ISSN 2786-7102 (Online), ISSN 2786-7633 (Print)
https://doi.org/10.15407/srenergy2024.03.062

UDC 536.2

Artem Riabikov, https://orcid.org/0009-0003-6440-6202
General Energy Institute of NAS of Ukraine, 172, Antonovycha St., 03150, Kyiv, Ukraine
e-mail: riabikov1@gmail.com

ANALYSIS OF THE REGULATORY AND LEGISLATIVE BASE OF UKRAINE AND THE EUROPEAN EXPERIENCE IN CONDUCTING ENERGY AUDITS OF BUILDINGS

Abstract. *The article analyzes the regulatory and legislative base for the energy efficiency of buildings. It identifies the main areas for improving energy efficiency by improving the process of energy audit, as well as improving the system of indicators that determine the airtightness of the building and preservation of comfortable conditions for human stay in the room. The relevance of the work is determined by the problem of low energy efficiency of the housing stock of Ukraine, which affects the rational consumption of energy, necessitates the introduction of various measures aimed at rationalizing energy use in general and buildings in particular, setting maximum permissible energy consumption rates for buildings and strengthening relevant control. The imperfection of the regulatory and legislative base in the field of energy efficiency, the need to develop a state standard for the design of buildings with increased air permeability, the development of a methodology for determining the air permeability of a building, the legislative establishment of minimum requirements for building airtightness, the development of a methodology for testing buildings for airtightness, and the imperfection of the methodology for conducting an energy audit of a building form the basis for further research. To improve the energy management of buildings, it is proposed to introduce mandatory testing of the building for airtightness, which will standardize approaches to energy management and compliance with the relevant requirements for building airtightness will lead to an increase in the energy efficiency class of buildings.*

Keywords: energy efficiency, energy audit, air permeability, airtightness.

1. Introduction

In recent years, the problem of energy consumption has become increasingly acute. In Ukraine, the problem of rational energy consumption is related to the fact that the housing fund has about 80 % of buildings with low energy efficiency. To solve this problem, it is necessary to implement various measures aimed at rationalizing energy use in general and in buildings in particular, to set maximum permissible energy consumption rates for buildings and to increase control over energy consumption.

2. Analysis of recent research and publications

The authors of [1–4] analyzed the impact of building airtightness on its overall energy efficiency, in particular, they showed the impact of the air permeability indicator and proposed mandatory testing of buildings for airtightness.

Ukraine needs to develop a state standard for the design of buildings with increased air permeability, there is a need to develop a methodology for determining the air permeability of a building, there are no mandatory minimum requirements for airtightness of buildings, and the methodology for testing buildings for airtightness needs to be further improved, which is the basis for further research.

The purpose of the article is to develop proposals for improving the energy audit of buildings by introducing minimum requirements for building airtightness using the air permeability coefficient.

3. Summary of the main material

In recent years, a set of regulatory documents aimed at improving the energy efficiency of buildings, in particular, the design of external envelope structures has been created and is constantly being improved in Ukraine. The set of documents was created on the basis of systematic research of energy efficiency and thermal reliability of building facilities, taking into account European practice. The research is based on the representation of the building as a single energy system. This allows us to determine one of the main indicators - its energy efficiency.

According to [5], the energy efficiency of building is defined as the property of its thermal insulation envelope and engineering equipment to ensure optimal microclimatic conditions of the building's premises at actual or estimated heat energy consumption for heating. The law has a prolonged timeframe and is designed for decades to come, for example, an energy efficiency certificate is valid for 10 years. After this period, a new energy certificate can be drawn up for this building.

Ukrainian legislation defines seven energy efficiency classes for buildings from A (the highest) to G (the lowest). The energy efficiency class is determined for each building subject to certification. The main provisions on certification of energy efficiency of buildings are defined by the same law [5]. The law also defines such concepts as an energy certificate and certification of energy activities.

Energy efficiency certification is mandatory for new construction, state-owned buildings with a heated area of more than 250 square meters, which are frequently visited by citizens and all premises of which are occupied by state and local government bodies, and buildings undergoing thermal modernization at the expense of the state.

