DEVELOPMENT OF A METHOD FOR A COMPREHENSIVE STUDY OF THE EFFICIENCY OF THE POWER SUPPLY SYSTEM OF INDUSTRIAL ENTERPRISES

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ABSTRACT:

A method has been developed for a comprehensive assessment of the efficiency of the functioning of the power supply system of industrial enterprises based on the method of normalizing indicators. The structural scheme for calculating the coefficients characterizing the energy efficiency of the power supply system of industrial enterprises has been determined. The developed method makes it possible to study in detail the possibilities of the power supply system of industrial enterprises and identify additional resources for energy saving.

Keywords: energy efficiency, power quality, generalized index, correlation analysis, index normalization method, power supply system reliability, power supply system efficiency.

INTRODUCTION:

To comprehensively and objectively evaluate the energy efficiency of industrial enterprises around the world, research is being conducted to create express analytical methods that can summarize energy efficiency indicators into a single indicator and, on this basis, more accurately determine the energy savings in production. In this direction, the priority is given to research, including the integration of efficiency indicators into a dimensionless unit and the rational development of the order of their sequence according to the level of importance. At the same time, one of the actual tasks is to determine additional possibilities of energy saving based on a complex analysis of power consumption at industrial enterprises [1,2].

The generalized power efficiency factor consists of three indicators: energy coefficient; power quality coefficient; power redundancy coefficient of the power supply system. The power supply system's efficiency coefficient consists of two indicators: the coefficient of automation and the coefficient of information security. The economic efficiency of the power supply system is determined by the coefficient of capital efficiency.

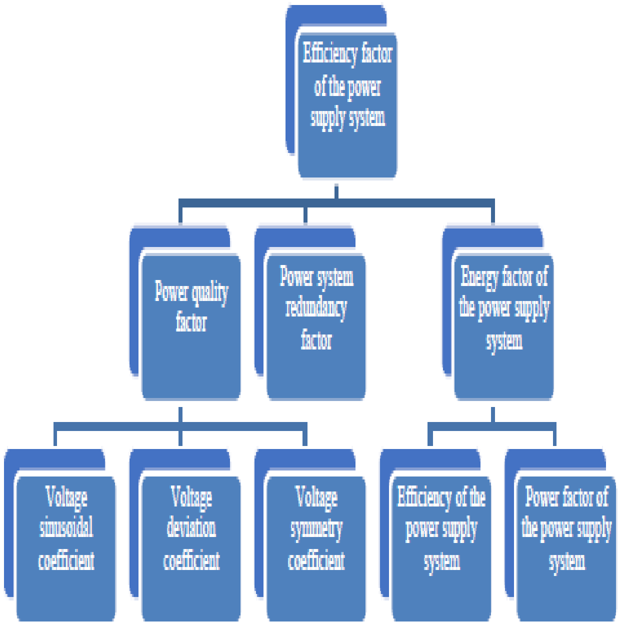

Fig.1. Efficiency coefficient of the power part of the enterprise power grid

The generalized coefficient of efficiency of the power supply system is determined by summing the coefficients of the power part and the control part of the power supply system according to the following formula:

$$K_{mex} = \sum_{n=1}^{n} \alpha_i \cdot K_i , \qquad (1)$$

where Ki is the efficiency coefficient n of the power supply system capabilities, characterizing its efficiency; αi- the weighting coefficient of the power supply system capabilities; i- the number of the place occupied by the efficiency coefficient in the overall rating [3,4].

Let's conduct a comparative correlation analysis of the indicators with each other and calculate the correlation coefficient to determine the degree of mutual influence of the indicators on the coefficient of efficiency of the power supply system of the enterprise [5,6].

Table 1 Daily power consumption by LLC EVROSNAR

measuring period	К(en)	К(qua)	К(red)	К(epss)
8	0,8	0,93	0,93	0,96
9	0,8	0,92	0,97	0,96
10	0,84	0,93	0,98	0,97
11	0,84	0,94	0,96	0,97
12	0,79	0,92	0,97	0,95
13	0,79	0,92	0,98	0,95
14	0,8	0,93	0,97	0,96
15	0,79	0,9	0,95	0,95
16	0,8	0,93	0,98	0,96
17	0,79	0,92	0,95	0,95
18	0,8	0,93	0,97	0,96
19	0,8	0,93	0,96	0,96
20	0,8	0,93	0,97	0,96
21	0,8	0,93	0,96	0,96

