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Development of Analog Software Models for Energy Efficiency Management and Control

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ABSTRACT: This article presents the methods and principles of developing an analogue model for mathematical modeling of energy efficiency management systems.

KEYWORDS: energy efficiency, automatic control, analog models, heat and energy sources, device, apparatus, technological line, communications, spinning-preparation, weaving-preparation, weaving, assistant, boiler room.

1. Introduction

Traditional electricity metering and monitoring systems include meters that directly receive information about electricity consumption, as well as data transmission elements and their subsequent transfer to main power plant with the possibility of computer processing. The disadvantages of such a system are that there are many meters, data transmission devices, programmers and software manufacturers on market that are trying to "adapt" their products for integrator companies. Sometimes it happens that the protocols are incompatible with each other, and the drivers require separate software, and so on. All of this takes time and, most importantly, resources, that client must pay for. Scientific work is underway to eliminate such cases. More and more solutions appear on the market, which differ in their completeness. Software and hardware produced by one company reduces the risk of incorrect connection [3-4].

Currently, the production of intelligent electricity metering and monitoring systems is not developing in Uzbekistan. Due to difference in power supply systems of foreign countries, imported systems are not always compatible with our power supply system. Therefore, an urgent task is the development of local intelligent systems for metering and monitoring of electricity to assess the energy efficiency of an enterprise and improve efficiency. One of the means of increasing energy efficiency is organization of a system for constant monitoring of electricity consumption in shops and production premises of the enterprise, taking into account production indicators and climatic factors, as well as warnings about possible equipment malfunctions and thus make a possible forecast [1].

2. MATERIALS AND METHODS

The control system is created as a combination of two systems: control and controlled (control object). The control subsystem generates control actions G(t), the controlled subsystem (control object) is under the influence of control actions.

The influence of the control subsystem on the control object is considered as a process, and the influence of control is considered as a sequential change in the values of G(t) [1].

The relational model of the formation of the control effect is presented in Table 1.

The initial impact q(t) is formed on the basis of the normalization of energy costs, the initial data for which are individual objects (device, apparatus, technological line, communications), manufactory (mill, elevator, feed mill, boiler room), in general, make up the energy balance of the enterprise.

Consumption rates of heat and energy sources are developed in natural units adopted during planning per unit of finished products (tons of products, etc.) or per unit of work (compressor, refrigerator, etc.).

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Table 1. Relational model of control action formation

Level	The essence of the degree	Result
I	1. Collection of information, transfer to points of collection and processing 2. Analysis of incoming, collected and unaware information on energy saving. 3. External factors: the energy saving system and its changing trends, tariffs, regulatory framework for energy consumption and energy saving, the state of the environment.	Making a decision on the development of strategic and short-term plans for increasing energy efficiency of production
II	1. Conduct energy audits at all stages of energy consumption and change 2. Creation of energy balances of energy consumption	Determination of the energy intensity of the product, the potential for energy saving both for the enterprise as a whole and for individual processes and equipment.
III	1. Prioritize energy conservation 2. Feasibility study of energy saving measures. 3. Financial analysis of energy saving projects.	Development of an energy saving program
IV	1. Standardization of energy consumption	1. Formation of the beginner setting action q (t)
V	1. Comparison of the initial (setting) action q (t) and the controlled parameter y (t) 2. Analysis of deviations S = [q (t) ~ y (t)]	Formation of controlled action G(t)

Deviation of the controlled parameter from the norm is an integral part of the development and improvement of the functional system. The very deviation from the norm is an incentive to return to normal. The source of deviation is the environment, external influences.

External influences f (t) (change in quantity, quality, energy parameters, implementation of energy-saving projects, implementation of energy-saving measures, such as frequency-controlled transmission of electricity, thermal insulation, use of thermal energy, etc.) varies depending on known and random laws [2].

During the implementation of technological processes associated with energy changes are accompanied by a large number of factors affecting their course and often of a random nature.