Energy efficiency certification of buildings in Ukraine is gradually gaining momentum. In 2020, energy auditors issued 5018 certificates [6]. This is almost 4 times more than in 2019 (about 1300 certificates). For comparison, in January–February 2019, this area was just emerging and included the first 4–14 certificates issued. At the end of 2020, 6379 buildings were certified: 6022 – in the certificate database on the website of the State Agency on Energy Efficiency and Energy Saving as of the end of November 2020; another 357 – in the Unified State Electronic System in the field of construction from December 1 to December 31, 2020. Thus, as of January 1, 2021, about 6 thousand buildings in Ukraine have received energy certificates. Of these, almost 44 % have the lowest energy efficiency class "G", and only 1.4 % have the highest class "A". This level of energy efficiency is not in line with Ukraine's progress in reducing energy consumption by residential buildings and improving the comfort of people's living.

Since 2021, Ukraine has established minimum requirements for energy efficiency of buildings for the first time (see Table 1) [7]. Establishing minimum energy efficiency standards for buildings will have an economic effect not only for the state, as it will allow for the efficient use of energy resources, but also for home and building owners, who will be able to save on utilities.

The exceptions to the minimum energy efficiency requirements are a number of facilities, including individual residential buildings, historic buildings, industrial and agricultural buildings, transport, energy and defense facilities, as well as construction works to restore certain structures of buildings and structures to eliminate the consequences of emergencies and restore the functioning of facilities intended to ensure the vital activity of the population.

Amendments were also made to the Methodology for Determining the Energy Efficiency of Buildings, which is used in the design of facilities and during certification [9]. The methodology stipulates that when determining the energy efficiency class of a building, mandatory information on climatic conditions, functional purpose of the building and geometric (including the location and orientation of building envelopes), thermal and energy characteristics of the building, sanitary and microclimatic conditions of the building's premises, etc. must be taken into account. This information is not obtained because of specific measurements, but is determined by the relevant standards and regulations [10–14], which can lead to unreliable energy audit results.

Ukraine is implementing European certification practices, including a gradual increase in the minimum energy efficiency requirements for buildings, which provides owners and occupants of a building with valuable information about its condition and energy consumption, energy efficiency class, and clear recommendations for improving it.

Table 1. Minimum requirements for energy efficiency of buildings [7, 8]

	Type of buildings	Minimum requirements	Indicators
1.	New construction	Energy efficiency class not lower than class C in terms of indicator energy consumption for heating and cooling	$-20 \le \Delta_{EP} \le 0$, where $\Delta_{EP} = [(EP_{use} - EP_p) / EP_p] \times 100$ EP_{use} – yearly calculated or actual value of the total specific energy consumption of the building for heating and cooling; EP_p – limit value of specific energy consumption for heating and cooling of residential, kWh/m^2 , and public buildings, [kWh/m ^{3}]
2.	Reconstruction with a change of functional purpose		
3.	Reconstruction without changing the functional purpose	The total indicator of specific energy consumption for heating and cooling does not exceed the relevant threshold value	$EP_{use} \le 1{,}2EP_p$, where $EP_{use} = EP_{H,use} + EP_{C,use}$ where $EP_{H,use}$ – specific energy consumption during heating, kWh/m^2 [kWh/m^3]; $EP_{C,use}$ – specific energy consumption during cooling, kWh/m^2 [kWh/m^3];
4.	Major repairs of individual parts (roof, exterior walls, windows) are not allowed patchwork insulation	The reduced heat transfer resistance of the building envelope is not lower than the minimum permissible value	$R_{\sum пр} \ge R_{qmin}$, where $R_{\Sigma пр}$ – the reduced heat transfer resistance of the building envelope, m^2 ·K/W; R_{qmin} – minimum permissible value of heat transfer resistance, m^2 ·K/W;
5.	Overhaul of engineering systems (weather-controlled IHS, balancing valves, etc.)		Energy efficiency class of engineering equipment and availability of automated building monitoring and management systems (ABMS)

According to the law [15], the indicators of a building's energy efficiency are the specific energy consumption for heating, cooling, hot water supply, ventilation systems, lighting, as well as specific energy consumption of primary energy and greenhouse gas emissions. All these indicators are estimated.

Also, Article 1, paragraph 6 of the Law [15] defines the concept of energy audit of buildings as a systematic process of assessing the efficiency of energy consumption (use) by a building or a group of buildings within the scope of work determined by the customer of the energy audit of the building, in order to determine economically justified recommendations for improving the energy efficiency of a building or a group of buildings.

