ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 2, February 2024

# Share of Electricity Losses in Low-Voltage Distribution Networks

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**ABSTRACT:** Given the ever-increasing cost of electrical energy, minimizing of power losses is one of the main tasks for the electric grid systems. In this paper, we propose an algorithm for selecting activities to reduce power losses for electric grid companies.

## I. INTRODUCTION

The high level of electricity losses in electrical grid complexes indicates the problems accumulating in them, which require urgent solutions in the reconstruction and technical re-equipment of electrical networks. Solving the problem of electricity losses in electrical networks is one of the "Priority directions of development of science, technology and engineering in Uzbekistan.

The problem of high levels of losses manifests itself most deeply in electrical distribution networks. Reducing this level is necessary not only to increase the cost-effectiveness and efficiency of electrical networks, which in turn leads to a reduction in operating costs of distribution network complexes (DGCs) and increased company profits, but also to reduce electricity tariffs.

Minimizing electricity losses in DGCs is possible through the development and implementation of a set of measures aimed at their optimization. Despite the fact that at present there are many works on calculation methods, analysis of electricity losses and the selection of measures to reduce them [2,4], the problem of ensuring an acceptable level of losses under operating conditions has not yet been solved.

The purpose of this work is to develop tools that allow, under operating conditions, to achieve the optimal value of electricity losses with minimal costs.

1. Development of an algorithm for selecting the optimal set of measures that ensures maximum reduction of losses.

2. Illustration of the sequence of actions to reduce losses using the example of an existing DGC.

Under operating conditions, an enlarged structure of electricity losses is used, in which losses are divided into components based on their physical nature and the specific methods of determining their quantitative values [2]

The structure of electricity losses when divided according to this criterion is shown in Fig. 1.

The enlarged structure of actual losses does not provide a clear idea of the level of losses in one or another of its components and does not allow us to assess the real situation in the network. Selecting measures to reduce electricity losses in networks based only on the aggregated structure of actual losses is not possible due to its low information content.

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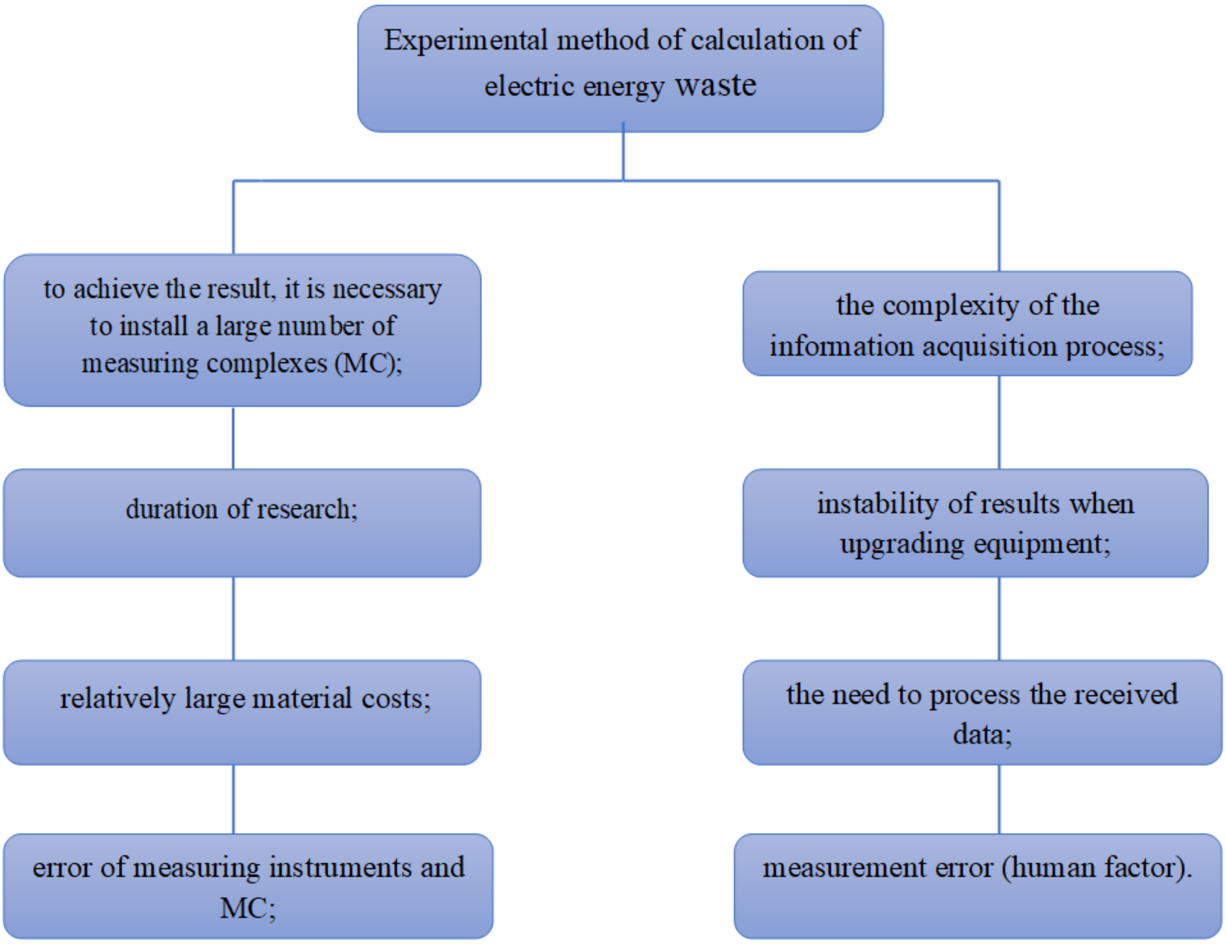


