Energy Saving Of Power System

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Abstract. This paper mainly introduces the significance, methods and technical measures of power system energy saving, through reasonable selection of electrical equipment, reasonable calculation of load, voltage loss, and the correct and reasonable design of distribution system to achieve the purpose of energy saving.

Keywords: Power System, Energy Consumption, Energy Saving

1. Introduction

Energy saving of electric power system can not only reduce users' electricity expense, improve enterprises' economic benefit, excavate power supply capacity of distribution equipment[1], but also have great significance to environmental protection. Therefore, this paper must mainly from the following aspects of energy saving measures.

2. Energy saving measures for power systems

The loss of power system is mainly rented by the loss of distribution lines, bus bars, high and low voltage switchgear and isolation switch components.

Firstly, the power factor should be increased and the reactive compensation device should be selected reasonably. If the reactive power is reduced, the load will decrease accordingly, and the reduction of the current will reduce the loss on the switchgear and the line.[2] The reactive power compensation mode includes high voltage side concentrated compensation; Low pressure side centralized compensation; Three kinds of low voltage local compensation. Low voltage side centralized compensation is a compensation method that is widely used. For equipment with large capacity and low power factor, low voltage local compensation method is adopted. Generally, the factory usually adopts the centralized, decentralized and local combination. According to the change of load, the automatic switching mode of capacitor can not only completely compensate, but also avoid the over-compensation caused by over-voltage burning equipment. In the past, automatic switching of capacitor was usually only carried out on the low-voltage side.[3] In recent years, the automatic compensation device
on the high-voltage side has been gradually popularized. In addition, other methods to improve the power factor can be adopted, such as replacing asynchronous motor with synchronous motor and using contactless switch.

![Compensation diagram of shunt capacitor](image)

**Figure 1.** Compensation diagram of shunt capacitor

Reasonable choice of transformer capacity and number. The transformer capacity should be selected from the initial investment and economic operation of the two aspects of comprehensive consideration, reasonable choice of the number of transformers, for seasonal load, such as boiler room and other winter load, can be set up special transformers. If there are two transformers in the system, the load curve can determine when to put one transformer and when to put two transformers. One transformer: SN ≥ SC, the capacity of a general transformer is 60% ~ 70% ideal. Two transformers: SN = (0.6 ~ 0.7) SC and SN ≥ SC (1 + II) or higher. The calculation method of transformer loss is as follows:

\[
\Delta P_T = \Delta P_{Fe} + \Delta P_{cu} \approx \Delta P_0 + \Delta P_k \left( \frac{S_c}{S_N} \right)^2
\]  

(1)

\[
\Delta Q_T = \Delta Q_0 + \Delta Q = \Delta Q_0 + \Delta Q_N \left( \frac{S_c}{S_N} \right)^2 \approx S_N \left[ \frac{I_{0\%}}{100} + \frac{U_k}{100} \left( \frac{S_c}{S_N} \right)^2 \right]
\]  

(2)

Energy-saving transformers should be selected, such as S11 series transformers, which reduce no-load loss by 7.3% and short-circuit loss by 25.33% compared with SL7 series, with an average annual power saving of 20KWh.

The choice of two transformers is a more flexible junction mode, and can be timely load adjustment with the transformer's load rate, to ensure that the transformer operation in the best state of load. The three-phase load of the transformer should be balanced. Unbalanced operation not only reduces the output, but also increases the loss[^4].

To reduce the line loss, the substation should be as close as possible to the load center to shorten the distribution radius and reduce the line loss. The selection of routes should generally follow the following principles:

Select the conductor and section according to the allowable voltage loss, that is, when the conductor and cable (including bus) pass through the normal maximum load current (i.e. calculated current), the voltage loss generated on the line shall not exceed the allowable voltage loss during normal operation.

Voltage loss calculation of uniform non-inductive line

\[
\Delta U = \sum_{i=1}^{n} U_i = \sum_{i=1}^{n} \frac{P_i r_i + Q_i x_i}{U_N}
\]

\[
\Delta U \% = \frac{1}{10} \frac{1}{U_N^2} \left[ r_i \sum_{i=1}^{n} P_i l_i + x_i \sum_{i=1}^{n} Q_i l_i \right]
\]  

(3)  

(4)
\[
\Delta U_0^\% = \frac{r_1}{10U_N^2} \sum_{i=1}^{n} P_i L_i = \frac{1}{10} \frac{\sum_{i=1}^{n} M^2}{CA} \tag{5}
\]

According to the above algorithm, the wire section is selected to minimize the voltage loss and save energy.

Selecting wire and cable section according to economic current density selecting wire and cable section according to mechanical strength is also a kind of energy-saving method, if selecting wire section according to economic current density selecting wire section, selecting wire section is big, initial investment is big, but in the long run, line loss reduction operation cost is low. \(^{[5]}\)

Therefore, technical and economic comparison can be made and selection can be considered comprehensively.

\[
A_{ec} = \frac{I_{30}}{f_{ec}} \tag{6}
\]

After calculating the economic section Aec, the standard section closest to but smaller should be selected.