In Ukraine, the requirements for conducting energy audits are regulated by a number of regulatory documents [16–20]. They define the procedure for conducting energy audits, measuring and verifying the level of achieved/attainable energy efficiency, requirements for audit and certification bodies, etc.

In [1], the author analyzed the regulatory base of 10 European countries on energy efficiency of buildings and found that in the UK, France, Ireland and Denmark, mandatory testing of buildings for air tightness has come into force. Most EU countries are considering mandatory airtightness testing of buildings due to the growing impact of heat leakage from buildings on the overall energy efficiency of low-energy buildings. The need for further research on the impact of air tightness on energy consumption and indoor air quality is also emphasized.

Paper [2] presents the results of analyzing the impact of energy efficiency measures on several buildings of different ages and number of floors in Finland, Estonia, and Lithuania. It is shown that improving energy efficiency through thermal modernization measures, in particular, increasing air permeability, can have both a positive and negative impact on the quality of the internal environment and the quality of life and health of people who stay in buildings for a long time. This necessitates the establishment and further improvement of the minimum acceptable standards for the quality of the indoor environment of a building in national legislation, as well as the development of a system for monitoring such indicators.

In [3], the author proposes to use the air infiltration coefficient per unit area of the envelope as an index for assessing the indoor environment of public buildings.

In [21] proposes a comprehensive approach to determining and analyzing data on the level of CO2 concentration in educational institutions with natural air exchange and in the absence of mechanical air circulation and establishes that the level of energy consumption of a building depends on the actual level of air exchange and that the ventilation component accounts for 30–60 % of the total energy balance. The results obtained by the authors can be used to monitor the airtightness of the building and take it into account during the energy audit of the building.

National legislation does not approve a standard for designing buildings with increased air permeability, and state standards do not provide for a methodology for testing buildings for airtightness. Adoption of national standards will have a significant impact on the development of the energy management system.

In [4], based on a typological approach to buildings in Belgium, a model of energy efficiency before and after modernization was built and it was found that the reduction in energy consumption due to the repair of window seams, which affects air tightness and air permeability, does not depend on the length of the seams. The lack of a standardized basis for defining building typology in Ukraine makes it difficult to build energy efficiency models before and after thermal modernization. There is also a need to develop a typology for structural components in existing buildings that could be used to assess the energy saving potential and the relative importance of modernizing each structural component.

In [22], the influence of temperature and wind characteristics of outdoor air on the natural component of air exchange in different locations of representative rooms of an 8-storey building was analyzed and it was found that in the dynamics of energy consumption of a building with standard air exchange and the calculated value, the natural component differs by 50–75 %, which is a possible level of savings under real air exchange conditions compared to standard ones.

Ukraine has adopted national standards for energy audit and energy management, harmonized with international regulations (Table 2) [16–20].

The basis of the developed complex is a systemic document [8] at the level of the State Construction Standards.

Another systemic document is DBN V.1.2-11 [23], which belongs to the class of regulatory documents that disclose the provisions of the Technical Regulations for Construction Products, Buildings and Structures [24]. This document defines the basic requirements for products, buildings and structures to ensure energy savings. Accordingly, [23] formulates the requirements for regulatory documents of all subsequent levels that are created in the field of energy saving of construction facilities during the design, construction and operation of construction facilities, as well as energy saving requirements.

The state standard [25] is aimed at methodological support of energy audit of buildings, the implementation of which should be regulated at the legislative level. This standard is one of the basic standards that ensure the determination of the parameters set in the energy passport during the energy audit of buildings in operation and the first national standards for the experimental determination of energy parameters of buildings.

According to the provisions of [25], the indicator of specific heat consumption for heating a building is determined in the field and evaluated for compliance with the requirements of [8]. The method established by this standard allows determining the total heat transfer coefficient of the building envelope. Standard [26] describes experimental equipment for testing the air permeability of building envelopes and buildings, as well as a set of regulatory documents relating to design solutions for facade insulation. At the same time, this complex was supplemented by a standard [27] for products such as double-glazed windows, which determine the energy efficiency of translucent structures.

