ANALELE UNIVERSITĂŢII
"EFTIMIE MURGU" REŞIŢA
ANUL XXI, NR. 3, 2014, ISSN 1453 - 7397

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Determination of the Level of Influence of Various Factors on the Reliability of Power System

Consumers supply with qualitative electric power is one of the priority requirements imposed to power systems. Currently, in electricity networks take place a number of planned and unplanned disconnections, which interrupt the power and affect consumers, causing economic damage. To ensure the quality of power supply it is essential to know the factors that influence the reliability of power systems, which have a visible impact on the variation of reliability of equipment installed in power systems. This paper is devoted to problems of calculation and analysis of power systems reliability and estimation of the impact of various factors that influence the supply of consumers.

Keywords: electrical equipments, electrical distribution systems, indicators of reliability, causal factors of refusals

1. Introduction

Currently in power systems, there are a large number of disconnections caused by various factors of influence. Determining the factors of cause of these interruptions and estimation of the level of their influence on the reliability of the equipment installed in the power system allows developing measures to ensure continuity of qualitative supply to consumers.

Distributions in time of disconnections, the causes of appearance and their impact on the reliability of electricity supply to consumers have not been studied up to the present and are not known.

Reliability of electricity supply to consumers can be provided only on the basis of knowledge of the factors that have a noticeable impact on indicators of reliability, which allows justified planning of measures to ensure the level of confidence.

2. Materials and methods of research

To assess the level of influence of random factors on the reliability, the subject of the carried out investigations have established the characteristics of refusals in power systems caused by different factors.

When solving problems formulated for research were used: graph theory and matrices, probability theory, statistical analysis and processing methods of experimental data, the theory of linear and nonlinear equations, mathematical modeling, computing technology.

Highlighting the influence factors was made based on a concept of generalized methodological approach regarding the processing and flow classification of rejections which occurred in the networks examined. Under this process all interruptions were classified according to the geographical location of network and the causes of occurrence.

To estimate the impact of factors influencing reliability indicators was used the concept of weighting coefficient of influencing factors on the level of reliability and mathematical expressions were developed for the determination of these coefficients for each factor separately. For example, for any factor n, the weighting coefficient is determined by the expression:

$$k_{p_n} = \frac{\sum_{v=1}^{t} NC_{nv} \cdot T_{nv}}{\sum_{k=1}^{m} NC_{1k} \cdot T_{1k} + \sum_{l=1}^{p} NC_{2l} \cdot T_{2l} + \sum_{r=1}^{s} NC_{3r} + ... + \sum_{v=1}^{t} NC_{nv} \cdot T_{nv}} \cdot 100\,\%. \quad (1)$$

In this expression were noted:

NC_{1k} - The number of consumers affected by disruptions k, duration T_{1k}, caused by random factor of influence f_1 ;

NC_{2l} - The number of consumers affected by disruptions l, duration T_{1k}, caused by random factor of influence f_2;

NC_{3r} - The number of consumers affected by disruptions r, duration T_{3r}, caused by random factor of influence f_3 ;

NC_{nv} - The number of consumers affected by disruptions v, duration T_{nv}, caused by random factor of influence f_n .

3. Results and discussion

According to the proposed criterion to estimate the impact of factors influencing reliability in the first phase were obtained by calculating the values of reliability indicators that appreciate the quality of operation of power systems: the

average duration of refusals (τ) the average frequency of rejections (λ), the average restoration refusals (μ), the average total time of refusals (T_{med}). The results of the calculation of reliability indicators are shown in Table 1 .

