Results of implementation of the Energy Efficient Quarter program in the pilot territory

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Abstract. In Russia, a large number of the state projects of programs of energy saving and increase in energy efficiency is implemented. It is possible to consider the Energy Efficient Quarter program implemented in several cities of Russia as one of such projects. In this article, the results of implementation of this program in the city of Tyumen in the pilot territory are described. The content of actions, the estimated indicators and costs for the implementation of these actions are specified

1 Introduction

In the modern world, energy is the basis for the development of basic industries that determine the progress of social production. In all industrialized countries, the pace of energy development has outpaced the pace of development of other industries.

Despite the factors of the negative impact of energy on the environment, the increase in energy consumption did not cause particular alarm among general public, as it was clear how this effect could be reduced from technical point of view. This continued until the mid-70s of the last century, when experts had in their hands numerous data indicating a strong anthropogenic pressure on the climate system, which poses a threat of global catastrophe with an uncontrolled increase in energy consumption [1].

Since then, no other scientific issue has attracted such close attention as the issue of real, and in particular, upcoming climate change. It is believed that the main reason for this change is energy, and energy means any area of human activity related to the production and consumption of energy.

However, a correct analysis of the issue of upcoming climate changes and their consequences is possible only with all the factors taken into account. At the same time, undoubtedly, it is necessary to bring maximum clarity to the question of how global energy consumption will be changed in the near future, whether humanity should establish strict self-restrictions in energy consumption in order to avoid a catastrophe of global warming.

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The generally accepted classification divides the sources of primary energy into commercial and non-commercial. The global energy industry as a whole throughout the entire industrial phase of the development of society is based primarily on commercial energy resources. Although it should be noted that there is a whole group of countries (equatorial zone of Africa, Southeast Asia), whose large population maintains its existence almost exclusively at the expense of non-commercial energy sources [2].

Energy saving - implementation of legal, organizational, scientific, industrial, technical and economic measures aimed at the efficient (rational) use (including economical use) of fuel and energy resources and the involvement of renewable energy sources in the economic turnover. Energy saving is an important task for conservation of natural resources.

Currently, household energy saving, as well as energy saving in the field of housing and communal services are the most pressing. The main obstacle to its implementation is to restrain the growth of tariffs for the population for certain types of resources (electricity, gas), lack of funds from utilities for energy saving programs, a low proportion of calculations for individual metering devices and the application of standards, as well as the lack of mass culture of household energy saving.

Efficient use of energy, or "fifth type of fuel" - the use of less energy to provide the same level of energy supply of buildings or technological processes in production.

Unlike energy saving, mainly aimed at reducing energy consumption, energy efficiency is a useful (efficient) energy expenditure [3,4].

International cooperation in the field of energy efficiency is one of the important directions in the activities of the Ministry of Energy of Russian Federation. In the implementation of a number of energy saving and energy efficiency projects, advanced experience of developed countries is already used, and achievements in the field of energy efficiency are also taken into account when forming the basic documents in this field. Thus, the energy dialogue between Russia and EU members since 2000 provides for cooperation in a number of areas, including in the field of energy efficiency. As part of the activities of the Thematic Group on Energy Efficiency, there is a continuous exchange of information and experience in the areas that are part of the Energy Efficiency Initiative. Memorandums and declarations on cooperation in the field of energy efficiency are also concluded with the relevant ministries of France, Italy, Japan, the Netherlands, Denmark, and the United Kingdom [5,6].

In addition to international cooperation in Russia, a large number of government projects on energy saving and energy efficiency programs are being implemented. The Energy Efficiency Quarter program implemented in several cities of Russia can be attributed to one of such projects, which is included in the list of priority areas for improving energy efficiency [7].

2 Methods

The purpose of the pilot project “Energy Efficient Quarter” is to work out the organizational, legal and financial-economic measures in the field of energy savings in the residential and social facilities of the city.

In the city of Tyumen in Russia, activities are being developed and carried out as a part of implementation of the comprehensive program “Energy Efficient City”.

