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Оценка энергоэффективности зданий общежитий ФГАОУ ВО «СПбПУ Петра Великого»

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Аннотация. Работа посвящена определению класса энергоэффективости зданий общежитий, располагающихся в Санкт-Петербурге. Было обследовано 6 зданий с определением их основных параметров. В результате проведенной работы согласно определенному классу энергоэффективности для некоторых зданий были предложены меры по проведению реконструкции для повышения класса энергоэффективности. Для остальных общежитий реконструкция возможна только с большими экономическими затратами.

Ключевые слова: Энергоэффективность, класс энергоэффективности, сопротивление теплопередаче, строительство, реконструкция, утепление.

Energy efficiency assessment of Peter the Great Saint-Petersburg Polytechnic University's dormitories

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Abstract. The research is devoted to definition of a building's class of energy efficiency of the dormitories, which are located in St. Petersburg. Six buildings were inspected with determination of their key parameters. According to the calculated energy efficiency, class measures for carrying out reconstruction were proposed for increase in a class of an energy efficiency for some buildings. For other dormitories, reconstruction is possible with big economic costs.

Keywords: Heat transmission resistance, energy efficiency, energy efficiency class, civil engineering, reconstruction, heat insulation.

Introduction

The problem of energy efficiency of buildings and constructions in our country becomes more and more significant every year. The construction of modern buildings in Russia is made according to requirements of 261 federal law. According to this law, the construction shall be conducted taking into account actions for providing an energy efficiency. Russia takes the third place in the world on the total volume of energy consumption and its economy differs in the high level of power consumption (amount of energy per unit of GDP). On energy consumption volumes in the country first place is won by manufacturing industry, in the second place — housing sector (about 25% at everyone).

The energy efficiency and energy saving enter 5 strategic directions of priority technology development designated on commission session on upgrade and technology development of economy of Russia on June 18, 2009. One of the most important strategic tasks of the country - to reduce by 2020 power consumption of domestic economy by 40%. Realization requires creation of a perfect control system of energy efficiency and energy saving.

The indicator of energy efficiency is used for energy efficiency assessment for products or engineering procedure. It estimates consumption or losses of energy resources [1-3].

The provided energy characteristic of the building needs to be determined for assessment of a general energy consumption of the building, which would contain power consumptions of various nature in the amount.

Design and construction specifications 50.13330.2012 "Thermal protection of buildings" [4] allows to calculate a class of energy efficiency of buildings proceeding from their key parameters - total area of the enclosure structures, the area of a glazing, type definition of heating system and ventilation, thickness and structure of the enclosure structure, an arrangement of buildings on parts of the world, the heated amount and the area. The choice of actions for increase in thermal protection in case of buildings reconstruction is recommended to conducted on the basis of technical and economic comparison of project solutions of increase or replacement of a heat-shielding of separate types of the building protecting structures (garret and socle overlapping's, face walls, facade walls, translucent structures and other). It is necessary to begin with increase in operational qualities of cheaper options of the enclosure structures.

Literature review

The following scientists enclosed the significant contribution to the solution of the theory and practice of energy efficiency and protecting designs: A.S . Gorshkov, V.G. Gagarin, M.S. Trutneva, O.D. Samarin, I.N. Butovsky, M.N. Efimenko, Yu.A. Tabunshchikov, L.D. Boguslavsky, V.K. Savin, V.A. Yezerskiy, P.V. Monastyrev, R.Yu. Klychnikov. and many others. The actions directed on reduction of losses of heat and increase of level of thermal protection of external protecting designs always demanded an economic justification. Payback of such actions investigated L.D. Boguslavsky, V.G. Gagarin, O.D. Samarin, etc. [5-7].

The most consecutive and reasonable approach is developed by V.G. Gagarin. He offered improved mathematical model of conditions of an economic return on increase of level of thermal protection, which considered also discounting of economy of operational expenses. According to its model, the major parameter defining economic conditions of increase of thermal protection of protections in the country or the region, limit value for one-time costs is. In the articles V. G. Gagarin compared value of interest rates, and also degree-days of the heating period and the price of thermal energy in the cities of the Russian Federation and EU countries and the CIS and revealed that conditions for increase of thermal protection of buildings in Russia are less favorable, than in the developed countries [8, 9, 10].

A.S. Gorshkov develops the schedule of dependence of thermal losses through 1 sq.m of a protecting design from the specified resistance to a heat transfer, from where it is visible that change is shown in hyperbolic dependence, however notes possibility of economically inefficient capital expenditure for construction of designs for decrease in expenses on heating. The author cites the schedule to determine the optimum thickness of the wall structure by the method of reduced costs. He produces the diagram to determine the optimum thickness of the walls of aerated concrete with different useful life [11,12].

