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FURTHER IMPROVEMENT OF METHODS FOR DETERMINING ENERGY EFFICIENCY OF BUILDINGS AND STRUCTURES IN THE REPUBLIC OF KAZAKHSTAN

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One of the most important strategic objectives is to create a sustainable model for the development of the Kazakhstan economy, which is closely linked to the solution of energy saving and energy efficiency in the construction industry. The main principles of the energy efficiency strategy include integrated approach (efficient use of energy at all stages of the facility's life cycle for all types of energy resources, with legal support and organizational and technical control by the state) and systematic approach (the study of the process using general rather than partial approach). The article analyzes key problems and barriers that prevent the successful implementation of energy saving and energy efficiency policies. A significant role in the rational use of energy resources belongs to the regulatory framework. It was revealed that currently existing regulatory and technical documents in the country, unlike similar documents in EU countries, have a number of inaccuracies and disadvantages that do not allow for a full accounting of energy consumption. At present, there is practically no effective methodology for determining the energy efficiency of residential buildings and structures in Kazakhstan. In this regard, a methodology for determining the energy efficiency of buildings and structures, harmonized with EU requirements (taking into account energy consumption for heating, ventilation, high-temperature water supply, cooling and lighting) is currently being developed. The energy efficiency improvement of new, renovated and operated buildings will make it possible to reduce greenhouse gas emissions, thus contributing to solving both global environmental problems and energy and environmental security in the Republic of Kazakhstan.

Key words: energy efficiency class, certification of energy efficiency performance, energy saving, energy consumption, energy audit, energy-efficient buildings

INTRODUCTION

The problems of energy-efficient construction in the Republic of Kazakhstan are currently very relevant because the generation of a sustainable pattern of the country's economic development without addressing the issues of energy efficiency and energy saving is practically impossible.

In terms of energy saving and its effective use, the Republic of Kazakhstan lags far behind the industrialized world, which makes our goods and services non-competitive in the world market due to the high energy component affecting the cost of production. Besides, too intensive consumption of energy resources may eventually lead to depletion of natural reserves of organic fuel and significant environmental pollution [1]. The high energy intensity of goods and services causes shortages of heat and power capacities.

Construction and Housing and utility sectors consume approximately 11% of electric energy and more than 40% of thermal sendout, due to which energy saving and energy efficiency become a highly topical issue. Housing facilities stock of Kazakhstan is over 290 mln. sq. meters, the major part of which is composed of old apartment blocks built during the Soviet period and having energy losses that do not meet modern requirements. The research has shown that in Kazakhstan the required thermal energy in buildings is about 270 kWh/m^2 per year, which is significantly higher than average European consumption – 100-129 kWh/m^2 per year [1, 2].

MATERIALS AND METHODS

One of the directions of energy saving and energy efficiency improvement is legal and regulatory support of this process. The basic document of this direction has become the Law of the Republic of Kazakhstan No. 541-IV "On Energy Saving and Energy Efficiency Improvement" which was put into effect on January 13, 2012 [4].

As part of the reform of the technical regulation system for the construction sector, new normative and technical documents on energy-efficient construction issues have been prepared among others, according to paper [5]. However, it should be noted that the approaches to determining energy efficiency classes of buildings in these documents have a number of disadvantages and require

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further improvement, as is proven in paper [6]. For this purpose, it is necessary to harmonize national technical normative documents with the requirements of European norms on the energy performance of buildings, which are deprived of these disadvantages. These documents should apply to heated residential and public buildings, administrative and domestic buildings of industrial enterprises at the stage of design, construction and operation regardless of their form of ownership and departmental affiliation and establish requirements for defining their energy efficiency class.

Main objectives of the documents:

- rational, economical use of energy sources (oil products, natural gas, solid fuel, etc., which are also the main sources of carbon dioxide (CO_2) emission;
- reducing energy use in buildings and increasing use of renewable energy sources necessary to comply with the Kyoto Protocol of the UN Framework Convention on Climate Change [7];
- improving energy efficiency in the Republic of Kazakhstan;
- reduction and limitation of the release of carbon dioxide into the environment in order to reduce the emission of greenhouse gases;
- reduction in primary energy consumption;
- harmonization of technical documents with the requirements of the Directive 2010/31/EU of the European Parliament and Council of May 19, 2010 on the energy performance of buildings [8].

