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# Research On Grid Losses Reduction Measures For Medium And Low Voltage Distribution Network

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**Abstract—** In order to effectively reduce the network losses of the medium and low voltage distribution network and fully utilize the possibilities of network loss reduction, six measures to reduce the network losses of the medium and low voltage distribution network are studied, including the reconstruction of the network. distribution network. Renewal of 10kV distribution line, domestic lines and input lines, replacement of distribution transformer of high energy consumption, rational power selection of distribution transformer and installation, compensation of reactive power and balanced three-phase load. The research results can provide a benchmark for electricity distribution companies to reduce network losses in medium and low voltage distribution networks..

**Keywords—**Distribution Network, Grid Losses Reduction, distribution line, distribution transformer.

## I. INTRODUCTION

Network loss is not only an important technical and economic index for national assessment of power supply enterprises, but also a comprehensive reflection of the management level of power supply enterprises. It can be used to measure the planning management, technical management, operation management, business management and measurement management of power supply enterprises. Reducing network loss, on the one hand, can improve the efficiency of energy utilization and power supply enterprises, on the other hand, it can provide more power to users and promote economic and social development under the condition of limited grid resources.

For provincial grid companies, the loss of medium and low voltage distribution network generally accounts for 35% - 40% of the total network loss, which has a great space for loss reduction. In view of the common problems of 10kV distribution line power supply radius exceeding the standard, unreasonable selection of distribution transformer capacity, unbalanced three-phase load and so on in the national medium and low-voltage distribution network, this paper respectively reseached six measures such as 10kV distribution line reconstruction, household line and entrance line reconstruction, replacement of high energy consumption distribution transformer, reasonable selection of distribution transformer capacity and installation location, reactive power compensation and leveling three-phase load. The guidance scheme of each measure is put forward for the reference of power supply enterprises at all levels.

## II. 10KV DISTRIBUTION LINE RECONSTRUCTION

The 10kV distribution line in the city shall be made of ACSR. The cross section of the conductor shall be selected according to the economic current density, with a development margin of not less than 5 years [1], not less than 35mm$^2$. The last section of the line with small load can be selected as 25mm$^2$. The insulation wire can be used in the busy area where the contradiction between the tree line is prominent. The cross- section of the main line of 10kV distribution network in the county shall be selected according to the medium and long- term planning, and shall not be less than 100mm$^2$ [1]. For regions prone to freezing disaster, the section size higher than the calculation result should be selected in the selection of conductor steel core. The transmission power of 10kV overhead line shall not be greater than 3000kW, and the transmission distance shall be determined according to the allowable value of voltage loss, load density and power supply reliability, which shall not be greater than 8-10km; the transmission power of 10kV cable line shall not be greater than 5000kW, and the transmission distance shall not be greater than 10km.

The cross-section of rural low-voltage line shall be selected according to the maximum working current. The main line shall not be less than 35mm$^2$, and the branch line shall not be less than 25mm$^2$. The main line shall be bare conductor, but in order to ensure the safety of power consumption, insulated wire can be used as appropriate. In addition, in recent years, the low-voltage cluster wire has been applied in many places. The practice proves that the cluster wire has obvious effect on reducing the leakage loss. The main line of the low-voltage distribution network in the county town should be insulated conductor, the cross section of the conductor should not be less than 63mm$^2$, and the cross section of the overhead insulated conductor or bundle conductor of the branch line should not be less than 35mm$^2$ [1]. The transmission power of low-voltage overhead lines shall not be greater than 100kW, and the transmission distance shall not be greater than 250m; the transmission power of low-voltage cable lines shall not be greater than 175kW, and the transmission distance shall not be greater than 350m.