Markov's article describes the experience of the design and construction of energy efficient buildings, talks about the principles of formation for such buildings (architectural, urban planning and engineering solutions energy saving). The present article focuses on the experience of designing «passive» houses in Darmstadt. It describes the experience of designing, a model of a residential complex of energy efficient buildings for the conditions of the Gatchina District, Leningrad Region, architectural planning, design, engineering solutions of the complex and technologies of renewable energy in this model [13-15].

N.I. Vatin, D.V. Nemova, P.P. Rymkevich. in the research carry out the analysis of influence of level of thermal protection of protecting designate sizes of losses of thermal energy, operational expenses and expenses fuel energy resources during the heating period (in 10, 30 and 50 years of operation buildings) on the example of one residential multiroom building. At the heart of the analysis calculation of transmission losses of thermal energy (heat losses lies through external protecting designs – walls, windows, entrance external doors, a covering etc.) the residential multiroom building for the heating period in relation to the climatic to conditions of the city of St. Petersburg [16-18].

According to review of the literature, previously released publications had no direct target to increase the building's energy class and upgrade its energy efficiency [19]. Methods, discussed in this article, makes possible for everyone to analyze and identify the necessary steps for reconstruction of residential or public building.

Purpose and goals of article

Determination of the energy efficiency class of the campus of the subway station "Lesnaya" of Peter the Great Saint-Petersburg Polytechnic University became the purpose of this article. Following the results of the article, it is supposed to offer a number of actions for reconstruction of dormitories for increase in their energy efficiency. The following tasks have been solved for performance of a research:

- definition of the dormitory's main characteristics
- carrying out the analysis of basic data of dormitories for calculation of the energy efficiency class according to Design and construction specifications 50.13330.2012 "Thermal protection of buildings"
- the offer of actions for dormitory's reconstruction and calculation of the energy efficiency class after reconstruction.

Materials and methods

Assessment of energy efficiency was conducted for the following dormitories:

Table 1. Name of the building. Address.

№	Name of the building	Address
1	Dormitory № 1	St. Petersburg, Lesnoy ave., 65, k.1, building A
2	Dormitory № 3	St. Petersburg, Lesnoy ave., 65, k.3, building B
3	Dormitory № 4	St. Petersburg, Pargolovskaya St., 11, k.1, building A
6	Dormitory № 6 and 6F	St. Petersburg, Harchenko St., 16, building A
7	Dormitory № 7	St. Petersburg, Lesnoy ave., 67, k.2, building A
8	Dormitory № 11	St. Petersburg, Kantemirovskaya St., 24, building A

On the surveyed objects were collected data for calculation of energy efficiency. Thickness and the areas of walls, doors, windows, and thermal resistance were measured. The volume of the heated rooms, type of heating system and ventilation according to technical passport of buildings was defined. Initial data are given in table 2:

Table 2. Initial data.

Dormitory №	V_h,m^3	A_w, m^2	R_w^r, m^2·°C/W	A_F ,m^2	R_F^r, m^2 °C/W	A_{ed}, m^2	R_{ed}^r, m^2 °C/W	A_l, m^2
1	70875	2586,2	1,78	1018,6	0,34	25,12	0,26	12896,1
3	15700	2447,49	0,854	530,07	0,34	8,64	0,26	2292,5
4	44929	5898,11	1,36	732,16	0,34	257,16	0,26	9862,5
6	47792	4018,29	1,36	2669,5	0,34	30,72	0,26	10095,7
7	19368	1683,852	1,18	43,68	0,34	43,68	0,26	2677,6
11	44929	5898,11	1,36	732,16	0,34	257,16	0,26	9862,5

A_w, A_F, A_{ed}, A_l, A_f – area of walls, windows, external doors and gates, coverage (garret floors), socular floors (or platforms on soil);

R_w, R_F, R_{ed}, R_c, R_f – reduced of heat transmission resistance of existent external envelops;

V_h – heating volume of building, m^3;

Assessment of the energy efficiency class is determined by percentage of normalized the specific expense on heating and ventilation for the heating period and received from calculations.

According to this relation of the building are divided into the classes given in table 3.

Table 3. Classes of building’s energy efficiency [4].