At any given time, it is impossible to define the process by taking into account all factors in advance. In accordance with the problems that need to be solved in the process, it is possible to take into account the circumstances that arise in order to influence the process only through operational participation in the process every time trends or deviations arise in the process.

Functional systems arise due to the qualitative ordering of relationships under the influence of the external environment: informational resonance, as a signal of deviation (in the form of negative feedback), began to form closed circuits of self-regulation - homeostasis.

In the energy efficiency management system, the feedback (value of the monitored parameter) is formed as the lowest level of the control output and the highest level of the input.

Controllable parameter y (t) - energy efficiency indicator - coefficient of efficiency of standard energy consumption at the consumer:

$$\eta = \varepsilon_n / \varepsilon \quad (1.1)$$

where S is the generalized direct energy consumption;

$$\varepsilon = R_E E + R_W W + R_B B_{np} \qquad (1.2)$$

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Here:

E - power consumption;

W - heat energy consumption;

Bnp - direct use fuel consumption;

RE, RW, RB - conventional fuel equivalents.

S_P is the generalized final energy consumption (useful work), which is determined in a normative manner on the basis of electricity, heat energy, direct use fuel power Vs and heat Vt measured in the devices.

$$\varepsilon_n = R_E E\eta_E + R_W W\eta_W + R_B^T B_C\eta_C + R_B B_T\eta_T \qquad (1.3)$$

where ηE, ηW, ηC, ηT are respectively weighted average coefficients of efficient use of energy sources in the processes of electricity consumption, heat energy, direct fuel consumption in capacities Vs and heat W devices.

In theory, R^T_B is the energy equivalent of fuel equivalent [3].

The control system provides for an additional control effect $G_d(t)$, which is aimed at increasing the level of training of employees and workers on energy saving issues, providing engineers and workers with information on ways and means of improving energy efficiency.

Additional management impact also includes two groups of information documents that make up the organizational and methodological support of the management system.

By organizational support we mean a set of organizational and managerial documents that determine the procedure for performing the management function, who, what and when. These include organizational standards, unit regulations, job descriptions, decisions and orders.

A methodology is a set of guidelines that define how a specific function is performed.

An analog model of the developed control system is shown in Figure 1.

