New line-loss management technology of distribution area based on electricity information collection system

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Abstract: With the application of electricity information acquisition system and the gradual improvement of related functions, the management on line-loss in intelligent distribution area operated by power supply enterprises has made great progress. However, due to the influence of the subjective and objective factors, the line-loss management has not reached the expected target, which directly affects the economic benefit of power supply enterprises. This article mainly introduces a new management technique of line-loss in intelligent distribution area based on electricity information acquisition system. The abnormal loss of electric energy in intelligent distribution area caused by the current with unbalanced three-phase and the meter connection mode is mitigated.

1 Introduction

The line-loss management of intelligent distribution area is a management method for the statistical analysis of the electric energy loss in the public distribution power supply range [1, 2]. In recent years, it has been carried out along with the promotion of urban power grids, rural power grids, as well as the energy consumption reduction project.

At present, the main problems that affect the energy loss in intelligent distribution area have converted to the loss of management, which includes the unclear relationship among users, electricity stealing, the unbalanced three-phase, and the meter connection mode [3, 4].

The line-loss ratio is a comprehensive core economic indicator for power supply enterprises. Therefore, strengthening the line loss management is a long-term strategic task and systematic project for power supply enterprises [5, 6]. With the reformation of electric power system, it becomes more and more important to reduce the line loss. The elaborate line-loss management is a future general trend, and improving the efficiency of line loss management is the most urgent hope for power enterprises [7].

Electricity information acquisition system can collect and process users' electricity information with real time monitoring, and it can also achieve automatic acquisition, abnormal measurement monitoring, power-quality monitoring, and other functions [8].

2 Influence factors of line loss

2.1 Triphase load imbalance

In power supply system, the unbalanced current in the power grid increases copper loss of electric power lines and transformers, the iron loss of the transformers, but reduces the output of the transformers that even affect the safe operation of the transformers, leading imbalanced three-phase voltage. The unbalanced three-phase power supply does not only lead to the increase of line loss, but also affect the quality of power supply [9].

2.2 Incorrect wiring of the ammeter

In low-voltage power distribution area, there are some issues. For example, the zero curve and live wire of single-phase ammeter are in reverse (L/N in reverse), and the wiring sequence of three-phase meter is wrong (reverse-phase sequence). These problems make the collection system cannot collect the actual power of users, which can increase line loss.

2.3 Incorrect user membership

The user membership errors often appear in the city network platform, especially in the new enabled district. The main reasons are as follows.

(i) User data are not maintained effectively. The user membership files in the system have long been neglected in effective maintenance and management.

(ii) Carelessness of the staff of business expansion causes the new users to fall into the neighbourhood.

(iii) The information between operation-maintenance and marketing is not shared.

(iv) The public electricity section of the new enabled district is part of the chaos [10].

The above problems result in inaccurate user files in the collection system, which will affect the line loss in the intelligent distribution area and lead to abnormal line loss.

2.4 Line leakage

It is very difficult to analyse the main reason of the daily line loss through the acquisition system. After excluding the user's stealing factors, the line operation and maintenance personnel should carefully inspect the route of the station to find out line leakage, which is usually caused by external forces. It is mentioned in the literature [10] that whether there is a leakage phenomenon in the circuit by measuring whether the zero curve is charged. It can be served as a reference. The leakage of the line will result in the power supply of the platform far less than the power supply, which can lead to the high line loss of the intelligent distribution area.

2.5 Electric larceny

This kind of problem generally occurs in the area where the user is more dispersed and the telegraph poles are used for distribution. It is usually a structure change in the measurement circuit to steal...
unbalanced. Theoretical calculations draw the following conclusions:

\[ I^2 = I_A^2 + I_B^2 + I_C^2 \]

This makes the total power loss of the three-phase four-wire system is balanced power loss + three-phase load current. Assuming that \( I_A > I_B > I_C, I_0 \neq 0, \beta_1 = I_B/I_A, \beta_2 = I_C/I_A \). The values of \( \beta_1, \beta_2 \) reflect the imbalance of the three-phase load current. Assuming that the coefficient of imbalance loss is \( \alpha \), and it represents the multiple of theoretical linear loss value when the three-phase load current in three-phase four-wire system is unbalanced. Theoretical calculations draw the following conclusions:

\[ \alpha = \frac{1 + \beta_1^2 + \beta_2^2 + (1 - ((\beta_1 + \beta_2)/2)^2)}{(1 + \beta_1 + \beta_2^2/2)} \]

If \( \alpha \) in (1) is introduced into the theoretical line loss formula of three-phase circuit, the power loss of three-phase four wire system can be expressed as:

\[ \Delta P = 3a(kI_0)\beta R \times 10^{-3} \]

\[ = 3aI_0^2R \times 10^{-3} \]

where \( \Delta P \) represents loss power; \( I_0^2 \) represents average load current; \( I_0 \) represents load root-mean-square current; \( R \) represents the shape coefficient of load; \( R \) represents the resistance of the phase line [12].

Due to the fluctuation of the load, it is difficult to solve the three-phase load imbalance problem accurately by the existing technologies. Here, a new monitoring method based on electricity consumption information system is introduced as follows.

