ESTIMATION, COMPARISON AND RANKING OF OPERATIONAL RELIABILITY INDICATORS OF OVERHEAD TRANSMISSION LINES OF ELECTRIC POWER SYSTEMS

Farhadzadeh E.M., Muradaliyev A.Z., Abdullayeva S.A.

•

Azerbaijan Scientific-Research and Design-Prospecting Institute of Energetic
e-mail: elmeht@rambler.ru

Abstract

The regular increase in relative number of units of equipment, devices and installations (further - objects) electric power systems, which service life exceeds normative value and the consequences connected with this fact, including, including unacceptable ones, demand acceptance of drastic measures on increase of efficiency of their work. The main efforts today aimed at improving the methods of recognition and control of their technical condition. In other words, the problems of increasing the reliability of work and the safety of service brought to the fore quite justifiably. In the article, it is propos to carry out monitoring of the technical condition of overhead lines with a rated voltage of 110 kV and above monthly on the basis operational reliability parameters. New methods and algorithms for their estimation, comparison and ranking presented. As the operational reliability parameters are multidimensional, the existing methods for comparing and ranking one-dimensional statistical estimates for them are unacceptable, as the neglect preconditions of these methods conducts to essential growth of risk of the erroneous decision. The proposed new methods based on the fiducial approach, imitating modeling and the theory of statistical hypothesis testing. The cumbersomeness and laboriousness of manual calculation of operational reliability parameters, the science intensity of calculation methods is compensated by the transition to automated systems that provide information and methodological support with information about the technical condition of overhead lines. The recommended methods are included in the group of risk-focused approaches of increase the efficiency of the electric power systems.

Keywords. Operational reliability, overhead lines, estimation, comparison, ranking, classification, fiducial approach, risk of the erroneous decision.

I. Introduction

Increase of the efficiency of the electric network enterprises (further – ENE) is one of the most important problems of electric power systems. Formed and intensively developing in the energy economy a new scientific direction "Development of the asset management system for electric network companies." In our opinion, this direction is the most fully reflected in the concept [1], where it is noted: “the organization of the activities of the electric network companies in a competitive environment brings to the fore the economic criteria with *unconditional assurance of reliability”.*

In [2], at the same time, it is rightly noted: "the activity on the transmission of the electric power has monopoly character. Because of this, there is practically no motivation to increase the efficiency of work.".

And, at last, it is well known, that today the service life of more than 50% of ENE objects exceeds the normative value and there is no hope of decrease this value, or at least not exceeding it [3]. The relevance of the problem of reliability of objects, the service life of which exceeds the normative value is clearly confirmed by the materials of international conferences [4, 5]. It is necessary to consider:

– in opinion of leading experts, the efficiency of work today is determined not only by efficiency, but also reliability and safety [6];
– the consequences of failures in EPS are increasingly unacceptable and violate energy security;
– the social importance of increase in electricity tariffs determines the systematic support by the state of the electric power companies, with an increase in their operating costs;
– there is no opportunity, and necessity of mass replacement and modernization of objects, which service life, exceeds normative value.

And if all this is taken into account, today the major problem EPS is *increase of reliability and safety of objects, which service life exceeds normative value.* The methodical approach of authors to the decision of this problem based on some assumptions, allowing using the approaches accepted in others, completely, different systems. First of all, it is offered to agree with a known postulate according to which «*the person creates objects similar to himself*». This opinion allows using the approaches used for increase of vital functions of the specialist of a pension age. The main thing here is the increase in intensity of the control of a state of health. For electric power objects this sounds as « increase in intensity of the control of a technical condition» (further - the TC). And this is well known to us on the recommendation of transition from scheduled precautionary repair to repair on the TC [7], detailed explanations of expediency of the account of the TC [8, 9, 10] and increases of intensity of the control. An analogue of the operational control of the TC is the monthly preparation of the form of 3-tech (energy) [11], which characterizes the TC of power units of thermal power stations.

However, the opportunity does not always exist. An illustrative example of such an object is overhead transmission lines (further - OHL) with a rated voltage of 110 kV and above. By development of methods and algorithms of an estimation of parameters of operative reliability and safety in the illustrative purposes these will be used OHL.

