To the structure of electricity losses in distribution networks 6 - 110 kV

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Abstract. The article presents the main types of electricity losses depending on the operating parameters and parameters of distribution networks, as well as their structural components. The existing methods of obtaining information about operating parameters in 220-110-35-10-0.4 kV networks, the volume of measurements of operating parameters at substations of various voltage classes are described

Keywords. Actual losses, operating and system parameters, substation feeder, measuring clamps.

1 Introduction

As you know, the production, transmission and distribution of electricity are accompanied by the inevitable use of some of the generated energy for the implementation of these processes. The share of this energy is characterized by technological losses and is consumed to carry out work on the transport of electricity through electric networks from power plants to consumers.

The technical and economic indicators of the electrical system as a whole significantly depend on the value of electricity losses (EE), the cost of EE losses is included in the reduced costs and annual operating costs for the transmission of EE. There is a certain relationship between the cost of the electrical network and the energy losses in it [1-8].

The projected electrical network must provide an optimal balance between these two indicators. However, during operation, energy losses can increase, degrading the performance of the system. Thus, the ultimate goal of calculating and analyzing losses is to reduce them with the help of economically feasible measures.

During the operation of EPS, the concept of actual (reported) electricity losses has become widespread, which is defined as the difference between the EE supplied to the network and released from the network (productive supply), determined according to the data of the electricity metering system **(Fig. 1).**

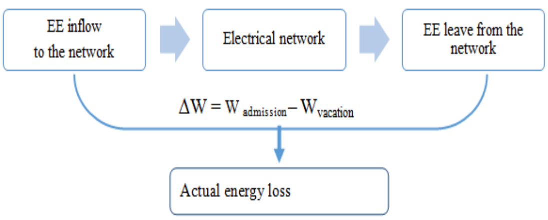

Fig. 1. Actual losses of electricity in networks

2 Main part

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. For detailed analysis and rationing of losses, it is advisable to use an enlarged structure of electricity losses, in which the losses are divided into components, based on their physical nature and specificity of methods for determining ix quantitative values.

Based on this criterion, the actual energy losses (EFL) can be broken down into four enlarged components, each of which has its own physical nature [9-14]:

technical losses (TechPE) -ΔW_t due to physical processes occurring during the transmission of electricity through electrical networks and expressed in the conversion of part of the electricity into heat in the elements of electrical networks;

electricity consumption for auxiliary needs of substations (RESNP) -ΔW_{ps}, necessary to ensure the operation of the technological equipment of substations and the life of the service personnel**;**

underestimation of electricity (PEPPU) -ΔW_y, due to large negative errors of metering devices for consumers in comparison with similar errors of devices that record its entry into the network. Errors of metering devices in passport data are characterized by two-sided errors (plus - minus), however, for a number of reasons, there is a systematic negative error in the electricity metering system at the facility, which includes hundreds and thousands of measuring complexes. This error leads to an underestimation of electricity, therefore the term “losses” is applied to it. Under the current operating conditions of metering devices, the underestimation of electricity turns out to be significant;

The sum of the first three components of losses due to the technology of the production process of transmitting electricity through networks and instrumental accounting of its receipt and supply is called **technological losses (TPE). Commercial losses (ComPE)** -ΔW_k, caused by theft of electricity, a discrepancy between meter readings and payment for electricity by household consumers and other reasons in the field of organizing control over energy consumption.

In accordance with the above, the reported losses can be presented in the following form (**Fig. 2**).

$W_o = \Delta W_t + \Delta W_{ps} + \Delta W_u + \Delta W_k$

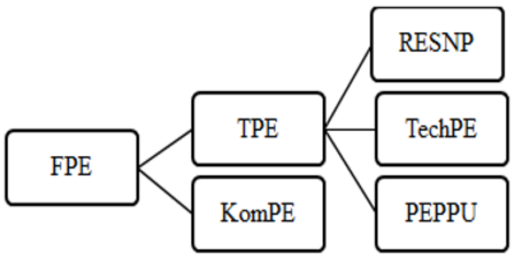

Fig. 2. Enlarged structure of energy losses in electrical networks

The fourth component is the impact of the "human factor" and includes all manifestations of such an impact: deliberate theft of electricity by some subscribers by changing meter readings, energy consumption other than meters, non-payment or incomplete payment of meter readings, determination of the useful electricity consumption by subscribers by calculation, temporarily connected without meters, etc [15-19].

