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The Procedure Of Substantiation Of Selection Of The Energy-Efficient Design Solutions For Residential Buildings

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Abstract

The paper is dedicated to the theoretical and experimental studies in the area of increasing the energy efficiency of the residential buildings and to the solution of the tasks of saving energy resources by development and implementation of the target program of energy-saving in the housing fund of municipal education. According to the Federal Law d/d 23.11.2009 № 261-FL 'On energy saving and improving the energy efficiency and on introduction of alterations to separate legal acts of the Russian Federation' the key tools for improvement of the energy efficiency of the economy of the constituent entities of the Russian Federation and economy of the municipal units are the long-term target programs. The paper considers the information model of the resource-engineering support of the energy sanation of the residential fund on the basis of which selection of the energy efficient solutions for residential buildings at the pre-design stage of reconstruction or major repairs is performed. The main links of this system are the units of the economic and the technical evaluation of the design solutions on the basis of which the most efficient of them are defined. The paper presents the results of experimental studies in the area of improvement of energy-efficiency by reconstruction of the urban area.

Keywords: resource-engineering model, energy-saving, residential stock, target programs, organizational-engineering support.

1. INTRODUCTION

During the recent years a number of regulatory documents upgrading the legal framework in the area of the housing and public utilities sector were adopted [5]. This was determined primarily by unsatisfactory state of the residential stock, increase in

the number of the ramshackle and substandard building, high level of the public services cost and low energy efficient performance of the. [1, 2, 3, 4]

In order to solve these problems amendments N 271-ФЗ d/d December 25, 2012 to the Housing Code have been accepted that change the mechanism of organization of the capital repairs system at the expense of the owners' contributions and by means of establishing a fund at specialized non-commercial organizations performing activities aimed at conduct of capital repairs of the common property in multi-family houses.

According to the FL № 261- Article 11 paragraphs 6 and 7 the design solutions shall ensure compliance of the buildings and facilities with the requirements to energy efficiency and equipping with metering devices for measurement of the energy resources consumed by means of selection of the optimal architectural, functional-engineering, structural solutions and appropriate implementation thereof by construction, reconstruction, capital repairs. It is not allowed to perform commissioning of buildings and facilities constructed, reconstructed and subjected to capital repairs that do not meet the relevant requirements to energy efficiency and equipping with metering devices for measurement of energy resources consumed.

Because of the limited financial possibilities by planning of the budget for performance of the energy sanation of the residential stock the design of the most efficient organizational-engineering solutions on the basis of the information support of the energy sanation of the residential stock becomes rather topical.

2. INFORMATION MODEL OF THE RESOURCE-ENGINEERING SUPPORT OF ENERGY SANATION OF THE RESIDENTIAL STOCK

Adoption of the efficient organizational-engineering solutions on the energy sanation of the residential stock is based on the resource-engineering modeling of parameters included in the list of the compulsory energy measures (Fig. 1). The information support of the system designed is based on the maintenance and updating of the database of the design solutions for energy sanation of the residential buildings and the relevant design specifications and estimates.

The procedure of estimation of the organizational-engineering solutions for energy sanation of the residential stock consists of the following stages:

I stage. Collection of information about energy parameters of the residential buildings;

II stage. Determination of the energy efficiency class and comparison with minimum permissible heat-insulating parameters;

III stage. Design of the energy-saving options;

IV stage. Engineering and economic evaluation of the solution adopted.