The abovementioned technical documents should provide for the establishment of fundamental requirements for energy efficiency of buildings, as well as the basic indicators used in assessing the energy performance of buildings and requirements for energy efficiency classes of buildings, according to European Directive [8].

Energy labeling of buildings in the Republic of Kazakhstan is made by means of energy certification. For this, the relevant standards have been developed. The energy efficiency certificate helps monitor the energy efficiency of building which means a certain level of energy consumption for heating, subject to comfortable conditions. According to the norms applicable in the Republic, the energy efficiency of building is characterized by one of five classes: A++, A+, A, B+, B, C+, C, C-, D, E. Energy efficiency class is determined by the amount of deviation of design (measured or normalized) value from standard, in percentage terms. Energy efficiency class of the used apartment blocks is determined based on the actual values of specific annual consumption of thermal energy for heating, ventilation and hot water supply, and on the compliance with energy efficiency requirements of buildings, facilities and structures.

Baseline standards establish the requirements for energy efficiency and thermal protection of buildings by energy efficiency class “C” (“normal”) and observance of standard sanitary-engineering and comfortable conditions. Energy efficiency class is determined by comparing the design (actual normalized) (qh^{des}) and (qh^{req}) baseline level of C-class values of specific energy consumption for heating and ventilation of building for the heating period by the amount of deviation of qh^{des} from qh^{req}, in percentage terms.

Design of newly constructed residential buildings of D and E classes should not be allowed.

In European countries, energy efficiency standards for buildings are gradually tightening and are accompanied by control and punitive sanctions for non-compliance. For instance, in Sweden, the construction regulations were revised in 1975, 1980, 1988, and 1998: energy consumption for heating of buildings did not increase since 1970-s, although the area of living space has increased by nearly 50%.

In the Republic of Kazakhstan, the main parameters used for assessment of energy efficiency of buildings, in accordance with the established norms, should be revised at least once every 5 years.

Currently, there is practically no effective methodology for determining the energy efficiency of residential buildings and structures in Kazakhstan. Many obstacles are preventing the development of this methodology. We will try to specify some of them:

- There is no clear answer to the question of who benefits from energy savings;
- There is little interest in energy saving and energy efficiency among important decision-makers in the construction sector (i.e. from architects to owners) and this is even though energy costs represent a significant percentage of the costs associated with the maintenance of the building;
- AOC (apartment owners' cooperatives) are most often in such a financial position that they do not have their own funds to address energy saving and energy efficiency problems;

Table 1: Energy efficiency classes of buildings

No.	Class	Description of energy efficiency class	Amount of deviation of design (actual) value of energy efficiency for heating and ventilation of building from standard, %
For design and use of new and reconstructed buildings			
1	A++ A+ A	Very high	below -60 from -50 to -60 from -40 to -50
2	B+ B	High	from -30 to -40 from -15 to -30
3	C+ C C-	Normal	from -5 to -15 from +5 to -5 from +15 to +5
For the use of existing buildings			
4	D	Lower	from +15.1 to +50
5	E	Low	over +50

- This problem is not perceived as a means for solving a wide range of economic and environmental problems at all levels of decision-making.

First of all, the elimination of the mentioned obstacles requires state support for energy saving and energy efficiency, as demonstrated in paper [9].

The key pillar currently in use in European countries, which may become the most efficient, is the mandatory provision of energy efficiency assessments of buildings to prospective purchasers/tenants. The most appropriate way to provide such information is a certification scheme for the energy efficiency performance of buildings [16-18]. If the certification scheme is not included as a mandatory one, experience shows that such information will not be provided. Such a scheme should be complemented by reliable procedures for monitoring and measuring energy performance, as is proven in works [10, 11].