Implementation of this program is expected to achieve the following targets:

- reduction of the overall level of energy and resource consumption by industries of the city by 25-30% to the base level;

- reduction of family expenses for payment of housing and communal services by an average of 15-25%;
- reduction of energy consumption per square meter in total area of residential buildings by 20-30% to the base level;
- reduction of municipal budget expenditures in terms of utility payments for energy and resources by 15-25% to the base level;
- reduction of harmful emissions that pollute the environment in the city, by 10-15% to the base level;
- equipping with energy metering and control devices up to 100% by the time of the Program implementation;
- reducing the level of energy and resource losses to regulatory indicators;
- reducing the accident rate to 0.1 accidents and damage per 1 km of networks per year.

These figures are very impressive and have significant socio-economic efficiency.

Quarterly development within the boundaries of Republic street - Kholodilnaya - Maurice Toreza - Malygina street is defined as a pilot area for the implementation of activities in the city of Tyumen. In this territory, in Tyumen (along with 3 other cities - Apatity, Kazan and Perm) the project “Energy-efficient quarter” is being implemented. The list of priorities that are outlined by the State Program for Energy Saving and Energy Efficiency Improvement includes organization of energy accounting, replacement of incandescent lamps with energy-efficient lamps, and development of small and alternative energy.

Financing of the activities is carried out according to the following scheme:
- local budget funds - 10%;
- funds of the regional budget -15%;
- funds of the federal budget (including the Housing and Communal Services Reform Fund) - 20%;
- credit funds of banks sent for sale.

About 13 thousand people live on the territory of the modernized quarter, the total area of residential buildings is 356 thousand m2, 45 apartment buildings, with a total area of 356,597.7 square meters, the number of apartments 5.178 (from 22 to 390 apartments in the house), where 12,945 people live by registration.

The houses have4 to 13 floors, the largest share (60%) falls on 5 and 9 storey houses. Year of construction of houses varies from the 60s to 2009 (Figure 1), the largest share is occupied by houses built in the 60-80s., which is 69%, requiring a comprehensive overhaul.

Depending on the qualifications of buildings, the largest share falls on brick-built houses - 41 houses (91%), 3 houses (7%) are panel houses, 1 house (2%) belongs to block houses (Figure 2).

Also in the district there are 5 social infrastructure facilities (2 schools, 1 kindergarten, 1 maternity hospital with antenatal clinic, 1 clinic), 6.6 km of heating networks, 13.8 km of electric networks, 9.4 km of water networks, 7.4 km of sewage networks.

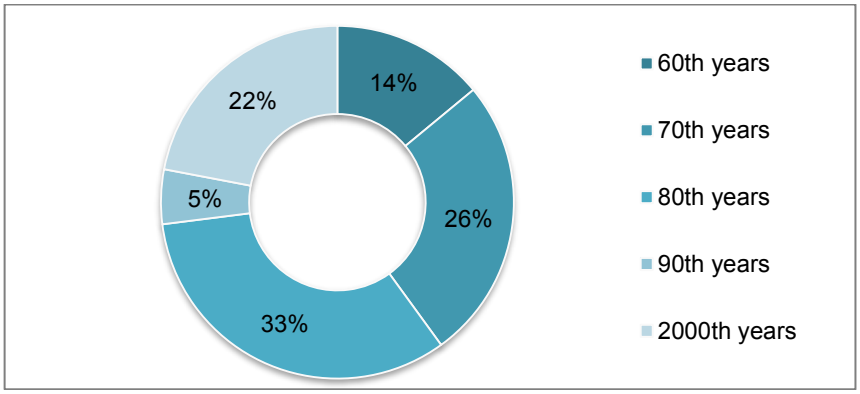

Fig. 1. The structure of apartment buildings in the pilot quarter of the city of Tyumen (by year of construction)