Where, К(en)-energy coefficient, К(qua)-coefficient of quality of power supply system, К(red)- regulation (automation) coefficient, К(efficiency of PSS)- efficiency of the power supply system

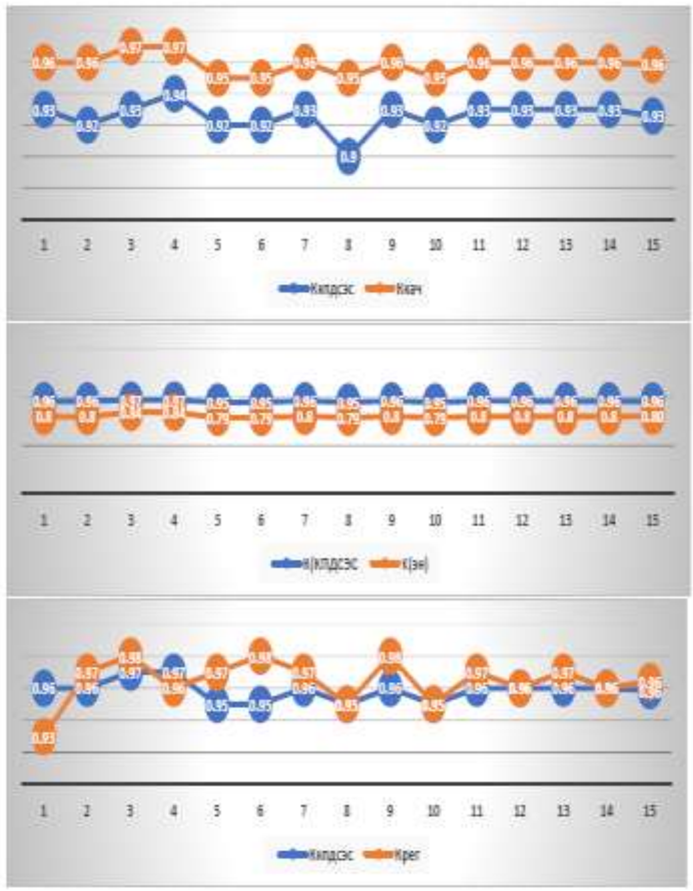

Fig.2. Correlation plot of the studied pairs

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Let's calculate the correlation coefficient for the compared pairs:
Ken-Kepss, the correlation coefficient - 0.89.
Kqua- Kepss, the correlation coefficient - 0.76.
Kred- Kepss,the correlation coefficient - 0,15.

As can be seen from the calculations, the most interrelated indicators are the energy coefficient and the coefficient of efficiency of the SES, followed by the quality coefficient and the coefficient of regulation[7,8].

Based on the correlation analysis of the indicators, the ranking order is compiled. The weighting coefficients were calculated by the Fishburn formula.

$$\alpha_i = \frac{2(n-i+1)}{n(n+1)}; \sum_{i=1}^{n} \alpha_i = 1; i = 1, n \quad (2)$$

where: α- weighting coefficient for the ith indicator; i- number of performance coefficient place, n- total number of indicators.

Let us determine analytically the expression of the generalized indicator:

$$K_{эф.сэс} = \sum_{n=1}^{6} \alpha_i (K_n) = \alpha_i (K_{с.ч.} + K_{эф.ф} + K_{эк)}) = \left(\frac{6}{21} \cdot K_{эн} + \frac{5}{21} \cdot K_{кач} + \frac{4}{21} \cdot K_{рез}\right) + \left(\frac{3}{21} \cdot K_{ав} + \frac{2}{21} \cdot K_{ио}\right) + \frac{1}{21} \cdot K_{эф} \quad (3)$$

where: $К_{эн}$ - Coefficient of energy, which characterizes the efficiency of electricity transmission; $К_{кач}$- Coefficient of quality, which characterizes the efficiency of the power supply system to ensure the quality of electricity; $К_{над}$- Coefficient of power supply system redundancy, which characterizes the uninterrupted operation of the power supply system; $К_{авт}$- coefficient of power supply system automation, which characterizes the level of power supply system automation; $К_{уч}$--coefficient characterizing the level of information security

To comprehensively and objectively evaluate the energy efficiency of industrial enterprises around the world, research is being conducted to create express analytical methods that can summarize energy efficiency indicators into a single indicator and on this basis more accurately determine the energy savings in production. In this direction, the priority is given to research, including the integration of efficiency indicators into a dimensionless unit and the rational development of the order of their sequence according to the level of importance. At the same time, one of the actual tasks is to determine additional possibilities of energy saving based on a complex analysis of power consumption at industrial enterprises.