Energy efficiency class	Class name	The size of a deviation of calculated (actual) value of the specific characteristic of an expense of heat energy on heating and ventilation of the building from normalized, %	The recommended actions developed by territorial subjects of the Russian Federation
At design and exploitation of the new and reconstructed buildings			
A++	Very high	Lower -60	Economic stimulation
A+		From -50 to -60 inclusive	
A		From -40 to -50 inclusive	
B+	High	From -30 to - 40 inclusive	Economic stimulation
B		From -15 to -30 inclusive	
C+	Normal	From -5 to -15 inclusive	Actions aren't developed
C		From +5 to -5 inclusive	
C-		From +15 to +5 inclusive	
At expluatation of the existing buildings			
D	Low	From +15,1 to +50 inclusive	Reconstruction at the corresponding economic justification
E	Very low	More than +50	Reconstruction in case of the corresponding economic case, or demolition

According to the obtained data, calculations were carried out of the specific characteristic of an expense of heat energy on heating and ventilation. Calculations were performed according to Design and construction specifications 50.13330.2012 "Thermal protection of buildings".

Table 4. Calculated and basic specific characteristics of an expense of heat energy on heating and ventilation of buildings.

№	Dormitory number	The normalized (basic) specific characteristic of an expense of heat energy on heating and ventilation of buildings ,$W/m^3{}^\circ C$	Calculated specific characteristic of an expense of heat energy on heating and ventilation of buildings, $W/m^3{}^\circ C$	Energy efficiency class
1	Dormitory № 1	0,359	0,334	C+
2	Dormitory № 3	0,359	0,587	D
3	Dormitory № 4	0,359	0,435	D
6	Dormitory № 6 and 6F	0,359	0,497	D
7	Dormitory № 7	0,319	0,633	D
8	Dormitory № 11	0,359	0,549	D

Proceeding from a class of energy efficiency for dormitories with a class "D" it is necessary to carry out works on reconstruction for the purpose of increasing energy efficiency classes.

It is reasonable to vary value of the wall thermal resistance, carrying out works on insulating of facades. It is the most economic and effective method of changing of an expense of heat power in the building, because thermal resistance - one of the most significant coefficients of a settlement formula. Modern technologies allow carrying out insulation of facades without eviction of residents from buildings that is very urgent in relation to dormitories behind impossibility to move students for the period of carrying out reconstruction.

In the research, we revealed a pattern of the specific drain of energy on heating and ventilation on the building thermal resistance of an external wall for matching insulation with optimum characteristics.

Diagram shows this dependence for the researched dormitories according to Design and construction specifications 50.13330.2012, the normalized value of the specific characteristic of drain of heat energy is noted for two types of buildings with different number of stories.