## III. HOUSEHOLD LINE AND ENTRANCE LINE RECONSTRUCTION The insulated conductor shall be used for the household

line. The section of aluminum core insulated conductor shall not be less than 10mm$^2$, and that of copper core insulated conductor shall not be less than 4mm$^2$. When the length of the household line in a long lane exceeds 50m, two or three household line shall be set up, and rubber insulated conductor shall be used, with the cross section of 16-25mm$^2$. The cross section of aluminum core insulated wire from the metering box to the user shall not be less than 4mm$^2$, and that of copper core insulated wire shall not be less than 2.5mm$^2$ [1]. The phase line and neutral line of each entrance line in bungalow residential area shall be laid separately, and the neutral line shall not be shared, and the total length shall not exceed 50m. In residential and commercial areas of buildings, due to the large lighting load, four core copper cable should be used as the entrance line, with one phase power supply for every 4-6 households. In order to make the neutral current of the three-phase four wire system line not exceed 25% of the rated current of the distribution transformer, it is required that the connection points of the household lighting grounding line and the low- voltage line shall be T-connected to the adjacent poles in the sequence of three-phase U, V, W and N lines from the beginning of the line.

## REPLACEMENT OF HIGH ENERGY CONSUMPTION DISTRIBUTION TRANSFORMER

In the mid-1990s, China launched a new S9 series distribution transformer, replacing the old transformer before 1980 with a new S9 type transformer. The investment amount can be recovered from the saved electricity fee within no more than 3 years, regardless of the recovery fund of the old transformer. With the rapid development of China's electric power industry, domestic electrical manufacturers have developed the upgraded products S11

series distribution transformers. S11 series distribution transformers are divided into the following three types according to different materials and structures of iron cores. The first is S11 distribution transformer with laminated core structure; the second is S11-
M.R.T. distribution transformer with amorphous alloy, the no-load loss is 75% lower than that of S9 with the same capacity on average. According to the general index model, the annual comprehensive loss of S11-M.R.T. amorphous alloy transformer is 40% - 42% less than that of S9 transformer; the third is S11 distribution transformer with r-coil core structure, according to the general index model According to the calculation, the annual comprehensive loss of s11-m.r winding core transformer is 13% - 17% less than that of S9 transformer. With the wide application of new process, new material and new technology, the new low loss transformer is not only the new S9 and S11 type, for example, oil immersed transformer has appeared S10 series which is more energy-saving than the new S9 series, and dry-type transformer has appeared SC9 series products [2], showing the energy-saving potential of distribution transformer in China. S11 series amorphous alloy core and coil core energy-saving transformer are preferred for distribution transformer, and resin dry insulation, adjustable capacity and Dyn11 wiring group distribution transformer are popularized.

## REASONABLE SELECTION OF DISTRIBUTION TRANSFORMER CAPACITY AND INSTALLATION LOCATION

### *A.* Capacity Selection of Distribution Transformer

The following five basic principles should be followed in the selection of distribution transformer capacity: Minimize the power loss of distribution transformer itself. For example, when the power load is the same, the loss of one 100kVA distribution transformer is smaller than that of two 50KVA transformers of the same model, and the price of the former is lower than that of the latter; Make the distribution transformer have high utilization ratio, and take as many loads as possible with different properties and different power consumption time periods; The reserve capacity of distribution transformer should not be too large. Excessive increase of reserve capacity will increase the investment of equipment, increase the reactive power loss of transformer and reduce the power factor of power grid; Make the capacity of distribution transformer adapt to the power supply range of low-voltage power grid. The reasonable power supply radius of low-voltage line shall not exceed 500m, and the reasonable transmission power shall not exceed 100kVA. If the capacity of distribution transformer is too large, it may increase the load point of transformer power supply, expand and extend the low-voltage distribution line, resulting in the confusion of network layout in distribution station area, and the voltage quality can not be guaranteed; In order to limit the short-circuit current at the low-voltage side in case of short-circuit fault, the capacity of a single distribution transformer shall not exceed 500KVA, and the total capacity of multiple distribution transformers in the distribution station area shall also be properly controlled.

