Relationship between mains costs and voltage switches

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Abstract. The article deals with the issues of interconnection of network costs and power quality, in particular voltage deviations. The graphs of the distribution of voltage deviations for electrical receivers are given for two calculated load modes - the highest (100%) and the lowest (25%), corresponding to the choice of wires of 10 and 0.38 kV overhead lines for economic loads and voltage stabilization on 10 kV buses of 35/10 kV RTP at the level of + 5%.

Keywords. Power quality, voltage, deviations, range, modes, costs, transformer

With the given characteristics of the technical means used in the networks, the voltage quality depends on the costs incurred, therefore, it is possible to establish probabilistic links between the technical and economic indicators of the network and the permissible voltage deviations. These dependencies make it possible to objectively assess the national economic costs necessary to ensure certain voltage deviations. On the other hand, they should be used to solve the problem of optimizing power quality indicators [1-8].

When establishing the probabilistic dependences of the technical and economic indicators of the network on the permissible voltage deviations, it is necessary to proceed from the most economical solutions. Such solutions, as you know, are provided by the choice of overhead line wire cross-sections according to economic loads. Therefore, when constructing the initial models, one should use overhead lines of 10 and 0,38 kV, the cross-sections of the wires in which are selected according to economic loads [9-14].

Distributions are rather accurately described by truncated normal curves

$$f(\Delta U_э) = \frac{1}{A_э \sigma_э \sqrt{2\pi}} e^{-\frac{(\Delta U_э - \Delta \bar{U}_э)^2}{2\sigma_э^2}} \quad (1)$$

wherein $\Delta U_э > 0$.

The parameters of the distribution curves have the following meanings

$$\Delta \bar{U}_{10э} = 4{,}51\ \% \ ; \sigma_{10э} = 2{,}25\ \% \ ;$$

$$A_{10э} = 1 - \int_{-\infty}^{0} f(\Delta U_{10э}) d\Delta U_{10э} = 0{,}977 \ ;$$

$$\Delta \bar{U}_{0.38э} = 3{,}5\ \% \ ; \sigma_{0.38v} = 4.5\ \% \ ;$$

The indicated distributions were taken as the initial ones when establishing the fluctuations of the technical and economic indicators of the networks and the permissible voltage deviations [15-17].

The selection of wire cross-sections in electrical networks in terms of economic loads corresponds to the above reduced costs and certain (let's call them economic) limits of voltage deviations from consumers.

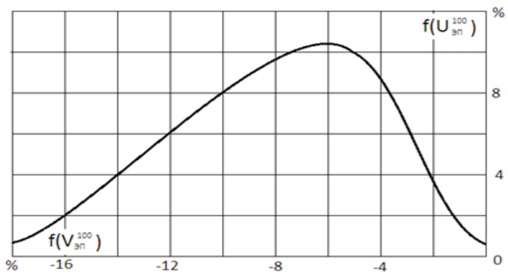

Fig. 1. Distribution of voltage deviations at power consumers in the highest load mode.

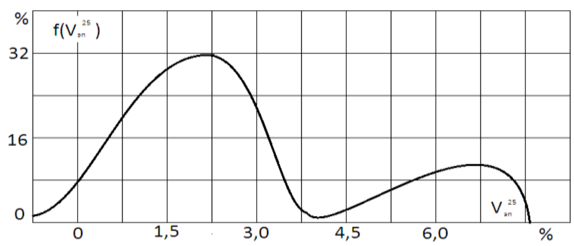

Fig. 2. Distribution of voltage deviations at power consumers in the lowest load mode.

In fig. Figures 1 and 2 show the distributions of voltage deviations for electrical receivers for two calculated load modes - the highest (100%) and the lowest (25%), corresponding to the choice of wires of 10 and 0,38 kV overhead lines for economic loads and voltage stabilization on 10 kV buses RTP 35/10 kV at +5% [18-24].

The technique for constructing these distributions is reduced to finding the laws of distribution of the sum of

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two independent random variables: V_{shol} (voltage deviation on the buses 0,4 kV for 10/0,4 kV transformer substations) and ΔU_o, z_{8e} (voltage loss of 0,38 kV lines).

$$F(V_{эк}^{100}) = \iint_{(D)} f(V_{ш0,4}) f(-\Delta U_{0,38э}) dV_{ш0,4} d\Delta U_{0,38э} \quad (2)$$

where D— region of integration determined by the range of variation of values $V_{m}o$, each zone of transformer additions, and direct $V_{эп}^{100}$=$V_{Ш,0,4}$+(—$U_{0,38э}$); /($V_{Ш,0,4}$)— the distribution law of voltage deviations on the 0.4 kV TP buses of each zone of the transformer additions (0; 2,5; 5%, etc.) [25-31].

Calculations have shown that a change in the accepted cost of 10/0,4 kV regulated transformers within a relatively wide range has little effect on the total reduced costs, and only noticeably changes the metal consumption and the number of regulated transformers [32-35].

Table 1.

Technical and economic indicators of networks depending on permissible voltages

Calculated limits of permissible voltage deviations	Relative rise in price (%) of the variable part of the reduced costs at the stage of unregulated transformer taps		Additional metal costs (%) at the step of unregulated transformer taps		The number of regulated transformers (in% of the total number) at the stage of unregulated taps	
%	2,5 %	5 %	2,5 %	5 %	2,5 %	5 %
Voltage stabilization (+ 5%) at 35/10 kV substation						
-15÷+7,5	-	-	-	-	-	-
-10÷+7,5	2,5	4	9	13,5	-	-
±7	7,5	16	18	25	-	20
±5	22	22	25	20,5	56	62
Counter regulation (from 0 to +5%) at 35/10 kV substation						
-10÷+7,5	-	1	-	1,5	-	-
±7	2	4	2	5	-	-
±5	5	9	11	20	-	-

The need for transformers with on-load tap-changers can be reduced by using booster transformers (VDT). The efficiency of their application depends on the number of 10/0,4 kV transformers with on-load tap-changers in the network and its configuration. Calculations have shown that at the accepted costs, the use of RCCB is economically justified if or it is possible to replace 8-10 10/0,4 kV transformers with OLTC. It is possible to use RCCBs to ensure the permissible limits of voltage deviations at consumers with an increase in the calculated (design) loads of the networks. In newly constructed networks, they should be rarely used [36-38].

The technical and economic indicators of distribution networks (reduced costs, consumption of conductive metal and the required number of adjustable transformers 10/0,4 kV) at some limits of voltage tolerances, calculated according to the above method, are given in Table. 2% [39-40].

The results obtained make it possible, in particular, to assess the effectiveness of the use of counter voltage regulation on the 35/10 kV RTP, the expediency of splitting the steps of the regulating branches of transformers, etc. 25 it can be seen that the implementation of counter voltage regulation at the RTP 35/10 kV in the range from 0 to +5% allows you to select the cross-sections of wires in the 10 and 0,38 kV overhead lines according to economic loads, ensuring minimal costs for the construction of these lines. The greatest limits of voltage deviations for electrical receivers will practically not exceed –10÷+7,5%. The use of counter voltage regulation, in comparison with stabilization, significantly reduces the cost of the network and when going from the normalized voltage deviations —10÷+7,5% to ±5%. In the presence of counter regulation, it is possible to practically abandon the use of distribution transformers with on-load tap-changers and RCCBs.

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