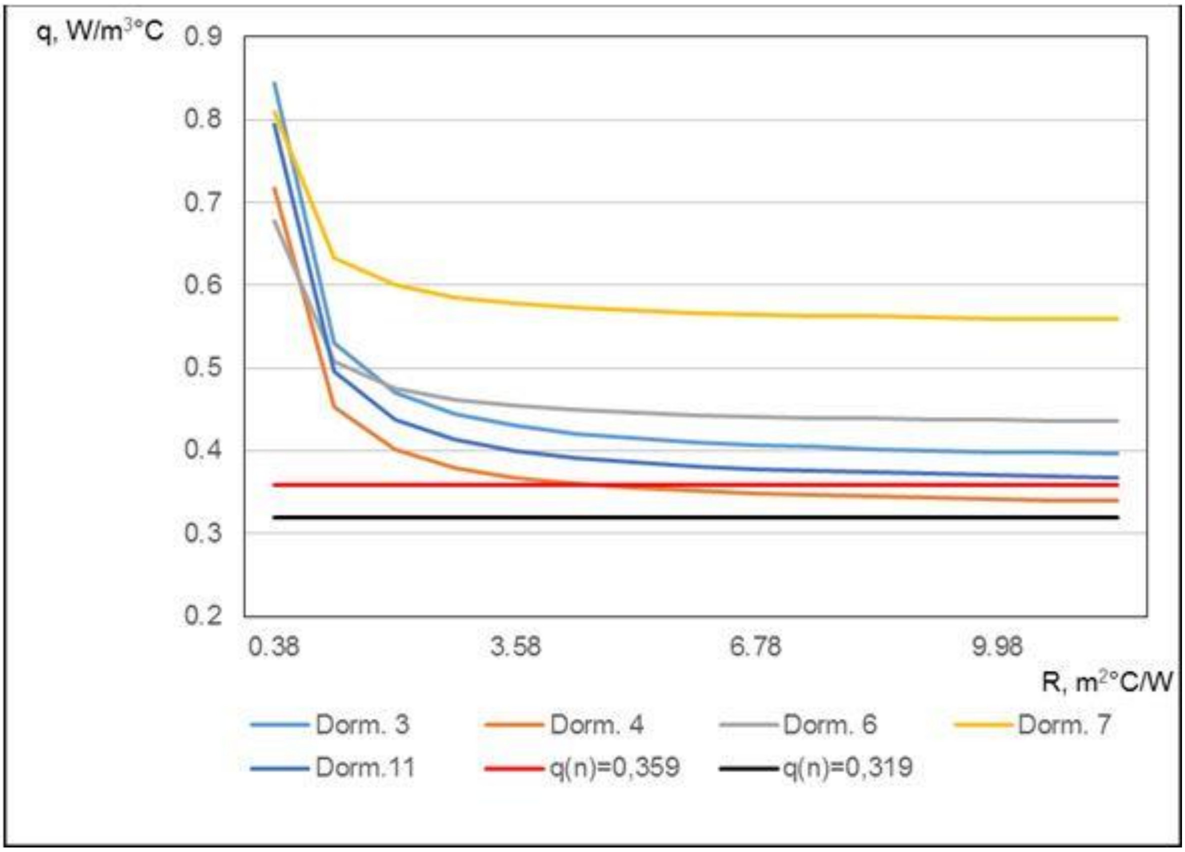

Fig. 1. Specific drain of energy on heating of building dependence of thermal resistance of the wall.

According to the schedule it is visible that for each dormitory the specific characteristic of an expense of heat power on heating and ventilation aims at a certain value in case of changing of thermal resistance of a wall. It follows, that for those dormitories, which schedule has crossing with a line of standard value of the characteristic of TE consumption or it is at least close to it, there is an opportunity to achieve increasing of energy efficiency class by insulating external walls. Otherwise, there is no possibility of increasing energy efficiency by using insulation.
For buildings, which class of an energy efficiency can be raised by changing the thermal resistance of walls, in article was carried out calculation for matching of a heater optimum on energy and economic indicators. Its brand, the price and required thickness is given. Dormitory's energy efficiency class after carrying out reconstruction is also determined.
ISOVER FACADE insulation material was used for dormitory №4 and №11. It has rather low price and value of heat conductivity 0,037 m^2K/W.

Table 5. Insulation Data.

Name of insulation material	Price, rub/m^2	Thickness, mm
ISOVER FACADE	256	100

Also the analysis of the new dormitory's enclosure structure on an arrangement of a condensation zone has carried out with use of this insulation. The calculator of heat losses "SmartCalc" was used for creation of the schedule.

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According to the schedule the condensation zone in a wall is absent. It means that the design is correctly designed. The design will serve longer, remoistening of a heater won't be observed during operation.

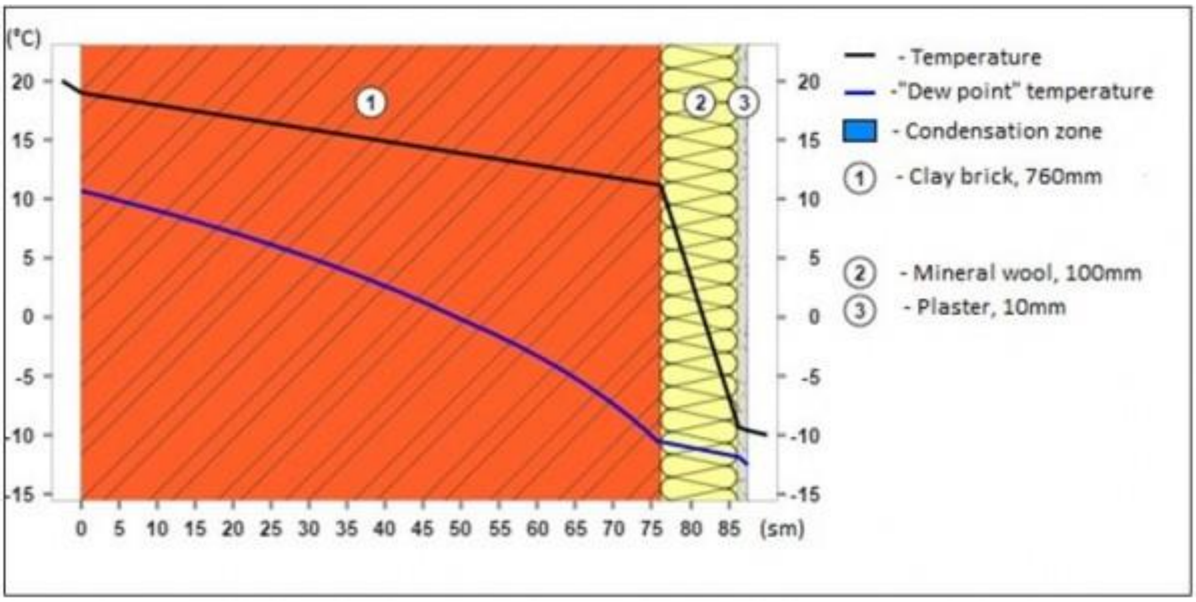

Fig. 2. Condensation zone.