The nature, size and development of electric load are the fundamental factors to determine the capacity of transformer. For factories and mining enterprises, it is necessary to determine whether to put in large capacity transformers at one time, increase the number of transformers in batches, or put in or stop transformers according to seasons according to their development and production properties, the increase and decrease of capacity of electrical equipment and the approximate time. For the rural comprehensive power distribution transformer with small load change and high load rate, it should meet the needs of agricultural and sideline products processing and residential comprehensive load, and the rated capacity can be determined by 1.2 times of the actual peak load. For the rural seasonal power distribution transformer, such as the special transformer for drainage and irrigation or the transformer mainly supplying power for rural workers and sidelines, the synchronous rate of

starting the supplied motor shall be considered to meet the demand of instantaneous large current. The rated capacity can be determined by twice the average value of rural seasonal power load. For the special transformer of rural residents' living electricity, the rated capacity can be determined according to the approximate value of the total load of the electrical equipment.

### *B.* Installation Location Selection of Distribution Transformer

The following three basic principles shall be followed in selecting the installation location of distribution transformer: The installation site shall be high in terrain and firm in foundation, which shall not be flooded or washed by water, and shall not be inclined or toppled by collapse, and the access line shall not obstruct the traffic; Make the distribution transformer close to the load center as much as possible, and set it near the crossroad to facilitate multi-directional power supply and maintenance; The interval between power supply points should not be too large. If the secondary low-voltage line of distribution transformer is too long, the low-voltage fuse should not be fused, and there is a potential safety hazard of burning the transformer.

Determining the installation position of distribution transformer according to the load center can reduce the low- voltage line loss in the distribution station area, which is also the most widely used method at present. The so-called "load center" refers to the center obtained by the product of the transportation capacity and the transportation distance (called load distance), which is not necessarily the geographical location center of the load [3].

## VI. REACTIVE POWER COMPENSATION

The general principle of reactive power compensation of medium and low voltage distribution network is comprehensive planning, reasonable layout, decentralized compensation and local balance [4]. Centralized compensation and decentralized compensation are combined, mainly distributed compensation; medium voltage compensation and low-voltage compensation are combined, mainly low-voltage compensation; voltage regulation and loss reduction are combined, mainly loss reduction.

### *A.* 10kV Distribution Line Decentralized Compensation

10kV distribution line compensation refers to single point or multi-point capacitor compensation by installing capacitors on the line poles: single point compensation shall be carried out when the line length is 1-5km, and the compensation location shall be 2/3 of the reactive load when it is 2/3 away from the first end of the line; two-point compensation shall be carried out when the line length is 5-10km, respectively installed at 2/5 and 4/5 away from the first end, and the compensation capacity shall be none respectively 2/5 of the power load; if the load is very heavy and the line is very long, it is necessary to effectively integrate automatic compensation and fixed compensation, adopt three-point decentralized compensation, install a group of compensation capacitors at 2/7, 4/7 and 6/7 of the line respectively, and the compensation capacity is 2/7 of the reactive load. According to the actual situation in rural areas, the compensation points of rural power lines should not be too many, the control mode should be simple, and the protection mode can adopt fuses and lightning arresters as simple protection of over-current and over-voltage. When selecting capacitors, the over-voltage capacity, short- circuit discharge capacity, inrush current and operation environment of the capacitors should be considered. In fact, each group of compensation devices should be installed with 100-200kvar [5]. The 10kV line pole reactive power compensation mode improves the overall utilization rate of the equipment, which is very helpful for the later management and maintenance.

### *B.* Centralized Compensation of 10kV Bus in Substation

The main function of the centralized compensation device in the substation is to compensate the reactive power loss of the main transformer and the medium voltage distribution line, and improve the bus voltage of the terminal substation. As for the determination of the centralized compensation capacity, it is appropriate to allocate 10% - 30% of the main transformer capacity for 110kV and below substations [1]. For the industrial substation with concentrated load, the compensation capacity is 0.1-0.15 times of the rated capacity of the main transformer according to the requirements of the excitation and leakage reactance reactive power of the main transformer; for the substation with decentralized agricultural load, the reactive compensation should not only balance the reactive loss of the main transformer, but also meet the needs of the reactive load at peak load [5], and the compensation capacity is 0.2-0.3 times of the rated capacity of the main transformer. The compensation equipment should be divided into two groups. Under the premise of ensuring the voltage is qualified and the compensation effect is the best, the operation times of capacitor bank switching should be minimized as much as possible.

