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ENERGY SAVING WITH THE HELP OF INFORMATION AND MEASURING SYSTEMS: SECURITY SYSTEM MODELING

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Introduction. In conditions of uncertainty and risk, the task of saving energy production or consumption costs in the aspect of safety is relevant. An effective tool for solving the problem is the use of information and measurement systems. **Aim**. Building safety models for energy saving using information and measurement systems based on a systematic approach. **Materials and methods.** Traditional approaches to solving problems using information and measurement systems do not take into account the systematic approach to risk accounting. New models and method based on a systematic approach to risk accounting are proposed. The model of the security system includes a set of necessary energy-saving measures. The model for assessing the effectiveness of a security system for energy-saving measures takes into account the interests of all information and measurement systems participating in the implementation process. The method for creating a security system takes into account the interconnections of energy-saving measures. **Results.** The developed models and the plan for creating a security system make it possible to minimize economic, informational, psychological, environmental and didactic risks when implementing energy-saving measures using information and measurement systems. **Conclusion**. The implementation of the developed models and the plan for creating a security system at the Chelyabinsk thermal power station-2 ensured a reduction in risks when performing energy-saving measures using an automated system of integrated energy metering.

Keywords:information-measuring systems; energy saving; safety; automation; modeling.

Introduction

The introduction of automated means leads to an increase in damage as a result of an increase in the number of large-scale accidents. The magnitude of the damage is commensurate with the annual growth of gross domestic product. For example, in August 2003, damage in the United States and Canada amounted to more than 10 billion dollars, as a result of massive power outages. In another example, the massive loss of life and the sharp rise in fuel prices were the result of a catastrophic fire and massive explosions in March 2004, at the large American refinery of the British Petroleum company in Texas City [1–4].

This situation is explained by a number of reasons associated with the long life of equipment and measuring instruments, as well as the presence of a large measurement error associated with the characteristics of the personnel [5].

Neural technologies or knowledge management systems (expert systems), trained with the connection of network expert procedures, could help here [6].

The implementation of energy-saving measures will ensure economic growth [7].

The use of automated information and measuring systems ensures an increase in the efficiency of energy-saving measures.

Full automation of the measuring channels can reduce the number of errors, increase the efficiency of information processing and reduce the number of employees associated with working with information.

On the one hand, as a result of automation of settlements for heat carrier costs, payment for their consumption can be reduced, since the errors in calculations can be reduced by 1–2 %. For example, the effects of changes in gas density and composition, as well as atmospheric pressure, are often ignored when calculating gas flow. On the other hand, using models to create and evaluate a security system based on the interests of all participants allows you to effectively carry out technical diagnostics of measuring channels, which makes it possible to improve the efficiency of energy-saving measures related to the safe operation of measuring instruments [8].

To ensure energy saving, the task of step-by-step introduction of automated information and measuring systems. Reliability, cost, volume of automated work, measurement errors, number of measuring channels, skill level and number of staff, as well as the impact on the performance indicators of an automated control system and heat power equipment determine the economic efficiency of the implementation of automated systems [9].

Effective tools for risk management in the conditions of introduction of new information technologies is the use of management models and methods of efficiency assessment [10, 11].

Terms of reference

An important task of industrial and energy enterprises is to reduce the cost of production or consumption of energy resources. Automated information and measurement systems (AIMS) are used to solve the problem. The most widespread in Russia was hardware-software system "Energy" [12].

When introducing new information technologies, the experience of enterprises is used and mathematical modeling is applied. For example, the experience of implementing information systems in FSUE "Russian Post" and Chelyabinsk thermal power station-2 is known [13, 14]. Theoretical laws or experimental data underlie mathematical modeling [15, 16]. The presence of AIMS makes it possible to minimize the costs for the collection and analysis of big data [17].

The Department of Applied Mathematics of the South Ural State University has developed a method for searching for unacceptable energy losses based on a network mathematical model that takes into account the interaction between input and output energy flows. The implementation of the method allowed to reduce the time and labor of works in the zone of possible damage to the energy carrier, and also effectively plan measures for further troubleshooting [18].

An important task is to monitor compliance with the safe operation of equipment. The method [19] allows improving the efficiency of energy-saving measures related to the safe operation of equipment and the objectivity of working with personnel.

The application of the method of planning personal development trajectories on the basis of the competence model makes it possible to minimize economic and didactic risks in the training of personnel for working with information and measuring systems [20].

The maximum effect in the implementation of any project is achieved by taking into account the impact of all potential risks [21].

The use of information-measuring systems allows you to save the cost of generating or consuming energy in the face of uncertainty and risk. The aim of the study is to build safety models in the implementation of information-measuring systems.

1. Building models for creating and evaluating the efficiency of systems providing energy saving safety

As an object of research for energy conservation, an automated integrated energy accounting system was chosen at Chelyabinsk thermal power station-2. The object of the study includes an automated workplace and a complex of technical means "Energy", which unites a local computer network (Fig. 1).