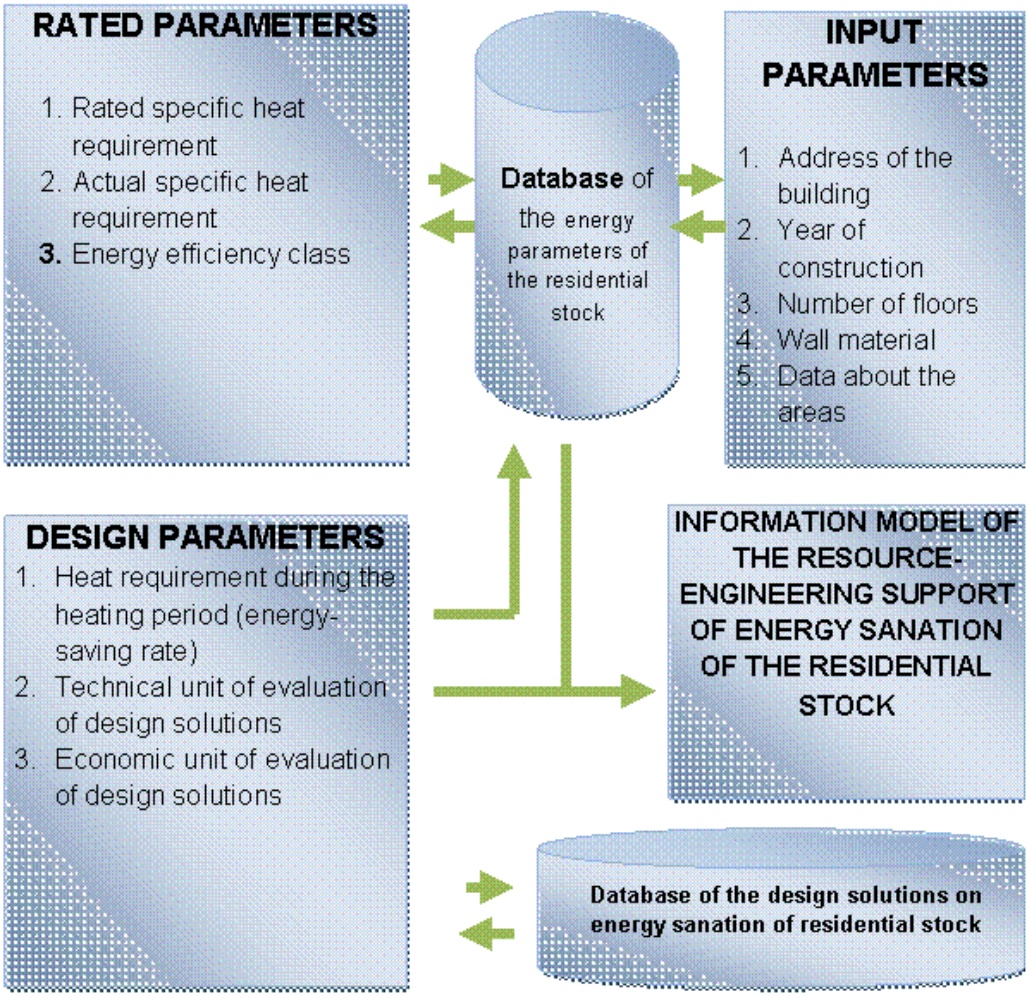


Fig. (1) – INFORMATION MODEL OF THE RESOURCE-ENGINEERING SUPPORT OF ENERGY SANATION OF THE RESIDENTIAL STOCK

According to the proposed procedure the algorithm of selection of the most efficient organizational-engineering solutions by energy sanation of the residential stock presented in the Fig. 2 has been designed that is implemented in the information model.

The use of the information model designed allows estimating the necessity of implementation of the compulsory energy measures and provides the aggregate cost estimate at the pre-investment stage already.