II. Methodical Features Of An Estimation Of Parameters Of Operative Reliability OHL

Formulas of an estimation of parameters of reliability OHL well known and are used for the analysis of the reasons of occurrence of emergency switching-off. Increase of a faultlessness of recommendations is reached by using of statistical data for a number of years of supervision. Reference books and technical literature provide estimates of specific damageability, average downtime in emergency and planned (capital) repairs. Estimations are average, as a rule, on a class of a voltage, occasionally - for the reasons of refusal or a material of support. Specific damageability is led OHL in the extent of 100 km.

In other words, classification of statistical data is spent traditionally on one, a maximum three attributes. The algorithm of use of these estimations, on the recommendation of M.N. Rozanov (1984) consists in the following: «it is necessary to calculate failure of refusals for of some years of operation, to construct a graph and extrapolate frequency of refusals approximately for five years forward. The resulting failure refusals should be used in estimation the reliability of newly constructed objects". In table 1 according to Guk Y.V. (1974) intervals of change of estimations of specific number of damages OHL.

Table 1. Intervals of change of estimations of specific number of damage OHL.

Voltage, kV	Specific number of damages, on 100 km/years	
	Stable	Unstable
100; 154	0,5-1,7	5-7
220	0,25-1,5	1-2
330	0,15-1,6	0,5-1,5
500	0,2-1,1	0,15-2,5

These data are interesting in that the intervals of change in the specific number of damages crossed. This testifies to the inexpediency of their classification on the basis of "voltage class". The above-stated allows to conclude, that existing methods of an estimation of parameters of reliability OHL are unacceptable for an estimation of parameters of operative reliability.

In table 2 recommended main parameters of the operative reliability OHL and formulas for their calculation.

Table 2. Recommended parameters of operative reliability OHL.

Name of a parameter	Symbol	Unit of measure	Formula of an estimation
Parameter of a stream of refusals	λ_i^*	open/km.month	$\left[\sum_{i=1}^{N_i} n_{\Sigma,i,j}\right] \Big/ b_L \sum_{j=1}^{N_i} L_j$
Parameter of a stream of stable refusals	ω_i^*	open/km.month	$\left[\sum_{i=1}^{N_i} n_{y,i,j}\right] \Big/ b_L \sum_{j=1}^{N_i} L_j$
Average monthly probability of stable refusal	$R_{y,i}^*$	relative unit	$\frac{\omega_i^*}{\lambda_i^*}$
Average monthly duration downtime in emergency repair	$M_i^*(\tau_a)$	hour/month	$\left[\sum_{j=1}^{n_{y,i}} \tau_{e,i,j}\right] \Big/ n_{st,i}$
Average monthly coefficient downtime in emergency repair	$K_{\Pi,i}^*$	relative unit	$K_{P,i}^* = \frac{M_i^*(\tau_a)\cdot\omega_i^*}{T_i}$

The note: N_i ---number of working OHL in i-th month; $n_{\Sigma,i,j}$ - number of refusals of j-th OHL in i-th month; L_j - length of j-th OHL; $n_{st,i,j}$ - number of stable refusals of j-th OHL in i-th month; $\tau_{e,i,j}$ - duration of downtime in emergency repair of j-th OHL in i-th month; b_L - coefficient characterizing the length of a conditional line (L_y). It is calculated as $b_L=1/L_y$.

III. Methodical features of comparison of estimations of parameters of operative reliability OHL.

As noted above, "mechanical" comparison of estimates of parameters of operative reliability is associated with a high risk of erroneous decisions and caused by casual character of compared estimations. The relevance of the following operational problem is doubtless: *estimation of a degree of influence on reliability OHL EPS of performance of preliminary made decision concerning reorganization of operation, change of system of maintenance service and repair (further - STMR). This* estimation is spent by comparing the parameters of operative reliability before and after these changes.

Is no less actual the task: *the control of a infallibility of observed* regularity *of change of parameters of operative reliability over time with the purpose of use of this law for forecasting reliability*. The accounting of casual character of statistical indicators can be spent on the basis of the verification theory of statistical hypotheses. But, since the main task of the risk-focused approaches is decrease the risk of an erroneous decision, it is unacceptable to neglect the requirements, in accordance with which:

– the law of distribution of random variables must be known;
– application of criteria for testing statistical hypotheses calculated for one-dimensional random variables to multidimensional, ones sharply increases the risk of erroneous decisions.