The standards for laboratory test methods set forth methodological rules for determining the thermal reliability of building products, materials and structures, which are normalized by the requirements [8].

Thus, the created regulatory complex covers the issues of standardization of mandatory energy safety requirements, establishment of indicators characterizing the fulfillment of these requirements, rules for assessing indicators at the stage of designing construction projects, their experimental manufacture and use, planned operation of buildings, test methods and criteria for assessing the conformity of construction products and facilities.

This will ensure the required operational level of domestic buildings and address the issue of further reducing heat losses for heating buildings during their operation. At the same time, the set of documents not only

Table 2. National standards for energy audit and energy management

№	Name of the regulatory document	Summary	Main indicators
1.	DBN V.2.6-31:2021 Thermal insulation and energy efficiency of buildings	Defines technical parameters for ensuring energy efficiency of buildings. Establishes requirements for energy efficiency indicators of buildings, thermal performance of building envelopes (thermal insulation envelope), energy efficiency indicators of engineering equipment of buildings during their design and construction, and criteria for the rational use of energy resources for heating and cooling of buildings to ensure the normative sanitary and hygienic parameters of the microclimate of premises, durability of building envelopes during the operation of buildings.	$EP_{use} \leq EP_p$, where EP_{use} – yearly estimated or actual value of the total specific energy consumption of the building for heating and cooling; EP_p – limit value of specific energy consumption for heating and cooling of residential, kWh/m², and public buildings,[kWh/m³]; $EP_{use} = (Q_{H,use} + Q_{C,use})/A_f$ – for residential buildings and hotels; $EP_{use} = (Q_{H,use} + Q_{C,use})/V$ – for public buildings; where $Q_{H,use}, Q_{C,use}$ – yearly energy consumption of the building for heating and cooling, respectively, kWh; A_f, V – air-conditioned (heated) area for residential, m², and air-conditioned (heated) volume for a public building (or part of it), m³ Actual value EP_{use}, kWh /m², [kWh /m³], are determined according to DSTU B V.2.2-39, DSTU EN ISO 52000-1
2.	DBN V.1.2-11:2008 "System of ensuring the reliability and safety of construction facilities. Basic requirements for buildings and structures. Energy saving"	Formulated requirements for regulatory documents of all subsequent levels, which are created in the field of energy saving of construction facilities during the design, construction and operation of construction facilities, to the main requirement for energy saving.	The energy performance of a building EPB is represented by the EP indicator, which is related to the conditioned (heated) area A_f or the conditioned (heated) volume V of the building. The building is characterized by the following energy efficiency indicators, the numerical values of which are set by the requirements DBN V.2.6-31, namely, energy demand of the building EP_{nd}; energy consumption of the building EP_{use}; delivered energy EP_{del}; primal energy E_P; mass of greenhouse gas emissions m_{CO2}.
3.	DSTU B V.2.2-21:2008 "Buildings and structures. Methods for determining the specific heat consumption for building heating"	Aimed at methodological support of energy audit of buildings.	The total heat transfer coefficient of external envelope structures can be represented as: $K_{build} = f(Q, \Delta t, F_{\Sigma}, k)$, where: Q – indicators of heat energy supply and consumption; Δt – temperature indicators of indoor and outdoor air; F_{Σ} – total internal surface area of all external enclosing structures, m²; k – correction coefficients. The value of specific heat consumption for heating a house for the heating period $q_{буд}$, kWh/m² або kWh /m³ - for residential buildings $q_{build} = \frac{Q_{year}}{F_h}$ - for public buildings $q_{build} = \frac{Q_{year}}{V_h}$
4.	DSTU ISO 50001:2020 Energy management systems. Requirements and guidance for use (ISO 50001:2018, IDT)	Defines requirements for the creation, implementation, maintenance and improvement of energy management systems that allow organizations to reduce energy costs, reduce energy dependence and increase the efficiency of energy use.	The indicator of specific heat loss of the house is determined: $q_{build} = \frac{Q_{year}}{F_h}$, Wh/m² The energy efficiency class of a building is determined in accordance with annex F of DBN V.2.6-31:2021 based on the analysis of the expression: $\left[\frac{(q_{build} E_{max})}{E_{max}}\right] \cdot 100\ \%$
5.	DSTU EN 16247-1:2015 Energy audits. Part 1: General requirements (EN 16247-1:2012, IDT)	Establishes general requirements for conducting an energy audit, which allows to assess energy use in organizations and identify potential opportunities for reducing energy consumption and improving energy efficiency.	
6.	DSTU ISO 50002:2018 Energy audit. Recommendations on general requirements for energy audit	Provides recommendations for conducting an energy audit, including determining the scope and composition of the audit, methods for assessing energy needs, and identifying energy saving measures.	

covers the issues of regulating energy security requirements, but also addresses global environmental issues related to a significant reduction in greenhouse gas emissions due to the macroeconomic effect of energy saving.