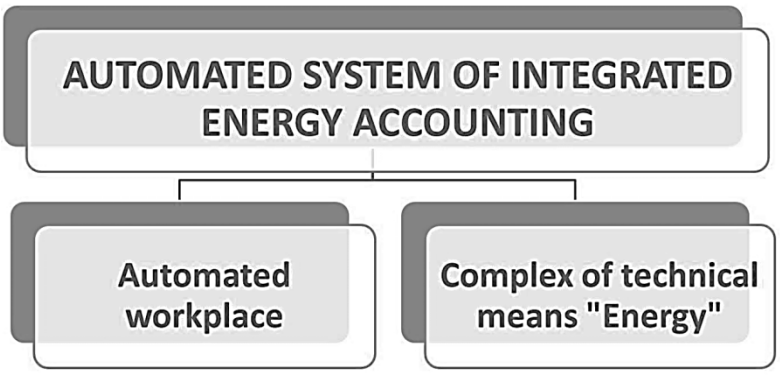

Fig. 1. Composition of an automated integrated energy accounting system at Chelyabinsk thermal power station-2

As a result of automation of data collection, unbalance of electricity decreased by 10 times, the entries in the meter reading log, the calculation of unbalance and the filling of output forms became unnecessary.

The introduction of the Energy technical equipment complex at Chelyabinsk thermal power station-2 allowed reducing the claimed peak power by 10 %.

Security model for energy conservation includes risks, steps and actions to minimize the impact of risks.

For the selected object, a model of the security system is formed (Table 1).

Table 1

Model of safety system presentation for energy saving at Chelyabinsk thermal power station-2

Stage	Event
Economic risks	
1.1. A large number of levels of automation of measuring channels for energy accounting	The choice of the automation level of the measuring channels for energy accounting according to the economic criterion
1.2. Inadmissible energy losses	The use of effective methods of searching for unacceptable energy losses
1.3. Loss and distortion of data as a result of untimely detection of invalid measuring channels	Organization of a site of on-duty engineers for operative search of unreliable measuring channels
Information risks	
2.1. Errors of operational and repair personnel	Organization of emergency response training for operational and maintenance personnel
2.2. Loss of data at the time of elimination of invalid measuring channels	Switching to duplicate measuring channels
Psychological risks	
3.1. The psychological barrier to mastering new methods	Organization of effective personnel policy
Environmental risks	
4.1. The effect of electric current and energy on the health of staff	Search Methods for Unacceptable Energy Losses
Didactic risks	
5.1. Insufficient competence to apply new methods	Organization and conduct of refresher courses

Evaluation of the effectiveness of the energy saving system is carried out on the basis of quantitative assessments of the impact of risks ("1" is a minor effect, "2" is average, and "3" is strong).

The methodology for assessing the energy saving safety system was implemented at the Chelyabinsk thermal power station-2 (Table 2).

2. Designing the safety system for energy saving

The algorithm for designing a security system for energy saving is presented below:

1. An expert group is developing a safety model for energy conservation. The model includes risks and measures to minimize them. An example of a safety system model for the technical diagnostics of measuring Channels is given in Table 1.

2. Based on knowledge and experience, each expert creates a safety assessment model for energy saving. The model includes possible risks and their weight ("1" – the influence of an insignificant, "2" – an average, "3" – a strong one). An example of a safety assessment model for the technical diagnosis of measurement channels is given in Table 2.

3. The final safety assessment model is based on the models of all experts. In this model, the weight of each risk is defined as the sum of the risk weights from the expert models.

4. A preliminary plan of measures for creating a security system is being developed on the basis of the final model for assessing the security system. In this plan, the procedure for implementing measures is determined by the scales of the corresponding risks of the final model.

5. Based on the interaction of activities, the action plan is adjusted to create a security system.

The described algorithm is implemented at Chelyabinsk thermal power station-2.

The expert group included all participants in the energy conservation process: heads of departments, representatives of maintenance and repair personnel.

Table 2

Model of safety system presentation for energy saving at Chelyabinsk thermal power station-2

Stage	Weight of risk
Economic risks	
1.1. A large number of levels of automation of measuring channels for energy accounting	3
1.2. Inadmissible energy losses	3
1.3. Loss and distortion of data as a result of untimely detection of invalid measuring channels	3
Information risks	
2.1. Errors of operational and repair personnel	3
2.2. Loss of data at the time of elimination of invalid measuring channels	3
Psychological risks	
3.1. The psychological barrier to mastering new methods	2
Environmental risks	
4.1. The effect of electric current and energy on the health of staff	2
Didactic risks	
5.1. Insufficient competence to apply new methods	2

The final model for evaluating the energy-saving safety system was implemented at Chelyabinsk thermal power station-2 (Table 3).