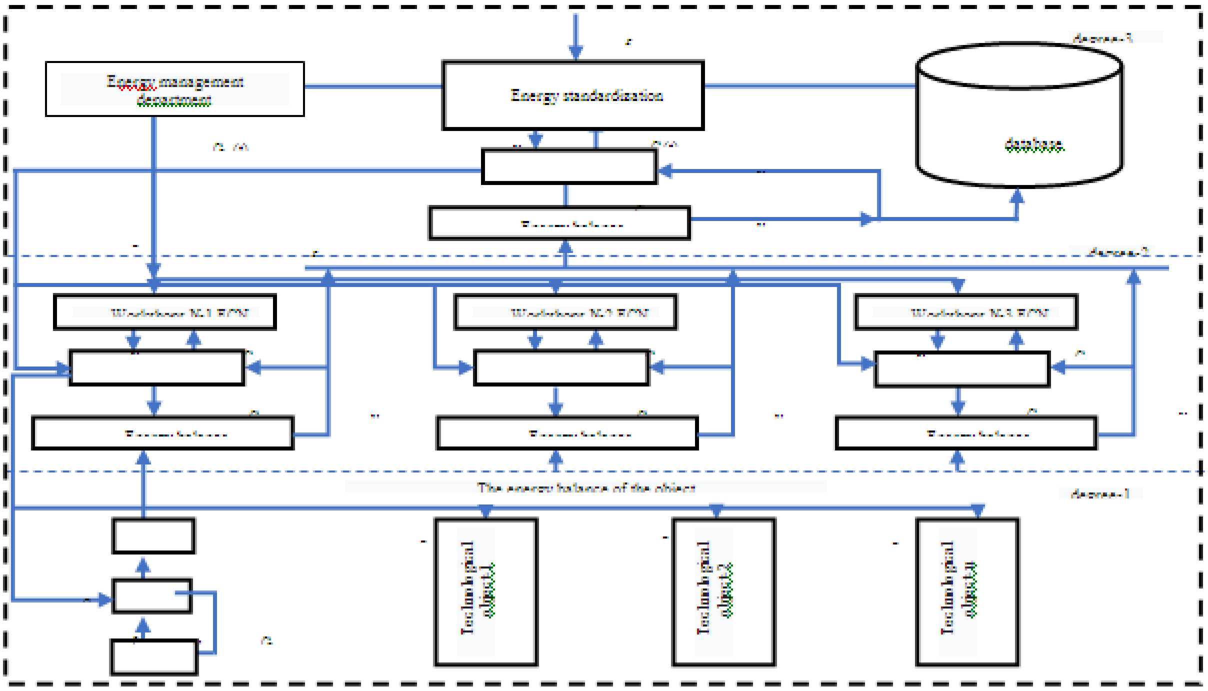

Figure 1.Analog model of the control system

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The following symbols are adopted in the scheme: DCPTD- a device for collecting, processing and transmitting data; ECN - energy consumption normalization; EB - energy balance; CD - control device; OC - object of control.

The database in this system consists of specially organized (structured) data and an integrated set of relationships between them. In other words, it is a clear image of the subject area of information.

Database design begins with an analysis of the domain and potential customer requirements.

The subject of this management system is the energy efficiency of the textile industry. Consumers are energy management employees. The consumer requirements set out in the information support are considered in the first section of the work.

The database design process can be divided into a number of interrelated stages, each of which has its own characteristics and methods.

Figure 2 shows the typical design steps for a database.

