Calculation of Electricity Losses in Non-Symmetric Mode

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In this article, the solution of problems associated with the loss of electrical energy in asymmetrical modes was considered. The article provided general information about the structure of electrical energy losses, studied the types of electrical energy losses and methods for calculating electrical energy losses in asymmetric modes.

Keywords: asymmetrical mode, power supply, low voltage, load, uneven load, power lines, phase, currents of direct and reverse sequence.

Introduction

Improving the efficiency of voltage regulation in electrical networks is an important scientific and technical task, the solution of which makes it possible to bring the voltage level in the system closer to the nominal one, thereby minimizing the loss of electrical energy, subject to compliance with its quality standards, both at remote points of the power grid and on the buses of the main step-down substations.

One of the most effective ways to minimize power losses is voltage regulation, which is carried out by changing the transformation ratio of power transformers under load. At the same time, in order to implement effective control of the voltage regime in the network, it is necessary to take into account the length of the outgoing lines, the power of consumers, the distribution of the load and the modes of its operation in the electrical network, the regulating effects on voltage, the presence and composition of local devices for regulating and compensating for voltage deviation.

The structure of the power grid distribution complex, the composition of loads and the features of the technological process of industrial enterprises form special requirements for the power supply modes of technological electrical equipment and the quality of electrical energy. In addition, the limited amount of measuring and transmitting information about the power consumption of individual electrical installations does not allow you to quickly maintain the voltage level on the buses of the step-down substation with variations in the structure and load parameters.

Literature Review:

1) Zhelezko Y.S., a recognized source in the CIS countries on the problem of losses in electrical networks. "Calculation, analysis and rationing of electricity losses in electrical networks". - M.: NU ENAS, 2002. - 280 p. This book shows in detail the structure of electrical energy losses, methods for analyzing losses and choosing measures to reduce them.

2) A review of another bookby the same author was also made. Zhelezko Yu.S. "The choice of measures to reduce electricity losses in electrical networks: A guide for practical calculations. "-M.: Energoatomizdat, 1989. - 176 p. This literature focuses on methods for calculating losses in all types of electrical networks, and the application of calculation methods and measures to reduce electricity losses is highlighted depending on the type of network.

3) Budzko I.A. and Levin M.S. "Power supply of agricultural enterprises and settlements. - M.: Agropromizdat, 1985. - 320 p. In this book, the problems of power supply are considered in detail, the main attention was directed to the distribution networks of agricultural enterprises and settlements. This book provides recommendations for improving the system of management and accounting of electricity consumption.

4) Vorotnitsky V.E., Zhelezko Yu.S., Kazantsev V.N. "Loss of electricity in electrical networks of power systems. - M.: Energoatomizdat, 1983. - 368 p. In this publication, the authors consider general issues related to the reduction of electricity losses: methods for calculating losses in networks, structural analysis of losses and calculation of their technical and economic efficiency, loss planning and measures to reduce them.

Methodology

When studying the problems of electricity losses, various methods were considered, which are the main indicator of the numerical values of the topic under consideration. An example of this is the method of calculating electricity losses in asymmetrical modes.Calculation of single-ended modes. An asymmetrical mode in a three-phase system occurs if at least one of the conditions for the symmetry of the phase EMF of the source and the equality of the resistance of the receiver phases is violated.

The method ofY.S. Zhelezko was also considered. The most widely used methods for determining losses by the method using the coefficients of symmetric components and the method proposed by Y. S. Zhelezko. As you know, any asymmetric system (voltage, current) can be represented as the sum of three symmetrical ones. Thus, the expression for calculating additional losses using symmetric component methods will be:

$$\Delta P_{HEC} = \Delta P(1 + k_{1I}^2 + k_{0I}^2(1 + 3\frac{r_N}{r_\phi})), \qquad (1)$$

Discussion:

The division of losses into components can be carried out according to different criteria: the nature of losses (constant, variable), voltage classes, groups of elements, production units, etc. Taking into account the physical nature and specificity of methods for determining the quantitative values of actual losses, they can be divided into four components:

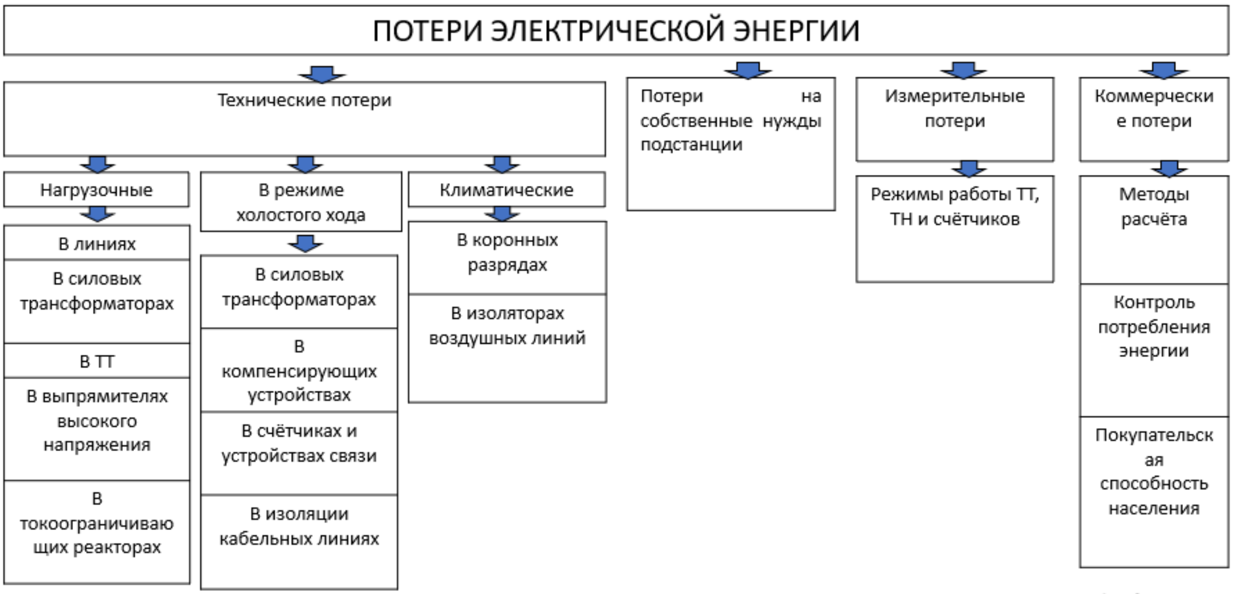

Figure-1. Scheme of electrical energy losses.

1) technical losses of electricity ΔW_T, due to physical processes in wires and electrical equipment occurring during the transmission of electricity through electrical networks.

2) electricity consumption for the own needs of substations ΔW_{CH}, necessary to ensure the operation of the technological equipment of substations and the life of maintenance personnel, determined by the readings of meters installed on the auxiliary transformers of substations;

3) electricity losses due to instrumental errors in their measurement (instrumental losses) ΔW_{ISM};

4) commercial losses ΔW_K due to theft of electricity, discrepancy between meter readings and payment for electricity by household consumers and other reasons in the field of organizing control over energy consumption. Their value is defined as the difference between the actual (reporting) losses and the sum of the first three components:

1. No-load electricity losses in a power transformer, which are determined during the time T according to the formula, thousand kWh:

$$\Delta W_X = \frac{\Delta P_X}{U_H} \cdot \int_0^T U^2(t)dt \quad , \quad (2)$$

where ΔP_x is the no-load power loss of the transformer at the nominal voltage U_N; $U(t)$ is the voltage at the connection point (at the HV input) of the transformer at time t.

2. Losses in compensating devices (CU), depending on the type of device. In 0.38-6-10 kV distribution networks, static capacitor batteries (STCs) are mainly used. Losses in them are determined on the basis of known specific power losses Δp_{BSK}, kW / kvar:

$$\Delta W_{\text{БСК}} = \Delta p_{\text{БСК}} \cdot \Delta W_{Q\text{БСК}} \quad , \quad (3)$$

where $W_{Q\,BCC}$ is the reactive energy generated by the capacitor battery during the billing period. Usually $\Delta p_{BCC} = 0.003$ kW/kvar.

3. Losses in voltage transformers. Active power losses in the TN consist of losses in the TN itself and in the secondary load:

$$\Delta P_{TH} = \Delta P_{1TH} + \Delta P_{2TH}. \quad (4)$$

Losses in the TN ΔP_{1TN} itself consist mainly of losses in the steel magnetic circuit of the transformer. They grow with increasing nominal voltage and for one phase at the rated voltage are numerically approximately equal to the rated voltage of the network. In distribution networks with a voltage of 0.38-6-10 kV, they are about 6-10 watts.