The unbalanced loss coefficient \( \alpha \) is calculated by real-time monitoring of phase separation load, and then the theoretical line loss of three-phase transmission lines is obtained. When the line loss exceeds the regulation value, the on-site staff can be arranged to perform the reverse operation, which can solve the problem of excessive line loss caused by unbalanced three-phase load effectively.

3.2 Phase separation management based on electrical acquisition system

3.2.1 The technical key to realise phase division management: Using the characteristics of the 120 degree phase difference of the electric voltage in the three-phase AC of the low-voltage power line, the synchronous processing is carried out with the zero point of the electric voltage of each phase AC as the time reference. The differential division of the electrical communication signal in each phase is effectively carried out to transmit signals via power line within 3.3 ms around the current phase voltage zero point. In half cycle time 10 ms of the power grid frequency (50 Hz), every intersection flow electric has a zero voltage crossing point in time, using their 3.3 ms low-voltage power line carrier communication module between the concentrator and the carrier, to improve overall economic efficiency; the use of zero transmission carrier signal, low-voltage power line carrier communication system of an intelligent distribution area with the same natural synchronous references [12]. The schematic diagram is shown as Fig. 1.

As for zero-crossing of three-phase synchronous transmission technology and complicated technology, the time reference for each physical channel in three-phase AC is spaced by 3.3 ms. Through three-phase alternating current in accordance with their own time benchmark concurrent carrier signals, three-phase signal in different time slots for transmission, carrier module according to each phase over 0 times compared to the concentrator command time, accurately identify the carrier module (Energy meter) of the power supply phase Fig. 2.

3.2.2 The implementation process of phased management:

3.2.3 The functions that can be achieved based on phased management: The following functions can be realised by using the phase separation management technology based on the power information acquisition system.

(i) The line (phase) where the meter is located can be known, and the number of meters mounted on each line can be counted, which provides an optimal solution for the distribution of the energy meter for each line.

(ii) It is possible to calculate the electrical energy on each line, reduce the three-phase unbalance, reduce the overall line loss of the line, and reduce the risk of single-phase overload.
(iii) The line loss of each line can be calculated. For the area with high line loss and difficult control, the phase of the electric energy meter can be distinguished, the line loss can be treated in phase and the difficulty of the line loss control in the whole area can be reduced.

The phase loss analysis and statistics of a district using phase-division management technology is shown in Fig. 3.

3.3 L/N reciprocity and reverse-phase sequence management based on electricity acquisition system

Current technology cannot effectively identify the phenomenon of L/N reciprocity and reverse-phase sequence in the intelligent distribution area. The traditional way is to find a zero-volume user through the acquisition system and perform reverse electricity demand measurement for the zero-power user, or confirm the presence of the meter to confirm whether the meter wiring is abnormal [13, 14]. This paper presents an automatic identification of L/N reciprocity and inverse sequence based on the principle of over zero synchronous transmission, which relies on the power information acquisition system. Overall, the information collection system issues a special command to the concentrator, to determine whether there is a case that L/N and the reciprocal of the reverse-phase sequence according to the feedback information Fig. 4.

3.3.1 The automatic recognition process of L/N reciprocal and reverse-phase sequence:

3.3.2 Application of L/N reciprocal and reverse-phase sequence automatic recognition technology:

(i) Using L/N reciprocal automatic identification and monitoring technology, the problem of single-phase surface zero/fire line connection can be found in time, the guidance for field connection adjustment can be provided, and the problems such as damage to electricity equipment and electric safety accidents can be avoided.

(ii) The automatic identification and monitoring technology of three-phase meter reverse-phase sequence can be used to detect the problem of phase sequence error of the three phase table in time, avoiding the inaccurate measurement of the electric energy meter, damaging the electric equipment, and the accident of the electric safety accident.

(iii) Adopt L/N reciprocal and reverse-phase sequence automatic identification technology to provide basis for field line adjustment, ensure that the segregated electric energy recorded by the concentrator is consistent with the total energy measured by the master meter, and improve the line loss of the station area rate.

Using the automatic identification technology of L/N reciprocity and reverse-phase sequence to calculate the abnormal energy meter in a certain area is shown in Fig. 5.

In the actual work, it is necessary to promote the construction of electrical information collection system actively and explore new line loss control measures actively to solve the practical problems. Therefore, in the analysis and calculation of the line loss, the automatic data acquisition system is used to improve the effective management of the line loss. Establish a set of systematic, scientific and comprehensive index control system, and guide the orderly development of control measures. Line loss management is an important index of the economic development of enterprises. Innovating line loss management measures will realise the minimum line loss in intelligent distribution area [15, 16].

4 Conclusion

The management of line loss in intelligent distribution area has a long way to go. Based on the study of the electricity information collection system, this paper uses this metric to innovate and actively explore the methods of line loss management. As a new method of line loss management for the development of the smart grid, it effectively solves the problems of the three-phase unbalance in the platform area, the L/N reciprocity and reverse-phase sequence in the current management of the platform area. The line loss management in the intelligent distribution area is more transparent and efficient with the proposed technology. Exerting its comprehensive management role in marketing management, the goal of energy saving and loss reduction can be achieved eventually.

5 Acknowledgments

This work is supported by State Grid Shandong Electric Power Research Institute. The authors are grateful to the institute for providing with technical guidance and equipment support.
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