Analyzing the degree of influence of indicators characterizing modes of electricity consumption and efficiency of the power supply system of industrial enterprises, the groups of integrated indicators, ranking order of generalized indicators, and values of weighting coefficients of generalized indicators are determined.

The order of ranking the generalized indicators and the values of the weight coefficients are determined based on the methods of "averaged expert evaluations", "method of ranking the criteria by the degree of importance" and "analysis of hierarchy MAI" and Fishburn formula. To begin with, let us make a correlation matrix:

Table-2 Correlation matrix for the studied methods

	Method 1	Method 2	Method 3	Method 4
Method 1	1	0,992	0,99	0,992
Method 2	0,992	1	0,996	0,996
Method 3	0,99	0,996	1	0,996
Method 4	0,992	0,997	0,996	1

The results of the analysis of the indicators and comparison of these methods are shown in Fig. 2.

The correlation coefficients for all pairs fall within the range of ±0.7 to ±1. which indicates a high correlation dependence of the data obtained. This means that any of the above

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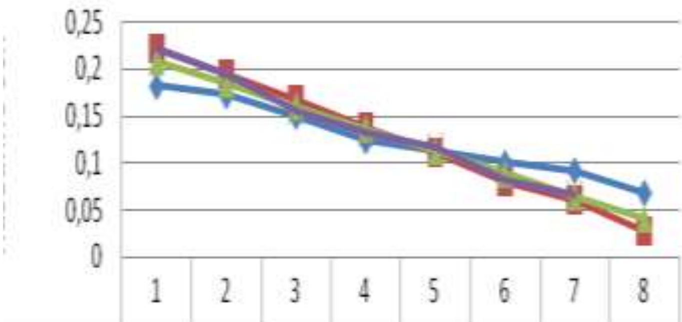
methods can be used to assess the efficiency of the use of electricity in the enterprise.

Based on the analysis of the results, the method of ranking the criteria by the degree of importance was adopted, in which the value of weighting coefficients is determined by the Fishburne formula in the following form:

$$\alpha_i = \frac{2(n-i+1)}{n(n+1)}; \sum_{i=1}^{n} \alpha_i = 1; i = 1, n \quad 4)$$

where: α- weighting coefficient for the ith indicator; i- number of performance coefficient place, n- total number of indicators.



	1	2	3	4	5	6	7	8
Метод 1	0,182	0,172	0,15	0,124	0,112	0,1	0,092	0,068
Метод 2	0,222	0,194	0,167	0,139	0,111	0,08	0,06	0,027
Метод 3	0,2083	0,1845	0,1607	0,1369	0,1131	0,0893	0,0655	0,0417
Метод 4	0,222	0,194	0,156	0,133	0,117	0,083	0,067	

3

Let us carry out a comparative correlation analysis of the indicators with each other and calculate the correlation coefficient to determine the degree of mutual influence of the indicators on the coefficient of efficiency of the power supply system.

The developed generalized indicators were used in energy surveys of industrial enterprises for a comprehensive study and identification of reserves to improve the electrical efficiency of the enterprise. In this case, the generalized indicator of the efficiency of the power supply system of the enterprise was determined by the formula (3). The results of the study are recorded in the final table-3.

Table -3 Conducted research at LLC Evrosnar

Coefficient	K_{en}	K_{qua}	K_{red}	K_{av}	K_{ia}	K_{kv}	K_{ek}	K_{ud}	K_{pss}	K_{epss}
During the energy audit	**0,8**	**0,93**	**0,66**	**0,93**	**0,5**	**0,5**	**0,8**	**0,96**	**0,78**	**0,82**
After implementation of improvement options	**0,97**	**0,96**	**0,7**	**0,98**	**0,67**	**0,6**	**0,8**	**1**	**0,87**	**0,88**
% change	**+17**	**+3**	**+6**	**+5**	**+25**	**+15**	**+2**	**+4**	**+10**	**+7**

*The first line of the table shows generalized indicators obtained during the energy audit of the enterprise;
** The second line shows the expected generalized indicators after the implementation of energy-saving measures; the third line shows the change in the generalized indicator as a percentage.

