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Increase Energy Efficiency By Improving The Heating System In Buildings

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Abstract

In this scientific article the issue of energy efficiency improvement by improving the heating system in administrative buildings on the basis of an energy audit is analyzed. The article examines the importance of heat energy spent to ensure a favorable microclimate in the building, losses in pipeline networks, the state of operation of radiators, hydraulic balance, the useful work coefficient of the boiler device and automatic control means. The calculations compared the area and volume of the building to be heated, indoor and outdoor air temperatures, heat loss due to ventilation, and the conditions of the heating system before and after modernization. The results showed that by making a comprehensive improvement of the heating system, heat consumption can be significantly reduced.

Keywords: energy audit, heating system, heat loss, boiler FIC, automatic control, thermostatic valve, energy efficiency.

On a global scale, the issues of rational use of energy resources and energy efficiency development have significant momentum. Buildings account for the bulk of energy consumption, with heat supply systems accounting for 30–40% of total energy consumption. Therefore, the

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improvement of heating systems in buildings is considered one of the most important areas of energy saving.

In the Republic of Uzbekistan, a number of programs are being implemented aimed at efficient use of energy resources, introduction of energy-saving technologies and also to reduce heat energy losses. Improving energy efficiency in buildings provides not only cost efficiencies, but also environmental sustainability.

Today, the rational use of energy resources and improving the energy efficiency of buildings is one of the urgent scientific and practical tasks. In administrative and service buildings a large amount of thermal energy is consumed to create a comfortable microclimate in the winter season. If the heating system is outdated, pipes are not insulated, radiators are not working properly or there are no automatic controls available, energy consumption will exceed normal.

The main function of the heating system is to maintain a set temperature in the room, to ensure the transmission of heat carrier from the source to the consumer and create comfortable conditions for users. In practice, heat losses in pipeline networks, hydraulic equilibrium disturbance, air leakage, low boiler FIC and manual control lead to excessive energy consumption of the heating system.

A legal and organizational framework for saving, rational use of energy and increasing energy efficiency has been created in the Republic of Uzbekistan. This is why it is important to conduct an energy audit of existing buildings, identify heat losses and develop technically sound modernization measures.

The study used methods of theoretical analysis, energy auditing, calculation of heat losses, estimation and comparison of specific heat load. During the energy audit, the building area and volume, indoor and outdoor air temperature, heating system elements, pipelines, radiators, ventilation and automatic controls were analyzed.

Classical equation for stable heat exchange was used to determine the calculations of heat loss:

$$Q = k \cdot A \cdot \Delta T$$

where: Q is the heat loss capacity, W; k is the coefficient of heat transfer, $W/m^2 \cdot K$; A — heat exchanger surface, m^2; ΔT is the difference between indoor and outdoor air temperatures, K.

The total heat loss of the building is determined by the following expression:

$$Qgeneral = Q_{wall} + Q_{window} + Q_{roof} + Q_{floor} + Q_{vent} + Q_{pipe}$$

The amount of heat lost through ventilation and air exchange is estimated by the formula:

$$Q_{vent} = 0.335 \cdot n \cdot V \cdot \Delta T$$

where: Q_{vent} — heat loss through ventilation, W; n — coefficient of air exchange, 1/hour; V — the volume of the building, m³; ΔT is the temperature difference, K.

Calculations

The calculations were carried out based on estimated conditions for the winter season. The following initial conditions were adopted for the analysis: internal air temperature +20 °C, calculated outside air temperature −7 °C, temperature difference ΔT = 27 K, building heated capacity 3136 m³, total area 896 m², air exchange coefficient n_1 = 0.5 1/h, in improved state n_2 = 0.35 1/h.

Heat loss through ventilation for the present state:

$$Q_{vent1} = 0.335 \cdot 0.5 \cdot 3136 \cdot 27 = 14184 \text{ W} = 14.18 \text{ kW}$$

For improved status:

$$Q_{vent2} = 0.335 \cdot 0.35 \cdot 3136 \cdot 27 = 9929 \text{ W} = 9.93 \text{ kW}$$

This means that heat loss through ventilation and air leaks is reduced to 4.25 kW.