RESULTS

Today in Kazakhstan, there is no methodology for determining the energy efficiency of buildings that meets modern requirements. In order to solve this problem, at present, JSC "Kazakh Research and Design Institute of Construction and Architecture" together with its Belarusian colleagues are carrying out the research work No. AP05133504 of the Ministry of Education and Science of the Republic of Kazakhstan with the topic of "To conduct a study of European experience and develop a methodology to determine the energy efficiency of buildings and structures, harmonized with EU requirements (taking into account energy consumption for heating, ventilation, high-temperature water supply, air conditioning and electric power supply)". Some results of this research have been demonstrated in previous papers [12-14].

The methodology for determining the energy efficiency of buildings and structures, in accordance with the European Commission's Energy Performance of Buildings Directive (EPBD), adopted in 2002 and amended in 2010 (2010/31/EU), takes into account the fact that the constructed buildings must comply with the minimum requirements for energy efficiency, with respect to the local climate and resources and with the possibility of using renewable energy sources.

The methodology will include at least the following components:

- thermal characteristics of buildings (envelope, internal partitions, etc.). These characteristics may also include air tightness;
- heating systems and hot water supply, including their insulation parameters;
- air-conditioning units;
- ventilation;
- built-in lighting systems (mainly in the non-residential sector);
- location and orientation of buildings, including the external climate;
- passive solar systems and protection from sunlight;
- indoor climate conditions, taking into account the microclimate of the premises according to the project.

Further, if necessary for the calculation, the positive impact of the following aspects will be considered:

- active solar systems and other heating and power systems based on renewable energy sources;
- electricity produced by the CHP;
- centralized heating and cooling systems;
- daylighting.

The calculation method takes into account the standards and rules applied in the Republic of Kazakhstan in accordance with the law.

Currently, Kazakhstan is taking the necessary measures to establish minimum requirements for the energy efficiency of buildings. These requirements are somewhat different for new and existing buildings, as well as different categories of buildings. These requirements are planned to be reviewed regularly, at least every five years and, if necessary, they will be updated in order to reflect technological progress in construction.

Minimum requirements for the energy performance of buildings are set with respect to the optimal costs. Cost optimality is calculated using the comparative method.

Ensuring the improvement of the energy performance of buildings with a total usable area of more than 1000 m^2 after total renovation is expected, which will allow to achieve the minimum requirements to the extent that it is technically, functionally and economically feasible. Requirements can be established either for a renovated building as a whole, or for repaired systems or components when their reconstruction is carried out for a limited period of time in order to improve the energy performance of the building as a whole.

Major repairs of existing buildings larger than a certain size should be considered as an opportunity to take economically feasible measures to increase their energy efficiency. Major repairs include, for example, cases where the total cost of repairing the building envelope and (or) energy systems, for example, heating, hot water, air conditioning, ventilation, and lighting systems, is more than 25% of the value of the building minus the cost of land on which the building is constructed, or cases when the repair affects more than 25% of the building envelope.

Audit of the energy performance of existing buildings should be aimed at identifying opportunities and potentials for energy saving and cost reduction. In order to reduce the energy consumption of the building and improve the quality of the indoor microclimate, measures can be taken to increase energy efficiency. In many cases, these measures pay off by reducing energy costs in a short period of time.

With regard to reducing energy consumption and limiting carbon dioxide emissions, the necessary measures are proposed to ensure regular inspections of air con-

ditioning systems with an effective rated power of more than 12 kW. Such control will include an assessment of the effectiveness of air conditioning and system capacity compared to the cooling needs of the building.

In addition, after each inspection, providing a report on the inspection of the heating or air conditioning system is expected. The inspection report will contain the results of the inspection and recommendations for cost-effective improvement of the energy performance of the inspected system.

Conducting a quality energy audit is impossible without qualified specialists. Currently, requirements are being developed for experts compiling the Energy Performance Certificates and inspecting the heating and air conditioning systems. These experts are accredited in accordance with their professional competence, and the information on their training and qualifications, as well as lists of accredited experts/companies, is published. It is planned to create an independent quality control system that will ensure the quality of the Energy Performance Certificates and audit reports.

