Improving the energy efficiency of a residential building

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Abstract. The possibilities of introducing energy-saving technologies to increase the energy efficiency of an apartment building with a central heating system are considered. The efficiency of using heat energy will increase in accordance with the value of reducing heat loss to the environment. When implementing the project of the proposed energy-saving measures with effective overhaul, the energy efficiency indicator in terms of the specific consumption of thermal energy by a residential building can reach a value close to the base, and the efficiency class to normal D and claim to be increased C.

The energy efficiency of buildings is determined by a combination of many factors, the main of which in Russia are harsh climatic conditions in a large territory of the country [1], the relatively low cost of fuel and energy resources and the heat-shielding properties of external building envelopes [2]. Over 60% of the total volume of thermal energy consumed during the operation of residential buildings is accounted for by heating and ventilation [2, 3].

In the countries of the European Union, the largest consumers of energy (more than 40%), and their number is growing, are residential buildings and the service sector, despite the fact that most of these countries are located in temperate and warm climates. In this regard, the need to limit the consumption of fuel and energy resources and increase the energy efficiency of buildings is relevant.

Directives 2002/91 / EC and 2010/31 / EC (updated version) on the energy characteristics of buildings contain requirements for assessing and standardizing energy efficiency (certification - setting energy efficiency classes) of designed, new and operated public, occupied by public authorities and residential buildings [4].

Moreover, they are constantly and consistently improving, increasing demands not only on thermal insulation, but also on engineering systems for heating, ventilation, hot water supply and air conditioning. When designing new buildings, it is required to use local and centralized systems that operate in whole or in part on renewable heat resources and heat pumps. For reconstructed buildings and for overhaul, it is recommended to use the same sources, but with a feasibility study. Preferably, the design of new buildings with almost zero energy consumption.

After 2018, all new public buildings, and after 2020 all new residential buildings must meet the requirements for buildings with almost zero energy consumption. Until 2015, all existing buildings with a useful area of 500 m² and higher were certified according to the criteria of energy efficiency, and after that, houses with an area of up to 250 m².

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The main goals: reducing energy consumption, carbon dioxide emissions and increasing the share of renewable energy in the overall energy balance by 20% compared to 1990. An example of the EU is followed by Canada, the USA, Japan, Georgia, Armenia and Kyrgyzstan.

In Russia, for newly created buildings (including apartment buildings), structures, structures, the specific characteristic of the consumption of thermal energy for heating and ventilation decreases according to [5]: from January 1, 2023 - by 40%, from January 1, 2028 - by 50%.

Also, from January 1, 2023, for designed, reconstructed, overhaul buildings, with the exception of apartment buildings, it is recommended (if there is technical feasibility and a feasibility study) to install renewable and alternative sources of energy and secondary energy resources in engineering systems.

Thus, buildings become energy efficient, they provide the necessary level of comfort with standard or lower costs of thermal energy and the use of other types of energy - Figure 1 [6].

![Figure 1. Schematic diagram of an energy-efficient building](image)

The generally accepted energy characteristics of buildings of various categories are thermal protection and the specific annual consumption of thermal energy for heating, ventilation and hot water supply (in the European Union for a year, in Russia for the heating period).

The energy efficiency class of multi-apartment buildings (houses) in Russia is determined by the deviation of the actual total annual specific consumption of energy resources (heat energy for heating,
ventilation and hot water supply and electricity supply in terms of electricity consumption for common house needs) per 1 m² of the total area of apartments and useful the area of non-residential premises from the baseline for the heating period [3].

The basic levels depend on climatic conditions [1, 3] and the number of storeys of operated buildings (2, 4, 6-12 and higher) and for the city of Irkutsk are 330, 305, 293-275, respectively, including thermal energy for heating and ventilation 216 , 180, 144-126 kWh / m² per year.

When establishing the base level of the specific annual consumption of energy resources, the following design conditions were adopted: the temperature of the indoor air in the apartments is 20 °C, the population of 20 m² of the total area of the room per resident, which corresponds to the normative air exchange of 30 m³ / h per resident, and the specific domestic heat input 17 W / m² total area.