Commercial losses do not have an independent mathematical description and, as a result, cannot be calculated autonomously. Their value is determined as the difference between the actual losses and the calculated process losses. It is obvious that each enlarged component has its own more detailed structure. Technical losses can be divided into element-wise components, electricity consumption for auxiliary needs of substations includes 23 types of electrical receivers, under-accounting of electricity includes components due to measuring current and voltage transformers and electricity meters, commercial losses can also be divided into numerous components that differ in the reasons for their occurrence. We call such a loss structure detailed structure of electricity losses**. (Fig. 3)**

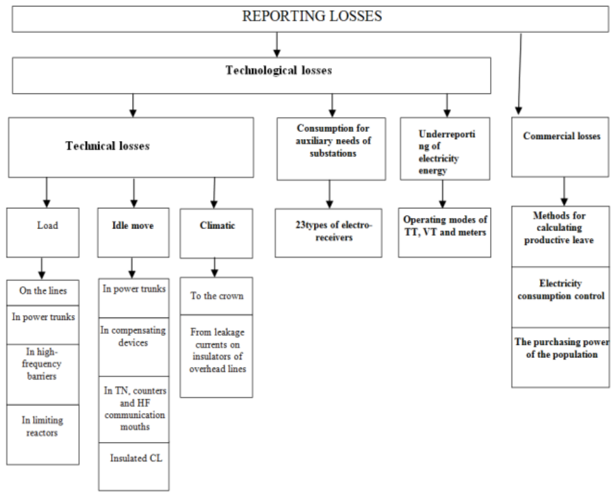

Fig. 3. Detailed structure of electricity losses

According to the peculiarities of schemes and modes, as well as information security of electrical networks in the energy system of Uzbekistan, the following four groups of networks are distinguished:

-Main electrical networks 220 kV and above and some 110 kV networks;

- Distribution (open) networks 35-110 kV;
- Distribution networks 6-10 kV;
- Electric networks 0.4 kV.

To solve a complex of problems of calculation, analysis, planning and control of the operating modes of EPS networks and the level of losses in them, it is necessary to have a large amount of information about the parameters of circuits and modes that change significantly during the working period. The circuit parameters include the totality of all its constituent elements: power lines, transformers, generators and other elements.

As a rule, information about the structure of the circuits is given in a numerically unambiguous form and does not change during the considered period of the system's operation. All network elements are represented by corresponding equivalent diagrams. The parameters of the equivalent equivalent circuit are: if the branch consists of a cable or overhead transmission line, then set: active and reactance (for branch i-j, $z_{ij}=r_{ij}+jx_{ij}$) and capacitive line conductivity (b_{ij}). If the branch consists of two (or three) winding transformers, then the following are set: active and reactance (for three winding transformers, the resistances of the HV, MV and LV windings are set), the transformation ratio ($K_{tij}=U_i/U_j$) and the installed power of the j-th node transformer ($Sycm_j$).

The operating parameters are the parameters of the loads given in various forms and the corresponding voltages.

In the power system, information about the mode is incomplete both in terms of the description of the mode in time and in the number of measured parameters. Moreover, the quality and completeness of information decreases in medium and low voltage networks. So the most accurate information about the parameters of the mode is available for the main networks in which the voltage and power of the lines are controlled, however, the control is carried out only for the most important elements of the power supply circuit. Telemetry systems are installed on the generator voltage buses of all stations of the system, supplying and receiving ends of lines above 220 kV and main transmission lines of 220 kV. 110kV lines are equipped with a limited telemetry system. In the absence of telemetry, many 110kV substations are controlled by a dispatcher. So, on the main networks there is hourly information on energy flows, power connections and voltage levels in the nodes [20-23].

As you know, RS 35-110 kV operate according to a radial redundant scheme. Several feeders depart from each substation, which supply consumers with electricity. Information on electricity consumption at load nodes is obtained by seasonal measurements made at substations on the days of control measurements (typical winter and summer days). The most reliable measurements are carried out by the substation duty personnel, which are transferred to the control room. These include measurements at the head section of open-loop RS feeders departing from large substations, where voltages, active and reactive power and/or effective current values are measured, recorded in the schedule by the dispatcher. Some central substations of regional significance are controlled by a dispatcher. They are also measured by feeders four times a day or twice a month. Thus, in the RS 35-110 kV, the main source of operating information is the data of seasonal measurements, performed manually not more than twice a year by the operating personnel.

