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# SELECTION OF A COMPLEX OF PARAMETERS OF DISTRIBUTION ELECTRIC NETWORKS WITH RESPECT TO TECHNICAL LIMITATIONS

*A D* Taslimov[1]

[1]Tashkent state technical university, Department of Power Supply, University street №2, Tashkent, 100095, Uzbekistan

**Abstract.** The article contains an optimization analysis of the regularities of the formation of the parameters of urban distribution networks of 10 kV, taking into account the technical limitations by the method of criteria analysis, which revealed the feasibility of using a limited number of used cable cross-sections, depending on the density of the electrical load and on the schemes of urban distribution networks.

## Introduction

Ongoing transformations in the electric power industry of Uzbekistan give particular urgency to the use of a modern approach when justifying the choice of the main parameters of distribution electric networks (RES). In addition, the planned scale of new construction, technical re-equipment and reconstruction of power grid facilities necessitate the development of technical solutions that reflect modern technical and economic realities and meet international standards. At the same time, the low level of implementation of resource and energy saving technologies, the slow pace of renewal of the RES lead to an increase in technological losses and systematic interruptions in the supply of electricity. Analysis of the state of the operating RES showed that 90-92% of low-voltage cable lines 6-10-0.38 kV have been in operation for more than 25 years, which requires urgent measures to be taken for further development and formation of a reliable, effective scheme for constructing electrical networks [1-5].

In these conditions, an integrated technical and economic approach to a comprehensive solution to the problems of choosing a set of optimal parameters for a distribution system and the possibility of unifying the lines under construction is especially relevant. At the same time, the determination of the optimal values of the RES parameters should be solved using all the available information and existing mathematical models of network elements, taking into account all the restrictions [6-8].

Optimization of the REM parameters and taking into account a set of restrictions requires the use of a mathematical programming method to solve the problem. This method is a criterion analysis or programming method that allows solving a set of optimization problems. The application of this analysis method makes it possible to identify the optimal network parameters without resorting to a variant calculation. In addition, this method allows for multiparameter optimization taking into account a set of constraints, for which a program for optimizing nonlinear functions with nonlinear constraints using the criterion programming method is used [9-11].

Taking into account the technical and economic models of total capital costs (the cost of cables, electrical installation and construction work), operating costs and electricity losses, a comprehensive technical and economic model of costs for 10 kV RES within one power source (IP) was obtained [7]:

$$З^{C} = З_{C(1)}\delta^{-0,5}S_{\text{ТП}(\text{У})}^{-0.25}S_{\text{ИП}}^{0.75}M_C^{0,5} + З_{(2)}\delta^{-0,5}S_{\text{ТП}(\text{У})}^{0,31}S_{\text{ИП}}^{0.19}M_C^{1,06}F_{2,C} + З_{C(3)}\delta^{-1,5}S_{\text{ТП}(\text{У})}^{-0,88}S_{\text{ИП}}^{1,38}M_C^{-0,13}F_{2,C}N_C^{-1} + З_{C(4)}\delta^{-0,5}S_{\text{ТП}(\text{У})}^{0,04}S_{\text{ИП}}^{2,46}M_C^{-1,21}F^{-1}{}_{2,C}N_C^{0,3}, \quad (1)$$

This is, $S_{\text{ТП}(\text{У})}$ - installed capacity of TS; $\delta$ - electrical load density; $З_{C(1)}$, $З_{C(2)}$, $З_{C(3)}$, $З_{C(4)}$ – generalized coefficients, which are the initial data [11]:

As a comprehensively optimized parameters, the number of lines from the IP ($M_C$), section of the head section of 10 kV lines ($F_{2,C}$) and the number of used cable cross-sections and 10kV ($N_{F,C}$), according to which "competing effects" are formed in model (1).