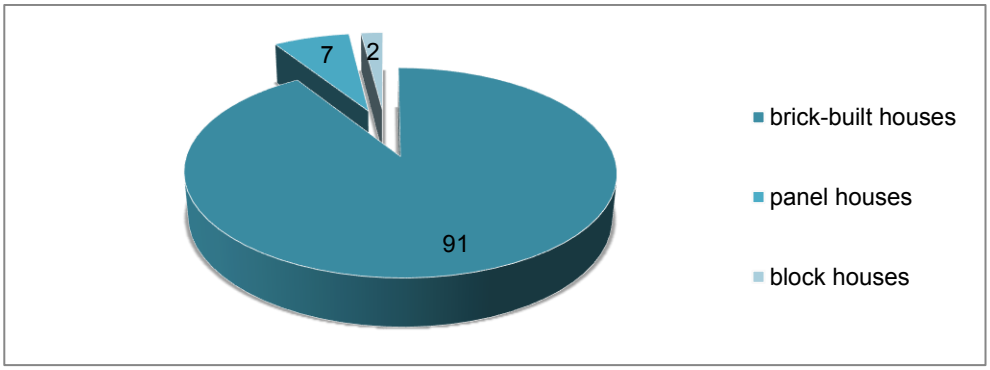

Fig. 2. The structure of apartment buildings of the pilot quarter of the city of Tyumen (on the qualification of buildings)

Losses in electric networks are about 12%, in heat networks - 14%, in the water supply system - 33.4%. On the territory of the quarter there are 224 lighting poles. In addition, various commercial facilities are located in the quarter.

Table 1 shows the general characteristics of the engineering infrastructure of the pilot quarter.

Table 1. General characteristics of the engineering infrastructure of the pilot quarter

№	Indicators	Units of measurement	Value of the indicator
1.	Heating networks / including Hot water supply	M^2	6.619 / 273
2.	Water supply networks	Km	9.4
3.	Wastewater networks	Km	7.6
4.	Power supply networks	Km	13.8
5.	Gas supply networks	M	330.6
6.	Objects of outdoor lighting, incl.		
6.1.	- lamps	pcs	301
6.2.	- poles	pcs	224
6.3.	- outdoor lighting networks	Km	10.7
7.	Connection	Km	3.396

7% of houses are equipped with collective heat meters, 4% of houses are equipped with hot water meters. The energy efficiency level of buildings, after an energy audit at 41 apartment buildings, is estimated between categories D and E (low and very low). Houses built after 2000, are estimated by energy efficiency category C - normal.

For the "Energy Efficient Quarter" program of the city of Tyumen, the concept of organizing measures to improve the energy efficiency of residential buildings in 3 stages was adopted. All activities are structured according to several criteria: mandatory, stages of implementation, utility systems, availability of energy-saving effect and method of accounting for capital investments in the economic justification of measures programs (Table 2,3,4).

Table 2. Systematization of the list of measures to improve the energy efficiency of a residential building (Stage 1)

Stages and activities	**presence of energy saving effect**	**Calculation of the incremental capital investments**	**obligation of the activities**
Heating system			
Installation of house metering stations and automation equipment	yes	no	yes
Flushing of indoor heating systems	yes	no	no
Installation of energy efficient windows in common areas	yes	yes	no
Installation of heat-reflecting screens in common areas	yes	no	no
Overhaul of the heating system in the basement or attic (depending on the layout)	no		no
	Hot water supply		
Search and repair of plumbing with leaks	yes	no	no
Overhaul of the HWS system in the basement (or attic), depending on the layout	yes	yes	no
Power supply			
Replacement of distribution switchgears with installation of two-tariff meters	yes	no	no
Replacing incandescent bulbs in common areas	yes	yes	no
Presence Detectors Installation	yes	no	no
Cold water and sewage			
Household metering of cold-water	yes	no	yes
Search and repair of plumbing with leaks	yes	no	no
Overhaul of the cold water system in the basement (or attic), depending on the layout	yes	yes	no
Other activities			
Coloring of staircases in light colors, installation of entrance and tambour doors with a door closer	no		no

Table 3. Systematization of the list of measures to improve the energy efficiency of a residential building (Stage 2)

Stages and activities	**presence of energy saving effect**	**Calculation of the incremental capital investments**	**obligation of the activities**
Heating system			
Overhaul of the heating system on the risers	yes	yes	no
Installation of balancing valves	yes	no	no
Installation of individual thermostatic elements on heating devices	yes	no	no
Hot water supply			
Installation of individual metering devices	yes	no	yes
Overhaul of the hot water system in risers	yes	yes	no
Power supply			
Installation of two-tariff counters	yes	no	no
Cold water supply			
Installation of individual metering devices	yes	no	yes
Overhaul of the cold water system in risers	yes	yes	no