For automated calculation of generalized indicators developed an algorithm and a computer program "Program for calculating the generalized indicator of the effectiveness of the power supply system of an industrial enterprise. The information infrastructure that provides the initial data is shown in Fig. 3, the communication channel consists of a meter type, two modems type, and an acellular communication channel. At the request of the operator program "Energomer" (or Admintools) reads the data from the meter and transmits it through the communication channels to the computer in the form of a spreadsheet in the format of "excel". The developed program reads data from spreadsheets and static data, characterizing elements and schemes of the power supply system of the enterprise, and makes calculations of generalized indexes.

A summary index of power supply system efficiency is formed according to the readings of commercial (ASKUE) and technical (ASTUE) electricity meters (Fig. 3). PSS efficiency is determined mainly by the efficiency of transmission, quality, and reliability of energy supplied elimination of damaged elements and abnormal modes of operation of the PSS. Interrelated indicators are summarized and get a single coefficient, which determines the degree of distortion of these indicators at the output of the power supply system. For universality, all indicators are calculated in relative units.

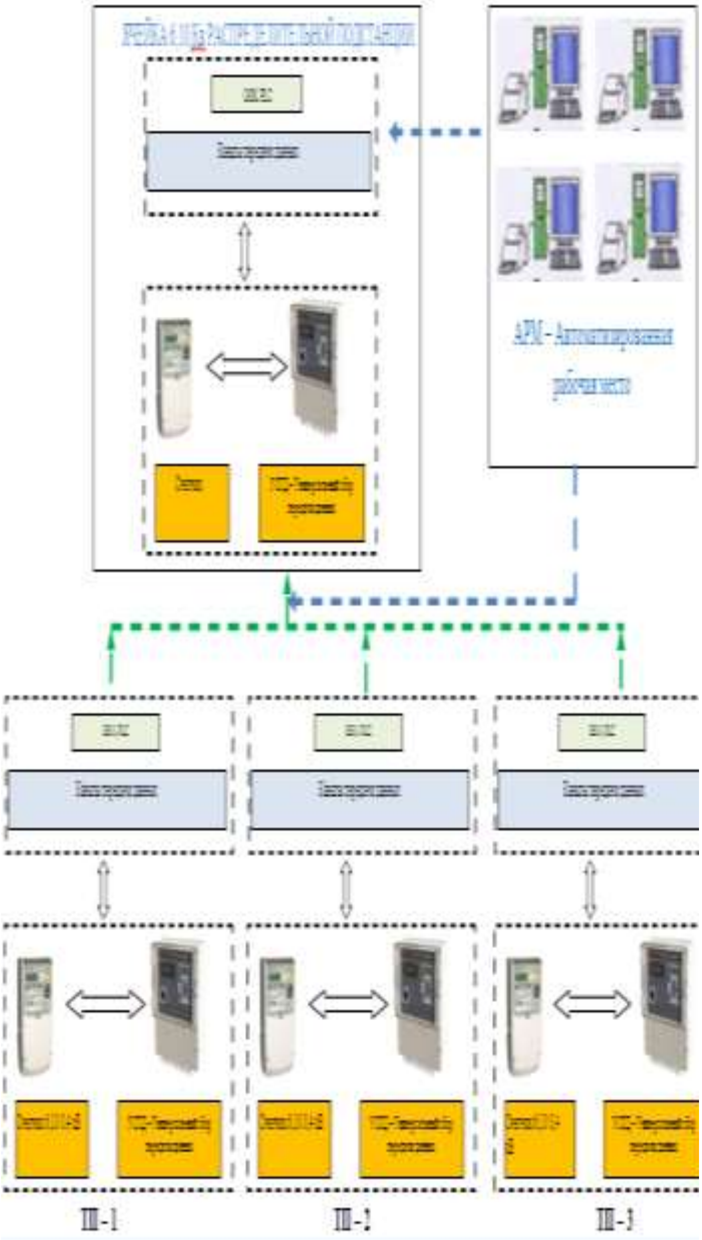


Fig. 4. Information infrastructure for monitoring power consumption indicators

The results of calculations of generalized indicators are shown in Fig. 4.