Actual values of the specific annual consumption of energy resources are reduced to design conditions, proportionally decreasing or increasing them by linear interpolation from the established design conditions. Depending on the deviation of the actual specific annual energy consumption from the base level, energy efficiency classes are established from A ++ (highest, deviation of –60%) to G (very low, deviation of more than +50%).

Consider the possibility of improving the energy efficiency of a residential multi-apartment five-story brick building located in the city of Irkutsk.

Its main characteristics: external dimensions: length - 30 m, width - 10 m, height - 15 m; the thickness of the walls of the facade (external fencing without thermal insulation) - 0.65 m; total area of apartments - 1395 m²; windows with wooden bindings; heating appliances - cast iron radiators.

There is a heating unit without automatic control of the temperature of the coolant, depending on the temperature of the outdoor air, but equipped with a common house meter for thermal energy. The heat consumption of a building, as a rule, exceeds that established by the contract with the energy sales company. So in 2019, the heat overrun (heat loss to the environment) amounted to about 9.3 thousand kWh.

Since there are no individual apartment-based heat energy meters in the building, automatic temperature control of the coolant depending on the outdoor temperature, energy-efficient (LED) lighting of common areas, the energy efficiency requirements, therefore, the energy efficiency class of this multi-apartment building cannot be established. Moreover, the energy efficiency class of a building determines the level of energy efficiency of a building’s energy consumption, which characterizes its energy efficiency during operation.

To reduce the loss of thermal energy into the environment and ensure comfortable living conditions for residents of an apartment building, it is proposed to prepare a project and carry out the following priority energy-saving measures when preparing and conducting major repairs of the building with mandatory confirmation of energy efficiency requirements [5].

Insulation of the building facade by restoration of damaged layers of the building plaster with painting or using modern thermal insulation materials. So when installing a ventilated (hinged) type of facade, a multilayer structure [7], consisting of a metal frame, a heat insulation layer 0.05 m thick (basalt mineral wool), air gap and cladding (siding), will reduce heat loss by 13.33% per annum thermal energy consumption.

Installation of modern heating devices (high-quality and aesthetic aluminum with anodic oxidation of surfaces or bimetal radiators [8] at the choice of apartment owners). Both types of radiators are designed for maximum pressure in the central heating system up to 1.5 MPa, corrosion-resistant to the quality of the coolant, it is possible to connect a temperature sensor and an automation system. The reduction in heat loss will be 5% of the annual heat energy consumption.

Insulation of plastic PVC profile windows [9, 10, 11], providing noise insulation, tightness (heat saving) and a comfortable microclimate. The reduction of heat loss when replacing all the windows in the building will be 12.24%, and the common house windows 1.1% of the annual heat energy consumption.

Installation of an electromagnetic common-house heat energy meter with automatic systems for taking readings and regulating the temperature of the coolant depending on the outdoor temperature [12,
13]. Installation and maintenance of a common house metering device is carried out at the expense of the supplier of resources [12]. The reduction in heat loss will be 10% of the annual heat energy consumption. In total, when implementing the proposed energy-saving measures, thermal energy savings will amount to 29.43% of its annual consumption, and when replacing all the windows in the building, 40.57%.

Specific brands of heat-insulating materials, types of windows, heating devices, heat metering systems and other installed equipment for the implementation of a project to improve the energy efficiency of a building are discussed and accepted by all owners of the apartment building.

In Russia, in accordance with the Federal Law [14,15,16], a Program of state support for energy efficiency projects for apartment buildings during capital repairs has been adopted and is working. A reimbursement of 70-80% of the cost of implementing energy-saving measures with an expected efficiency of at least 10% is envisaged.

For this, the meeting of owners should determine and unanimously adopt the list and cost of the work, select the contracting organizations for their implementation and submit an application to the Government.

When implementing the project of the proposed energy-saving technologies during energy-efficient capital repairs, the energy efficiency indicator of the building in terms of specific heat consumption can reach a value close to the base (see above), and the efficiency class [3] to normal D and claim to be higher C.

Confirmation of the energy efficiency requirements of an apartment building [5] is provided by managing organizations of homeowners, housing and other specialized cooperatives that manage apartment buildings using the instrumental calculation method (energy examination with the development of an energy passport of the building).

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