ANALYSIS OF THE POSSIBILITIES OF APPLYING MODERN INFORMATION TECHNOLOGIES IN ENERGY EFFICIENT URBAN DEVELOPMENT (on the example of Karabakh region)

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Abstract

Solving the problems of energy saving and efficient use of thermal energy in the construction industry is primarily associated with a number of insufficiently developed scientific and technical problems of urban planning, infrastructure, building thermal physics, such as thermal conductivity and humidity conditions of complex outdoor structures, heat resistance and general heat exchange of a room, air regime buildings, non-stationary joint heat, moisture and air exchange, as well as the durability of the external building envelope. Today, energy saving in urban planning, in the restoration of the destroyed cities and towns of Karabakh, as well as in their further operation, is increasingly relevant due to the high rate of construction of buildings for various purposes, with the deterioration of the environment, the rise in the cost of energy, material and labor resources. Today, world energy is one of the most powerful, actively functioning global systems that determines the most diverse aspects of the life of human society and largely determines the direction and pace of development of the world economy. The paper discusses the application of modern information technologies in solving issues of urban planning, construction and operation of buildings and structures in Karabakh.

Keywords: urban planning, outdoor structures, thermal energy, energy efficiency, operating conditions, optimal control

I. Introduction

In many countries of the world, a huge amount of thermal energy is wasted due to inefficient and irrational design of new cities and towns, the choice of external building envelopes, irrational distribution of thermal energy among consumers, mismanagement of the mode of consumption of thermal energy, etc.

These countries, unfortunately, include Azerbaijan and other CIS countries that developed their economies on the principles of extensive use, and not on the principles of rational use of thermal energy, which became inherent in the economies of the developed countries of the world after the first energy crisis in 1973.

An analysis of the state of affairs in the thermal economy of cities and towns of the republic showed a lot of pressing problems. The current situation in the heat supply system of the cities of Baku, Sumgayit, Ganja and other regions of the republic is characterized by technical, technological and organizational backwardness, low efficiency, inconsistency and unreliability in the most extreme situations. Therefore, increasing the share of volumes of the structure of the heat and power system with the simultaneous design of potential and energy-efficient buildings and increasing the quality of their energy supply is the first step in solving the problem of increasing the efficiency of the energy sector of Karabakh.

II. Methodology

Currently, there are many mathematical models for optimal control, planning and distribution of thermal energy, but in real conditions their use is often difficult. First of all, this concerns the operational management and distribution of thermal energy between consumers, when there is a problem of prompt adjustment of the initial information and feedback on actual consumption. At the same time, one has to deal with the uncertainty of goals that arise when simultaneously performing different tasks for managing and providing the required amount of thermal energy in extreme climatic conditions or emergency situations. As a result of the influence of disturbing factors (climatic parameters of the environment, operating conditions of buildings, organizational factors, emergency situations, etc.), as well as incompleteness and inaccuracies of the initial information, the main controlled parameters turn out to be fuzzy. In this regard, today, in almost all operational control rooms, operators mainly use their own decision rules based on their own experience and intuition. Such actions do not guarantee mathematical optimality, they are not always adequate to real conditions and are not implemented in practice.

It is obvious that further improvement of the system of planning, management and distribution of thermal energy between consumers of different categories, increasing the efficiency and reliability of the operation of newly built buildings, especially for the climatic zone of Karabakh, is associated with the transition to a new modeling system, in particular to a new information technology, and the creation based on it qualitatively new systems of optimal and operational management, distribution and operation.

With the advent of "intelligent" technologies in the construction industry, it became possible to raise quality and energy efficiency indicators (safety, optimal comfort, information service, optimal management, efficient use of thermal energy, etc.). All engineering systems of newly built cities and settlements in the Karabakh zone should be managed by a single center, which allows reducing heat and power resources, saving costs for maintenance personnel, reducing the likelihood of accidents, predicting and planning the mode of consumption of thermal energy [1].

III. Results

Profound changes in the global construction market, and in connection with this, the need to develop modern energy-saving technologies are forcing enterprises and companies in this industry to introduce more and more powerful control systems into production at all information levels, while ensuring the optimal use of energy resources and other potentials. And this defines a new stage in the development of the scientific concept of managing the indoor microclimate and energy consumption, which ensures the possibility of efficient use of energy resources.

At present, the intensive growth of thermal energy consumption necessitates the development of modern schemes for automatic control of the technological regime of the system, data collection from measuring sensors and computer systems, their storage, display and processing based on the use of information technologies [2, 3].

