JEL Classification: H53; I23; I25

UDC 378.09:005.332.4

DOI: 10.30857/2415-3206.2021.2.2

ENERGY CERTIFICATION AND ENERGY AUDIT OF HIGHER EDUCATION AS A METHODOLOGICAL TOOL TO IMPROVE THE ENERGY EFFICIENCY OF THE UNIVERSITY

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BACKGROUND AND OBJECTIVES. Improving the energy performance of buildings is one of the least expensive ways to reduce energy consumption and greenhouse gas emissions. Building energy performance certification increases public knowledge about energy conservation and allows consumers and other decision makers to compare buildings based on their lifetime performance. In addition, energy performance certifications are an incentive for owners to improve the efficiency of existing buildings.

METHODS. It is proposed to use in the process of energy certification and energy audit of university buildings collection and evaluation of basic information (including information about local climate, method of use, value of thermal conductivity coefficient and building envelope area, orientation) to determine the level of energy efficiency of the building on a generally accepted scale. In the Certificate of energy efficiency to take into account the calculated results from the assessment of the energy performance of the building.

FINDINGS. It is suggested that the results of the energy certification of university buildings be presented in a simple, clear form, to ensure clarity, ease of use and comparability. For the energy certification of university buildings, a comparative labeling from A to G is proposed for use. The scale, on which the current national building standard is at "C," provides ample room for improving the rating of both new and existing buildings. If necessary, the scale should be expanded to add a label such as A1, A2, or A+, A++ when it comes to high-performance buildings.

CONCLUSION. Accurate and reliable energy performance certification is a necessary foundation that will help ensure consumer confidence and the success of the certification program. The certification program must be clearly coordinated to ensure a smooth transition of the construction industry to the new rules.

KEYWORDS: energy certification; energy audits; universities; energy efficiency.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
10	0	1

JEL Classification: H53; I23; I25

УДК 378.09:005.332.4

DOI: 10.30857/2415-3206.2021.2.2

ЕНЕРГЕТИЧНА СЕРТИФІКАЦІЯ ТА ЕНЕРГЕТИЧНИЙ АУДИТ ЗАКЛАДІВ ВИЩОЇ ОСВІТИ ЯК МЕТОДИЧНИЙ ІНСТРУМЕНТАРІЙ ПІДВИЩЕННЯ ЕНЕРГОЕФЕКТИВНОСТІ УНІВЕРСИТЕТУ

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ПОСТАНОВКА ПРОБЛЕМИ ТА ЗАВДАННЯ. Підвищення енергетичної ефективності будівель – це один із найменш витратних способів скорочення енергоспоживання та викидів парникових газів. Сертифікація енергетичних характеристик будівель підвищує рівень знань у суспільстві про енергозбереження та дозволяє споживачам та іншим особам, які приймають рішення, порівнювати будівлі, виходячи з їхньої ефективності за період експлуатації. Крім того, свідоцтва про енергоефективність – це стимул для власників підвищити ефективність існуючих будівель.

МЕТОДИ. Запропоновано використовувати в процесі енергосертифікації та енергоаудиту будівель університету збір та оцінку основної інформації (у тому числі інформації про місцевий клімат, спосіб використання, значення коефіцієнта теплопровідності та площу оболонки будівлі, орієнтації) для визначення рівня енергетичної ефективності будівлі за загальноприйнятою шкалою. У Свідоцтві про енергетичну ефективність враховувати обчислені результати за підсумками оцінки енергетичних характеристик будівлі.

РЕЗУЛЬТАТИ. Запропоновано результати енергосертифікації університетських будівель представляти у простій, чіткій формі для забезпечення ясності, простоти у використанні та можливості порівняння. Для енергосертифікації університетських будівель запропоновано до використання порівняльне маркування від A до G. Шкала, на якій сучасний національний будівельний стандарт знаходиться на позначці "C", дає достатньо місця для покращення рейтингу як нових, так і існуючих будівель. У разі потреби шкалу слід розширити і додати таке маркування як A1, A2 або A+, A++, якщо йдеться про високоефективні будівлі.

ВИСНОВКИ. Точність та надійність свідчень про енергетичну ефективність – це необхідна основа, яка допоможе гарантувати довіру споживачів та успіх програми сертифікації. Необхідно чітко координувати виконання програми сертифікації, що дозволить забезпечити плавний перехід будівельної галузі до нових правил.