Thus, the set of regulatory documents based on [8] generally covers the regulatory space established in the EU Directive on the energy efficiency of buildings [28]. In general, the current level of the national regulatory base meets European and international standards.

However, there are areas of construction whose regulatory support does not meet the current technological capabilities of the industry and the realities of design and construction. These areas need to be harmonized with existing EU regulations.

4. Conclusions

Compared to EU countries, Ukraine may be lagging behind in certain aspects of building energy efficiency, but active reform is underway to bring it closer to European standards. Many EU countries have more developed infrastructure and experience in energy efficiency, as well as relevant legislation and programs that promote investment and improved energy efficiency technologies.

The analysis of the legislative and regulatory base and requirements for energy efficiency in buildings, as well as the European experience in conducting energy audits, showed that Ukraine has taken many steps to improve the legislative base for energy efficiency, but national standards do not take into account a number of aspects that have a significant impact on the results of energy audits of buildings. National legislation does not require mandatory calculation of airtightness and air permeability of buildings. In addition, the provisions of DSTU EN ISO 9972:2022 do not clearly define the test conditions that have a significant impact on the final result and may lead to an incorrect determination of the building class during its energy audit.

The key aspects of the European experience in conducting energy audits of buildings are standardization and regulation, mandatory audit, financial support, technological innovation, stakeholder engagement, and monitoring and updating.

To improve the energy management of buildings, it is proposed to introduce mandatory airtightness testing of buildings, which will standardize approaches to energy management, and compliance with the relevant requirements for building airtightness will lead to an increase in the energy efficiency class of buildings.

References

1. Leprince François, V., Carrié, R., & Kapsalaki, M. (2017, September). Building and ductwork airtightness requirements in Europe – Comparison of 10 European countries (pp. 192–201). AIVC 2017 Conference, Nottingham. URL: https://www.aivc.org/resource/building-and-ductwork-airtightness-requirements-europe-comparison-10-european-countries (Last accessed: 10.03.2024).
2. Prasauskas, T., Martuzevicius, D., Kalamees, T., Kuusk, K., Leivo, V., & Haverinen-Shaughnessy, U. (2016). Effects of Energy Retrofits on Indoor Air Quality in Three Northern European Countries. *Energy Procedia*, 96, 253–259. https://doi.org/10.1016/j.egypro.2016.09.134
3. Ji, Y., Duanmu, L., & Hu, S. (2024). Measurement and analysis of airtightness safeguard measures for typical ultra-low energy buildings. *Energy and Built Environment*, *5*(3), 348–363. https://doi.org/10.1016/j.enbenv.2022.11.003
4. Van Craenendonck, S., Lauriks, L., & Vuye, C. (2016). Energy efficient renovation of Belgian houses: sensitivity analysis for thermal bridges. *Energy Procedia*, 96, 158–169. https://doi.org/10.1016/j.egypro.2016.09.117
5. On the energy efficiency of buildings: Law of Ukraine dated January 1, 2024, No. 1818-IX. *Official website of the Verkhovna Rada of Ukraine*. Kyiv: Vidomosti Verkhovnoi Rady (VVR), 2022, 2, 8. URL: https://zakon.rada.gov.ua/laws/show/1818-20 (Last accessed: 08.02.2024) [in Ukrainian].
6. UA Energy Map. (n.d.). Energy certificates database for buildings. URL: https://map.ua-energy.org/uk/resources/ed1b45b2-9ed8-4957-9b71-dd40cfd3ec83/ (Last accessed: 10.03.2024) [in Ukrainian].
7. On the approval of the Minimum requirements for the energy efficiency of buildings: Order dated October 27, 2020, No. 260. Kyiv: Ministry of Development of Communities and Territories of Ukraine. URL: https://ips.ligazakon.net/document/view/re35540?an=1&ed=2020_10_27 (Last accessed: 17.02.2024) [in Ukrainian].
8. Thermal insulation and energy efficiency of buildings: DBN V.2.6-31:2021. (2022). Kyiv: Ministry of Development of Communities and Territories of Ukraine. URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=98037 (Last accessed: 08.02.2024) [in Ukrainian].