Fig.1. Experimental method of calculation of electric energy waste

To select the optimal set of measures to minimize losses, the procedure presented in Fig. 2 is proposed.

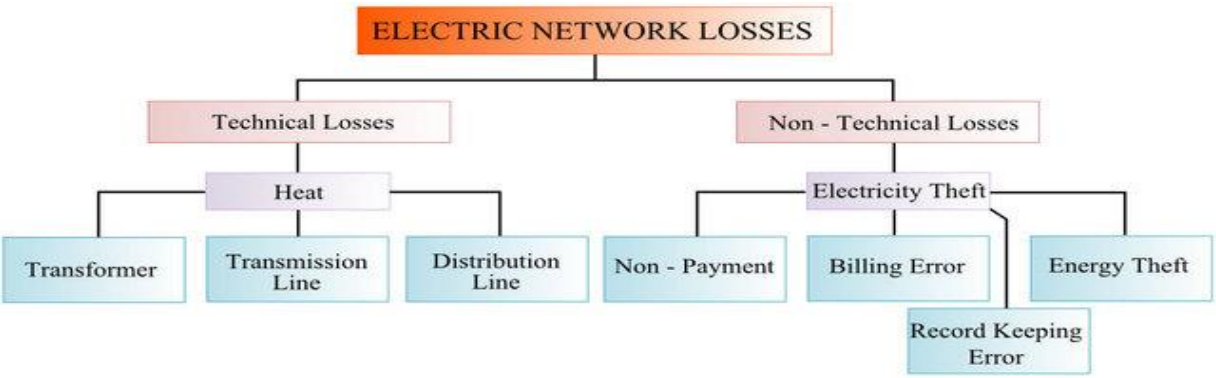


Fig. 2. Power losses qualification in electric network.

Calculations of electricity losses in networks to solve problems of increasing the efficiency of the operation of the electric grid complex are related to intra-facility technical and economic problems. To solve such problems, the maximum possible detail of calculations is required, with the determination of losses in each network element [3]. This is necessary for further analysis of the level of losses. Technological losses of electricity are a standard component of

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
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actual losses and must be calculated in accordance with [5]. Commercial losses cannot be measured with instruments and calculated using independent formulas. They are defined mathematically as the difference between actual and technological losses of electricity.