Considered at the analysis of reliability OHL random variables far do not always correspond to the normal law, and estimations of parameters of operative reliability are multidimensional.

Overcoming of these difficulties is reached by application a fiducial approach, imitating modeling and the principles of the theory of testing statistical hypotheses [12]. With a high degree of accuracy, modeling algorithms for of some parameters of operative reliability can be replaced developed express method based on the approximation of fiducial distributions of some nonlinear function [13].

Unlike formulas for an estimation of parameters of operative reliability OHL, algorithms of comparison of the average monthly estimations of parameters of operative reliability are identical. Let's designate an estimation (*) the generalized parameter (P) operative reliability as P^*. The algorithm of comparison of the average monthly estimation P^* in i-th month P_i^* with the average monthly estimation in preceded (i-1) month P_{i-1}^* as follows:

If $P_{i-1}^* \le P_i^*$, otherwise →

and $\left|L_{st,(i-1)}\right| \le \left|L_{st,i}\right|$ otherwise →
and $P_i^* > \overline{P^{**}_{(i-1)}}$, that $H \Rightarrow H_2$
otherwise $H \Rightarrow H_0$
and $P_{i-1}^* < \underline{P^{**}_i}$, that $H \Rightarrow H_1$
otherwise $H \Rightarrow H_0$

and $\left|L_{st,(i-1)}\right| \le \left|L_{st,i}\right|$ otherwise →
and $P_i^* \ge \underline{P^{**}_{(i-1)}}$, that $H \Rightarrow H_2$
otherwise $H \Rightarrow H_0$
and $P_{i-1}^* > \overline{P^{**}_i}$, that $H \Rightarrow H_2$
otherwise $H \Rightarrow H_0$ (1)

For illustrative purposes, formulas for calculating the boundary values of the fiducial interval of estimations $K^*_{P,(i-1)}$ and $K^*_{P,i}$ given in table 3.

Table 3. Formulas for estimating the boundary values of the fiducial interval: conditional downtime coefficients in emergency repair of OHL of EPS for (i-1) and i- th months of the year

Indicator	Evaluation formulas	Note
$\underline{\underline{K^{**}_{P,(i-1)}}}$	$K^*_{P,(i-1)} \cdot \left(1 - A_\alpha \big/ \sqrt{J_{(i-1)}}\right)$	$J_{(i-1)} = b_L \sum_{j=1}^{N_{(i-1)}} L_j$
$\overline{\overline{K^{**}_{P,(i-1)}}}$	$K^*_{P,(i-1)} \cdot \left(1 + A_\beta \big/ \sqrt{J_{(i-1)}}\right)$	
$\underline{\underline{K^{**}_{P,i}}}$	$K^*_{P,i} \cdot \left(1 - A_\alpha \big/ \sqrt{J_i}\right)$	$J_i = b_L \sum_{j=1}^{N_i} L_j$
$\overline{\overline{K^{**}_{P,i}}}$	$K^*_{P,i} \cdot \left(1 + A_{(1-\beta)} \big/ \sqrt{J_i}\right)$	

IV. Methodical Features Of Ranging Of Estimations Of Parameters Of Operative Reliability OHL ENE ESP.

The analysis of change of operative reliability OHL ESP is of course important, at least from the point of view of an estimation of influence on reliability of work carried out to improve the operation, STMR OHL. Clearly, that all these actions are spent in certain ENE and on certain OHL. Recognition of this OHL ENE carried out based on operating experience, intuitively, and often subjectively. This approach is not accidental. Simply there is no "help", allowing to reveal these «weak parts» and to lower risk of the erroneous decision. Below is a method and algorithm for solving this problem.

In the section discusses the varieties of the attribute by which it is expedient to spend ranging for revealing ENE, TC OHL, which demands intervention. To range them, i.e. to place in order of decreasing operational reliability, also does not represent special work. Difficulty consists that all these estimations of parameters of operative reliability OHL ENE have random character. This take place because of random character of their refusals. In other words, the observed difference of estimations, as well as their difference from parameters of operative reliability OHL EPS, can be casual, and classification itself is useless. We have met this fact at the analysis of specific number OHL of various voltage classes (see table 1).

