Research on Cable Loss Management and Loss Reduction Measures of 10kV Distribution Network

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Abstract. This paper discusses the importance of power supply companies to strengthen cable loss management for distribution networks of 10kV and below under the new power consumption situation. By analyzing the composition of cable losses, technical cable loss, management cable loss and assessment, etc., analyze the factors affecting cable loss and corresponding countermeasures. In terms of technical cable loss, the influence of 10kV distribution network structure and transmission and distribution equipment, energy metering device, reactive power, voltage and other factors on distribution network cable loss and countermeasures are analyzed. In the aspect of managing cable loss, the effects of factors such as quality of copying, energy metering, anti-stealing, and operation of distribution network on distribution cable loss are analyzed. From the perspective of assessment management, the establishment of the distribution network cable loss assessment management system, the implementation of the sub-pressure distribution sub-area assessment, cable loss indicator management, etc. were discussed.

1. Introduction
The cable loss rate of the power grid is a comprehensive technical and economic indicator that shows the economic benefits and management level of the power supply enterprise. It is also an important indicator for the state to implement the energy conservation policy and assess the power supply enterprises. Among them, the cable loss of 10kV and below directly reflects the power management level of the power supply enterprise. The cable loss rate of 10kV and below is a large proportion of the cable loss rate of the whole network, with considerable loss and power saving. Potential. Reducing the cable loss of distribution network of 10kV and below directly improves the economic benefits of enterprises, which is the most direct and effective way to increase profits.

2. Definition of cable loss
The production consumption and unidentified losses of power transmission and transformation equipment that occur in the power supply production process are collectively referred to as line loss power, referred to as “cable loss”. It is the power loss and loss from the power outlet side of the power plant (excluding the power consumption of the plant, boost voltage and bus cable loss) to the user's energy meter. Cable loss can be divided into three parts: fixed loss, variable loss and other losses.

The cable loss rate refers to the percentage of cable power consumption to the power supply. The cable loss rate is generally divided into two types: theoretical cable loss rate and actual cable loss rate. Cable loss rate is an important economic and technical indicator for the power industry. Reducing the
cable loss rate is the main way to implement the principle of saving electricity, achieving economic operation and improving economic efficiency.

Electrical energy is generated by the conversion of generators by consuming primary energy and transmitted to thousands of households through the grid. In this process, the lines from the generator to the grid, transformers, reactive devices, phase modulation and voltage regulating equipment, and insulating media transmission and conversion components such as measurement, metering equipment, and protection devices consume electrical energy. In addition, there are some unknown losses such as electricity theft, leakage, metering errors, meter reading effects, etc., which will also cause fluctuations in cable loss rate. With the standardization of the electricity market, one of the measures taken by power companies to achieve greater social and economic benefits is to reduce energy conservation.

3. Theoretical cable loss calculation method
The theoretical calculation of cable loss is a cumbersome and responsible task, especially for distribution lines and low-voltage lines due to the large number of branch lines, large load, large data, and difficulty. The simple manual calculation is to calculate the transmission line loss, distribution transformer loss and other related data, and the process is quite complicated. In order to meet the company's requirements for grid load measurement and cable loss theory calculations must be normalized, adapt to the characteristics of load measurability and accuracy of load measurement and cable loss theory calculation, combined with dispatch automation, through telemetry, remote signaling GPRS and other methods, using the energy management system, power distribution management system, load management system, reactive power MIS system and other existing automation systems, real-time information and data about grid operating parameters, calculate the cable loss theory calculation software system. The use of real-time data for theoretical calculation of grid cable loss can reduce human error, improve efficiency, realize real-time monitoring of theoretical calculation of power cable loss, improve timeliness and accuracy, and truly realize information management of theoretical calculation process.

At this stage, the power company uses Zhengzhou Dafang software cable loss theory calculation software. The software design principle and calculation formula of "Dafang 6-10kV theoretical cable loss calculation" are based on the national power industry standard "Power grid power loss calculation guide" (DL/T 686-1999), "Rural power grid technical regulations" (DL / T 738-2000), using the mode conversion technology, using the equivalent resistance method, rms current method for cable loss theoretical calculation analysis. The calculation results meet the requirements for the development of cable loss indicators and economic analysis, and the data is rich and the reports are complete. Output results include transformer iron loss, copper loss, lead cable loss, theoretical cable loss rate, economic load current, line equivalent resistance, etc. Can satisfy: (a). Line data file management; (b). the cable loss indicator is issued; (c). Line economic analysis; (d). Loss analysis to improve economic efficiency. Since the load measurement needs to record the operational data required for the calculation of active, reactive, power, voltage, etc. at the 24-hour hour of each measurement point in one day, although the cable loss theory calculation software provides users with a lot of convenience, Due to the large amount of data and short time, the user's workload is still large, so the theoretical cable loss is calculated once a year.

4. Improve power distribution in the network and improve power factor
In order to reduce the network power loss, measures such as changing the system operation mode, adjusting the operating parameters and the load rate, etc., make the power distribution of the network close to the economic distribution, making the network operation more economical and the power loss is the smallest. While the active power is allocated reasonably, the reasonable distribution of reactive power should also be achieved.
In practice, circuit capacitors or camera can be used. Generally, power capacitors are used to compensate for reactive power: parallel capacitors on inductive loads. The method of shunting capacitors on an inductive load can compensate the reactive power of the inductive load with the reactive power of the capacitor, thereby reducing or even eliminating the original energy exchange between the
inductive loads and the power source. There are three main methods for current reactive power compensation: low voltage individual compensation.