Based on the calculated quantitative indicators of actual electricity losses, the structure of losses is detailed. Technical losses are divided into load losses (depending on the load of the electrical network) and conditionally constant losses (the value of which does not depend or slightly depends on the parameters of the network mode).

## II. RESEARCH METHODS

Among the load losses, losses in power lines, power transformers and autotransformers stand out. Due to their small size and complexity of calculation, load losses in other elements of the electrical network - such as current-limiting reactors, connecting wires and buses of substation switchgears are determined on the basis of specific ones and are included in the composition of conditionally constant losses. Conditionally constant losses are divided into no-load losses in equipment, climatic losses and losses for the own needs of substations (NS).

The ultimate goal of the structural analysis of the resulting composition of actual losses is to rank the structural components according to the level of losses and identify areas of increased losses. The areas of increased losses are sections of networks or substations with the highest losses; they are determined based on the numerical values of the components of actual losses in the network. The more detailed and deeper the structural analysis of the composition of actual losses is carried out, the more accurately the areas of increased losses will be identified. This will allow achieving greater effect with lower costs for implementing measures to minimize them.

Currently, many measures have been developed to minimize energy losses. In order to correctly select measures to reduce the level of losses for one or another component of the structure of actual losses, it is necessary to determine the reasons for the occurrence of these losses. The main reasons for the high level of electricity losses and recommended measures to minimize them were systematized; they are shown in the table.

**Recommended activities depending on structural component of electricity losses**

| Components of losses | The main causes of electricity losses | Recommended activities |
|---|---|---|
| 1 | 2 | 3 |
| Commercial | 1. lack of energy sales activities and theft of electricity.<br>2. errors in calculating technical losses.<br>3. measurement errors of electricity supplied to the network and usefully supplied to consumers. | 1. modernization of electricity metering systems.<br><br>2. determination and reduction of methodological error in calculating technical losses.<br>3. combating electricity theft;<br>4. development of an incentive system for reducing electricity losses;<br>5. increasing the efficiency of metrological services of companies;<br>6. reduction of losses when issuing invoices;<br>7. calculation of commercial losses as financial losses of the company |
| Technical | 1) suboptimal network operating modes, characterized by large dispersion of active and reactive powers;<br>2) voltage deviations in nodes;<br>3) lack of regulatory means, absence and (or) unsatisfactory compensation of reactive power;<br>4) uneven graphs of electrical loads; | 1) optimization of voltage levels in distribution networks;<br>2) reactive power compensation and reactive power flow control;<br>3) improving the quality of electricity; |

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International Journal of AdvancedResearch in Science, Engineering and Technology
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| | | |
|---|---|---|
| | 5) non-compliance of the equipment used with the existing loads;<br>6) distortion of power quality. | 4) optimization of modes in distribution networks;<br>5) optimization of electrical network diagrams and disconnect points;<br>6) comprehensive automation and telemechanization of electrical networks;<br>7) reducing the duration of non-optimal<br>repair and post-emergency modes;<br>8) streamlining the capacity of transformers at substations and ensuring their economically feasible mode;<br>) transfer of extended networks to a higher voltage level and replacement of bare wires with insulated ones;<br>10) replacement of overloaded lines and equipment of electrical networks;<br>11) construction of new lines and power centers. |

First of all, measures aimed at reducing excess losses should be considered, since the costs associated with their payment are not compensated by tariff regulation and are direct losses to the network company. Next, measures are selected aimed at reducing standard losses for structural components with the largest share of actual losses. Reducing the level of standard losses will allow the network company to reduce payments for purchased electricity to compensate for electricity losses from the guaranteeing supplier.

## III. RESULTS

To achieve maximum effect, an integrated approach is required when choosing the optimal set of measures to reduce losses. To do this, it is necessary to rank the activities selected on the basis of identified areas of increased losses, according to the necessary costs and according to quantitative criteria. When ranking by cost, activities should be divided into low-, medium- and large-cost. This will allow us to develop the necessary set of measures to reduce losses, highlighting low-cost ones as priorities. First of all, these should include regime measures, since they do not require costs. If low-cost measures do not allow achieving the optimal level of losses in the network, it is necessary to consider medium-cost technical and organizational measures, and only lastly - large-cost ones. Medium- and large-cost activities include measures aimed at reconstructing and modernizing networks. Ranking by quantitative criteria is carried out based on the number of objects for which the selected control action is designed.