### *C.* Local Compensation of Low Voltage User Equipment

Factories, mining enterprises, agricultural and sideline products processing users, agricultural irrigation and domestic water supply and drainage users generally use large-scale motors, which are large reactive load households. The power factor of asynchronous motor with rated load is about 0.7-0.89, and that with 75% rated load is close to 0.8, but the motor load rate in actual operation is generally below 60%, and the power factor is very low. In terms of performance, the AC welding machine widely used in industrial and mining enterprises is a special transformer with flat or falling external characteristics. The natural power factor of ordinary AC welding machine is less than 0.5. In addition, fluorescent lamp, high-pressure mercury lamp and high-pressure sodium lamp also belong to inductive load. The additional reactive power consumed by the inductive ballast with stable current is about 10% - 25% of the lamp power. Fluorescent lamp is widely used in shopping malls and other entertainment places because of its advantages of soft light, good color rendering and low appearance temperature. The natural power factor of fluorescent lamp is generally 0.3-0.5. Although the power of a single lamp is very small, the total amount of use can not be ignored. High pressure mercury lamp and sodium lamp are the main lighting facilities in domestic roads and public places. The power factor of high-pressure mercury lamp is 0.45-0.62, the power factor of high-pressure sodium lamp is 35-1000w, and the power factor is 0.3-0.44. The large-scale use of these lamps will inevitably lead to a great reduction of the power factor of the power grid. Therefore, it is imperative to compensate the reactive power locally and improve the power factor of users. Under the same electrical structure of the distribution network, the economic benefit of the local reactive power compensation at the user side is more than twice that of the decentralized line compensation, the investment recovery is faster, and it is more conducive for the power supply enterprises to find unknown line loss.

## VII. LEVELING THREE-PHASE LOAD

In the three-phase power supply system, the causes of three-phase imbalance mainly include: ①It is impossible to transform the urban and rural power grids in all aspects. In order to reduce the cost, a certain number of single-phase two wire lines are set up everywhere, especially in the low- voltage branch lines, single-phase two wire and two-phase three wire lines account for a certain proportion. Even if the three-phase four wire line is erected, because the construction personnel do not have the consciousness of three-phase load balance, the single-phase load shall be connected at will during the construction process, and the single-phase load shall be connected to the middle two wires. ②In the daily operation and management work, the power supply department did not pay attention to the single- phase load evenly distributed to the three-phase. In the existing three-phase four wire low-

voltage lines in rural areas, the operators think that as long as the three ammeters on the distribution panel indicate the same or similar, the three-phase load balance is achieved, most of them fail to notice that the single-phase load is timely distributed to the three phase lines, or do not know how to balance. In some places, because the line load is small, the operators stop using one or two phases, thinking that the empty line does not consume power, which is actually the opposite. ③With the continuous improvement of people's living standards, electric blankets, air conditioners, induction furnaces, electric water heaters, electric massagers and other appliances using single-phase (220V) power supply have entered thousands of households, and the single-phase load power consumption has increased dramatically. Most of the urban lighting projects also use 220 V power supply.

