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ENERGY EFFICIENCY AND THE QUALITY OF HOUSING PROJECTS

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ABSTRACT

The authors answer the question of what role the system of housing and public services (HPS) plays in the economy of modern Russia. Presently it does not target consumers and is focused on meeting the needs of companies that supply electricity and heat, as well as utilities. That's why we need a new reform oriented on people and homeowners, the main criteria of which should be energy efficiency and energy conservation. The advantages and disadvantages of the Russian economy are considered in terms of energy efficiency standards. Arguments in favor of the construction of passive residential houses in Russia are provided. The next important step is the creation of conditions for the private sector in housing construction and HPS, under which it would be beneficial to create energy efficient facilities, taking into account the increasing energy efficiency thereof. Retraining and advanced training of civil servants, general public, managers and specialists of construction and development companies, construction enterprises, educational institutions in the spirit of new energy-saving concept are also required. International experience in the construction of energy efficient buildings is considered also.

Keywords: buildings, structures and design, energy conservation, renewable energy, sustainability.

1. INTRODUCTION

In recent decades, production, transportation and efficient use of energy have become one of the world's major issues (Smirnova *et al.*, 2013). Moreover, according to some experts they will only aggravate in the medium and long term (Hofman, 2007). Despite the very significant reserves of proven and emerging energy resources, the solution to these global issues is topical for modern Russia.

It creates the most tension in the construction sector of all national economies. This is largely due to the fact that both developers and buyers of individual residential houses and apartments are increasingly paying attention not only to the one-time price of creation and acquisition of property, but also to the costs it incurs during the period of its operation. That is why the list of factors of quality and competitiveness of housing construction has been topped by energy efficiency over the recent years (Andrews, 2007, Cocks, 2011).

The idea, common in our country, that energy resources to meet the needs of the national economy will always be enough, is only partly true (GEA Writing Team, 2012, Pluzhnikov, 2014, Weiss and Bonvillian, 2009). The current situation in Russia with excessively high energy consumption in the residential construction and HPS, both by regulations and by consumption hugely exceeding modern Western counterparts (Brown, 2008), should be considered unacceptable and require urgent solution. The purpose of this article is to examine the place and role of energy efficiency in ensuring the quality and competitiveness of housing projects. In the long run, the implementation of energy conservation measures will reduce energy consumption in the country and thus develop a sustainable economy.

2. MATERIALS AND METHODS

The methodology of carrying out this study is based on the scientific results presented in the works of the Russian scientists: Larionova *et al.* (2012), Aizinova (2007), and their foreign colleagues: Boyano *et al.* (2013), Rezessy *et al.* (2006), Heiskanen *et al.* (2013), Brandoni and Polonara (2012) and other and other, which are devoted to solving the energy-saving problems in HPS.

The scientific approach to understanding the ways of development of the modern economical science manifests itself in providing a certain balance between the latest trends on one side and the former scientific results on the other side. Many modern scientists and experts are of the opinion that the efficiency of a system of market relations is determined by the scientific feasibility of the approach to building the said system, the degree of sophistication of its regulatory and legal framework and the quality of professional training of specialists (Panibratov and Larionov, 2013).

3. THE MAIN PART: ADDRESSING A PROBLEM OF ENERGY EFFICIENCY

3.1 Strengths and weaknesses of energy-efficient system in Russia

The beginning of the second decade of XXI century in the global energy market was marked by the defeat of hydrocarbons in the battle with renewable energy sources (RES) on a global level. The point of no return, according to experts of Bloomberg New Energy Finance, came in 2013. In their report, the experts have stressed that the amount of electricity produced from RES had exceeded the total volume of gas, coal and oil generation. During 2014 investment in renewable energy reached $321.8 billion. In 2015, a steady increase in these types of energy will continue (Bloomberg New Energy Finance, 2015). At the same time, the International Energy Agency

estimates indicate that by 2050, solar energy will have taken the first place among the resources to ensure the world's energy needs. By 2050, about 80% of electricity will have been generated from renewable sources, which include large hydropower plants. Fossil fuels will be replaced by more efficient modern technologies based on biomass, solar collectors and geothermal energy.