Using the criterion analysis method, the model (1) was optimized and formulas were obtained that allow determining the values of the optimized parameters for 10kV RES:

$$N_{F,C}^{Э} = 1,405 \cdot З_{C(1)}^{1,58} \cdot З_{C(2)}^{-1,553} \cdot З_{C(3)}^{0,763} \cdot З_{C(4)}^{-0,79} \cdot S_{\text{ТП}(\text{У})}^{-1,579}, \quad (2)$$

$$F_{2,C}^{Э} = 0,544 \cdot З_{C(1)}^{1,743} \cdot З_{C(2)}^{-1,261} \cdot З_{C(3)}^{-0,112} \cdot З_{C(4)}^{-0,372} \cdot S_{\text{ТП}(\text{У})}^{-0,742}, \quad (3)$$

$$M_C^{Э} = 1,529 \cdot З_{C(1)}^{-1,327} \cdot З_{C(2)}^{0,465} \cdot З_{C(3)}^{0,2} \cdot З_{C(4)}^{0,664} \cdot S_{\text{ИП}} \cdot S_{\text{ТП}(\text{У})}^{0,327}, \quad (4)$$

Expressions (2) - (4) allow, with known initial data, to determine the economic values of the main parameters of 10 kV RES.

With the accepted initial data [12-16], the economic values of the parameters determined by (2) ÷ (4) $N_{F,C}$ *u* $F_{2,C}$ $M_c$ depending on the power of the TP are shown in Fig. 1a, b, c, on which dependencies: "I" - with loop circuits, "II" - with two-beam circuits of networks.

The obtained economic parameters of 10 kV RES may not satisfy the main technical limitations of 10 kV RES. For 10kV RES, these are the limitations on heating by current after an emergency mode and on the permissible voltage loss. To solve the above systems of equations, we used a special program developed for solving optimization problems for a nonlinear objective function with nonlinear constraints by the criterion programming method [17-19]. The peculiarity of this program is that it first checks the activity of the considered restrictions, since there are inactive restrictions that lead to a change in the optimized parameters.

The influence of certain active restrictions on parameter values $N_{F,C}$, $F_{2,C}$ and $M_C$ are shown in Fig. 1a, b, c.