The next step is to assess the economic effectiveness of the selected activities. Its purpose is to quantify the expected economic effect from the implementation of selected activities. The main task of valuing the results of implementing activities is to assess revenue and payback. Let's consider the presented algorithm using a specific example - the structure of actual electricity losses in the networks of one of the PCK.

Let's simulate a situation where, during the implementation of the first stage of measures to reduce losses, areas of excess losses were completely eliminated. Next, we will consider the components of technological losses.

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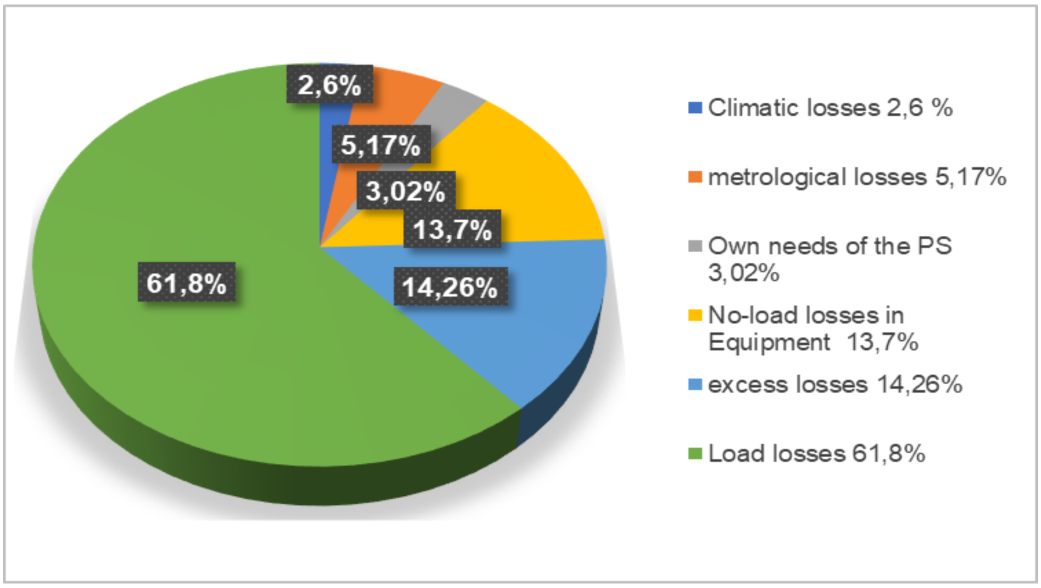


Fig.3. Structure of actual electricity losses in PCK networks

## IV.DISCUSSION

From the presented structure it is clear that the majority (61%) of the total volume of actual electricity losses in PCK is accounted for by load losses. The structure of load losses by type of equipment is shown in Fig. 4.