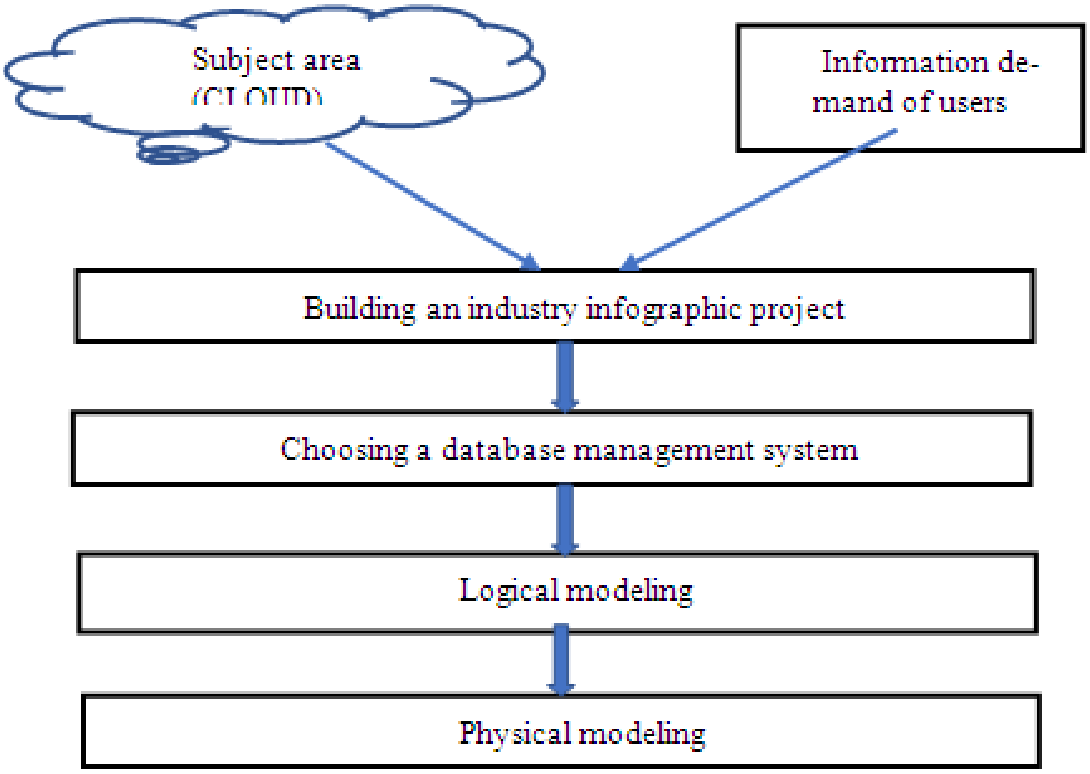

Figure 2. Database design stages

An infological (information-logical) model is a descriptive (informal) model of the subject area, which semantically defines the information (entity) and relationships between them that are of interest to users of the database from the subject area.

At the logical design stage of the database, the information divided in the infographic model is displayed as data in formats using the selected MBBT (Database Management System). The conceptual model describes data and connections stored on a computer, that is, a specific MBBT is directly related to the data description language. The challenge for physical design is to choose a method for storing data on physical media and methods of accessing it using the capabilities provided by MBBT.

Figure 3 shows the infographic model "The third level of the energy efficiency management system".

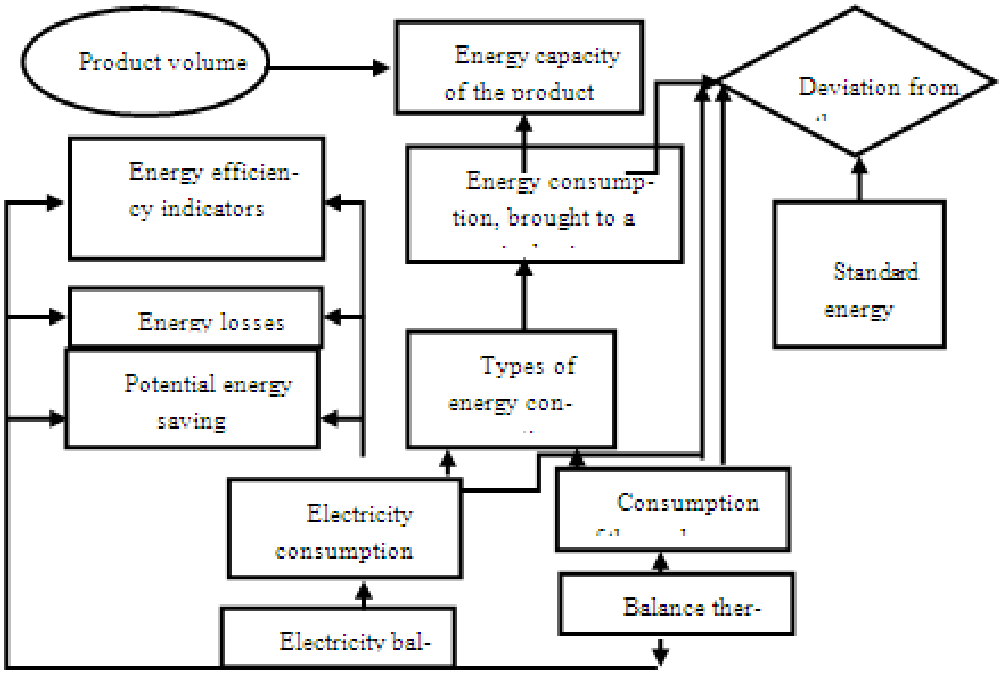

Figure 3. Infological model "The third level of the energy efficiency management system.

Energy efficiency management and control program interface is shown in Figure 4.