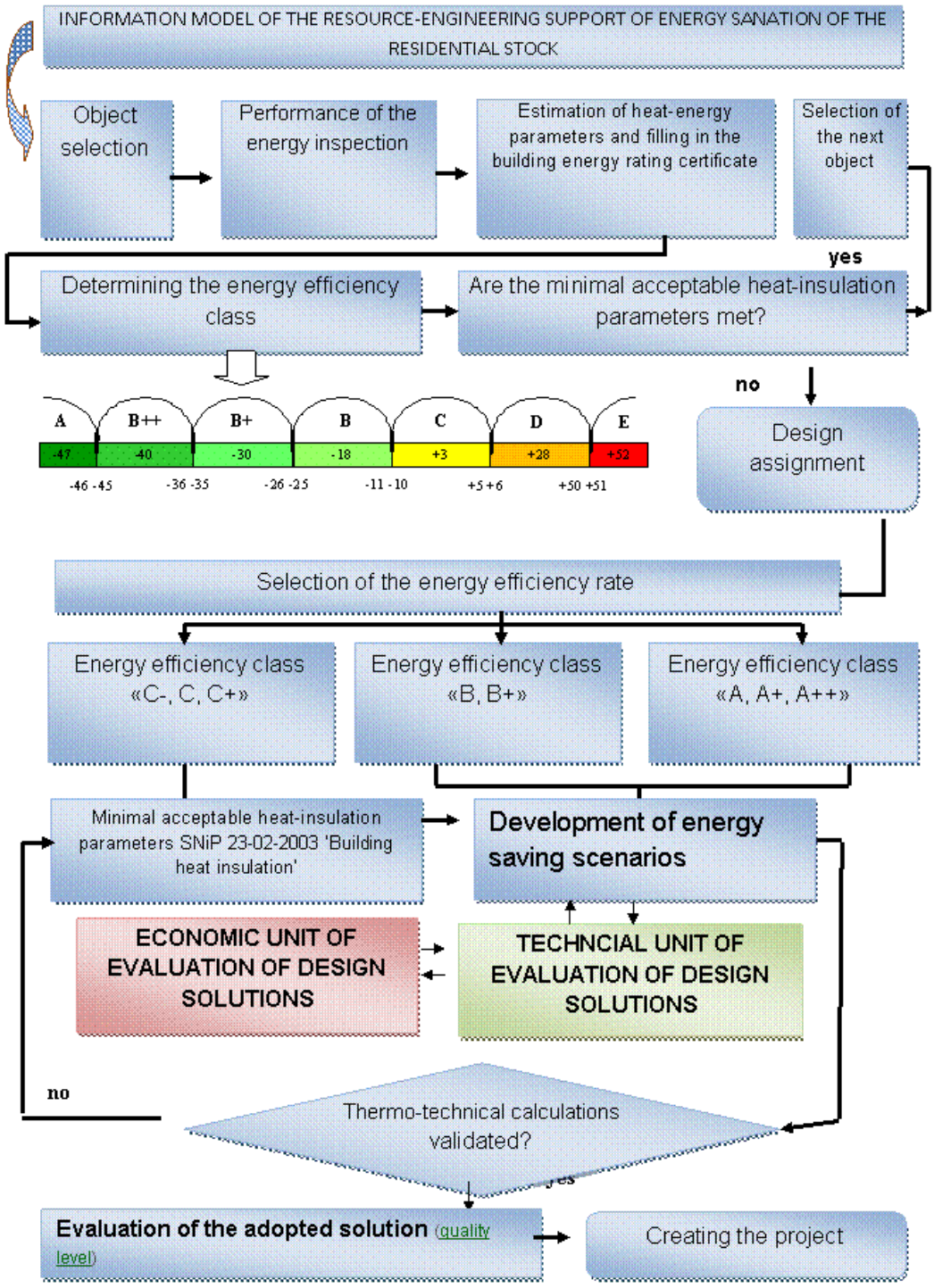


Fig. (2). – Algorithm of selection of the organizational-engineering solutions by energy sanation of the residential stock

3. INFORMATION SYSTEM OF TECHNICAL EVALUATION OF SELECTION OF THE DESIGN OPTIONS

The technical unit of evaluation of design solutions represents the information system (Figure 3) in which the compulsory measures on the energy sanation of the residential buildings with the use of the modern and traditional materials and engineering equipment are collected and systematized.