Table 3

The final model for assessing of the energy-saving safety system at Chelyabinsk thermal power station-2

Stage	Weight of risk							
	1	*2*	*3*	*4*	*5*	*6*	*7*	*Amount*
1.1	3	3	3	3	2	2	2	18
1.2	3	3	3	2	2	2	2	17
1.3	3	3	3	2	3	2	1	17
2.1	3	3	3	2	2	1	2	16
2.2	3	3	3	2	2	2	2	17
3.1	2	2	2	3	2	2	2	15
4.1	1	1	2	3	3	3	3	16
5.1	1	1	2	3	2	3	3	15

A preliminary plan of measures for creating a security system is developed on the basis of the final model for evaluating a security system for energy conservation. In this regard, the procedure for implementing measures is determined by the scales of the corresponding risks of the final model (Fig. 2).

Fig. 2. Preliminary plan for creating a security systemat Chelyabinsk thermal power station-2

Based on the interaction of activities, this plan has been adjusted (Fig. 3):

– After choosing the automation level of the measuring channels for energy accounting, it seems advisable to organize a site of duty engineers at the second stage (activity 1.3);

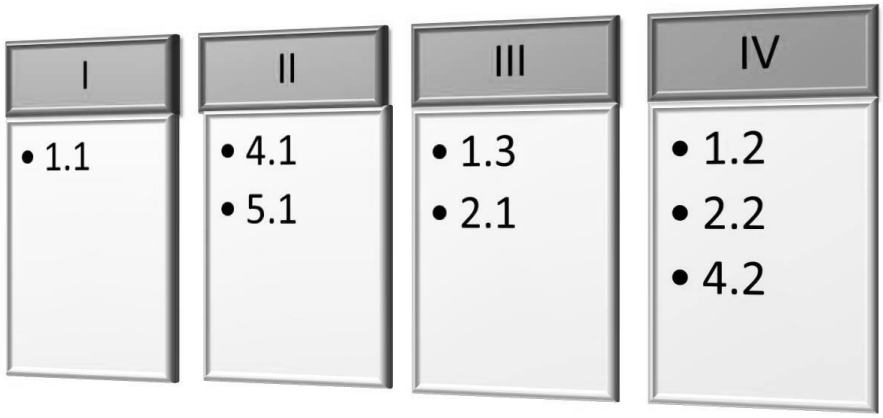

Fig. 3.The final plan for creating a security system at Chelyabinsk thermal power station-2

–After implementation of organizational changes in the structure of enterprises at the third stage, it is recommended to carry out activities related to personnel training for work in new conditions (activities 2.1, 3.1 and 5.1);

– At the fourth stage, measures 1.2, 2.2 and 4.1 are implemented, related to the implementation of professional duties of trained personnel.

As a result of the development of a security system for energy conservation, measures to ensure security were determined based on the interests of all participants in the energy saving process and an effective plan for creating a security system was developed taking into account the interconnection of activities.

Conclusion

The task of providing integrated safety of energy saving with the help of information and measuring systems based on the developed models was solved.

A new model of the security system includes a set of necessary energy-saving measures.

The new model for evaluating the effectiveness of the security system for energy-saving measures takes into account the interests of all participants in the implementation of information-measuring systems involved in the implementation process.

The plan for creating a security system takes into account the interrelationships of energy-saving measures.

The developed models and the plan for creating a security system allow minimizing economic, informational, psychological, ecological and didactic risks when performing energy-saving measures with the help of information-measuring systems.

The implementation of the developed models and the plan for creating a security system at the Chelyabinsk thermal power station-2 ensured a reduction in risks when performing energy-saving measures using an automated system of integrated energy metering.

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ЭНЕРГОСБЕРЕЖЕНИЕ С ПОМОЩЬЮ ИНФОРМАЦИОННО-ИЗМЕРИТЕЛЬНЫХ СИСТЕМ: МОДЕЛИРОВАНИЕ СИСТЕМЫ БЕЗОПАСНОСТИ

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Введение. В условиях неопределенности и риска актуальной является задача экономии затрат на выработку или потребление энергии в аспекте безопасности. Эффективным инструментом для решения задачи является применение информационно-измерительных систем. **Цель исследования**. Построение моделей безопасности для энергосбережения с помощью информационно-измерительных систем на основе системного подхода к учету влияния рисков. **Материалы и методы**. Традиционные подходы к решению задач с помощью информационно-измерительных систем не учитывают системного подхода к учету рисков. Предлагаются новые модели и метод на основе системного подхода к учету рисков. Модель состава системы безопасности включает комплекс необходимых энергосберегающих мероприятий. Модель оценки эффективности системы безопасности для энергосберегающих мероприятий учитывает интересы всех участвующих в процессе внедрения информационно-измерительных систем. Метод создания системы безопасности учитывает взаимосвязи энергосберегающих мероприятий. **Результаты**. Разработанные модели и метод создания системы безопасности позволяют свести к минимуму экономические, информационные, психологические, экологические и дидактические риски при выполнении энергосберегающих мероприятий с помощью информационно-измерительных систем. **Заключение.** Реализация разработанных моделей и метода создания системы безопасности на Челябинской ТЭЦ-2 обеспечила уменьшение рисков при выполнении энергосберегающих мероприятий с помощью автоматизированной системы комплексного учета энергии.

Ключевые слова: информационно-измерительные системы, энергосбережение, безопасность, автоматизация, моделирование.

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