9. On the approval of Changes to the Methodology for determining the energy efficiency of buildings: Order dated October 27, 2020, No. 261. Kyiv: Ministry of Development of Communities and Territories of Ukraine. Legislation of Ukraine. URL: https://zakon.rada.gov.ua/laws/show/z1254-20#Text (Last accessed: 08.02.2024) [in Ukrainian].
10. DSTU-N B V.1.1-27:2010 Protection against hazardous geological processes, harmful operational impacts, and fire. Building climatology. (2010). State Enterprise "NDIBK", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=26655 (Last accessed: 08.02.2024) [in Ukrainian].
11. On the approval of the procedure for conducting inspections of completed construction objects: Resolution dated April 12, 2017, No. 257. Cabinet of Ministers of Ukraine. Legislation of Ukraine. URL: https://zakon.rada.gov.ua/laws/show/257-2017-%D0%BF#Text (Last accessed: 08.02.2024) [in Ukrainian].
12. DSTU B A.2.2-8:2010 Section Energy efficiency in the project documentation of objects. (2010). State Enterprise "NDIBK", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page?id_doc=25827 (Last accessed: 08.02.2024) [in Ukrainian].
13. DSTU EN ISO 52000-1:2023 Energy performance of buildings. Comprehensive assessment of building energy performance. Part 1. General structure and methodologies (EN ISO 52000-1:2017, IDT; ISO 52000-1:2017, IDT). (2023). Technical Committee for Standardization TK 302 "Energy efficiency of buildings and structures", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=98995 (Last accessed: 08.02.2024) [in Ukrainian].
14. DSTU 9190:2022 Energy efficiency of buildings. Method for calculating energy consumption for heating, cooling, ventilation, lighting, and hot water supply. (2022). Technical Committee for Standardization TK 302 "Energy efficiency of buildings and structures", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=98995 (Last accessed: 08.02.2024) [in Ukrainian].
15. On the approval of the Methodology for determining the energy efficiency of buildings: Order No. z0822-18 dated July 11, 2018. Ministry of Regional Development, Construction and Housing and Communal Services of Ukraine. URL: https://zakon.rada.gov.ua/laws/show/z0822-18 (Last accessed: 08.02.2024) [in Ukrainian].
16. DSTU ISO 50002:2016 (ISO 50002:2014, IDT) Energy audits. Requirements and guidelines for their conduct. (2016). State Enterprise "UkrNDNC", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page?id_doc=64370 (Last accessed: 08.02.2024) [in Ukrainian].
17. DSTU ISO 50003:2016 (ISO 50003:2014, IDT) Energy management systems. Requirements for bodies providing audit and certification of energy management systems. (2016). State Enterprise "UkrNDNC", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page?id_doc=64374 (Last accessed: 08.02.2024) [in Ukrainian].
18. DSTU ISO 50004:2016 (ISO 50004:2014, IDT) Energy management systems. Guidance for the implementation, support, and improvement of an energy management system. (2016). State Enterprise "UkrNDNC", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page?id_doc=64375 (Last accessed: 08.02.2024) [in Ukrainian].
19. DSTU ISO 50006:2016 (ISO 50006:2014, IDT) Energy management systems. Measurement and verification of achieved/attainable energy performance using baseline energy consumption and energy performance indicators. General principles and guidance. (2016). State Enterprise "UkrNDNC", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=64377 (Last accessed: 08.02.2024) [in Ukrainian].
20. DSTU ISO 50015:2016 (ISO 50015:2014, IDT) Energy management systems. Measurement and verification of achieved/attainable energy performance of organizations. General principles and guidance. (2016). State Enterprise "UkrNDNC", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page?id_doc=64379 (Last accessed: 08.02.2024) [in Ukrainian].
21. Deshko, V., Bilous, I., Vynogradov-Saltykov, V., Shovkaliuk, M., & Hetmanchuk, H. (2020). Integrated approaches to determination of CO2 concentration and air rate exchange in educational institution. *Rocznik Ochrona Srodowiska*, *22*(1), 82–104. URL: https://ros.edu.pl/images/roczniki/2020/007_ROS_V22_R2020.pdf (Last accessed: 29.03.2024).
22. Bilous, I.Yu., Deshko, V.I., & Sukhodub, I.O. (2020). Building energy modeling using hourly infiltration rate. *Magazine of Civil Engineering*, *96*(4), 27–41.
23. State Enterprise "NDIBK." (2021). DBN V.1.2-11:2021 Basic requirements for buildings and structures. Energy conservation and energy efficiency. Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=98036 (Last accessed: 17.02.2024) [in Ukrainian].
24. On the approval of state construction norms: Order dated December 30, 2021, No. 366. Ministry of Development of Communities and Territories of Ukraine, Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=98021 (Last accessed: 17.02.2024) [in Ukrainian].
25. DSTU B V.2.2-21:2008 Buildings and structures. Method for determining specific heat losses for building heating. (2008). State Enterprise "NDIBK", Kyiv. URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=47762 (Last accessed: 08.02.2024) [in Ukrainian].
26. DSTU B V.2.6-37:2008 Methods for determining the indicators of air permeability of enclosing structures and their elements under laboratory conditions. (2008). State Enterprise "State Scientific Research Institute of Building Constructions", Kyiv. URL: https://ksv.do.am/GOST/DSTY_ALL/DSTY4/dstu_b_v.2.6-37-2008.PDF (Last accessed: 08.02.2024) [in Ukrainian].