![Diagram of reactive power compensation principle wiring diagram and phasor diagram](image)

**Figure 1.** Reactive power compensation principle wiring diagram and phasor diagram

Increase the power factor and increase the terminal voltage. It can reduce the active loss and voltage loss, reduce the reactive power sent by the generator and the reactive power transmitted through the line and transformer, and greatly reduce the cable loss.

5. **Ensure the economic operation of distribution transformers**

| Distribution network theoretical cable loss (kWh) | Composition ratio (%) |
|--------------------------------------------------|-----------------------|
| Total theoretical cable loss:                    | 100                   |
| (a). Line conductor cable loss                   | 15~20 averages around 18 |
| (b). Transformer copper loss                     | 10~15 averages around 12 |
| (c). Transformer iron loss                       | 55~85 averages around 70 |

It can be seen from Table 1 that the loss of the transformer of the distribution network accounts for a large proportion of the total cable loss of the whole system. Reducing the loss of the transformer is an important part of the grid loss. Then the ultimate goal of ensuring the economic operation of the transformer is to reduce the loss of the transformer. The methods to ensure the economic operation of the transformer are:

a). Under the premise of ensuring the safety of the transformer and ensuring the quality of the power supply, by selecting the optimal operation mode of the transformer, optimizing the load adjustment and improving the operating conditions of the transformer, the power loss of the transformer and the power factor of the power supply side are minimized.

b). The power loss can be reduced by appropriately adjusting the number of transformers that are put into operation according to changes in load. When the load is less than the critical load, it is more economical to reduce the operation of one transformer; conversely, when the load is greater than the critical load, parallel operation is more economical. Generally, more than two transformers should be designed and installed in the substation to change the technical basis of the system operation mode. In this way, the reliability of the power supply is improved, and the number of parallel operation transformers can be reasonably stopped according to the load, thereby reducing the transformer loss. At the same time, transformers generally need to use energy-saving type. For agricultural power
transformers whose load is greatly affected by seasonal changes, a sub-mother transformer can be used, and the switching capacity can be selected to reduce the no-load loss according to the load conditions of different seasons.

c). Reasonable adjustment of the operating voltage of the distribution network is inversely proportional to the square of the variable loss operating voltage of the distribution network. The fixed loss is proportional to the square of the operating voltage. According to the load characteristics of different time periods in a day, which loss is determined in the total the proportion of the loss in the loss to adjust the operating voltage to reduce the network loss.

6. Clean up tree barriers in time

Although the line is cleared every year, due to the rapid growth of trees in summer or incomplete cutting, especially in hilly areas, trees often touch the line. This phenomenon is more prominent in rural 10kV and below. These trees that touch the line will cause current. Leakage, exposure to wet and rainy weather will be more serious, endangering the safe operation of the line and personal safety. Therefore, it is necessary to strengthen the line inspection, timely cut down the trees that touch the line, maintain the line passage, reduce current leakage, and reduce cable loss.

Table 2 gives the protection zone regulations for overhead power lines. Table 3 shows the safety distances between overhead power line conductors and trees after maximum sag and maximum wind deviation.

| Line voltage (kV) | 1~10 | 35~110 | 154~330 |
|------------------|------|--------|--------|
| Distance (m)     | 5    | 10     | 15     |
| Region           | The protection zone of the overhead power line is the side of the wire to the sides Two parallel in-line regions formed by extending a certain distance |

| Voltage level (kV) | Maximum wind deviation distance (m) | Maximum vertical distance (m) |
|--------------------|----------------------------------|------------------------------|
| 1~10               | 3.0                              | 3.0                          |
| 35~110             | 3.5                              | 4.0                          |
| 154~220            | 4.0                              | 4.5                          |
| 330                | 5.0                              | 5.5                          |
| 500                | 7.0                              | 7.0                          |

7. Conclusion

In terms of reducing cable loss, this paper proposes the following measures: a). Strengthen the management of copying, nuclear and quality, further strengthen management of copying and collecting work, strengthen the responsibility for work of copying and collecting staff, especially meter readers, and professional ethics education, strictly check various assessments, block electricity consumption and leak phenomenon. b). Strengthen the energy metering management, correctly configure the energy metering device, and also to protect the interests of electricity customers. c). Anti-stealing management, strengthen management of inspection work, assess inspection rate and investigation rate, overcome the impact of social bad atmosphere, seriously investigate and deal with electricity theft, and fully use legal weapons to combat electricity theft. The supervision of internal work links can also be used as part of the audit work, such as supervising internal electricity use, investigating internal and external collusion, and supervising the quality of meter reading. d). Strengthen the assessment management. In the process of implementation assessment, the contractors of the line and the Taiwan area cannot simply administer the package, and the package is used. If the cable loss is large and the task is difficult, it must be proactively with the contractor. Analyze equipment conditions, user characteristics, find the cause of
loss, and take measures to reduce losses. Cannot be ignored, contused the management enthusiasm of the contractor, cannot arbitrarily adjust the indicators, so that cable loss assessment in the form.

Acknowledgements
This paper is funded by the Science and Technology Project of State Grid Liaoning Electric Power Company Ltd (2019YF-50), Research and Application of Key Technologies of Integrated Distribution Area Based on Primary and Secondary Convergence Technology.

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