These systems should implement the following main functions:

- information support for control and management at all levels;
- processing of measurement data and solution of various tasks of automatic and dispatch control;
- implementation of control functions;
- emergency protection of technological process and equipment.

Currently, domestic and foreign experts have carried out a significant amount of research on modeling and optimizing the mode of distribution of thermal energy in cities and towns, as well as on ensuring the microclimate in buildings [4, 5]. However, the developed methods are deterministic and do not take into account the actual operating conditions of the entire system of cities and individual buildings.

The solutions obtained with the help of these developments on the distribution of thermal energy between consumers of cities and regions of Karabakh and the provision of individual buildings with high-quality air correspond only to specific boundary conditions and are on the border of the permissible area. Therefore, even minor changes in the boundary conditions can not only significantly change the optimal solution, but also take it out of the region of technologically acceptable modes and lead to an emergency. Such solutions may not always be acceptable for practice, because they are often inoperable in real conditions.

Planning and production as well as dispatching services, specialists usually use their own solutions in practice, based on their experience and intuition. Such rules, although they do not guarantee mathematical optimality, sometimes turn out to be adequate to real conditions.

Modern cities with a continuous nature of operation are complex systems consisting of dozens of subsystems, which in turn are interconnected and characterized by dozens of parameters. The use of modern information technologies for the operation and management of these cities and the microclimate of individual buildings, and the consumption of thermal energy allows raising the social conditions of the city to a new qualitative level and will help solve the problem of optimizing energy saving in the region.

We assume that modern information technology management of the microclimate and thermal energy consumption for buildings can develop in two interrelated directions.

The first direction is determined by the effectiveness of the implementation of the theoretical knowledge base of technological processes, which create the basis for the dynamic development of indicators of the organizational and economic system of enterprises for the production of thermal energy.

The second direction is the use of efficient and optimal control systems to control the systems to provide thermal energy to cities, combining not only all levels and components of automated and automatic control, but also technical systems with the help of which the technological processes of these systems are implemented.

In our opinion, in the systems to ensure the microclimate of an environmentally friendly building with efficient use of thermal energy, it is necessary to introduce: complexes for modeling and optimizing the operating modes of these systems, electronic dispatch logs, systems for collecting and processing regime-technological and climatological (outdoor and indoor air) information , real-time systems, systems for graphical representation of objects (general plan of the territory and floor plans of individual buildings), various complexes of regime and technological tasks, control subsystems for individual buildings or premises.

These software tools make it possible to model complex multifunctional systems to ensure the optimal distribution of thermal energy between consumers of the city, to evaluate possible management and dispatching decisions not only in the conditions of normal operation of the system, but also in case of significant changes affecting the system of factors (a sharp change in climatic indicators of the environment, change in operating conditions, occurrence of an emergency, etc.).

To automate the control and regulation of systems for providing thermal energy to cities and towns of Karabakh, geoinformation software and hardware complexes that select, display, process, analyze and disseminate information about spatially distributed objects based on electronic maps, related databases and technologies can be used. Such technologies provide computer support for regulation, efficiency of data processing, provide high accuracy, as well as computer simulation of the system with hydraulic calculation and analysis of the mode of operation of the entire system [6].

However, control systems and optimal distribution of thermal energy between consumers should not only have interfaces for receiving and sending information, but also be able to automatically process the information received. At the same time, the degree of usefulness of software systems for controlling technological regimes is determined not only by the reliability of the initial information, but also by the adequacy of the mathematical models used for objects of central systems (climatization and distribution of thermal energy).

Despite the fact that in the modern world of information technology a decade is comparable to a century of progress in traditional technologies, models and solutions of the 60s of the last century are still used in the development of models of central air conditioning and heat distribution systems.

At present, the problem of mathematical modeling of these systems has become aggravated due to the use of new technologies, as well as the need to justify the economic efficiency of the methods used to control new energy-saving technologies in systems for providing a microclimate and optimal distribution of thermal energy between consumers.

In any information technology control system, it is necessary to provide for the accumulation, transmission, processing of primary information and a system for presenting information about decisions made in the required form and, based on these decisions, a system for reliably performing technological operations for processing, transporting and supplying heat energy to buildings in the required amount [6].