The specific heat load per 1 m² area was taken as a basis in the estimation of the total load of the heating system. In the current state, the specific load was 80 W/m², after modernization it was 58 W/m².

$$Q1 = 896 \cdot 80 = 71680 \text{ W} = 71.68 \text{ kW}$$

$$Q2 = 896 \cdot 58 = 51968 \text{ W} = 51.97 \text{ kW}$$

$$\Delta Q = 71.68 - 51.97 = 19.71 \text{ kW}$$

The relative energy efficiency degree is determined as follows:

$$E = ((Q1 - Q2) / Q1) \cdot 100 = ((71.68 - 51.97) / 71.68) \cdot 100 = 27.5 \%$$

Results analysis

According to the calculations, due to the modernization of the heating system, the heat load will be reduced from 71,68 kW to 51,97 kW. The total savings is 19.71 kW, and the relative savings is 27.5%. In terms of ventilation and air leaks, heat loss decreased from 14.18 kW to 9.93 kW, resulting in a savings of 4.25 kW.

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Table 1. Indicators before and after the improvement of the heating system

bullet	Existing status	Enhanced state	Tejalish
Specific Heat Load	80 W/m²	58 W/m²	22 W/m²
General heat load	71.68 kW	51.97 kW	19.71 kW
Ventilation loss	14.18 kW	9.93 kW	4.25 kW
Energy Saving Degree	—	—	27,5 %

To determine the annual energy savings, it was assumed that the heating system works an average of 10 hours a day during the winter season, and the heating season for 150 days.

$$W = \Delta Q \cdot t \cdot z = 19.71 \cdot 10 \cdot 150 = 29565 \text{ kWh}$$

If the conditional cost of 1 kWh of heat energy is assumed to be 800 soums, then the annual cost savings will be as follows:

$$S = W \cdot C = 29565 \cdot 800 = 23652000 \text{ UZS}$$

This means that as a result of improvement of the heating system it is possible to achieve energy savings of about 29,565 kWh and 23.65 million soums of economy during one heating season.

The analysis showed that the increase in energy consumption in the existing heating system is caused by several technical and organizational factors. Lack of insulation of the pipeline networks leads to cooling of the conductor until the heat carrier reaches the radiators. If there is an air blockage or sediment in the radiators, the ability to give heat is reduced. And when the hydraulic balance is broken, some rooms overheat, and some rooms are not heated enough.

The results of the calculation show that modernization of the heating system is a justified solution not only from a technical point of view, but also from an economic point of view. Insulating the pipeline network, cleaning radiators, restoration of hydraulic balance, installation of thermostatic valves and the introduction of an automatic control system allow to reduce energy consumption and improve the quality of the microclimate in the room system.

At the same time, coating of exterior walls, roofs and floor surfaces of buildings with modern thermal insulation materials significantly reduces heat loss. According to the results of an energy audit, quality insulation can reduce energy consumption by 15–25%. Improvement of heating systems in buildings is one of the most important areas of improving energy efficiency. It is possible to significantly reduce energy consumption by improving thermal insulation, introducing automated control systems, using modern heating devices and integrating renewable energy sources. As a result, cost efficiency increases, operating costs decrease, and negative environmental impact is reduced.

In conclusion, the results of the research and calculations carried out showed that the improvement of the heating system in buildings is an effective direction of increasing energy efficiency. Excessive consumption of thermal energy is mainly caused by insulation of the pipeline network, improper operation of radiators, violation of hydraulic balance, lack of automatic controls, as well as air leaks.

According to the analysis, through comprehensive modernization of the heating system, it is possible to reduce the total heat load from 71.68 kW to 51.97 kW, that is, achieve an energy saving of 27.5%. It is calculated that energy saving in one heating season is about 29,565 kWh, and in monetary terms it will cost 23,65 million soums.

In general, the improvement of the heating system based on the energy audit serves not only to save energy and increase cost-effectiveness, but also to ensure a favorable microclimate inside the building, reduce the load on the heating system, and improve environmental safety.

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