Mineral reserves suitable for power generation are dispersed unevenly on our planet, and very often they are used disproportionately to the volume of their production. For example, the USA and the EU countries together consume almost 40% of global energy output, although they produce only 23% of it. At the same time Europe imports about half of its total demand for energy. Therefore, the European Union is to reduce the share of imported energy from 50 to 35% by 2030 within the framework of enhancing their energy security plans (Bhusal *et al*., 2008).

Given the above, as well as the share of Russian exports in the global energy market (about 20% of natural gas and more than 11% of the crude oil produced in the world), it should be recognized that this country is a key player in the energy sector (Grabovyj and Popov, 2010).

However, research results suggest that in order to create a conventional unit of building product we consume 2 times as much energy as Canadian builders; 3 times more than the US builders; 4.5 times more than the Chinese builders (Injucyn, 2014).

Despite some success, by overall energy efficiency level in the industry, Russia takes the 108th position among 132 countries. The main reason for this situation lies in structural factors. State programs to improve energy efficiency, as well as the laws do not contain effective tools to promote the implementation of energy efficiency projects.

3.2 Energy efficiency of housing construction

The above makes it necessary to consider housing construction in close connection with its energy efficiency. The proposed approach corresponds to the results of some leading Western scholars (Fuerst and McAllister, 2011, Ojanen, 2007, Qian *et al*., 2013, Srinivasu *et al*., 2011) and allows us to qualify the energy efficiency of housing construction as a factor that directly affects its quality. In this context, it is even possible to talk about increasing the life cycle of residential property in case of reconstruction and technical re-equipment. Such a result can be achieved by using energy efficient technologies within the framework of the methodological basis of calculation of the LCC (Life Cycle Cost) of the property, developed by the European Commission in accordance with the ISO standards.

3.3 Factorfour phenomenon

In the course of identifying and justifying the place and role of energy efficiency in ensuring the quality and competitiveness of the housing projects, we cannot ignore the Factorfour phenomenon, well-known in the professional literature. Its essence lies in the fact that a group of foreign experts in the report of the Club of Rome back in 1995 put forward the idea of solving the environmental problems of housing construction, while increasing the efficiency of harvested resources due to the introduction of new technologies. In other words, they called for the need to learn to live and work two times better in comparison with the traditional practices, and spend for these purposes half the assets and harvests. This means to strive to double the wealth with the twofold saving of the resources.

3.4 Energy efficient buildings as an "engine" behind the development of the modern post-industrial civilization

3.4.1 Rocky Mountain Institute (USA)

The Factorfour principle is not a utopia, and the environmentally friendly, "green" construction is already a reality. Thus, according to Steel and Heath (2014), energy efficient buildings become the "engine" behind the development of the modern post-industrial civilization. Such buildings exist in the USA (Rocky Mountain Institute in Colorado), Germany (office of Commerzbank), the UK (the De Montfort University building) and others. During the construction of the headquarters of Rocky Mountain Institute - RMI (1982) almost all the available achievements in the field of energy efficient construction were used. Suffice it to say that its heating use only a few percent of the energy required for such buildings in the same area. The walls of the institute are made of stone, with an air gap, an outer layer of 100 mm insulation and foil. For the glazing argon-filled glass units with a special heat-reflecting layer have been used. Insulation, sealing, and thermal inertia of the building turned out to be so high that it was not necessary to heat it, even in -40°C frosts. During the ordinary winters 30% of the excess heat comes from internal sources and the sun.

3.4.2 ROCKWOOL Center for Research in Hedehusene (Denmark)

An example of modern technologies of energy conservation construction is the building of the ROCKWOOL Center for Research in Hedehusene (Denmark) (2000), which was recognized as one of the most energy efficient offices in the world. The company has demonstrated the benefits of its own technologies of energy efficient construction. The project aimed to reduce the cost of energy consumption compared with existing standards by almost four times. This was achieved through the implementation of effective insulation, the use of three-layer windows and new developments in the field of ventilation. The building was oriented so that the large windows were located on the south side. The thickness of the rock wool along the thermal-protection envelope of the entire building was from 25 to 50 cm. The intelligent ventilation system now operates in the Center.