But before to consider an opportunity of overcoming noted above difficulty, it is necessary to have in view of, that:

– the recommended method and algorithm do not depend on type of a parameter of operative reliability. Therefore we shall keep sense of estimations $P^{*}_{\Sigma,j}$, $\underline{P}^{**}_{\Sigma,j}$, $\overline{P}^{**}_{\Sigma,j}$, $P^{*}_{\nu,i,j}$, $\underline{P}^{**}_{i,j}$, $\overline{P}^{**}_{i,j}$. We take into account, that j - a ordinal number of month, j=1,12, i - a ordinal number of the varieties ν-th of the attribute, $i=1,m_{\nu}$; ν - a serial number of an attribute, $\nu=1,m_{a}$; m_a - number of consideration attributes;

– boundary values of the fiducial interval randomly differ from each other with a significance level of 2α. In other words, random character of a divergence of parameters of operative reliability OHL EPS and of some ENE yet does not mean random character of a divergence of all parameters of operative reliability OHL of these ENE.

The recommended method and algorithm of ranging of estimations of parameters of operative reliability OHL ENE EPS reduced to following sequence of calculations.

– the estimations $P^{*}_{\nu,i,j}$ located in ascending order are compared with $\underline{P}^{**}_{\Sigma,j}$. Are allocated in the first group of an estimation $P^{*}_{\nu,i,j}$ not exceeding $\underline{P}^{**}_{\Sigma,j}$, as estimations not casually differing from the estimation $P^{*}_{\Sigma,j}$;

– the remained estimations $P^{*}_{\nu,i,j}$ are compared with $\overline{P}^{**}_{\Sigma,j}$. The estimations $P^{*}_{\nu,i,j}$, not exceeding $\overline{P}^{**}_{\Sigma,j}$ are allocated the second group and characterized as an estimation casually differing from the estimation $P^{*}_{\Sigma,j}$;

– the part of estimations $P^{*}_{\nu,i,j}$ which exceeds $\overline{P}^{**}_{\Sigma,j}$ belongs to the third group. A rating of the first group (r1) ENE is agreed to estimate as "good", the second groups (r2) ENE - as "satisfactory", and the third group (r3) ENE - as "unsatisfactory".

Objective ranging of operative reliability OHL ENE involves overcoming another difficulty - presence of many parameters. This difficulty overcomes by transition to an integrated parameter. The recommended methodology for calculating the integral parameter was uses at the analysis of operative reliability of power units of thermal power stations [14].

The essence of recommendations is reduced:

– to the transition from the estimation of a parameter of operative reliability to the estimation of its probability on statistical function of distribution $F^*(P^*_{v,i,j})$. The value $F^*(P^*_{v,i,j})$ characterizes size of "wear" and is defined under the formula $Iz^*(P^*_{v,i,j}) = i_\nu / m^2_{in}$, where i - a ordinal number of ν -th parameter ENE in ranging data series for j-th month; ν=1,m_{in}, m_{in} - number of indicators of operative reliability;

– to calculation of an integrated parameter of operative reliability under the formula

$$In^*(Iz) = M^*\left[Iz^*(P_{i,j})\right] = \sum_{\nu=1}^{m_\nu} i_\nu \Big/ m^2_{in} \tag{2}$$

Not less significant it is necessary to consider a problem of an estimation of a degree of increase of operative reliability as a result of prospective change in STMR OHL ENE.

Let's consider methodology of the decision of this problem using the example of average duration of downtime in emergency repair $M^*_\Sigma(\tau_e)$. Suppose, that according on statistical data for j-th month of work it established, that:

– a monthly average estimation $M^*_{\Sigma,j}(\tau_{e,j}) = \sum_{i=1}^{n_\Sigma} \tau_{e,i,j} \Big/ n_\Sigma$, where n_Σ - frequency of downtime in emergency repair;