Table 4. Systematization of the list of measures to improve the energy efficiency of a residential building (Stage 3)

Stages and activities	**presence of energy saving effect**	**Calculation of the incremental capital investments**	**obligation of the activities**
Heating system			
Energy efficient windows in apartments and built-in and outbuildings	yes	yes	no
Installation of heat-reflecting screens in apartments	yes	no	no
Thermal insulation of floors above basements	yes	yes	no
Roof insulation	yes	yes	no
Wall insulation	yes	yes	no
Power supply			
power consumption of elevators	yes	yes	no
Replacing incandescent bulbs in apartments	yes	yes	no
Replacing old refrigerators and washing machines	yes	yes	no
Gas supply			
Installation of individual metering devices	yes	no	yes

At the first stage, only relatively low-cost measures are implemented in public places. Some of them are capital repair measures that do not give a direct energy-saving effect, but are important as a necessary condition for obtaining an energy-saving effect from other measures. The costs of such measures are taken into account in the cost estimates, but are

not taken into account when calculating the payback period of energy efficiency measures. Part of the measures can be implemented by traditional technology or through the use of energy-saving technologies (for example, replacement of windows and lamps in public places). Therefore, when calculating the payback period of these measures, the concept of incremental capital investments is used, that is, only the difference between the cost of a traditional and an energy-efficient solution is taken into account.

At the second stage, measures related to the installation of individual metering and regulation devices are implemented. At the third stage state support is provided to the population for the purchase and installation of energy-saving window blocks, heating devices and energy-efficient lighting systems and household appliances through the provision of subsidies to the population. At the same stage, it is possible to implement more expensive measures to insulate the building.

Some of the measures in this list are mandatory: their implementation is necessary in accordance with the requirements of the Federal Law of November 23, 2009 No. 261 “On Energy Saving and Energy Efficiency Improvement and Amendments to Certain Legislative Acts of the Russian Federation”. These include measures to equip apartment buildings with collective (house-wide) metering devices for used water, thermal energy, electric energy, as well as individual and common (for a communal apartment) metering devices for used water, natural gas, and electric energy. These metering devices must be installed and put into operation before January 1, 2012.

3 Results

As a test, proving the economic feasibility of energy-saving measures, a set of measures that can be implemented in a residential building in Tyumen in the pilot area of the program is presented.

The building was built according to a standard design in 1972 and has 5 floors, 6 entrances, 99 apartments, 210 rooms, and the number of residents is 200. Engineering and technical communications are located in the unheated basement. The building has a warm attic where air flows from the ventilation ducts (Table 5).

Table 5. General characteristics of a residential building

№	Indicators	Unit of measurement	Value of indicators
1	Year of construction	-	1972
3	Floors	-	5
4	Number of entrances	-	6
5	Number of apartments in the building	-	99
6	Number of inhabitants	people	200
7	Type of roof	-	pitched roof
8	Heated volume (in the project)	м^3	17421,0
9	Total area of the building	м^2	5142,9
10	Heated area	м^2	5142,9
11	Total area of residential premises	м^2	4417,3
13	Basement	-	technical underground
14	Light conduction	units	434
	Window	units	334
	including double glazing	units	70
	ordinary	units	264
	Balcony doors	units	100
	including double glazing	units	24

	ordinary	units	76
15	Number of entrance doors (entrance groups)	units	6
16	Area of building envelope, including:	м^2	3100
	the walls	м^2	776,8
	windows and balcony doors	м^2	701,2
	entrance doors	м^2	18
	Overlap 1st floor	м^2	0
	Overlap	м^2	1604
17	Electricity metering device for lighting of common areas	have / no	have
18	Electricity metering device for the maintenance of elevators	have / no	no
19	Electricity metering device for electric stoves	have / no	no
20	Apartment electricity metering devices	units	101
21	Electricity metering devices of tenants	units	1
22	House site of the commercial accounting of consumption of thermal electricity	have / no	no
23	House site of the commercial accounting of consumption of water	have / no	no
24	Domestic hot water metering devices	units	0
26	Means of regulating heat consumption in general for a building	type and availability	no
27	Means for regulating heat consumption in apartments	type and availability	no
28	Dates of the last major overhaul		18.05.2007-22.08.2007
29	Characteristics and type of work on the overhaul		heating, hot and cold water supply, sewage