27. DSTU B V.2.6-35:2008 Buildings and structures. External wall structures with facade insulation and finishing with industrial elements with a ventilated air gap. General technical conditions. (2008). PAT "KYIVZNDIEP", Kyiv. URL: https://scanroc.ua/wp-content/themes/scanrok/img/docs/doc-DSTU-B-V26-35-2008.pdf (Last accessed: 08.02.2024) [in Ukrainian].
28. Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. (2002). *European Parliament, & Council*. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0091 (Last accessed: 08.02.2024).

АНАЛІЗ НОРМАТИВНО-ЗАКОНОДАВЧОЇ БАЗИ УКРАЇНИ ТА ЄВРОПЕЙСЬКОГО ДОСВІДУ ПРОВЕДЕННЯ ЕНЕРГОАУДИТУ БУДІВЕЛЬ

Артем Рябіков, https://orcid.org/0009-0003-6440-6202
Інститут загальної енергетики НАН України, вул. Антоновича, 172, м. Київ, 03150, Україна
e-mail: riabikov1@gmail.com

Анотація. *У статті проведено аналіз нормативно-законодавчої бази щодо енергоефективності будівель та визначено основні напрями покращення енергоефективності шляхом вдосконалення процесу проведення енергоаудиту, а також вдосконалення системи показників, на основі яких визначається герметичність будівлі та збереження комфортних умов перебування людини у приміщенні. Актуальність роботи визначає проблема низького рівня енергоефективності житлового фонду України, яка впливає на раціональне споживання енергії, викликає необхідність запроваджувати різноманітні заходи, спрямовані на раціоналізацію використання енергії в цілому та будівлями зокрема, встановлювати гранично допустимі норми енергоспоживання будівель та посилювати відповідний контроль. Недосконалість нормативно-законодавчої бази у сфері енергоефективності, необхідність розробки державного стандарту проєктування будівель підвищеної повітропроникності, розробки методики визначення повітропроникності будівлі, законодавчого встановлення мінімальних вимог до герметичності будівлі, розробки методики тестування будівлі на герметичність, недосконалість методики проведення енергоаудиту будівлі становить підґрунтя подальших досліджень. Для вдосконалення енергоменеджменту будівель пропонується впровадження обов'язкового тестування будівлі на герметичність, що дозволить стандартизувати підходи до проведення енергоменеджменту, а дотримання відповідних вимог до герметичності будівлі призведе до підвищення класу енергоефективності будівель.*
Ключові слова: енергетична ефективність, енергоаудит, повітропроникність, герметичність.

Надійшла до редколегії: 23.04.2024