For buildings, which class of an energy efficiency can't be raised by changing the thermal resistance of walls we conducted a research directed on changing the resistance of windows and doors. This change did not lead to increase in a class as owing to the small area of windows and doors in comparison with the total area enclosure structures, changing of thermal resistance of windows and doors has a little effect on the specific consumption of premises heat-energy.
For buildings, which class of energy efficiency can't be raised by changing of thermal resistance of walls it is inexpedient to carry out reconstruction by insulating of the existing enclosure structures. It is necessary to conduct measures for reconstruction of the building in general. These dormitories are badly architecturally designed, have the big heated area at the small area of premises.
By results of calculation, it has been revealed what dormitories need reconstruction according to a certain class of energy efficiency.

Table 6. Reconstruction according to results of calculation.

Number of the dormitory	Energy efficiency class	Results of calculations
Dormitory №1	C	Reconstruction isn't required
Dormitory №3	D	The class "C" is reached using: 1) Mineral wool insulation, δ=500 mm

		2) Mineral wool insulation, δ=170 mm at a thickness of double-glazed window of 130 mm. Conclusion: Reconstruction by insulation of external walls is inexpedient from the economic point of view. Building is not energy efficient.
Dormitory №4	D	The class C is obtained with use of "ISOVER FACADE" insulation, δ=100 mm Thermal resistance of a wall after reconstruction: R_w^r = 4,16 (m^2·°C/W)
Dormitory №6	D	Big economic costs for reconstruction. Building is not energy efficient.
Dormitory №7	D	Big economic costs for reconstruction. Building is not energy efficient.
Dormitory №11	D	The class C is obtained with use of "ISOVER FACADE" insulation, δ=100 mm Thermal resistance of a wall after reconstruction: R_w^r= 4,16 (m^2·°C/W)

Discussion

Other authors already conducted similar calculations for determination of the energy efficiency class of buildings. D.V. Nemova. carried out calculation of thermal loadings and compared to the standard the actual values. In addition, the review of measures on increase of energy efficiency of the building and constructions is carried out, relevance of calculations of terms of their payback and definition of their cost intensity or efficiency is revealed [20].
D.V. Nefedova, D.S. Tarasova presented results of energy inspection of educational building “Gidrocorpus-2” of Peter the Great Saint-Petersburg Polytechnic University [21]. In both articles a number of actions has been offered on reconstruction and increase in a class of energy efficiency of buildings.
However, in this article authors have made deeper analysis with definition of actions for increase in a class of energy efficiency. Conclusions can be drawn about the energy efficiency class of dormitories, and with the minimum costs to provide decrease energy consumption and to increase comfort of accommodation at them applying results of this article. The technique of

calculations for materials matching for similar actions is applicable for any buildings that does it by the universal decision for increase the energy efficiency class of buildings.

Conclusion and results

For the purpose of reduction of costs of administration of Peter the Great Saint-Petersburg Polytechnic University's campus on heating, and also for ensuring comfortable accommodation in dormitories of the campus, which is located on the subway station "Lesnaya", it is necessary to insulate protecting structures of dormitories. The building of the dormitory №1 has "C+" energy efficiency class. This class corresponds to energy efficient buildings, so reconstruction is not required.
Winterization of dormitories №11 and №4 will be effective, after reconstruction buildings will become energy efficient.
For dormitories №3, №6, №7 energy efficiency class "C" cannot be reached by insulating external walls, reconstruction can be carried out only with big economic costs - these buildings are not energy efficient. For such buildings, it is necessary to carry out complex reconstruction. It includes technical inspection of the building, inspection of designs and soil, engineering networks, acoustic inspection, creation of project drawings with indication of problem zones.
In the article we considered the least costly method on increase in a class of the building energy efficiency. Therefore, by results of calculation, only for dormitories №11 and №4 it is possible to raise an energy efficiency class in such a way.

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