Three phase load leveling should follow the following basic ideas: ① The user is the most basic unit of electricity consumption, the meter container is the basic unit of wiring, the base point of three-phase load balance can achieve the most accurate balance only when it is placed on the end user. In the actual work, we should pay attention to the balanced distribution of consumers, not only in the form of one third of the number of single-phase load users per phase connection, but also in which the consumers with similar power consumption should be equally distributed to the three-phase.
② The three-phase current balance at the outlet of the transformer and the three-phase balance at the outlet of the line are the roughest balance. The real three-phase load local balance refers to the balanced distribution of the single-phase load at the ignition point to the three-phase. Therefore, the primary and secondary order of three-phase load balance in a low voltage platform area should be: balance of all ignition points → balance of all line sections → balance of all line outlets → balance of all line outlets → balance of transformer outlets. The balance of the ignition point is the foundation of the local balance of the consumers. Only by consolidating the foundation can the power consumption be reduced to the maximum extent. ③The load of the power grid is constantly changing. At one time, one of the three phases is balanced, and at the other time, it is not necessarily balanced, or even very different. Therefore, the typical time shall prevail. The rule of rural households' electricity consumption is that they seldom use electricity before and after breakfast, turn on fans and watch TV before and after lunch, and the electricity consumption will surge and last for a long time after dark. Therefore, the rural power distribution network should be based on the three-phase balance during the light peak period at night, taking into account other times. The rule of power consumption of urban residents' families is that three meals of electric cooker, microwave oven and electromagnetic oven are used in a large amount and the time period is basically the same, and the power load of air conditioning, bathing, entertainment and party is the largest and lasts the longest at night. Therefore, the three-phase balance of power load of light peak in the evening shall prevail in the urban power distribution network, and the three times of small cooking peak shall be taken into account at the same time.

To sum up, the significance of three-phase load balance actually includes four aspects: ①the three-phase current value is equal, ②the three-phase load property is the same, ③the three-phase load is balanced locally, ④strive to achieve three- phase balance in each time period.

The measures to improve the unbalanced operation of three-phase load include: ①Measure the load of three-phase grounding wire regularly, check whether the three-phase load is balanced, and adjust it in time in case of any imbalance. ② During the installation of power supply and distribution equipment, three single-phase grounding wires shall be led out from three phases a, B and C on one pole as far as possible. ③ Shorten the total length of single-phase household line, if the line is long, re erect three-phase four wire system line. ④Install three-phase phase break protection in the distribution room or large power users, so that any phase wire break or

any phase fuse can send a signal in time and cut off the power supply, reducing the probability of three-phase load imbalance. ⑤The asymmetric load is distributed to different power supply points as far as possible, so as to avoid the problem that the imbalance degree exceeds the allowable value caused by centralized access. ⑥The asymmetrical load is connected to the grid with higher voltage level to increase the short-circuit capacity of the connection point. ⑦ Adjustable balance on-line devices are adopted, such as static var compensator (SVC) and static var power supply (SVG) with split phase compensation function.

## VIII. ANALYSE AND SUMMARY

In view of the common problems of 10kV distribution line power supply radius exceeding the standard, unreasonable selection of distribution transformer capacity, unbalanced three-phase load and so on in the national medium and low- voltage distribution network, this paper respectively reseached six measures such as 10kV distribution line reconstruction, household line and entrance line reconstruction, replacement of high energy consumption distribution transformer, reasonable selection of distribution transformer capacity and installation location, reactive power compensation and leveling three-phase load. The research results provide a reference for the power supply enterprises at all levels to reduce the loss of medium and low voltage distribution network.

## REFERENCES

[1] Rural Power Work Department of State Grid Corporation of China, Xian Gongdian Qiye Xiansun Guifan Guanli Fudao. Beijing: China Electric Power Press, 2006.

[2] ZENG Yunbo, “Discussion on energy saving measures to reduce consumption of distribution transformer,” China New Technologies and Products, vol. 4, pp. 260, February 2011.

[3] DONG Zhilong, “Discussion on selection of installation position of distribution transformer,” Guangxi Electric Power Technology, vol. 25, pp. 66-68, 71, December 2002.

[4] WANG Jingbo, “Analysis on Optimal Configuration of Rural Grid Reactive Compensation,” North China Electric Power, vol. S1, pp. 143- 145, June 2009.

[5] ZHU Jianjun , LU Zhigang, “Reactive Power Compensation in Low and Medium Voltage Distribution Grid,” Power Capacitor & Reactive Power Compensation, vol. 32, pp. 19-23, August 2011.