3.4.3 New homes with zero CO_2 emissions in UK

In the UK, all new homes by 2016 are to be built with zero CO_2 emissions. This means that the house itself

is self-sufficient in providing energy from renewable sources, including the costs of heating, hot water, ventilation, and lighting. The criteria for defining a house as passive in Europe are: specific consumption of thermal energy for heating, not exceeding 15 kW·h/m^2 per year, and the total consumption of primary energy for all household needs not exceeding 120 kW·h/m^2 per year.

3.4.4 EKONO-house (Finland)

In Otaniemi, near Helsinki, there is energy efficient EKONO-house building (1979) built on the Factorfour principle. To select the optimal energy-saving solutions and calculation of their parameters, the creators of the EKONO-house building used computer modeling. On the roof of the EKONO-house building solar collectors are installed. In the summer, the heat of solar radiation is collected in the solar collectors and due to the heat transfer fluid is directed to the heat exchanger. The massive base of EKONO-house has cavities, in which heat transfer fluid circulates, heated by solar radiation in the heat exchanger. Thus the massive base, on which the building is constructed, serves as a natural heat accumulator. Then the heat of solar radiation accumulated in the base is used in the ventilation system to heat the inlet air. Furthermore, for heating the inlet air the heat of solar radiation directly from the solar panels can be used. The heating, ventilation and lighting control is carried out by means of the automatic control system. It is noteworthy that the specific heat consumption of the second section of the EKONO-house building is 70 kWh/m^2, specific power consumption - 57 kWh/m^2, which is about one third of the energy consumption of traditional buildings of this type.

3.5 Energy efficient solutions of the "Oilon" company

In Finland, quite considerable scientific and practical interest are the results of the "Oilon" company (annual turnover of 80 million euros, 350 employees) on the topic "*Energy efficient solutions in design and construction of residential buildings*." The strategic vector of activity of the "Oilon" company is the production of burners for heat pumps with very low emissions of harmful substances into the environment (well below the maximum allowable). Through continuous research, "Oilon" offer customers the most competitive eco-burners. An important feature of modern technology of "Oilon" is that it allows to heat residential buildings in winter, and to cool - in summer. These projects have been implemented in a school in Helsinki, as well as in Denmark, in the course of creation of a summer ice rink and the surrounding infrastructure. The practice of using this technology shows that although a solar collector is 2 times more expensive than the heat pump, Finland does not give up on the development of solar energy units. The reason for this is that the export of applied research is relevant for countries where the number of sunny days per year predominates. Moreover, at present "Oilon" is developing a "solar atlas" for Europe and other countries. Of particular interest to the specialists is the technology "Hibrid Heating System": experts of "Oilon" literally take energy out of water, air, sun, wind and other sources.

3.6 Standard of energy efficient equipment as a reality for Finland

As a result, Finland intends to abandon coal boilers in a few years. To this end, many Finnish companies are diversifying their research and practical activities under the slogan of reducing dependence on foreign energy suppliers, including first and foremost Russia. An important feature is that the state does not participate in the financing of these developments, and generally does not stimulate the private companies that are engaged. For example, the above-mentioned "Oilon" company spends about 6% of its budget for such research.

At the same time, in the final stage of the development, the state sponsors the developer or the investor of up to 10% of the costs incurred, if the existing residential building or community facility installs and operates energy efficient equipment in the modernization process. The economic interest of private investors, developers and construction companies to implement energy efficiency projects in housing construction is in short (5-6 years) payback period. An example of the construction of community facilities is a "Home for the elderly", which is largely saturated with energy efficient equipment, built by the "NCC" construction company near Helsinki. Standard of energy efficient equipment is a reality for this country.

The analysis of the world experience in building energy efficient homes and provision of energy conservation in existing ones demonstrates that modern technology allows to renovate and modernize even the houses with very considerable service life to such an extent that in many ways (including energy efficiency), they become not inferior to the new houses and are compatible with passive houses using RES (Larionova and Pavlova, 2014, Hurst, 2012, Jakob, 2006, Jokisalo *et al.,* 2009).