Losses in the secondary load ΔP_{2TN} depend on the accuracy class of TN $K_{TN.}$. Moreover, for transformers with a voltage of 6-10 kV, this dependence is linear. At the rated load for the TN of this voltage class, $\Delta P_{2TN} \approx 40$

W. However, in practice, the secondary circuits of the TN are often overloaded, so these values must be multiplied by the load factor of the secondary circuit of the TN β 2TN. Taking into account the foregoing, the total loss of electricity in the TN and the load of its secondary circuit is determined by the formulas, thousand kWh:

$$\Delta W_{TH} = (\mathrm{U} + \beta_{2TH} \cdot \Delta P_{2TH} \cdot K_{TH}) \cdot T \cdot 10^{-6}$$

. (5)

4. Losses in the insulation of cable lines, which are determined by the formula, kWh:

$$\Delta W_{каб} = T \cdot b_c \cdot U^2 \cdot tg\varphi \cdot L_{каб}$$

, (6)

where b_c is the capacitive conductivity of the cable, Sim/km; U - voltage, kV; L_{cab} is the length of the cable, km; tgφ is the tangent of the dielectric loss angle, determined by the formula:

$$tg\varphi = (0.003 + 0.0002 \cdot T_{сл}) \cdot (1 + a_\tau \cdot T_{сл})$$

, (7)

where T_{sl} is the number of years of operation of the cable; a_τ is the aging coefficient, which takes into account the aging of the insulation during operation. The resulting increase in the dielectric loss tangent is reflected in [2] formulas e.

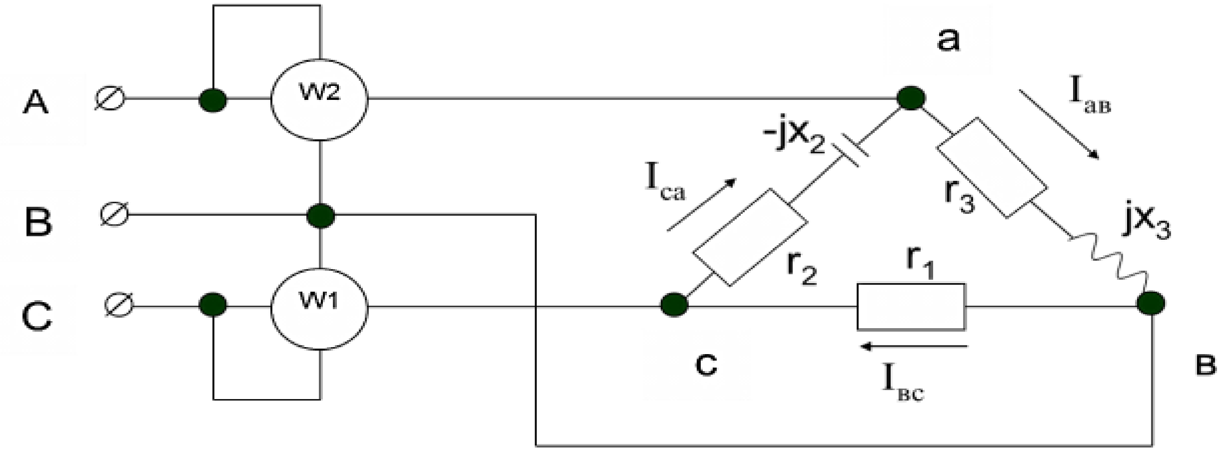

Figure-2. Diagram of connection of consumers in non-symmetric mode.

Accurate determination oflosses over the time interval T is possible with the known parameters R and Δ P x and the time functions I (t) and U (t) over the entire interval. The parameters R and ΔP_x are usually known, and in calculations they are considered constant [3, 4, 5]. But at the same time, the resistance of the conductor depends on the temperature.

Information on the operating parameters I (t) and U (t) is usually available only for the days of control measurements. At most substations without maintenance personnel, they are recorded 3 times per control day. This information is incomplete and limitedly reliable, since measurements are carried out by equipment with a certain accuracy class and not simultaneously at all substations.

Outcomes

Depending on the completeness of the amount of information about the loads of network elements, the following methods can be used to calculate load losses:

Element-by-element calculation methods using the formula:

$$\Delta W_{н} = 3 \cdot \Delta t \cdot \sum_{i=1}^{k} R_i \cdot \sum_{j=1}^{T/\Delta t} I^2{}_{ij}$$

, (8)

where k is the number of network elements; I_{ij} is the current load of the i-th element with a resistance R_i at time j; Δt is the frequency of polling sensors that record the current loads of the elements.

Methods of accounting for characteristic modes use the formula:

$$\Delta W_{н} = \sum_{i=1}^{n} \Delta P_i \cdot t_i , \qquad (9)$$

where ΔP_i is the load power loss in the network in the i-th mode of the duration of t_i - hours; n is the number of modes.

Conclusion: When studying the problem of electricity losses, it is important to take into account that this problem is relevant today. At this time, the rate of electricity losses in the distribution networks of Uzbekistan during transmission and distribution is 14-16% and higher than the useful supply, which is higher than that of foreign companies (6-8%) [8]. Therefore, if we can reduce this figure by at least 0.1%, then we will achieve savings in electrical energy, which is an important and valuable indicator of modern household life and industry.

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