INFLUENCE OF ELECTRICAL ENERGY QUALITY ON ELECTRICAL ENERGY WASTE

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Annotation: *The article discusses the impact of electricity quality on energy waste. In particular, the components of losses and their causes were studied. In non-sinusoidal and asymmetric modes, the occurrence of additional losses and methods for their elimination are shown, as well as the optimal voltage values corresponding to the smallest loss value, depending on the structure and operating modes of electrical networks.*

Keywords: *Power quality, electrical networks, power losses, non-sinusoidal and asymmetric modes.*

Power quality indicators such as voltage and frequency deviation, non-sinusoidal and nosimetry of voltages and currents affect power and electricity waste in power networks.

For reporting purposes, waste ΔW is divided into technical, technological and commercial waste. The waste in the report is determined by the difference between the electricity supplied to the grid and the electricity received from the grid and consumed by the consumer.

Technical waste ΔW_T, the substation's own consumption ΔW_(own.ex), is the technological waste caused by W_measurement from the losses and errors of measuring devices, because they are the technological needs of the process of transmission of electricity through networks and measuring devices during its reception and transmission to the consumer is determined by taking into account.

Commercial wastage is found as follows:

$$W_{К} = \Delta W - \Delta W_{Т} - \Delta W_{ўз.эх}, -W_{ўлч}$$

Commercial waste is the result of "human factors" and includes losses related to theft of electricity, non-payment of payment for consumed energy in full or in part, and others.

In technological waste, additional components can be determined conditionally due to nominal or nominal deviations in the operating modes of electrical equipment and measuring devices.

One of the factors that lead to this waste is the quality of electricity. In order to understand the essence and principles of measuring additional technological losses in non-sinusoidal and non-symmetric modes, it is necessary to consider the power balance in the system.

Power generators are determined by higher harmonic generators and symmetrical generators of currents and voltages:

For a four-wire system (phase currents and voltages)

$$P_1 = 3U_1I_1\cos\varphi_1;\ P_2 = 3U_2I_2\cos\varphi_2;\ P_0 = 3U_0I_0\cos\varphi_0; \quad (2)$$

$$P_{n\Sigma} = \sum_{ABC}\sum_{n=2}\sqrt{3}U_nI_n\cos\varphi_n \quad (3)$$

For three-wire systems (line currents and voltages)

$$P_1 = \sqrt{3U_1I_1\cos\varphi_1};\ P_2 = \sqrt{3U_2I_2\cos\varphi_2}; \quad (4)$$

$$P_{n\Sigma} = \sum_{n=2}\sqrt{3}U_nI_n\cos\varphi_n \quad (5)$$

Calculation and analysis of losses is carried out at the corresponding frequency of the harmonic or sequence of symmetrical constituents. The active component of power describes the transformation of electrical energy into other types of energy and is equal to the following for non-sinusoidal and non-symmetrical currents and voltages in a three-phase system:

$$P_{\Sigma} = P_1 + P_{n\Sigma} + P_2 + P_0 \quad (6)$$

Assume that the energy of the higher harmonics is reversed and does no useful work in zero sequence. Then the additional power losses for electrical consumers or part of the power system with non-sinusoidal, symmetrical currents and voltages are equal to the sum of the quality-destroying powers and it is defined by the following expression:

$$\Delta P_{\text{кўш}} = P_{nE} + P_2 + P_0 \quad (7)$$

The active power dissipation ΔP_n in a system with resistance R depends on the value of the applied voltage U.

$$\Delta P_n = \frac{P^2 + Q^2}{U^2}r, \quad (8)$$

Here R and Q are the active and reactive power transmitted by the network element.

The steady-state power ΔP_x is found from the following expression through the conductance g in an element with an active conductance.

$$\Delta P_x \approx U_{\text{в}}^2 g \quad (9)$$

Here $U_{\text{в}}$— is the voltage of the network element (compensating devices of the line, etc.) or the voltage on the upper side of the transformer.

From the last two expressions, we can see that in order to reduce the losses caused by the load, it is necessary to increase the value of the voltage, and in the second case, it is necessary to reduce the value of the load itself in the purely working state.

Optimum voltage values corresponding to minimum losses for a specific electrical power system depend on the structure and operating modes of networks of all voltage classes. In 110 kV networks, the first loss is higher compared to the sum of load losses, normal operation losses and climatic losses, and in 6-35 kV networks, only operation mode losses and climatic losses are higher than load losses.

Thus, the development of measures to adjust the voltage in the networks of the electric power system should be carried out taking into account the composition of their losses.

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