In addition to the mandatory measures of the Federal Law "On Energy Saving and Energy Efficiency Improvement", it also requires that management companies develop proposals for energy saving and energy efficiency measures that can be implemented in an apartment building, with an indication of the cost of their implementation, the volume of the expected reduction of the energy resources used and the payback period of the proposed measures and communicate to the owners of premises in an apartment building at least once a year.

Such a list of measures is given in Table 6, 7, 8 with an indication of energy savings, financial costs and estimates of the payback period.

Table 6. The list of measures to improve the energy efficiency of the building (Stage 1)

Content of measures	Units	Total cost	Energy Efficiency Costs	Expected annual economic effect	Schedule of implementation of measures to improve energy efficiency of the building, years		
					2016	2017	2018
Stage 1							
Heat point with metering and regulation	Heat point	19166.67	16805.56	1715.57	+		
Washing of house heating networks	systems	1388.89	0	19.64	+		
Installing screens behind radiators in common areas	screens	100	100	19.64	+		
Installation of energy efficient windows in common areas	м^2	6750	2375	115.32	+		

House node for cold-water metering	nodes	504.44	504.44	1552.32	+		
Search and repair of plumbing with leaks	building	55.56	555.56	543.56	+		
Replacing incandescent lamps in public places and in outdoor lighting with energy-saving compact fluorescent lamps	lamps	120.83	80.56	80.72	+		
Installation of presence sensors in common areas	sensors	120.83	120.83	161.43	+		
Replacement of distribution switchgears with installation of two-tariff meters	units	309.32	309.32	40.11	+		
Coloring of staircases in light colors, installing entrance and vestibule doors with a door closer	building	19970.07	0	0	+		
Overhaul of electrical equipment	building	20993.86	0	0	+		
Total stage 1		69480.47	20851.26	4248.32			

Table 7. The list of measures to improve the energy efficiency of the building (Stage 2)

Content of measures	Units	Total cost	Energy Efficiency Costs	Expected annual economic effect	Schedule of implementation of measures to improve energy efficiency of the building, years		
					2016	2017	2018
Installation of individual two-tariff electricity meters	apartments	3296.53	3296.53	640.71	+		
Installation of individual hot water metering devices	apartments	2337.50	2337.50	175.31	+		
Installation of individual cold water metering devices	apartments	2337.50	2337.50	543.22	+		
Installation of individual thermostatic elements on heating devices	units	1636.11	1636.11	98.61	+		
Installation of balancing valves on the main heating pipelines	units	800	800	59	+		
Overhaul of the heating system on the risers	м^2	1857.19	371.43	19.64		+	
Overhaul of the hot water system on risers	м^2	2071.49	414.29	87.61		+	
Overhaul of the cold water system on risers	м^2	1142.89	228.57	386.83		+	
Total stage 2		15479,21	11421.93	2010.94			

Table 8. The list of measures to improve the energy efficiency of the building

Content of measures	**Units**	**Total cost**	**Energy Efficiency Costs**	**Expected annual economic effect**	**Schedule of implementation of measures to improve energy efficiency of the**

					building, years		
					2016	2017	2018
Installation of energy efficient windows in apartments	windows	36666.67	23833.33	426.57		+	+
Installing screens behind radiators in apartments	screens	1391.67	1391.67	98.38		+	+
Replacing incandescent bulbs in apartments	bulbs	360.42	360.42	393.24		+	+
Replacing old refrigerators	units	194.44	194.44	18.10		+	+
Total stage 3		3861.19	25779.86	936.28		+	+
Total for all stages		123572.88	58053.06	7195.54		+	+
Energy Saving Activities		123572.88	58053.06	7195.54		+	+
Peak power release from daily zoning	kw	0	0	252.50		+	+
Peak power release from increased lighting efficiency	kw	0	0	252.50		+	+
Peak power release from refrigerator replacement	kw	0	0	16.83		+	+
Activities not included in the program		0	30722.22	452.54		+	+
Repair of windows with the installation of heat reflecting film	windows	3666.67	3666.67	213.29		+	+
Wall insulation	$м^2$	26972.22	26972.22	236.18			

Payback periods are estimated only for energy saving measures. When calculating payback periods, the concept of incremental capital investments is used, that is, only the difference between the cost of a traditional and energy efficient solution is taken into account (Tables 6,7,8). In the calculations of payback periods, prices and tariffs for utility resources for 2018 are used.

