|----------|----------|-------------------------|
| Live mechanic | Man days       | 9.3042   | 9.4125   | 9.5500   | 9.5333   | 9.45                    |

Table 2: Measurement of labor quota consumption

| Serial number | Material name and model | Indicator unit | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Quota labor consumption |
|---------------|-------------------------|----------------|----------|----------|----------|----------|-------------------------|
| 1             | Rubber insulated gloves (10KV) | A pair         | 0.0889   | 0.0889   | 0.0889   | 0.0889   | 0.0889                  |
| 2             | Sheepskin protective gloves | A pair         | 0.2222   | 0.2222   | 0.2222   | 0.2222   | 0.2222                  |
| 3             | Insulated safety helmet   | Item           | 0.0800   | 0.0800   | 0.0800   | 0.0800   | 0.0800                  |
| 4             | Goggles                  | A pair         | 0.1333   | 0.1333   | 0.1333   | 0.1333   | 0.1333                  |
| 5             | Insulating clothing      | a suit         | 0.0635   | 0.0635   | 0.0635   | 0.0635   | 0.0635                  |
| 6             | Insulating overshoes     | A pair         | 0.0430   | 0.0430   | 0.0430   | 0.0430   | 0.0430                  |
| 7             | Insulated safety belt    | A set          | 0.0800   | 0.0800   | 0.0800   | 0.0800   | 0.0800                  |
| 8             | Insulation blanket       | A piece        | 0.4444   | 0.4444   | 0.4444   | 0.4444   | 0.4444                  |
| 9             | Insulation blanket clip  | Item           | 0.2857   | 0.2857   | 0.2857   | 0.2857   | 0.2857                  |
| 10            | Wire shield              | Item           | 0.1224   | 0.1224   | 0.1224   | 0.1224   | 0.1224                  |
| 11            | Jumper insulation shield | Item           | 0.2105   | 0.2105   | 0.2105   | 0.2105   | 0.2105                  |
| 12            | Cross arm insulation shield | Item       | 0.0580   | 0.0580   | 0.0580   | 0.0580   | 0.0580                  |
| 13            | High voltage down cable support | A set      | 0.0100   | 0.0100   | 0.0100   | 0.0100   | 0.0100                  |
| 14            | Spare cable tools        | A set          | 0.0100   | 0.0100   | 0.0100   | 0.0100   | 0.0100                  |
| 15            | Bypass load switch(A)    | A set          | 0.0100   | 0.0100   | 0.0100   | 0.0100   | 0.0100                  |
| 16            | Bypass high voltage downlead cable | Item | 0.0300   | 0.0300   | 0.0300   | 0.0300   | 0.0300                  |
| 17            | Bypass cable             | Item           | 0.0150   | 0.0150   | 0.0150   | 0.0150   | 0.0150                  |
| 18            | Complete set of accessories for overhead laying bypass operation system | A set       | 0.0025   | 0.0025   | 0.0025   | 0.0025   | 0.0025                  |
| 19            | Discharge pole           | Item           | 0.0083   | 0.0083   | 0.0083   | 0.0083   | 0.0083                  |
| 20            | Insulated transmission rope | kg            | 0.1026   | 0.1026   | 0.1026   | 0.1026   | 0.1026                  |
| 21            | Insulated wire tightener | Item           | 0.0526   | 0.0526   | 0.0526   | 0.0526   | 0.0526                  |
| 22            | Felt cloth 2m × 3m       | A piece        | 0.0040   | 0.0040   | 0.0040   | 0.0040   | 0.0040                  |
| 23            | Other tools and materials | Yuan       | 128.65   | 128.65   | 128.65   | 128.65   | 128.65                  |

Table 4: Measurement of quota consumption of machine shift

| Serial number | Machine name and model | Indicator unit | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Quota labor consumption |
|---------------|------------------------|----------------|----------|----------|----------|----------|-------------------------|
| 1             | Insulated bucket arm truck, hybrid arm, 10kV, 21m|m one day work for a car | 2.3260   | 2.3531   | 2.3875   | 2.3833   | 2.3625                  |
| 2             | Cable laying car, 10kV | 1.1630         | 1.1766   | 1.1938   | 1.1917   | 1.1813   |
| 3             | Electric engineering vehicle, small | 1.1630 | 1.1766   | 1.1938   | 1.1917   | 1.1813   |

3.3. Price of manpower, material and machine

The average labor price of electric power construction workers in typical sample areas in 2020 is 345 yuan / workday. The labor price of electric power construction workers in electric power quota is 120 yuan / workday and 194 yuan / workday (taking the fees and adjustment coefficient), and the labor conversion adjustment coefficient is 1.78, which is converted to the measured labor consumption, The
manual adjustment consumption is obtained as manual adjustment consumption = manual conversion adjustment coefficient × The measured labor consumption is 1.78 × 9.52 = 16.94 man days.