Reduce the number of contacts and contact resistance. According to the design specification, the distribution level of power supply and distribution system with the same voltage shall not exceed two levels. The connection between conductors exists universally and the number of connection points is numerous, which not only becomes the security weak link in the system, but also is the important factor that causes the increase of line loss. Attention must be paid to the construction technology of the joints to ensure that the conductors are in close contact with each other. Special attention should be paid to lap joints between different materials.

Lighting energy saving, mainly refers to light efficiency, light pass maintenance rate, average life is three important parameters. At the same power, the higher the light efficiency of the light source, the higher the light pass maintenance rate and the longer the life, the more energy saving.

Select Energy-saving Light Source:

choice of high-efficiency light sources. Light sources are divided into three categories, one is thermal radiation light sources, such as incandescent lamps, halogen tungsten lamps and so on; considering that incandescent lamps have the lowest light efficiency in all kinds of light sources, we should try to control the use of incandescent lamps in various places, except for some special places, where mercury lamps consume the most electricity; and metal halogen lamps consume the least electricity. Another category is LED lights, civilian lighting is now gradually replaced by LED lights. Mercury lamp, high power energy saving lamp and metal halide lamp are widely used in industrial lighting. Although the initial investment of metal-halogen lamps is slightly more expensive and mercury lamps are the cheapest, both metal-halogen lamps and high-power energy-saving lamps have advantages over mercury lamps in terms of total operating costs. To use \(\text{For example, when the same lighting effect is achieved, the metal halide lamp is saved by 45% compared with the mercury lamp and the energy-saving lamp is 22% lower than that of the mercury lamp. Therefore, both metal halide}\)
lamps and high-power energy-saving lamps are far higher than mercury lamps in return on investment. Before the energy saving index, the mercury lamp is obviously not as good as the high-power energy-saving lamp and the metal halide lamp. "High light efficiency, long life, good color rendering" is the general principle of light source selection. The price of such light sources is relatively high, but it is reasonable in general considering that it can reduce the amount of use, reduce the maintenance cost and long use time.

Selection of high efficiency and energy saving lamps. The precondition of choosing high efficiency lamps is to meet the requirements of glare restriction and light distribution. The efficiency of fluorescent lamps and lanterns needs to meet certain requirements. Lamps and lanterns should be reasonably used according to different places of use light control, lamps and lanterns as far as possible to choose both good luminous flux maintenance rate, but also to use high light utilization coefficient.

Select high power factor start-up equipment. Compared with the inductive ballast, the advantage of electronic ballast is more obvious, the starting voltage is low, the temperature rise is low, and there is no stroboscopic, and more than 10% of the current is saved than the former. with remarkable power saving effect.

Power system design, to meet the requirements of energy saving. Try to achieve three-phase balance. Taking a small office building as an example, the total capacity of lamps and lanterns is about 60KW, and the total active power load is 60KW if uniformly divided into three phases a, b and c. if only connected to phase a, the total active load reaches 180 kw. Therefore, three-phase balance plays a very important role in the energy saving of lighting system. In addition, the power factor for many gas discharge lights is only 0. About 5, the design should consider the choice of self-compensation device lamps. It should also consider the combination of natural light and artificial lighting, using electronic dimmer, time-delay switch, acousto-optic control switch, Shoulder switch instead of ordinary switch, can play a role in reducing lighting energy consumption.

Choose energy-saving light source. The light source is divided into three categories, one is the thermal radiation light source, such as incandescent lamp, halogen tungsten lamp; One is the gas discharge light source, such as xenon lamp, sodium lamp; Another kind is LED light, civil lighting is now gradually replaced by LED light. Mercury lamp, high power energy saving lamp and metal halide lamp are widely used in industrial lighting. Mercury lamps consume the most electricity; Metal halide lamps consume the least power. Although the initial investment of metal halide lamps is slightly more expensive, mercury lamps are the cheapest, both metal halide lamps and high-power energy-saving lamps have advantages over mercury lamps in terms of total operating costs. Take lighting 12 hours a day for a year as an example. In the case of achieving the same lighting effect, metal halide lamps save 45% of the cost compared to mercury lamps, and energy-saving lamps save 22% compared to mercury lamps. Therefore, the return on investment of metal halide lamps and high-power energy-saving lamps are far higher than mercury lamps. Before energy-saving index, mercury lamp is inferior to high-power energy-saving lamp and metal halide lamp obviously.

The design of power system should meet the requirement of energy saving. Try to achieve three-phase balance. Taking a small office building as an example, the total capacity of selected lamps is about 60KW. If evenly divided into a, b and c, the total active load is 60KW. If only connected to phase a, the total active load is 180KW. Therefore, three-phase balance
plays a very important role in the energy saving of lighting system. In addition, the power factor of many gas discharge lamps is only about 0.5, the design should consider to choose the own compensation device lamps. And also should consider the combination of natural light and artificial lighting, the use of electronic dimmer, delay switch, sound and light control switch, induction switch instead of ordinary switch, can play a role in reducing lighting energy consumption.