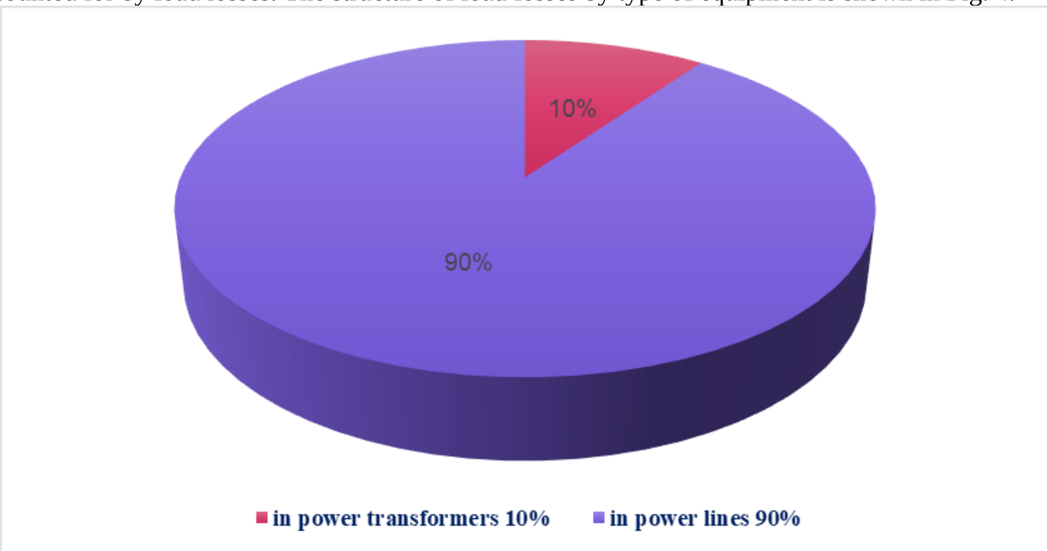


Fig.4. Structure of load power losses.

As you can see, 90% of the load losses of electricity are losses in the conductors of power lines (PTLs). To select point control actions, we divide the load losses in power lines by rated voltage classes. Let us present the resulting composition of losses (Fig. 5).

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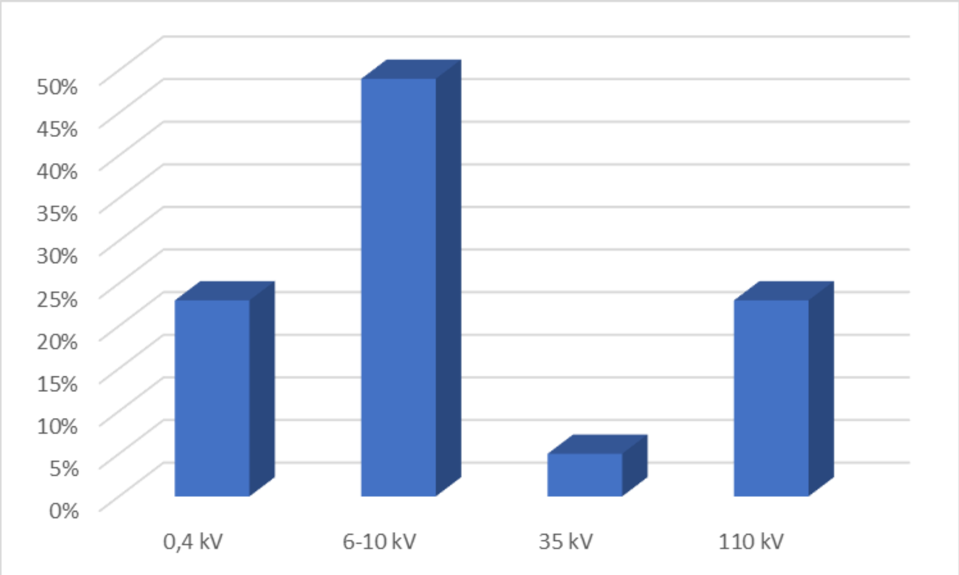


Fig. 5. Composition of losses in power lines.

Thus, based on the structural analysis of losses, we conclude that in this case the source of increased losses is load losses in 6-10 kV power lines.

The next stage after identifying the source of the greatest losses in the network is the selection of organizational and technical measures to minimize electricity losses. Low-cost measures aimed at reducing the level of load losses in 6-10 kV networks include:

## V.CONCLUSIONS

Optimization of voltage levels in distribution networks. In 6-10 kV networks, counter voltage regulation should be used, i.e. the voltage should be highest during periods of heavy loads and lowest during periods of light loads.If in 6-10 kV networks there are transformers with PPV in the power center (CP), then the functions of providing voltage regulation in these CPUs are transferred to a transformer with PPV in the CPU of a higher voltage network. By regulating voltage levels in the network, it is possible to change the flow distribution of reactive power, thereby increasing the network capacity and reducing electricity losses.

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