The quota unit price is converted to the same caliber as the quota Beijing price in 2019, and the calculation is as follows:

\[
\text{Unit price of fixed labor in 2019} = \text{unit price of fixed labor in 2019} \times (1 + \text{fee rate}) \times (1 + \text{adjustment factor}) = 120 \times (1 + 31.8\% \times 1.15 + 12\% \times 1.15) \times (61\%) = 194.18 \text{ yuan / workday}
\]

In the process of determining the price of materials and machinery, according to the existing materials and machinery in the material and machinery warehouse, implement the "2013 quota benchmark material warehouse price of electric power industry" and "2013 quota benchmark machinery warehouse price of electric power industry". For the materials and machinery not included in the quota material and machinery warehouse, according to the price composition of materials and construction machinery shift, after investigating the relevant market price information and parameters, Detailed calculation. Tables 5 and 6 show the unit prices of new materials and machinery.

### Table 5 Determination of unit price of new materials (Unit: Yuan)

| Serial number | Material Science | Unit | Original price of materials | Material transportation cost | Premium rate | Transport loss rate | Purchase and storage rate | Unit price of materials (quota base price) |
|---------------|------------------|------|-----------------------------|----------------------------|--------------|---------------------|--------------------------|--------------------------------------|
| 1             | Insulated safety belt | A set | 1088.32                     | 11.50                      | 17.26        | 5.75                | 27.61                    | 1150.44                             |
| 2             | High voltage down cable support | A set | 4654.65                     | 49.20                      | 73.81        | 24.60               | 118.09                   | 4920.35                             |
| 3             | Spare cable tools | A set | 2322.31                     | 24.55                      | 36.82        | 12.27               | 58.92                    | 2454.87                             |
| 4             | Bypass load switch(200A) | A set | 108831.86                   | 1150.44                    | 1725.66      | 575.22              | 2761.06                  | 115044.3                            |
| 5             | Bypass high voltage downlead cable | Item | 11720.35                    | 123.89                     | 185.84       | 61.95               | 297.35                   | 12389.38                            |
| 6             | Bypass cable | Item | 23340.71                    | 247.79                     | 371.68       | 123.89              | 594.69                   | 24778.76                            |
| 7             | Complete set of accessories for overhead laying bypass operation system | A set | 293192.19                   | 3099.28                    | 4648.92      | 1549.64             | 7438.28                  | 309928.32                           |
| 8             | Insulated discharge pole | Item | 293.00                      | 3.10                       | 4.65         | 1.55                | 7.43                     | 309.73                              |

### Table 6 Unit price of new construction machinery (Unit: Yuan)

| Machinery name | Model and specification | Composition of machine shift expenses | Unit price of machine shift (standard base price) |
|----------------|-------------------------|---------------------------------------|-----------------------------------------------|
| Cable car      | 10kV                    | depreciation charge: 2989.18 inspection fee: 59.00 maintenance fee: 0  installation and removal fee and off-site transportation fee: 0  labor cost: 191.06 fuel and power cost: 223.72 other expenses: 508.55 | 3971.51                                      |

#### 3.4. Preparation of supplementary quota base price

Combine the quota consumption and unit price of labor, materials and machine shift to form the quota base price and quota items of actual measurement subhead, as shown in Table 7.

Table 7 basic price table of supplementary quota for uninterrupted power operation

| Quota number | BG-PX7-3 |
|--------------|----------|
| project      | Bypass operation maintenance of overhead lines (overhead laying) |
| Base price (Unit: yuan) | 22423.94 |
| in which     |          |
| artificial fee (Unit: yuan) | 2015.23 |
| Material fee (Unit: yuan) | 4646.84 |
| Machinery fee (Unit: yuan) | 15761.87 |
4. Comparison with similar quota level
In the supplementary quota subitem, the work content of bg-pt7-1 bypass maintenance overhead line is completely consistent with that of Beijing local 10-144 10kV bypass maintenance overhead line. Therefore, these two quotas are selected, and their levels are compared and analyzed by taking the actual standard section of uninterrupted power operation - 400m (usually grade 8) as an example.

The supplementary quota is 44.5% higher than the base price of similar quota, and the construction and installation cost of the supplementary quota is 63.0% higher than that of the similar quota. From the third level, the supplementary quota level has been lower than that of Beijing, until the eighth level has been lower than that of Beijing by 36.82%.

The main reason is that the supplementary quota, combined with the actual construction situation of uninterrupted power operation, takes the first level as the research object, calculates the consumption of labor, materials and machinery to complete the first level of work, and then only considers increasing the corresponding materials and a small amount of labor and machinery costs on the basis of the first level for each additional level. The idea of local quota calculation is to comprehensively consider the overall consumption of labor, materials and machinery of multi-level operation, and then spread it to each level of operation to get the average price level after considering the scale effect. It can be seen that the supplementary quota calculation method is more in line with the actual work situation, and the price level calculated is more reasonable.

5. Conclusion
This paper puts forward the calculation method of pricing standard for 33 items of uninterrupted power operation of distribution network within the scope of State Grid Corporation of China, which supplements the quota base price of the operation and ensures the interests of all parties of uninterrupted power operation of distribution network. The research results provide guidance and reference for the formulation of the price level of uninterrupted power operation, and are of great significance to further improve the cost management and standardization level of uninterrupted power operation in distribution network.

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