To achieve the planned results covered in the developed methodology for determining the energy efficiency of buildings and structures that is harmonized with the requirements of "Directive 2010/31 / EU for energy efficiency of buildings", and taking into account the climatic, economic and cultural characteristics of Kazakhstan, it is necessary to provide for the solution of the following issues:

1. Stage-by-stage strengthening of requirements for the classes of newly constructed buildings and buildings undergoing thermal modernization, reconstruction and overhaul repairs.
2. Organization of mandatory energy inspections (energy audits) of the used buildings with a specified frequency for the purpose of their certification, assignment to certain classes, confirmation of assigned classes.
3. Stage-by-stage introduction of voluntary and then mandatory certification of buildings by energy efficiency classes at the legislative level.

DISCUSSION

The European Union remains a leader in the efficient use of energy resources, and its experience is used by many countries of the world, including the Republic of Kazakhstan and other member states of the Eurasian Economic Union.

The energy efficiency certification system for residential buildings is expected to contribute to:

- rational and economical use of fuel, energy and material resources
- reducing energy consumption during the operation of residential buildings and improving the quality of life of people by providing comfortable living conditions;
- successful implementation of the housing policy of the state;
- reducing housing maintenance costs;
- reducing greenhouse gases emissions;
- creating market incentives for the construction of energy-efficient buildings and the renovation of existing buildings;
- the development and phased implementation of financial and economic mechanisms and organizational measures to stimulate the construction of energy-efficient residential buildings, the creation of a basis for decision-making on the priority of financing energy-saving measures in buildings, as well as measures to reduce the energy consumption of the housing stock, including thermal modernization of operating residential buildings;
- will provide stimulation of the development of alternative energy in Kazakhstan, will increase the share of renewable sources in the total energy consumption in the housing stock;
- introducing an affordable building valuation mechanism;
- independent assessment of the energy consumption of buildings of the same type;
- creating new jobs.

The development and implementation of such measures will allow:

- to give an assessment of the energy efficiency of buildings, taking into account all types of energy (for heating, ventilation, hot water, electricity to ensure the operation of engineering systems);
- to develop qualitatively new design solutions;
- to improve the quality of construction;
- to inform owners and residents (tenants) of the real energy performance of buildings [15].

The implementation of a system for assessing the energy efficiency of buildings (energy efficiency certification system) in Kazakhstan will require the phased implementation of a number of measures:

- enactment of a provision containing mandatory requirements for the procedure for assessing the energy efficiency of buildings and structures and energy audits;
- introduction of the European classification of buildings and structures for energy efficiency with phased tightening of requirements for classes of newly constructed buildings and buildings undergoing thermal modernization, reconstruction and total renovation;
- corrections of existing regulatory legal and technical regulatory legal acts of the Republic of Kazakhstan in accordance with the set goals and objectives. First of all, with the aim of creating a unified approach in the country in assessing the energy efficiency of buildings and drawing up a single document (energy

efficiency certificate);

- adoption of a set of standards interconnected with regulatory and technical documents that are, as far as possible, identical to EN standards;
- development of a national methodology for calculating the energy performance of buildings based on European standards [15].

CONCLUSIONS

In the Republic of Kazakhstan, energy certification of buildings can be considered as a system for assessing compliance of buildings with the established requirements of technical regulatory legal acts in the context of energy efficiency.

In most European countries, the procedure of mandatory energy certification of residential and administrative buildings is applied. The Directive 2002/91/EC (EPBD) of the European Parliament and the Council provided for the need for such certification. Since 2008 when selling real estate (buildings) the owner of the building as well as all landlords are obliged to have and, if necessary, present the energy certificate. Since 2013, homeowners who do not have the energy certificate are subject to penalties by the state.

In accordance with the Directive, the energy certificate of a building should include reference values obtained from the audit, which should allow the consumer to compare and evaluate the energy efficiency of the building. The main reason that stimulates consumers to opt for energy-efficient buildings is the possibility of reducing the cost of operating the building.