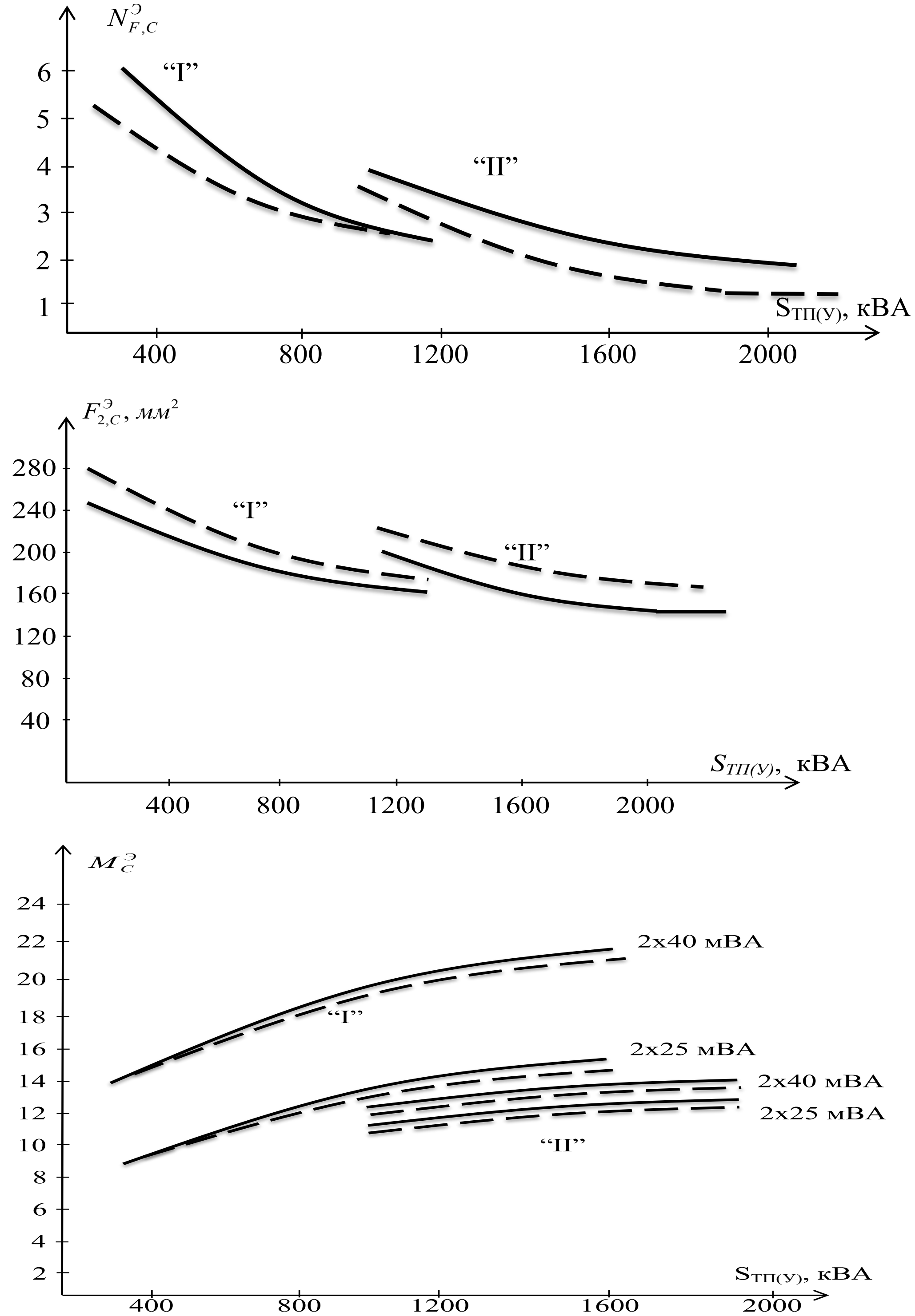


Fig. 1. The values of the number of cross-sections used (a), the cross-sections of the head sections (b) and the number of lines outgoing from the IP (c) RES 10kV (– – – subject to limitations, —— - no restrictions)

As the results of optimization of the technical and economic function show, taking into account a set of restrictions, including the limitation on heating 10 kV cables in almost all power ranges of the transformer substation is active, and the limitation on the permissible voltage loss in these networks is inactive. In this case, the conditions are met not by increasing $F_{2c}$, as is customary in practical design (increasing the cross-section with inadmissibility of heating), but by increasing the number of 10 kV lines leaving the power supply. In this case, the $F_{2c}$ value decreases slightly compared to the value obtained without taking into account the heating limitation. This, in turn, leads to a decrease in the value of $N_{F,C}$ this is especially noticeable at low TP powers (Fig. 1a). It can be assumed that the fulfillment of the condition for the admissibility of heating in the post-emergency mode automatically ensures the admissibility of the voltage loss in these networks [20-23].

Thus, the construction of a 10 kV RES at $S_{TП(y)}$=400-1200 кVA( δ<10 MVt/км$^2$) the optimal is the use of 2 ÷ 4 sections and at $S_{TП(y)}$=1200-2000кVA(δ=10-20MVt/км$^2$) it is advisable to use one or two cable cross-sections. In this case, it is recommended to use the sections of the head sections of the lines 240mm$^2$ or 185mm$^2$. And at $S_{TП(y)}$=2000 кVA and more (δ=10-20MVт/км$^2$ and more) it is advisable to build a 10 kV RES with a single (unified) cable section. In this case, it is recommended to use only the section 150 mm$^2$ [24-29].

## Conclusion

The results obtained by the number and value of the applied cable cross-sections in the RES correspond to similar foreign solutions (France, Russia, Poland, Germany, etc.), which is a certain confirmation of the reliability of the results obtained

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