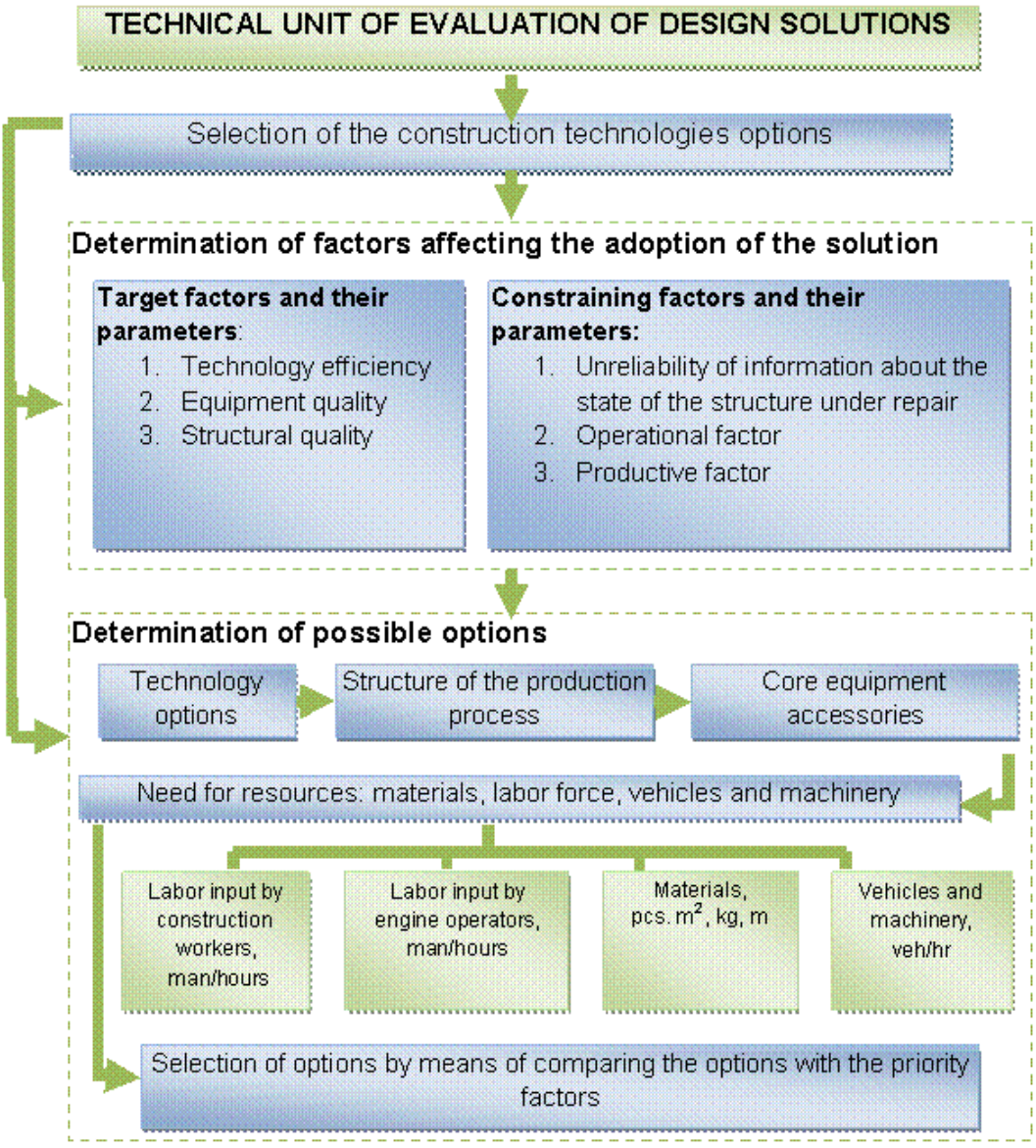


Fig. (3). – Information system of technical evaluation of the design solutions options

Selection of the optimum alternative of the design solution by technical evaluation of the design options is achieved by means of comparing the alternatives

with the priority factors and parameters divided into the target and constraining ones. The target factors refer directly to the technology, equipment used and state of the structure after mounting and repair and the external (constraining) factors – to the initial state of the structure (before repair), conditions of performance of the construction and repair works and further use of the structure [9,10].

