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Reliability Evaluation of Electrical Networks

The problems of the evaluation of reliability in electrical networks of the different class of voltage a have probabilistic nature, they discretely change and depend on the number of factors both definite and indefinite and have importance by selection of electric equipment, graph of development of electrical networks and voltage levels. The definition of the major factors, which have determining significance on their value and speed of their change allow to elaborate methods of their optimization and to elaborate effective methods of their growth limitation in electrical networks with the different class of voltage. The present work is devoted to problems of calculation and assessment of indicators of reliability of distribution systems and supply of electricity to consumers, both agricultural and industrial.

Keywords: reliability indicators, the reliability of electrical networks.

1. Introduction

At present the grade of complexity of electrical networks is in a continuous development. This is explained by the fact that due to socio-economic requirements of contemporary, there is a growing number of new consumers of electricity and this leads to the appearance of more power connections. This is welcome in socio-economic development of any country, but with it there are new requirements and issues related to ensuring network reliability, it increases significantly the complexity of structural schemes and equipment installed in electrical networks.

The unceasing increase in the number of component elements of network schemes increases the risk of failures and refusals to supply electricity to consumers. Ensuring reliability levels can only be achieved by knowing the behavior of influencing factors, that cause random refusals and condition economic losses.

Quite often in the equipment installed in electricity grids of different levels of tension, such as transformers, disconnectors, circuit breakers, etc., there are a large number of refusals, which determine the quality and security of electricity supply to consumers. Assessment of factors relevant to such refusals and estima-

tion of the level of their influence on the reliability of equipment and electrical networks allow the development of measures to ensure the continuity and quality of electricity supply to consumers.

This paper is devoted to assessing the quality of operation of the equipment installed in electrical networks for various tension levels, taking into account the influence of random factors, that cause refusals in operation.

2. Materials and methods of research

Research on the reliability and quality of electrical networks operation were performed under different levels of electrical networks tensions in Moldova. Object of researches have established refusals characteristics of examined networks, conditioned by various random factors of influence.

In order to conduct the assessment of the behavior of the factors of influence on the process of electricity supply to customers connected to the Republican power system were developed the structural scheme for calculating and the forecasting algorithm of the reliability level that gave the opportunity to highlight the factors of influence on the process of electricity supply and to systematize the sequence of operations performed in the assessment of the reliability of networks examined are presented in Table 1.

Table 1. Characteristics of the examined electrical network

No.	Voltage level, kV	summary length, km
1	0,4	39340
2	6-10	29430
3	35	2385
4	110	4070
5	330	530
6	400	214

The processing of characteristic information of conditioned refusals in the examined networks was carried out under a standard method of analysis and calculation using the following means: graph theory and matrices, probability theory, method of statistical analysis and processing of experimental data on refusals in electricity networks, reliability theory, the theory of linear and nonlinear equations, mathematical modeling, computers with specialized software in the statistical analysis.

3. Results and discussion

Using the criteria proposed for processing of experimental data on refusals in the examined networks, allowed the determination of frequencies of refusals caused by each random factor of influence. Based on the concept of general methodological approach on forecasting indicators that characterize the quality of operation of the equipment of electrical networks (transformers, disconnectors, etc.) were established the laws of occurrence of refusals, which allow to predict the behavior of factors influencing reliability of electrical networks.

Under this standard process the parameters of distributions of random disconnections caused by factors of influence were determined for the period of study. Table 2 shows the values of determined parameters, for example, for medium voltage networks (average number of interruptions per year, dispersion D, square standard deviation σ, coefficient of variation, minimum and maximum number of interruptions per year, the tuning fork , the marginal values of confidence intervals, coefficients of asymmetry and excess, type of distributions).

Examining the values of the parameters set it can be concluded that the nearest theoretical distribution of these events is the Gaussian distribution and the data we have allow us to estimate the marginal values of the expected deviations of the arithmetic mean in all the analyzed data, i.e. values limits of random interruptions specific for every year. The expected value of the arithmetic average of random disconnections for the power grid the length of which is 100 km is within $57.62 < Ndec. < 69.59$.

The values obtained indicate that in the republican networks the average intensity of random disconnections during the year exceed the amount of 57.62 disconnections per year per 100 km of network, but their number will not exceed an annual average of 69.59 random disconnects per 100 km of network. This forecast error is of about 5 %.

Given the fact that the distribution of these disconnection is close to the Gaussian and by experimental knowledge of the mean square deviation $\sigma = 11.61$, we can estimate the marginal values of the predicted number of random disconnections and of their parameters for electrical networks with different length. This is possible because we have shown that ensembles of data, which include the total number of random disconnection during the years 2006-2010 in different branches of the network belong to the same community of statistics data.