Based on the results of the study formulated a generalized indicator of electrical efficiency of the enterprise to monitor the electricity consumption of the enterprise. It is very difficult to determine the generalized indicator of electrical efficiency of the enterprise in the online mode because it requires information that requires a certain period of operation of the power supply system. Therefore, the indicators that can be fixed by measuring instruments at a certain point in time are taken for monitoring.

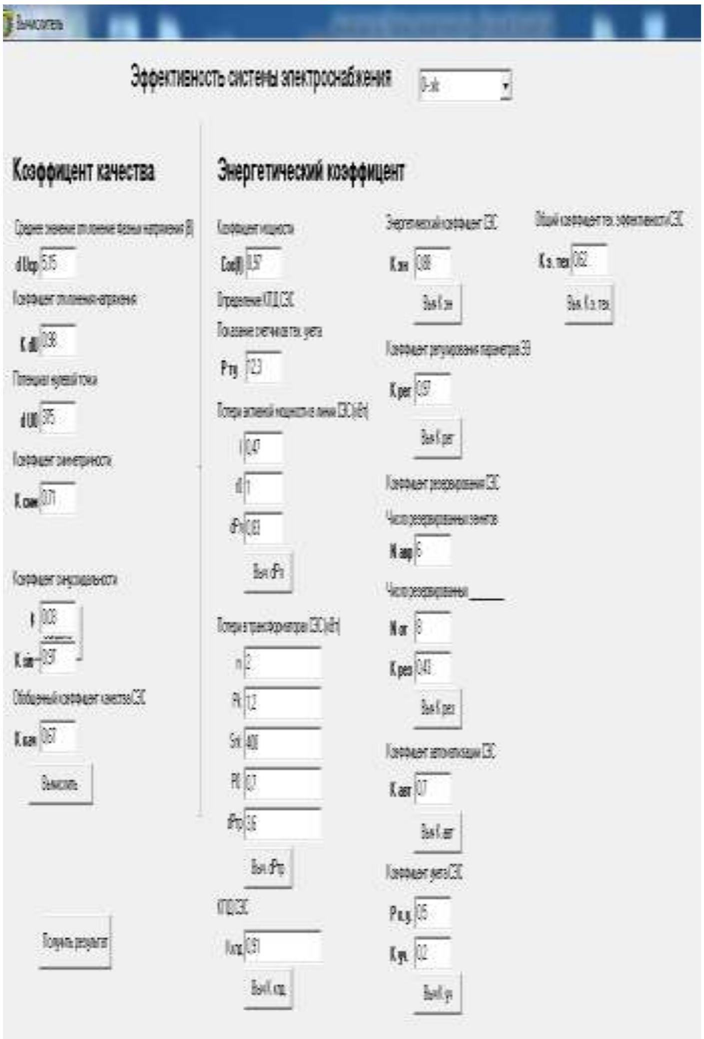


Fig.5. Calculation of data input and output form

Given the above, we propose a generalized indicator of electrical efficiency of an industrial enterprise by the following formula:

$$K_{э.тех} = \sum_{n=1}^{n} \alpha_i \cdot k_i = \frac{4}{10} \cdot K_{эн} + \frac{3}{10} \cdot K_{рег} + \frac{2}{10} \cdot K_{кач} + \frac{1}{10} \cdot K_{з}, \quad (6)$$

where: $K_{эн}$ - energy coefficient, which characterizes the efficiency of electricity transmission in power supply systems; $K_{рег}$ - coefficient of regulation of electricity parameters with the help of power supply system devices by; $K_{кач}$ - power quality factor,
$K_{з}$ - coefficient of electric equipment load, determined by the following formula:

$$K_{з} = 1 - \frac{|P_{оп} - P_{т}|}{P_{оп}}, \quad (7)$$

where: $P_{оп}$- optimal loading of electrical equipment;
$P_{т}$ - the current value of a load of electrical equipment of the company.

One of the conditions for efficient operation of the power supply system of an enterprise is optimal loading of power and technological equipment. Therefore, the total load of electrical equipment of the enterprise is controlled during monitoring.