3.7 Germany's experience to improve energy efficiency of existing homes

In this regard, we believe Germany's experience to improve energy efficiency of existing homes to be worthy of study and adaptation to modern Russian conditions. Last year, subsidies for the reconstruction of homes in order to reduce energy consumption in Germany amounted to about 4.5 billion euros. Homeowners who are planning to reconstruct the house in order to improve its thermal performance will enjoy a reduction in the tax burden by 20%. Houses with an area of over 1,000 m^2 in Germany have the certificates that contain important consumer issues: energy efficiency index, rating, reference values for the rating and all repairs. In Russia, people do not have anything that would encourage energy conservation.

3.8 Russian's experience of significant energy savings

Justifying the place and the role of energy efficiency in ensuring the quality and competitiveness of the housing projects in the future, we should pay attention to the construction and operation of passive residential houses. Under conditions of a permanent increase in

energy prices, not only in Russia, but throughout the world, passive houses (real estate with an independent power supply system) are a real opportunity to significantly reduce the operating costs of housing.

Examples of significant energy savings include buildings both built from the ground up and being in operation for more than a decade, residential and public buildings. In this context, we cannot but mention the two-storey building of innovative training center of Saint-Gobain Academy (operated for over 60 years), reconstructed by the *Saint-Gobain* corporation on the Boytsovaya street in Moscow in 2014. The outer lines of the building are insulated using heat insulation and glass; ventilation system is based on heat recovery; radiant panel heating and cooling systems are applied instead of the traditional radiators; vacuum solar collectors operate on the roof. The installed sensors allow tracking in real-time, how much energy the building uses, which room has the excessive concentration of carbon dioxide and requires supply of clean air, where power surges occurred, etc. In other words, all the changes of certain parameters of the building are monitored and adjusted automatically. Also, the Academy has the Energy Operation calculation system, allowing to form a full picture of the building functioning, to understand the real amount of cost savings. The application of these technologies caused the specific heat consumption to drop from 283 to 43 kWh/m^2 per year, i.e. more than 6 times.

Building the low-rise passive houses in Russia is considered a promising direction (Moklokov, 2014). It is advisable to form separate settlements with the use of energy efficient dome houses. According to Moklokov, modular development of areas of land on the basis of the concept of building settlements of energy efficient dome houses with RES, houses made of environmentally friendly materials and houses with zero energy consumption provide a combination of homogeneous and heterogeneous facilities of energy efficient low-rise property, as well as their complex construction and servicing.

4. DISCUSSIONS

4.1 Housing resource consumption

Unfortunately, as estimated by Grabovyj and Popov (2010), currently at least 30% of the energy produced in Russia is being consumed unproductively (direct loss in gas flares, during transportation of coal, in heating mains, during production, etc.). In our opinion, the Russian energy component underlies the formation of the high cost of not only housing, but also the production and provision of housing and public services (Larionov, 2014a). For example, the Russian power system (annual industry price in 2015 exceeded 4.2 trillion rubles) is a "black box", because its economy is opaque and incomprehensible to the final consumer. Formation of the cost of power generation in the CHP is not properly controlled, and consumers get the price on the basis of actual costs. 45% of the total energy produced in Russia is consumed by buildings, the majority of which are residential. At the same time the national HPS consume about 25% of the annual national energy resources (Larionov, 2014b, Larionov and Larionova, 2014).

In addition, housing has a very significant impact on the environment (both positive and negative). The scale and intensity of the impact are caused, in the first place, by housing resource consumption: demand for energy, water, minerals, forest resources leads to the destruction of soil and vegetative cover, atmospheric and water pollution, disruption of landscapes and so on.

In terms of energy efficiency, the state of the housing stock in our country has caused great concerns with employees of HPS and public authorities at various levels. If we sum up the status quo, an average Russian typical nine-storey residential building consumes about 72 kg of fuel per 1 m^2 (with an average power consumption of a residential building of 1.42 GJ /m^2), and in most EU countries, this consumption does not exceed 16 kg (with an average power consumption of a residential building of 0.74 GJ/m^2). Moreover, in new buildings of the developed European countries, this figure does not exceed 5-6 kg per 1 m^2.