The list of the compulsory energy measures was adopted on the basis of the Act N 887 d/d September 13, 2012 of the Russian Federation [6] that includes the following actions:

1. Heat insulation of the facade;
2. Heat insulation of roofs and attics;
3. Replacement of windows and door assemblies;
4. Upgrading the heating and hot-water supply systems;
5. Upgrading the electric power supply system.

4. ECONOMIC UNIT OF EVALUATION OF DESIGN SOLUTIONS

For the economic unit the evaluation of the design solutions cost on the basis of the resource-engineering model was (REM) proposed (Fig. 4) that allows:

- estimating the cost of the energy-efficient measureопределить стоимость at current prices at the initial stage of the project evaluation and design the feasibility report;
- estimating the cost of measures with account for the cost inflation for comparison of the options and selection of the most efficient design solution taking into consideration the regional conditions and market environment;
- to provide the cost evaluation of the scheduled construction or capital repairs at the pre-investment stage;
- to formulate the cost indicators of the target program of improvement of energy-efficiency in the residential stock.

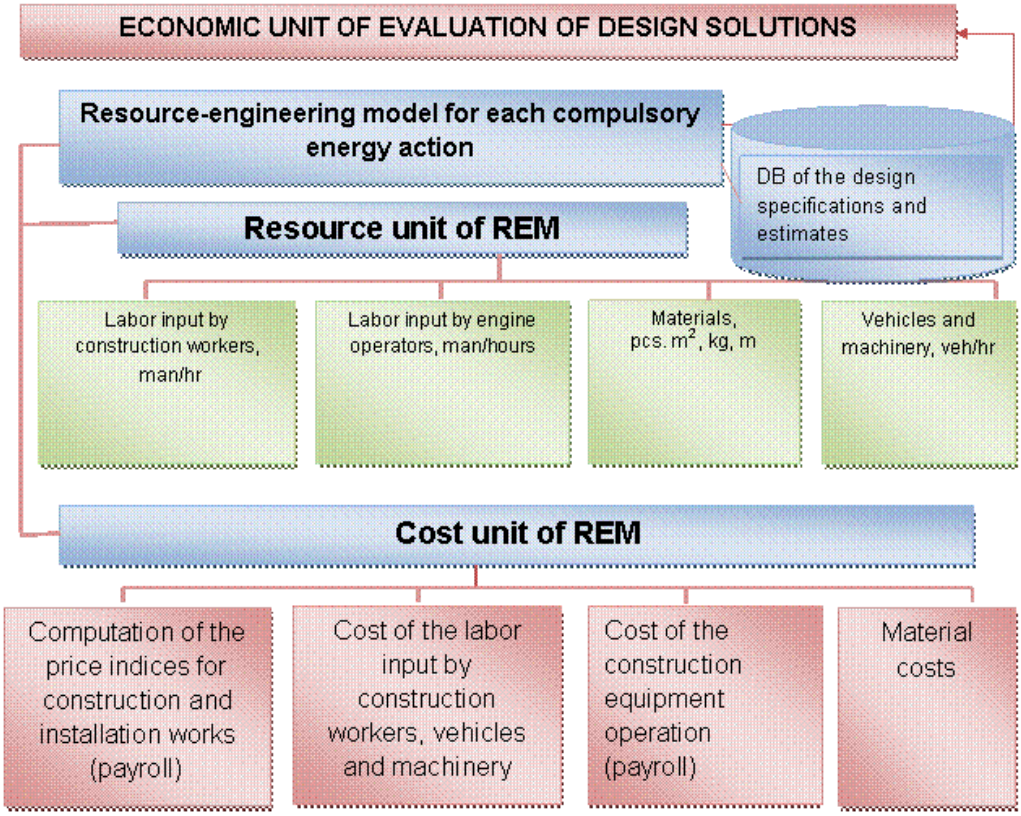


Fig. (4). – Economic evaluation of options on the REM-basis

5. EXPERIMENTAL STUDIES IN THE AREA OF IMPROVEMENT OF ENERGY EFFICIENCY OF THE RESIDENTIAL BUILDINGS

In order to get the initial parameters to be included in the resource-engineering model the experimental studies in the area of improvement of the energy efficiency were performed at the 3 comparable objects selected on the basis of classification of the reference residential stock [7] located in Rostov-on-Don at the addresses: Belomorsky pereulok, 20G, prospect of the 40th anniversary of Victory, 67/1, Tupoleva St., 8/1, the information about which before the energy sanation is presented in the Table 1.