Depending on the probability of the admitted error $\alpha = 1\%$ or 5%, which corresponds to the confidence level $\alpha\ 1 = 99\%$ or 95% marginal values can be determined for the expected limit of random disconnections in the network at 100 km. Thus the expected value of the arithmetic average of random disconnections for the network length of 100 km is within $57.62 < Ndec. < 69.59$. Based on figures received and knowing the summary length of the power grids we can determine the expected values of random disconnections during a year in networks, e.g. Ndec. min = 8168 and Ndec.max = 9935 disconnection.

Table 2. Parameters of a annual distributions of disconnections in the examined networks

Year	Parameters of the distributions disconnections											
	Average number of inter.	D	σ	Coef. of variation	Min. number of inter.	Max. number of inter.	The tunning fork	The lower marginal	The upper marginal	Coef. of asymmetry	Coef. of excess	Theoretical distribution close
2006	65,18	52,56	7,25	0,11	55,20	74,17	18,97	58,55	71,80	-0,23	-0,15	Normal
2007	54,83	121,8	11,04	0,20	44,53	68,22	23,69	48,20	61,45	0,50	-1,35	Normal
2008	68,09	243,6	15,61	0,22	51,95	91,00	39,05	61,46	74,71	0,63	-0,13	Normal
2009	56,59	24,10	4,91	0,08	48,03	60,65	12,61	49,97	63,22	-1,76	1,87	Normal
2010	73,37	55,80	7,87	0,10	59,30	77,45	18,14	66,74	80,00	-1,92	1,94	Normal
Total	63,61	134,7	11,61	0,18	44,53	91,00	46,47	57,62	69,59	0,66	-0,31	Normal

The proposed criterion permits that in dependace of lines length to forecast the number of random disconnections during each year. Statistical credibility of the

forecast on marginal limits of variation of the number of predicted disconnections is 95 % and the forecast error does not exceed 5%.

On this concept the laws of distribution can be determined, and the parameters reported in the 100 km of network for all influencing factors. Parameters obtained will be used to forecast the intensity of reliability indicators, based on the individual characteristics of each network.

Table 3. Indicators of reliability of equipment of examined electrical networks

The network system	Monthly situation				Seasonal Situation			
	τ_j, h	λ_j	μ_j, h	Tmed, h	τ_j, h	λ_j	μ_j, h	Tmed, h
1	0,12	0,09	1,34	1,57	0,33	0,28	1,18	1,54
2	0,31	0,21	1,53	2,81	0,63	0,60	1,06	2,12
3	0,74	0,76	0,99	1,79	1,40	1,42	0,99	1,80
4	0,19	0,16	1,24	1,66	0,68	0,25	2,81	2,74
5	0,11	0,21	0,54	0,64	0,33	0,40	0,82	1,58
6	0,55	0,20	2,85	2,45	1,72	0,69	2,54	4,62

To assess the quality of functioning of electrical equipment installed in electrical networks were calculated the main indicators of reliability: the average duration of disconnections τ, the average frequency of disconnections λ, the average recovery disconnection μ, the average total disconnection Tmed. In Table 3 are presented as an example the average annual values of reliability indicators calculated for equipment installed in the electrical networks.

Based on statistical analysis of groups of some experimental data on disconnections of electricity networks were established the distributions main parameters that characterize all refusals in operation caused by different factors of influence, depending on the duration of interruptions and the number of consumers affected (total number of interruptions, the average duration of interruptions, the average number of consumers disconnected, standard deviation σ, coefficient of variation, minimum and maximum duration of interruptions, minimum and maximum number of disconnected consumers, tuning fork, marginal values range trustof the confidence interval, asymmetry and excess coefficients).

The calculated indicators make it possible to predict the reliability of 95% of all the main parameters characterizing the refusals conditioned by factors of influence and determine the reliability level of the equipment installed in the electrical network (transformers, disconnectors, circuit breakers, etc.).

The results obtained on the quality indicator values of operation was performed the forecast of reliability of networks studied, taking into account the fol-

lowing indicators: average duration of disconnections, the average frequency of disconnections, the average recovery of disconnections, the average total time of disconnection. Forecast results margin of error is 5% and their use allows a justified planning of technical and economical point of view, of all measures to ensure rated indicators of reliability of electric networks with different levels of tensions and of equipment installed in these networks.

4. Conclusion

The calculated values of the main indicators of reliability of electrical networks characterize the operation quality of equipment installed in the republican electrical network and indicates a significant deviation from normal values.

Knowing of these indicators enables to forecast the parameters of random refusals that determine the level of quality and safety of operation of electrical networks and provides the opportunity to plan justly from technical and economical point of view the necessary measures of prevention and reducing the operating costs.

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