CONCLUSION:

1. A method of a comprehensive assessment of energy efficiency based on generalized indicators is developed. As a result, the definition of energy efficiency of the industrial enterprise is achieved based on a comprehensive automated analysis.
2. The choice of ranking order of generalized indicators and values of weighting coefficients, taking into account their influence on the generalized indicator of energy efficiency in the enterprise is justified. As a result, the company has the opportunity to prioritize energy-saving measures.
3. Developed a generalized indicator of the effectiveness of the SES enterprise with the method of relative normalization of performance indicators and summarizing them into a single coefficient. As a result, the efficiency of electricity consumption at the enterprise is evaluated by a single index.
4. An algorithm of automated calculation and computer programs for determining the generalized efficiency indicator of electricity use in industrial enterprises has been developed. As a result, enterprises will be able to conduct an express analysis to determine the need for energy research.
5. An algorithm and a computer program have been developed to calculate the generalized efficiency indicator, which allows the energy monitoring of the enterprise's electricity consumption in the "online" mode. As a result, the enterprises were able to reduce the time of energy inspections by 10% and total costs by 7%.
6. Recommendations for improving the energy efficiency of the enterprise developed based on the results of comprehensive studies of electricity consumption indicators allow additional reduction of energy losses by 2 - 3%. As a result, the enterprises make full use of energy-saving opportunities.
7. The developed express-method of complex research of electric power use efficiency was used in the development of energy-saving measures and energy inspections of the enterprises of Uzbekistan country, Bukhara region, which allowed reducing the cost and terms of these inspections within 7-10%.

REFERENCES:

1) Н.Н.Садуллаев., А.Х.Шобоев., М.Б.Бозоров., А.Т.Паноев. Система мониторинга электропотребления предприятия на основе коэффициента эффективности системы электроснабжения. Europaische Fachhochschule. Volume: 08 / 2016. P.40-43. URL: https://www.elibrary.ru/item.asp?id=27542999 e- ISSN: 2195-2183
2) Н.Н.Садуллаев., А.Х.Шобоев., М.Б.Бозоров., А.Т.Паноев. Оценка эффективности системы электроснабжения методом многокритериального анализа. Europaische Fachhochschule. Volume: 08 / 2016. P.36-39. URL: https://www.elibrary.ru/item.asp?id=27542998 e- ISSN: 2195-2183
3) Н.Н.Садуллаев., М.Б.Бозоров., Ш.Н. Нематов. Контроль эффективности функционирования промышленной сети по обобщенному показателю эффективности системы электроснабжения. Проблемы информатики и энергетики. Volume: 03 / 2018. P.57-62. URL: https://assets.uzsci.uz/edition/file/5e43dd733cce7.pdf#page=57
4) M.B. BOZOROV., I.I. XAFIZOV., J.M. ZOIROV., F.R. KAYIMOV., B.S. XAMDAMOV., D.A. ORIPOV., SHARIPOV A.SH. Forecasting electricity consumption of industrial enterprises using excel program. JournalNX- A Multidisciplinary Peer Reviewed Journal. Volume: 07 ISSUE 2 / 2021. P.346-350. URL: https://media.neliti.com/media/publications/342773-forecasting-electricity-consumption-of-i-ab0342bf.pdf e-ISSN: 2581-4230
5) Х.И.Хафизов., М.Б.Бозоров. Разработка метода комплексного исследования энергоэффективности системы электроснабжения промышленных предприятий. Сборник статей Международного научно-исследовательского конкурса. Петразаводск, Россия (2021). P.10-19. URL: http://is.nkzu.kz/publishings/%7BC1D6204A-6585-4F17-B6AD-E67180342C1C%7D.pdf#page=12
6) М.Б. Бозоров., И.И. Хафизов., А.Т. Паноев., Ж.М. Зоиров., Ш.К. Ергашев., Ф.Р. Каймов., Б.С. Хамдамов., Д.А. Орипов., А.Ш. Шарипов. Разработка метода оценки эффективности системы электроснабжения промышленных предприятий. Сборник научных статей по итогам международной научной конференции. Казань (2021). P.42-45. URL: https://www.elibrary.ru/item.asp?id=44776698
7) М.Б. Бозоров. Исследования энергоэффективности системы электроснабжения объектов энергосистем на основе обобщенных показателей эффективности. Сборник статей XVII международной научно-практической конференции. Москва (2018). P.69-71. URL: https://www.elibrary.ru/item.asp?id=36354438
8) Н.Н.Садуллаев., А.Х. Шобоев., М.Б. Бозоров. Исследование влияния регулирования параметровэлектроэнергии на выбор оптимальной схемы электроснабжения. сборник научных трудов XI Международной научно-практической конференции. Курск (2014). P.28-32. URL: https://www.elibrary.ru/item.asp?id=22546679