The electric motor is the most extensive electrical equipment in the electric power system. The electric energy consumed accounts for about 60% of the total industrial power consumption. The high-efficiency and energy-saving motor reduces the electric energy loss of the motor itself, including the iron loss, the copper loss of stator windings, the ventilation friction loss and stray loss, etc., which improves the efficiency of the motor and reduces the operating cost. The increased investment due to its high price can be recovered in a short time. The rated capacity of the motor should be selected according to the size of its load and determined by technical and economic comparison. Generally speaking, when the load rate of the motor is less than 50%, the motor with a smaller capacity should be replaced to avoid the phenomenon of "big horse and car", resulting in waste. Choose the voltage grade of the motor reasonably. If the capacity is less than 250kW, the low-voltage motor should be selected. If the motor capacity is more than 355kW, the high voltage motor should be selected.

The no-load loss of induction motor is mainly reactive power loss. For small and medium-sized motors whose no-load running time exceeds 5 minutes, they should stop in time. If the above situation occurs repeatedly in the working cycle of the motor, the no-load self-stop device shall be installed.

The motor should be maintained regularly and repaired in time when problems are found. When assembling the motor, the air gap between rotor and stator should be made even or reduced, and the rotating friction of rotor should be reduced if the lubrication and refueling work is done well. All these are conducive to reducing the power loss.

Rational planning of the grid can reduce the energy consumption of transmission and distribution lines. Power enterprises can rely on computer application technology, network technology and so on to calculate the relevant parameters of the grid, in order to select the optimal operation mode and reduce the loss of the grid. Power enterprises use detection technology, on-line monitoring technology, automation technology and so on to improve the efficiency of power dispatching, in order to reduce the power grid loss load. In the process of grid operation, it is necessary to set up reasonable and scientific distribution voltage and strengthen the control of voltage. High voltage will cause power loss, too low and cannot meet the demand for electricity, therefore, the power enterprise can reduce energy consumption by allocating reasonable voltage. In addition, it is possible to optimize the Power configuration. The reactive current in the grid wastes a lot of electric energy, and reactive power compensation is also an important way to reduce energy consumption. Choosing the correct compensation capacity, compensation mode and compensation point can stabilize the voltage level and prevent the line from transmitting a large amount of reactive current and losing electric energy. At the same time, the series compensation method can be used to further optimize the power grid. In the long distance transmission line, the reactance of the series compensation line can shorten the transmission distance of the circuit, improve the power transmission capacity of large capacity and long distance, and enhance the stability
and safety of the system. For example, in the same pole tower can be set up two or more circuits to reduce transmission line corridor and engineering costs, beneficial To achieve energy saving and consumption reduction.

3. Conclusion
At present, the focus of electrical energy saving work is to design power system correctly, reform high power consumption technology, choose energy-saving products, update and transform low-efficiency equipment, and realize economic operation of electrical equipment. All the methods and measures to save electric energy, which are technically feasible, economically reasonable and not harmful to environmental protection, are adopted to eliminate the waste of electric energy in the process of using electricity and improve the utilization rate of electric energy.

References
[1] un Jinwen, Wan Yunfei, Zheng Peiwen, et al. Coordinated charging and discharging strategy for electric vehicles based on demand side management [J]. Transactions of China Electrotechnical Society, 2014, 29(8): 64-69.
[2] Lou Suhua, Yi Lin, Wu Yaowu, et al. Optimizing deployment of battery energy storage based on lifetime predication [J]. Transactions of China Electrotechnical Society, 2015, 30(4): 265-271.
[3] Chai Dapeng, Cheng Huan, Ge Yujian, et al. Benefit analysis and optimization algorithm for thermal-pumped storage power joint operating system [J]. East China Electric Power, 2014, 42(5): 1012-1019.
[4] Zhang Chuan, Yang Lei, Niu Tongyang, et al. Comparison and analysis of energy storage technology to balance fluctuation of wind power output [J]. Power System Protection and Control, 2015, 43(7): 149-154.
[5] Li Jianlin, Guo Binqi, Niu Meng, et al. Optimal configuration strategy of energy storage capacity in wind/PV/storage hybrid system[J]. Transactions of China Electrotechnical Society, 2018, 33(6): 1189-1196.
[6] Lei Qi, Miao Shihong, Guo Baofu, et al. Comprehensive evaluation of hierarchical storage system based on analytic hierarchy process and improved technique for order preference by similarity to ideal solution[J]. Power System Protection and Control, 2017, 45(3): 13-19.
[7] Wang Yaping, Lin Shunjiang, Yang Zhbin, et al. Multi-objective stochastic dynamic optimal dispatch algorithm of microgrid [J]. Transactions of China Electrotechnical Society, 2018, 33(10): 2196-2207.