4.2 Energy consumption can be reduced twice in Russia

At the same time, Russia has such significant potential for energy conservation that the energy consumption, according to some estimates (Tabunshhikov *et al*., 2003, Panibratov and Larionov, 2013), can be reduced twice. That is why we believe that Russia's transition to energy efficient housing and energy conservation in HPS is a strategic objective of all the participants of the domestic housing market: the state and developers, scientists, builders, citizens, planners, manufacturers and suppliers of equipment, construction materials and structures.

4.3 The resource-extraction path

On the other hand, some authors believe that the country has formed an "energy lavishness" stereotype of thinking and behavior (Cohen *et al*., 2014, Kirillov, 2002, Pismennaya and Tanas, 2014). The rich natural reserves of energy resources, by means of which not only Russia, but also many European countries successfully passed the energy crisis of the 1970s, and at the same time putting their money on energy conservation, have created the illusion of cheap energy.

Russia's energy intensity (energy consumption per unit of gross domestic product) is 1.8 times higher than in the US and 2.5-3 times higher than in Japan, Italy and other industrialized countries. This makes Russian commercial products uncompetitive not only in the world but also in the domestic market. Cross-subsidization, when, due to higher prices for natural gas, electricity and heat for industry, energy prices were low for the people resulted, with a total lack of working capital, to mass non-payment for energy, increase of the share of subsidies from local budgets spent on payment of heat and power, in some areas up to 40%. As a result, the real financial opportunities both for the state and the economic entities

for the practical implementation of energy conservation measures were essentially reduced. The Russian economy has actually chosen the resource-extraction path that leads to further degradation of the scientific and technical potential and a significant increase in environmental loads. The economy of the country is based on the significant increase in production volumes of fuel and energy resources by increasing their production. Why save when everything is at hand, a whole lot of it. As a result, energy consumption in the Russian industrial production is 3-4 times higher than in Western Europe, 5 times higher than in the US and 8 times higher than in Japan. The Russian economy is now "eating through" all that has been explored and created until 1991. This is the diagnosis: scientific and technological backwardness in all fields of energy, acute shortage of investments, higher depreciation of fixed assets, quality deterioration and lagging development of raw material base, etc. As a result, the country faces a real threat to energy security, still living on over-reliance on oil and natural gas, and will continue to do so for another 20 years, gradually sinking into darkness and slowly freezing.

5. CONCLUSIONS

The above allows drawing some conclusions:

1. To date, the levels of energy consumption of production of the most important domestic industrial products are two times higher than the world's average, and 1.5-4 times higher than the world's best samples. Low level of energy efficiency generates low competitiveness of Russian industry. That is why the increased use of renewable energy sources (RES) is the main task of the Russian economy. Conservation and efficient use of energy in housing construction are imperative.

2. Russia has one of the world's highest technical potential of energy efficiency increase that is more than 40% of consumption level. Unfortunately, the system of the Russian HPS is not focused on the needs of consumers. A reform is necessary, focused on the interests of the people, the homeowners. Energy efficiency and energy conservation should be the main criteria for evaluating its results.

3. Energy efficiency of modern mass housing must be considered as a factor that directly affects its quality and competitiveness. In this respect, passive houses (real estate with an independent power supply system) are a real opportunity to significantly reduce the operating costs of housing.

4. The most important task of economic science and authorities is the formation of the concept of the rational and economic use of energy and the development of organizational and economic mechanisms. Over three years competitions have been held to conduct educational activities in the amount of 186.8 million rubles to train more than 19 thousand of professionals responsible for energy conservation and energy efficiency; research and development work has been performed in the field of energy conservation and energy efficiency of the total amount of 118.1 million rubles. However, this is clearly not enough. It is a drop in the ocean.

5. We need to create the conditions for the private sector, under which it would be beneficial to build energy efficient homes (for example, provide a solid guarantee of return on investment so that the financial institutions invested in HPS; form the scientific basis of the latest developments and best practices of the most advanced national and foreign scholars, experts, practitioners in the field of energy efficient construction), modernize HPS facilities in view to enhance their energy efficiency.

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