However, the environment of Karabakh and the internal climate of the buildings being built there are complicated complexes, for which it is practically impossible to conduct a full and comprehensive scope of full-scale tests. Moreover, the objective unattainability of the full scope of tests is associated with infinite sets of various unpredictable changes in environmental parameters and possible scenarios for operating systems (maintaining the required parameters of indoor air), the semantic variety of initial information that is subject to operational processing in real time and a lot of software functions that are subject to appropriate checks for tests. Therefore, before the introduction of such systems, such tasks as:

● system analysis of outdoor climatic parameters of construction areas and indoor air

● development of effective algorithms and mathematical models for making managerial decisions during the operation of heat supply systems for individual buildings;

● development of unified object-oriented models for simulating and optimizing technological facilities to ensure the microclimate of buildings (premises) and the optimal distribution of thermal energy between consumers of different categories;

● development of methodology and corresponding mathematical models for assessing and monitoring the reliability of automated control systems, etc. should be solved.

Simulation modeling is designed to study a system with a fixed topology and a given configuration of parameters. It can also be used to test the validity of a specific combination of external and internal environment parameters, i.e. as a means of testing and comparing analysis of technical solutions for managing the microclimate of buildings.

When compiling mathematical models, it is necessary to strive to obtain the simplest models with sufficient accuracy of the calculated data.

One of the common shortcomings in the practice of creating microclimate control systems for multifunctional buildings is a deterministic software approach to this problem. In this case, various classical approaches are used to model physical processes in technical systems with certain, sometimes significant, assumptions. As a result, the model is described by linear or non-linear mathematical equations, which are solved by analytical, numerical or probabilistic-statistical methods. As a result, the resulting solutions do not always provide sufficient flexibility to the requirements of the microclimate. This is due to the fact that: firstly, many random factors influence the functioning of the microclimate, and it is practically impossible to take into account all these factors in the model. Secondly, these systems are open systems, with unclearly predictable air parameters, with periodically changing operating conditions and parameters of the state of the buildings (or premises) themselves. As a result, the solution is accompanied by large computational difficulties:

● there is a large area of uncertainty for many model parameters;

● high inaccuracy of measured parameters;

● inadequate consideration of process parameters in the model, in particular at the junction of different technological solutions;

● presence of empirical coefficients and dependencies in the model;

● to identify model parameters, it is not possible to obtain real-time data at a given frequency, etc.

To get out of this situation, various modeling and optimization methods are used, which take into account the stochastic nature of the change in environmental parameters, as well as the random nature of the operation of the air conditioning system and the optimal distribution of thermal energy between consumers. Sometimes the model is a controlled non-stationary Markov process in which the control affects the probability of the system transition from one state to another [6]. If air conditioning and heat distribution systems are considered as technical systems, and design and optimization tasks are formulated as the choice of the most economical option that meets the established norm, reliability and probability of fulfilling certain ratios, then the model does not allow taking into account the material damage to consumers.

IV. Conclusion

Solar energy use becomes more and more globally. Like other countries, Azerbaijan is trying to meet its thermal energy and electricity needs by applying renewable energy sources. It is predicted that by 2050, about 50% of the total amount of energy will be produced by "green" energy technologies. At present time Azerbaijan meets only 8% of energy consumption needs with renewable energy.

The obtained results of the study allow making the next conclusions on an initial assessment of Under the new conditions, which were formed as a result of the introduction of various information and technological systems for managing the microclimate of buildings, there appeared both a necessary and a real opportunity to use neural networks and fuzzy controllers for analyzing and processing information when solving management problems.

Methods for interpreting and representing trained neural networks are currently being developed in various directions. The wide possibilities of using neural networks in production management are due to the fact that the technology for applying this technique forms a structure in which all types of imperfect knowledge (inaccuracies, uncertainties, etc.) can be represented in an appropriate way and combined for processing. In addition, with the use of various SCADA-type control software systems, a huge amount of information about control objects is accumulated, and they can be used to adapt models [6].

It should be noted that neural networks can be used with great success for diagnosing building climate parameters, microclimate control, and also for optimal distribution of thermal energy between consumers. Since the information environment for diagnosing and managing the climate of buildings should provide the necessary accuracy and reliability of detection, identification, and determination of air parameters. Neural network algorithms make it possible to eliminate redundancy and inconsistency of information, and also work in conditions of incomplete information.

Thus, when solving the problems of urban planning, as well as the efficient and rational distribution of thermal energy between consumers in the Karabakh zone, in order to provide consumers with quality air, it is necessary to consider the problem not in a narrow, but in a global sense, through the use of modern and economically cost-effective technologies.

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