Table 1 – Information about the comparable objects under consideration

Address, Rostov-on-Don	Number of floors	Year of construction	Material of enclosing structures	Heat source specifications
Belomorsky pereulok, 20 G	5	1972	sheet	centralized, without thermostats and auto-regulation
Prospect of the 40th anniversary of Victory, 67/1	5	1976	large-block	from an individual heating unit at the building basement. The individual heating unit is equipped with a heat accounting unit.
Tupoleva St., 8/1	2	1968	brick	centralized, without thermostats and auto-regulation

According to the design solutions prepared at each of the mentioned objects the capital repairs with the compulsory energy actions specified in the Table 2 have been performed.

The thermovision inspections of buildings at the addresses: Belomorsky pereulok, 20G, prospect of the 40th anniversary of Victory, 67/1, Tupoleva St., 8/1 performed during 2 years after completion of capital repairs showed that the class of their energy efficiency increased to C – 'Normal'. At the same time the average heat requirement was reduced by up to 35 %.

On the basis of the design specifications and estimates executed with account for the regional unit prices for the Rostov region with the use of the program GRAND-Smeta and procedure specified in MDS 81-17.2000 [8] the resource-engineering models for the compulsory energy actions were designed, the information about which is presented in the Table 3.

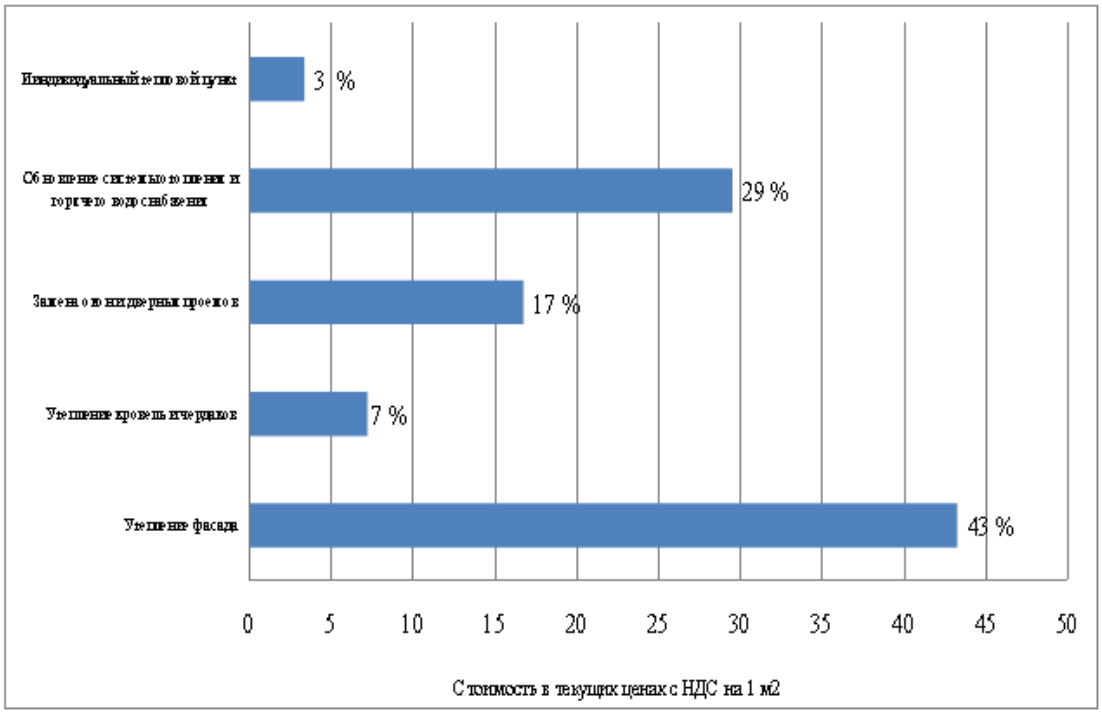
Table 2 – Series of actions aimed at improving the energy efficiency of the comparable objects