Energy efficiency certification of buildings allows to evaluate buildings in order to efficiently use energy resources and creates the basis for assessing and comparing the energy consumption of various buildings. The system is the basis of financial incentives, and obtaining an energy efficiency class creates the prerequisites and motives for the design and construction of new buildings with a high energy efficiency class and improving the energy efficiency class while modernizing existing ones.

REFERENCES

1. Van Chien, N. (2020). Energy Consumption, Income, Trading Openness, and Environmental Pollution: Testing Environmental Kuznets Curve Hypothesis. Journal of Southwest Jiaotong University, 55(1). https://doi.org/10.35741/issn.0258-2724.55.1.49
2. KAZENERGY Association. (2014). Review of the state policy of the Republic of Kazakhstan in energy saving and energy efficiency. Brussels.
3. United Nations Development Programme in Kazakhstan. Global Environment Facility. (2015). Why is it profitable to construct energy-efficient buildings? Astana.
4. Law of the Republic of Kazakhstan No. 541-IV "On Energy Saving and Energy Efficiency Improvement" (2012). Office of the President of the Republic of Kazakhstan. https://policy.asiapacificenergy.org/node/135
5. Sharipov, R. Zh., & Sabitbek, I. R. (2018). Implementation of the development program of standard technical documents of the Republic of Kazakhstan on the assessment of energy efficiency of buildings. Vestnik of JSC "KazNIISA", 4(80).
6. Sharipov, R. Zh., & Alimova, K. K. (2019). Topical issues of energy saving and energy efficiency. Vestnik of KazNRTU, 1(131), 148–152.
7. Kyoto Protocol of the United Nations Framework Convention on Climate Change. (1997). Kyoto. https://www.eea.europa.eu/policy-documents/kyoto-protocol-to-the-un
8. Directive 2010/31/EU of the European Parliament and Council on the energy performance of buildings. (2010). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010L0031
9. Sharipov, R. Z. (2018). Barriers to the implementation of energy-saving and energy efficiency measures in the construction sector of the Republic of Kazakhstan. Proceedings of the IV International Scientific and Practical Conference "Technical Regulation of the Construction Industry in Modern Conditions".
10. Kudrevich, O. O. (2014). Energy Efficiency Certification of Buildings. Minsk.
11. Lari, A. (2015). Energy efficiency certification of buildings. Best practices for energy performance certification of high-rise apartment buildings. Minsk.
12. Gorshkov, A. S., Vatin, N. I., Rymkevich, P. P., & Kydrevich, O. O. (2018). Payback period of investments in energy saving. Magazine of Civil Engineering, 78(2), 65–75. doi: 10.18720/MCE.78.5
13. Sharipov, R. Zh. (2019). Issues of energy-efficient construction in the Republic of Kazakhstan. Proceedings of the V International Scientific and Practical Conference "Technical Regulation of the Construction Industry in Modern Conditions", 14–17.
14. Sharipov, R. Zh., Yerzhanov, S. E., & Sabitbek, I. R. (2019). Issues of developing the methodology for the determination of energy efficiency of buildings and structures in the Republic of Kazakhstan. Moscow: The Bulletin of the Construction Technology, 8 (1020), 59–61.
15. Tarnagursky, A. V. (2016). Justification, recommendations and draft regulations for the step-by-step implementation of the energy efficiency certification system for buildings. Minsk.

16. Semin, A. N., Ponkratov, V. V., Levchenko, K. G., Pozdnyaev, A. S., Kuznetsov, N. V., & Lenkova, O. V. (2019). Optimization model for the Russian electric power generation structure to reduce energy intensity of the economy. International Journal of Energy Economics and Policy, 9(3), 379–387. https://doi.org/10.32479/ijeep.7552
17. Li, C., Pu, Y., & Zhang, J. (2017). Optimization of Energy Efficiency of Train Travelling Along Slope Using Sequential Quadratic Programming. Journal of Southwest Jiaotong University, 52(5). http://jsju.org/index.php/journal/article/view/53
18. Kuznetsova, E. L., & Makarenko, A. V. (2019). Mathematical model of energy efficiency of mechatronic modules and power sources for prospective mobile objects. Periodico Tche Quimica, 16(32), 529–541.

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