RS 6-10 kV, as well as 35-110 kV networks, are also open-circuited. Information about loads is single measurements on operating days of currents at substations 10/0.4, which are performed by measuring clamps during the period of the assumed maximum load (19-23 hours). Measurements are carried out twice a year and can take up to two months for all PCs, since one operational team can service 8-10 TPs per working day. The accuracy of such measurements is low. The random nature of the change in the measured current can lead to an error of 15-20%. More reliable and reliable data on the loads of the lines leaving the distribution transformers of the supply feeders.

In this case, the measurement error is 5-10%. For supply lines and substations of consumers, it is possible to determine data on electricity consumption in a given period of time. From this it can be concluded that in 6-10 kV RS, the data of the head section specified in the form of electricity supply or current measurements carried out 1-2 times a year are used as operating information [24-27].

Electric networks of 0.4 kV (380 / 220V) are, as a rule, radial lines connecting 0.4 kV lines of 6-10 / 0.4 kV distribution transformers with input devices of consumers.

Electric networks of 0.4 kV are distinguished by a large number of switching switches and are practically not equipped with a measurement system. Therefore, the information received about the mode parameters is the least complete and reliable.

Today, for 0.4 kV networks, it is possible to determine only the maximum currents or electricity supply for the substation, selectively measure currents or determine the voltage losses in the lines outgoing from the transformer substation.

Based on the foregoing, it can be concluded that the volumes of measurement of operating parameters at substations of various voltage classes are different, and it is also incomplete both in terms of the description of the mode in time and in the number of measured parameters. Moreover, the quality and completeness of information decreases in medium and low voltage networks.

References

1. Barquın, J., Vitoriano, B., Centeno, E., and Fernandez-Menendez, F. (2009). An optimizationbased conjectured supply function equilibrium model for network constrained electricity markets. Journal of the Operational Research Society, 60(12):1719–1729.

2. Alikhanzadeh, A. and Irving, M. (2012). Combined oligopoly and oligopsony bilateral electricity market model using cv equilibria. In Power and Energy Society General Meeting, 2012 IEEE, pages 1–8. IEEE

3. Alizadeh, B. and Jadid, S. (2011). Reliability constrained coordination of generation and transmission expansion planning in power systems using mixed integer programming. Generation, Transmission & Distribution, IET, 5(9):948–960.

4. Arroyo, J. M., Alguacil, N., and Carrion, M. (2010). A risk-based approach for transmission network expansion planning under deliberate outages. Power Systems, IEEE Transactions on, 25(3):1759–1766.

5. F.A.Hoshimov, I.I.Bakhadirov, M.S.Kurbanbayeva, N.A.Aytbayev. Development of specific standards of energy consumption by types of produced products of the spinning product // RSES 2020. E3S Web of Conferences. 216 (2020) 01169. https://doi.org/10.1051/e3sconf/202021601169

6. F.A.Hoshimov, I.I.Bakhadirov, A.A.Alimov, M.T.Erejepov. Forecasting the electric consumption of objects using artificial neural networks // E3S Web of Conferences. 216 (2020) 01170. https://doi.org/10.1051/e3sconf/202021601170

7. I.U.Rakhmonov, F.A.Hoshimov. Development of an algorithm for evaluating the dominant factors that have the greatest impact on the energy intensity of products // ENERGY-21. E3S Web of Conferences. 209 (2020) 07018. https://doi.org/10.1051/e3sconf/202020907018

8. Usmanov E.G. Stability in a parallel resonant circuit with active load // RSES 2020. E3S Web of Conferences. 216 (2020) 01160. https://doi.org/10.1051/e3sconf/202021601160

9. I.U.Rakhmonov, K.M.Reymov and S.H.Dustova. Improvements in industrial energy rationing methods // MIP: Engineering-2020. E3S Web of Conferences. 862 (2020) 062070. doi:10.1088/1757-899X/862/6/062070

10. A.D. Taslimov, . S. Berdishev,. M. Rakhimov and A.A.Yuldashev. Optimal tendency of selecting cable cross-sections for agricultural electrical networks // ICMSIT-2020. Journal of Physics: Conference Series. 1515 (2020) 022056. doi:10.1088/1742-6596/1515/2/022056

11. Abduraxim Berdishev, Abdurakhim Taslimov, Bakhtiyor Melikuziev and Alibi Bijanov. Reliability indicators of 10 kV cable lines in rural areas // FORM-2020. IOP Conf. Series: Materials Science and Engineering. 869 (2020) 011001. doi:10.1088/1757-899X/869/1/011001

12. A.D.Taslimov. Selection of a complex of parameters of distribution electric networks with respect to technical limitations // ENERGY-21. E3S Web of Conferences. 209 (2020) 07013. https://doi.org/10.1051/e3sconf/202020907013