The approximate project implementation schedule is shown in Table 5. It is drawn up in accordance with the three-stage project implementation scheme so that all costs, including capital repairs, that do not have the effect of energy saving, still pay off due to the savings obtained through the implementation of other measures.

At the first stage, the ESCO refinances 90% of the savings to the project, which reduces the need for borrowed funds. The loan amount itself is equal to 69043 euros. It was obtained taking into account the possibility of financing the project for 10 years with a grace period of 1 year at 15% per annum with quarterly payment. The interest rate on loans for ESCOs is subsidized at the expense of budget funds. These expenses are equal to 54784 euros.

At the second stage, targeted grants are allocated for the implementation of measures for energy saving and energy efficiency in the premises of the owners (installation of individual metering devices). They are represented by the MC, HOA after reaching the targets of the 1st stage. The budget expenditures for grants are estimated at 14679 euros.

After reaching the MC, HOA, HBC targets of the second stage in the third stage, the interest rate is subsidized at the expense of budget funds to the population on the basis that the loan is provided at 15% for three years. In this case, the budget accounts for about 44% of all costs for the purchase of equipment and the repayment of interest on loans for the

population. Budget expenditures for subsidizing interest rates for the population are 11583 rubles.

Tables 6,7,8 list and schedule energy efficiency measures for the building at ul. Karskaya 24.

The expenses of the population are equal to 38613.2 euros, and the expenses of the ESCO – 58396.5 euros. The budget share in the project costs depends on the interest rate on the loan. Estimation of savings made under the assumption of the growth of tariffs for utilities by 10% per year.

The approximate financing scheme of the project is shown in Table 6. The total costs of the project are equal to 123272.8 euros, and taking into account interest payments on the loan - 178057 euros.

To finance a project to develop energy efficiency measures for a residential building, the following funds are used: own funds of the energy service company (ESCO), budget - grants and subsidized interest rates for the population, household expenses and credit [5].

Project financing will take 10 years.

Table 9. Project Financial Flows

Year	Total expenses	Population expenses	Accumulated net income	Budget expenditures
2016	77480.9	0.0	2670.3	11796.4
2017	45791.9	38613.2	3494.4	21180.8
2018	5909.4	12923.3	5909.4	12923.3
2019	11924.2	11772.6	11924.2	11772.6
2020	21609.1	6760.5	21609.1	6760.5
2021	35331.2	5609.8	35331.2	5609.8
2022	53494.0	4459.1	53494.0	4459.1
2023	76541.7	3308.3	76541.7	3308.3
2024	104961.7	2157.6	104961.7	2157.6
2025	139294.7	1006.9	139294.7	1006.9
2026	191635.6	71.9	191635.6	71.9

4 Conclusions

Energy saving is currently the most important direction of the energy policy of the country. Energy saving is important for socio-economic development and contributes to the improvement of living conditions, increasing the comfort of housing, improving the means of transportation, facilitating working conditions.

It should be noted that it is important to save not only in the house itself, but also in each apartment. Energy-saving activities in the apartment are: replacement of incandescent lamps with energy-saving lamps; installation of thermostats on radiators; installation of metering devices for cold and hot water supply systems, and, if possible, for heating and gas systems; when replacing window units installation of triple-glazed windows; buying household appliances with less power consumption; installation of residential two-tariff meters; measures for the insulation of window openings and entrance doors.

World experience shows that there is a real possibility of reducing energy consumption by 2 times. However, to achieve such a result, long-term joint efforts of scientists, architects, designers, heat specialists, power engineers, construction industry specialists,

managers of building complexes and housing and public utilities are needed, step by step, successively increasing energy efficiency each in its own area.

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