Table 1. Values of reliability indicators for examined network sectors

The examined network sector	Indicator	Seasonal values				Anual
		Spring	Summer	Autumn	Winter	
1	τ, h	0,92	1,12	1,09	1,23	4,36
	λ	3,49	1,23	3,28	1,35	9,35
	μ, h	0,26	1,71	1,59	1,88	0,47
	T_{med}, h	3,81	3,54	3,58	3,88	3,70
2	τ, h	5,88	6,97	5,52	7,64	26,01
	λ	5,76	4,48	5,41	4,92	20,56
	μ, h	1,02	4,66	2,36	5,11	1,26
	T_{med}, h	5,95	6,29	5,59	6,89	6,18
3	τ, h	8,22	8,73	7,72	9,57	34,23
	λ	5,36	7,01	5,04	7,69	25,10
	μ, h	1,53	5,60	1,53	6,15	1,36
	T_{med}, h	7,28	8,04	6,84	8,82	7,75
4	τ, h	4,40	4,64	4,13	5,09	18,26
	λ	4,48	3,47	4,20	3,81	15,96
	μ, h	0,98	2,92	0,98	3,21	1,14
	T_{med}, h	4,01	6,95	3,77	7,62	5,58
5	τ, h	2,46	5,78	2,31	6,34	16,89
	λ	2,39	4,37	2,24	4,80	13,80
	μ, h	1,03	2,90	1,03	3,18	1,22
	T_{med}, h	4,87	4,29	4,57	4,70	4,61
Total	τ, h	3,99	7,03	3,74	7,71	22,47
	λ	3,64	3,67	3,42	4,02	14,75
	μ, h	1,09	4,22	1,09	4,63	1,52
	T_{med}, h	5,19	3,63	4,87	3,98	4,42

In accordance with the expressions obtained for the estimation of influence of these factors the weighting coefficients have been determined for the reliability indicator factors examined, the average annual values of which are shown in Table 2.

Table 2. The values of the weight coefficients of the factors of influence

Factors		Annual average values of weight coefficients					
		2008	2009	2010	2011	2012	Total
Nr	Description	$K_{p.med}$, %	$K_{p.med}$, %	$K_{p.med}$, %	$K_{p.med}$, %	$K_{p.med}$, %	$K_{p.med}$, %
1	Weathering	39,7	26,7	37,6	41,0	25,5	34,1
2	Defects in equipment	25,0	34,1	23,4	21,0	34,0	27,5
3	Unidentified factors	20,1	22,0	20,7	18,5	23,2	20,9
4	Vandalism	4,5	4,7	4,9	4,9	4,1	4,6
5	Defects in transport networks	3,1	4,3	4,6	4,7	3,7	4,0
6	PDC defects sites	1,7	1,4	2,7	2,9	2,1	2,1
7	Animal Action	1,2	1,7	1,2	2,3	2,0	1,6
8	Action of mechanisms	1,5	1,7	2,1	1,7	1,8	1,7
9	Damages caused by vegetation	1,5	1,6	1,1	1,5	1,8	1,5
10	Consumer Action	1,1	0,9	0,5	0,5	0,8	0,7
11	Electrical power quality	0,4	0,5	0,6	0,6	0,5	0,5
12	Operating errors	0,3	0,4	0,4	0,5	0,5	0,42

Looking at the average annual values of weight coefficients of the reliability for the 12 factors, it can be concluded that the most influential of them are: weather conditions, defects in equipment and unidentified factors.

It was established that in order to forecast the influence of random factors on the reliability of electric networks is absolutely necessary to determine the distribution laws for refusals caused by those factors and parameters of these distributions. According to those mentioned were considered experimental and theoretical distributions for the following indicators: frequency of rejections for each network system according to the season, the duration of refusals and the number of disconnected consumers.

At the second stage, according to the developed forecasting concept were considered experimental and theoretical distributions, and parameter values characterizing the weighting coefficients (Kp) on indicators of reliability for the 12 random factors of influence.

Parameters were examined The following parameters of distributions were examined: the average weight of indicators reliability, variance, standard deviation, coefficient of variation, minimum weight and maximum, tuning fork, the marginal values of the confidence interval, the coefficients of asymmetry and excess and type of theory function. The analysis made shows that the 12 factors of influence have a distribution of weights on indicators of reliability similar to the Normal - Gaussian for the investigated networks. The feature of influencing factors in order of their weight on indicators of reliability, indicate that the calculated weights have a flat and a slight annual variation.

The obtained results have given the opportunity to find that the factors examined determine the level of operating reliability of electrical networks and equipment installed in them and the results obtained regarding their forecasting, enable a justified planning of technical and economical insurance activities of continuity and quality of electricity supply to consumers in compliance with reliability rules.

4. Conclusion

Flow analysis of electric networks refusals of different levels of tension highlighted the factors that have a direct influence on the process of operating the equipment installed in these networks.

Mathematical expressions developed for estimating the impact of different factors influencing the reliability allowed to ascertain that the largest weight of reliability indicators have 3 factors: climatic conditions, defective equipment, unidentified factors.

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