– as a result of classification of statistical data OHL on ENE, their rangings in order of decreasing in operative reliability and an estimation of character of a divergence with $M^*_{\Sigma,j}(\tau_{e,j})$, it is established, that monthly average estimations $M^*_{\nu,j}(\tau_{e,i})$ of each of three groups ESP are accordingly equal:

$$M^*_{г1,j}(\tau_{e,j}) = \sum_{i=1}^{n_{г1}} \tau_{e,i,j} \Big/ n_{г1};$$

$$M^*_{г2,j}(\tau_{e,j}) = M^*_{\Sigma,j}(\tau_{e,j}) = \sum_{i=1}^{n_{г2}} \tau_{e,i,j} \Big/ n_{г2};$$

$$M^*_{г3,j}(\tau_{e,j}) = \sum_{i=1}^{n_{г3}} \tau_{e,i,j} \Big/ n_{г3}$$

where $n_{г1}$, $n_{г2}$, $n_{г3}$ - accordingly number of realizations of duration of emergency downtime in first, second and third groups ESP

Since in the third group are placed ENE, monthly average duration of downtime time in emergency repair in which nonrandom exceeds $M^*_{\Sigma,j}(\tau_{e,j})$, that, naturally, it is necessary to provide, first of all, restoration of wear OHL ENE of the third group. Obviously, as a result of restoration of wear, monthly average value $M^*_{г3,j}(\tau_{e,j})$ will randomly differ from the OHL ENE of the first group. At the same time, thus decrease in duration of downtime in emergency repair ENE of the third group will be equal:

$$\Delta\sum_{i=1}^{n_{г3}} \tau_{e,i,j} = \sum_{i=1}^{n_{г3}} \tau_{e,i,j} - M^*_{г1,j}(\tau_{e,j}) n_{г3,j} \tag{3}$$

And the relative size of this decrease is equal:

$$\delta M^*_{\Sigma,j}(\tau_{e,j}) = \frac{n_{г3,j}\left[M^*_{г3,j}(\tau_{e,j}) - M^*_{г1,j}(\tau_{e,j})\right]}{n_{\Sigma,j} \cdot M^*_{\Sigma,j}(\tau_{e,j})} \tag{4}$$

By analogy, formulas can be received of an estimation of relative value of change of operative reliability OHL EPS and for other parameters. Results of these transformations are shown in table 4.

Table 4. Formulas of an estimation of possible change of operative reliability OHL EPS as a result of restoration of wear

Parameter	Formulas for calculating a possible increase in operational reliability
$\delta\lambda^*_{\Sigma,j}$	$\left[b_L(\lambda^*_{r3,j}-\lambda^*_{r1,j})\sum_{i=1}^{N_{r3,j}}L_i\right] \Big/ b_L\lambda^*_{\Sigma,j}\sum_{i=1}^{N_\Sigma}L_i$
$\delta\omega^*_{\Sigma,j}$	$\left[b_L(\omega^*_{r3,j}-\omega^*_{r1,j})\sum_{i=1}^{N_{r3,j}}L_i\right] \Big/ b_L\omega^*_{\Sigma,j}\sum_{i=1}^{N_\Sigma}L_i$
$\delta M^*_{\Sigma,j}(\tau_{a,j})$	$\dfrac{n_{r3,j}\left[M^*_{r3,j}(\tau_{a,j})-M^*_{r1,j}(\tau_{a,j})\right]}{n_{\Sigma,j}M^*_{\Sigma,j}(\tau_{a,j})}$
$\delta K^*_{\Pi,\Sigma,j}$	$\dfrac{\omega_{r3,j}\left[M^*_{r3,j}(\tau_{a,j})-M^*_{r1,j}(\tau_{a,j})\right]}{\omega_{\Sigma,j}M^*_{\Sigma,j}(\tau_{a,j})}$
$\delta R^*_{\Sigma,j}$	$\dfrac{n_{r3,j}\left[R^*_{r3,j}-R^*_{r1,j}\right]}{n_{\Sigma,j}R^*_{\Sigma,j}}$

V. Methodical Features Of Benchmarking Of Operative Reliability ENE EPS.

Benchmarking of ENE EPS belongs to the category internal ones. Remind, that internal benchmarking [15]:

- it is a kind of the comparative analysis;
- its essence consists in revealing most and the least effective same type objects;
- it is least costly a kind of research;
- its main task - to reveal objects, which increase in the efficiency of which to the greatest extent increases the efficiency of the system as a whole;
- owing to the simplicity, is the best way of decrease in risk of the erroneous decision;
- the greatest effect takes place only at the regular comparative analysis. A single use only leads to temporary success.