Address	Class of energy efficiency before capital repairs	Heat-transfer resistance of external walls, $m^2°C/W$	Series of actions aimed at improving the energy efficiency
Belomorsky pereulok, 20 G	E 'Very low'	1,643	– heat insulation of roofs and facades; – upgrading the heating system; – replacement of windows; – upgrading the electric power supply system
Prospect of the 40th anniversary of Victory, 67/1	E 'Very low'	0,641	– heat insulation of facades; – upgrading the heating system; – replacement of windows; – upgrading the electric power supply system
Tupoleva St., 8/1	E 'Very low'	0,695	– heat insulation of facades; – replacement of windows

Table 3 – Figures of the resource-engineering models for compulsory energy actions

REM	Address	Cost estimate for urban development at the level of the estimate standards and prices introduced since 01.01.2001			Cost at the current prices 2014, VAT included per 1 m^2, RUR
		Labor costs, RUR	Machinery and vehicles, rubles	Materials, rubles	
1	Heat insulation of facades	190219,6	60842,1	12366,3	1022,9
2	Heat insulation of roofs and attics	8730,4	1939,8	35394,4	170,8
3	Replacement of windows and door assemblies	3629,7	714,43	126309,1	395,4
4	Upgrading the system of the heat and hot-water supply	32446,5	17102,72	298 963,7	697,4
5	Individual heating unit	1 122,9	194,87	42 117,7	79,5

Analysis of the structure of the unit cost of energy sanation per 1 m^2 of the average area showed that the most expensive works is ‘Heat insulation of the façade’ – 43 %. “Upgrading the heating and ventilation systems’ makes 29 % of the unit cost, ‘Replacement of windows and door assemblies’ – 17 %, ‘Heat insulation of roofs and attics’ – 7 %, ‘Installation of an individual heating unit’ – 3% (Fig. 5).



Индивидуальный тепловой пункт – Individual heating unit
Обновление системы отопления и горячего водоснабжения – Upgrading the heating and hot-water supply systems
Замена окон и дверных проемов – Replacement of windows and door assemblies
Утепление кровель и чердаков – Heat insulation of roofs and attics
Утепление фасада – Heat insulation of the façade
Стоимость в текущих ценах с НДС на 1м2 – Cost at the current prices including VAT per 1m2

Fig. (5). – Structure of the cost of compulsotry energy actions on the REM-basis

The data obtained were included in the economic unit and are used as the basic parameters of the resource-engineering model of the cost estimate of compulsory energy actions.

6. SUMMARY

The procedure of the stepwise evaluation of the organizational-engineering solutions for the energy sanation of the residential stock was proposed that allows estimating the necessity of implementation of the compulsory energy measures and provides the aggregate engineering estimate: the materials, work labor input, vehicles and mechanisms requirements.

Further modeling by the engineering uniform groups of material resources, wage level, cost of the construction equipment operation, overhead expenses and estimated profit, will allow providing the aggregate cost estimate thereof.

CONFLICT OF INTERESTS

The author confirms that the studies performed, the model and algorithm are based on analysis of results of studies by the foreign [11] and Russian researchers [12, 13] concerning the issues of energy-saving and do not contain a conflict of interest.

ACKNOWLEDGEMENTS

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