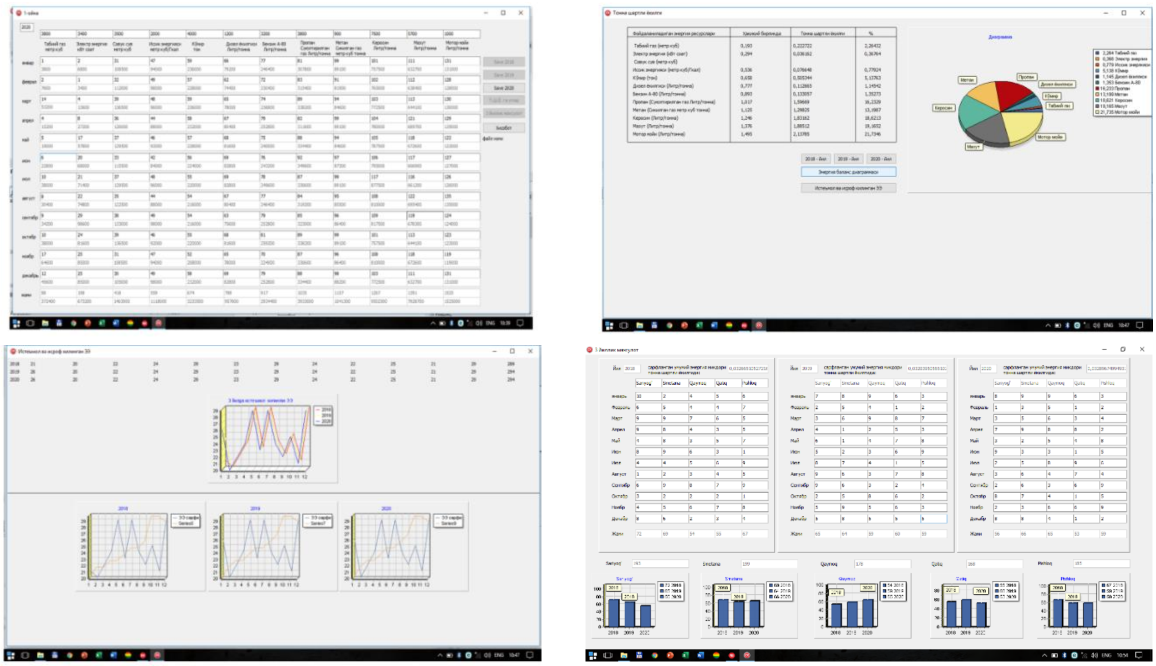

Figure 3. Automated software and information software for monitoring and managing energy efficiency.

Energomonitoring software technologies allow solving the problems of energy saving and increasing energy efficiency by balancing energy consumption, reducing transmission losses and optimizing energy production costs through comprehensive automation of power equipment. In addition, this system is suitable for power supply (heating and water supply networks), as well as for large enterprises producing and consuming

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various energy sources (natural gas, fuel oil, steam of various parameters, industrial water for various purposes, cold ammonia, process gases).

The automated systems implemented in the energomonitoring program perform all the standard functions required for automated control systems.

3. RESULTS

Energy efficiency management and control program functions

1. Calculation of energy consumption of the i-th type for the enterprise;
2. Calculation of energy losses of the i-th type for the enterprise;
3. Calculation of the energy saving potential of the i-th type for the enterprise;
4. Calculation of the total energy consumption per unit area;
5. Calculation of the total energy losses caused by one measurement;
6. The calculation of the total energy saving potential is reduced to a single measurement;
7. Goods tsh. calculation of energy consumption per unit of production;
8. Conventional unit of energy - t. calculation of prices;
9. Calculation of financial costs for the total energy consumption per unit area;
10. Calculation of the share of financial costs for energy supply from the cost of the product..

4. CONCLUSION

Creation of an intelligent system for monitoring the energy efficiency of electrical equipment of enterprises in the form of software and hardware, the purpose of which is to reduce energy costs and extend the life of electrical equipment, thereby increasing the energy efficiency of the enterprise.

An intelligent electricity metering and monitoring system has been implemented in the primary energy control system (energy audit) of power facilities of Bukharadonmakhsulotlari JSC, Kogondonmahsulotlari JSC, Korakuldonmahsulotlari JSC, Bukharagazsanoatkurilish JSC. These measures allowed to save from 12 to 30 percent in fuel, depending on the level of automation and design of heating nets and water intake.

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