The comparative analysis of operative reliability of set OHL ENE EPS allows to correctly solve many operational problems at level EPS. But it is absolutely insufficient for ENE themselves. And indeed. Certainly, it is important to management ENE to know, how they govern ENE differs from others ENE EPS; as reliability of work OHL in billing month has changed; how effective were the new approaches to the recognition of hazardous defects. But, first of all, ENE leader must know exactly, where to direct efforts for increase of rating ENE.

As noted above, "mechanical" classification OHL ENE is connected with high risk of the erroneous decision. For revealing of "weak parts», that reduce the ENE rating, it is necessary:

- For each ENE, whose TC rating is assessed as unsatisfactory:
  - to classify OHL and statistical data about their idle time in emergency repair on each of n_P-1 the signs attributes (except for an attribute name ENE) and to its varieties. Preliminary with the continuous character of change of varieties of attributes, they are transformed in discrete;
  - for each varieties of an attribute the estimation of a parameter of operative reliability $P^*_{\nu,i,j}$ is calculated;

* the maximal value of estimations $P^*_{\nu,i,j}$ is defined, with ν=1,m_i, where m_i - number of varieties i-th an attribute $P^*_{max,i,j} = \max\left\{P^*_{1,i,j},.......,P^*_{m_i,i,j}\right\}$. Obvious, that is the most significant varieties of the i-th attribute;
* the most significant attribute is defined;

$$P^*_{max,j} = \max\left\{P^*_{max,1,i,j}; P^*_{max,2,i,j};.....;P^*_{m_i,n_п,j}\right\}$$

– Attributes are defined, estimations of parameters operative reliability of which exceed the estimation $P^*_{г3,j}$;

– On these attributes classification OHL and statistical data about their downtime in emergency repair is carried out, according to which the estimation $P^*_{max,j}$ is spent calculated;

– Further calculations are carried out similarly to the above. Calculations completed by consideration of all possible and expedient classifications and all ENE with a unsatisfactory rating.

As a result of the calculations, for each ENE with a unsatisfactory rating are determined set of OHL, that determine this rating. This list recommended for restoration TC OHL.

Vi. Formation Of Information And Methodical Support For Management ENE And EPS.

By increase of reliability the risk-focused of the approach naturally is increase science intensity, cumbersomeness and laboriousness of manual calculation. Check of reliability is carried out by a method of the decision of "a return problem» when recommendations are trivial. Efforts are required only for preparation in the tabulated in form of monthly data on automatic emergency switching-off OHL. In day of input of the information Chief engineers EPS and ENE receive the specialized forms containing information on operative reliability, accordingly, OHL EPS and ENE and the recommendation on increase of an work efficiency [16].

For illustrative purposes, fig. 1 shows the form of information about the monthly average operative reliability OHL EPS. It is necessary to note, that the content of this form depends as on time of use of opportunities of the automated monitoring system of operative reliability OHL, and on the "interest" of the ENE and EPS managers.

Date of the analysis
05 may 2021 год

Chief engineer EPS
____

Data
about operative reliability OHL in April 2021

1. Monthly average value of a parameter of operative reliability is estimated as ***satisfactory****;*
2. In comparison with ***March*** *operative reliability has decreased on* ***15,3%;***
3. In the table And are resulted located by way of decreasing of operative reliability ENE EPS.
Table A. ENE EPS operational reliability details

Name ENE	*Integrated parameter of wear, r.u.*	*Relative change over time, %*	*Rating ENE*
ENE 5	*0,053*	*5,7*	*good*
ENE 7	*0,12*	*10,2*	*satisfactory*
ENE 2	*0,23*	*25,6*	*satisfactory*

4. Recommendations on increase of operative reliability.
4.1. In ENE, the rating of operative reliability OHL which is unsatisfactory, to lead selective survey OHL (see Table B)
Table B. List of OHLs subject to examination

Name	
ENE	Overhead transmission lines
ENE 2	*B 26*
	B 8
ENE 9	*B 36*
	B 49

4.2. On specified in table B OHL to lead diagnostics of a technical condition using modern methods of the analysis.
4.3. To organize for personnel ENE with unsatisfactory technical condition OHL short-term courses of improvement of qualification.

Fig. 1. The form of data on operative reliability OHL EPS.