13. K.M.Reymov, G.R.Rafikova, L.A.Nematov, Sh.Esemuratova. Existing condition and prospects of making power balance and managing load of electric consumers in

uzbek power system // ENERGY-21. E3S Web of Conferences. 209 (2020) 07015. https://doi.org/10.1051/e3sconf/202020907015

14. Dmitriy Bystrov, Toirov Olimjon, Mustafakulova Gulzoda, Yakubova Dilfuza NISS2020: Proceedings of the 3rd International Conference on Networking, Information Systems & Security, 54, P.1-3 (2020), https://doi.org/10.1145/3386723.3387873

15. Olimjon Toirov, Kamoliddin Alimkhodjaev, Akhror Pardaboev Analysis and ways of reducing electricity losses in the electric power systems of industrial enterprises, E3S Web of Conferences, SUSE-2021 (2021)

16. Baratov B., Toshov J., Baynazov U. Method of calculating the gear ratios of the cones of tricone drill bits // E3S Web Conf., Volume 201, 01012, 2020, Ukrainian School of Mining Engineering - 2020. https://doi.org/10.1051/e3sconf/202020101012

17. K.M.Reymov, G.Turmanova, S.Makhmuthonov, B.Uzakov. Mathematical models and algorithms of optimal load management of electrical consumers // E3S Web of Conf. 216 (2020) 01166. https://doi.org/10.1051/e3sconf/202021601166

18. A.N.Rasulov, M.R.Ruzinazarov, N.Toirova, T.Sh.Alibekova. Graphical-analytical method for constructing load characteristics // RSES 2020. E3S Web of Conferences. 216 (2020) 01171. https://doi.org/10.1051/e3sconf/202021601171

19. Yu.Bobozhonov, B.Seytmuratov, B.Fayzullaev, A.Sultonov. Study of the influence of different designs of massive rotor of asynchronous generator on their maximum power // RSES 2020. E3S Web of Conferences. 216 (2020) 01177. https://doi.org/10.1051/e3sconf/202021601177

20. Taslimov A D, Rakhmonov I U 2019 Optimization of complex parameters of urban distribution electric networks Journal of Physics: Conference Series 1399 doi:10.1088/1742-6596/1399/5/055046

21. Rakhmonov I U, Tovbaev A N, Nematov L A and Alibekova T Sh 2020 Development of forecasted values of specific norms for the issues of produced products in industrial enterprises Journal of Physics: Conference Series 1515 doi:10.1088/1742-6596/1515/2/022050

22. Rakhmonov I U, Reymov K M, Najimova A M, Uzakov B T and Seytmuratov BT 2019 Analysis and calculation of optimum parameters of electric arc furnace Journal of Physics: Conference Series 1399 doi:10.1088/1742-6596/1399/5/055048

23. Toshniyozov L.G., Toshov J.B. Theoretical and experimental research into process of packing in drilling. MIAB. Mining Inf. Anal. Bull. 2019;(11):139-151. [In Russ]. DOI: 10.25018/0236-1493-2019-11-0-139-151.

24. I.U.Rakhmonov, K.M.Reymov. Statistical models of renewable energy intermittency // RSES 2020. E3S Web of Conferences. 216 (2020) 01167. https://doi.org/10.1051/e3sconf/202021601167

25. I.U.Rakhmonov, N.N.Kurbonov. Analysis of automated software for monitoring energy consumption and efficiency of industrial enterprises // E3S Web of Conferences. 216 (2020) 01178. https://doi.org/10.1051/e3sconf/202021601178

26. F.A.Hoshimov, I.U.Rakhmonov, N.N.Niyozov. Technology to reduce energy costs in the electric steel melting shop // ENERGY-21. E3S Web of Conferences. 209 (2020) 07017. https://doi.org/10.1051/e3sconf/202020907017

27. A.Taslimov, M.Melikuziev, O.Matchonov, M.Ruzinazarov and M.Nasirov. Development of standard cable cross-sections of rural electrical networks // CONMECHYDRO – 2020. IOP Conf. Series: Materials Science and Engineering. 883 (2020) 012105. doi:10.1088/1757-899X/883/1/012105

28. I.Bakhadirov, N.Markaev, G.Aslanova, R.Tanatarov, S.Makhmuthonov. Differentiated tariffs of electricity for the improvement of steelmaking Uzbekistan // CONMECHYDRO – 2020. IOP Conf. Series: Materials Science and Engineering. 883 (2020) 012121. doi:10.1088/1757-899X/883/1/012121