Conclusion

1. Set of parameters of operative reliability and the formula of their estimation is proposed;
2. The new algorithm of an estimation of expediency of classification of multivariate data about refusals and duration of downtime OHL is developed. At each stage of classification total OHL is represented by three groups. The first group includes OHL, an estimation of a indicator of which operative reliability is not casual less estimations of a similar indicator for total OHL. The second group includes OHL, the estimation of a indicator of which operative reliability casually differs from a similar indicator for total OHL. The third group includes OHL, an estimation of a indicator of which operative reliability is not casual more estimations of a similar indicator for total OHL;
3. Methods and algorithms for comparing of two multivariate estimations of parameters of operative reliability OHL are developed, allowing to estimate character of change of reliability of these OHL in time;
4. Methods and algorithms of ranging of parameters of operative reliability OHL the electric network enterprises are developed, allowing to identify OHL, that demanding operational inspection;
5. Methods and algorithms of calculation of an estimation of an integrated parameter of operative reliability are developed;
6. Monthly information and methodical support of a technical management of the electric network enterprises and an electric power system is provided. Methodical support includes recommendations on increase of reliability OHL.

References

[1] Volkova I.O. Concept of construction of a control system by actives of the electric network companies in Russia on the basis on benchmarking. Economy and management of a power complex. Scientific and technical statements. SPbSPU №2, 2008, p.101-105;

[2] Karpov N.V. Strategy for managing the production of industrial actives of the electric network company. The bulletin of Omsk University Series "Economics", 2019, v.17, №2. ***DOI 10.25513/1812-3988.2019 s112-123****;*

[3] Grabchak E.P. Estimation of a technical condition of the power equipment in conditions of digital economy // Reliability and safety in power. 2017, v10, №4, p.268-274;

[4] V Scientifically Practical Conference «Control of a technical condition of the equipment of objects of electric power industry» / Electricity. Transmission and distribution - 2018;

[5] VI Scientifically Practical Conference «Control of a technical condition of the equipment of objects of electric power industry // Electricity. Transmission and distribution -2019;

[6] Danilov G.A. Improving the quality of functioning of overhead transmission lines. Monograph. Danilov G.A., Denchik Yu.N., Ivanov N.N., Sitnikov G.V. 3rd ed. M.- Berlin: Direct-Media, 2019, 558 p.;

[7] STO-34.01-24-003-2017. UNEG Production Assets Management System, 2017. Federal Network Company;

[8] STO-34.01-23.1-001-2017. Volume and rate of test of an electric equipment;

[9] STO-34-01-24-002-2018. The organization of maintenance service and repair of objects of electric power industry of the UNEG, 2018, FNC;

[10] STO-34.01-35-001-2020 Methodical instructions on carrying out of technical survey of the equipment of substations, overhead transmission lines. "Rosseti", 2020, 20 p.;

[11] RD 34.09.453 Typical algorithm of calculation the technical and economic indicators of powerful heating thermal power stations SPO "Soyuztekhenergo": Updated 01.01.2021;

[12] Farhadzadeh E.M., Muradalyiev A.Z., Abdullayeva S.A. Fidutsial the approach at comparison of the same objects. Kiev. Electronic modelling №1, 2019, p.55-66, ***DOI: 10.15407/emodel.42.01.013***;

[13] Farhadzadeh E.M., Muradaliyev A.Z., Dzhalagova E.I., Abdullayeva S.A. Method and algorithm of comparing the efficiency of gas piston power plants of electric power systems M: Izv. RAS "Energetika" No 2, 2019, p.106-17. **DOI: 10.1134/S0002331019020067;**

[14] Farhadzadeh E.M., Muradaliyev A.Z., Farzaliyev Yu.Z., Abdullayeva S.A. Comparison and ranging steam turbine installations of power units TES by operating efficiency. Heat power engineering, 2018, No. 10, p. 41-49. **DOI: 10.1134/S0040363618100028**;

[15] Cane M.M., Ivanov B.V., etc. Systems, methods and their tools of a quality management. 2nd ed. Id. "Peter", 2017, p. 576.

[16] Farhadzadeh E.M., Muradaliyev A.Z., Rafiyeva T.K., Rustamova A.A. Ensuring of reliability of methodical support of objects of electric power systems. M:, Electricity, No.2, 2020, p. 4-9. **DOI: 10.24160/0013-5380-2020-2-4-9**