Ключові слова: енергосертифікація; енергоаудит; університети; енергетична ефективність.

INTRODUCTION.

In the European Community, the construction sector consumes more than 40% of the energy given, and this figure is constantly growing. This trend will definitely lead to an increase in energy consumption and, as a consequence, an increase in carbon dioxide emissions. Since the oil crisis in the late 1970s, various countries have adopted different strategies to improve the energy efficiency of the national building stock. The Directive on the Energy Performance of Buildings, adopted in 2002 and finalized in 2010 (2010/31/EC), is a European Commission directive that obliges EU member states to set minimum energy performance standards for new and renovated buildings (Di Stefano, 2000). In addition, the directive requires each member state to implement energy performance certificates for new and existing buildings (Gryshchenko et al., 2017).

Energy performance certification of buildings is considered an important tool that will help to attract investments to improve the energy performance of buildings and increase consumer awareness of the energy saving potential of buildings (Kaplun and Shcherbak, 2016). Certification was created as a market-based tool that will help improve the energy efficiency of buildings, repairs, and utilities (Liu et al., 2019). Ideally, it is an easy way for consumers to compare and evaluate energy efficiency investments in buildings in terms of energy consumption in the long term. Implementation of the international standard ISO 50001 is necessary for all industries, educational institutions, trade, hotels, etc. (Shaposhnikova and Shimov, 2016).

Implementing an energy management system allows universities to improve the efficiency of their educational activities and to benefit greatly from the optimal use of their energy resources (Shcherbak et al., 2019). Inefficient energy processes can be seen at almost every enterprise, and it can be observed in the irrational use of energy resources, it can be the lack of control over the operation of compressors, engines, compressed air leaks, lack of motion sensors, the use of energy-intensive lighting and heating, it all leads to significant costs, which are transferred to the services provided (Vieira et al., 2020).

Implementation of energy management system provides opportunities for the university to solve all these problems (Xing et al., 2019). The main requirements for organizations in the implementation of ISO 50001: development of effective energy use policy, development of goals and objectives in accordance with the established policy, set the rules of understanding how to better use energy, regular measurement of results, analysis of the current energy management system (Nikolaieva, 2018). The aim of the article is to develop theoretical and methodological provisions for the formation of energy certification system and energy audit as a methodological tool to improve the energy efficiency of the university. Methodological approach to energy certification and energy audit was carried out on the basis of the survey of buildings of Kyiv National University of Technologies and Design (KNUTD) in 2021.

MATHERIALS AND METHODS.

According to Article 3 of the 2002 ECT, each member state has to adopt a calculation methodology for the energy performance of buildings, based on certain rules (On energy saving: Law of Ukraine, 2021).

The methodology for the calculation of the energy performance of buildings shall include the following:

(a) Thermal characteristics of buildings (envelope and interior partitions, etc.). These characteristics may also include air tightness;

b) Heating system and hot water supply, including their insulation parameters;

(c) Installation for air conditioning;

(d) Ventilation;

(e) Integrated lighting system (mainly in the non-residential sector);

(f) Location and orientation of buildings, including outdoor climate;

(g) Passive solar systems and solar protection;

(h) Natural ventilation;

(i) Indoor climatic conditions, including design room microclimate.

Further, if necessary for the calculation, the positive effects of the following aspects must be taken into account: a) active solar systems and other heating and power systems based on renewable energy sources; b) electricity produced by CHP; c) centralized heating and cooling systems; d) natural lighting.

The calculation methodology shall take into account the standards or rules applicable in EU member states according to their legislation. The energy performance of buildings must be presented transparently and may include an indicator of CO2 emissions. The European Community has prepared corresponding European EN standards, which must be adopted in the member states. These are, for example, simplified calculation formulas that member states can approve and apply at their discretion. Some member countries have chosen the option of integrating the calculation methodology into software or spreadsheets. In many cases, independent software developers have created licensed computer applications or software modules that conform to the calculation methodology of a particular member state. Most often, such applications are tested and approved by government agencies with expertise in building energy systems.

RESULTS AND DISCUSSION.

The Directive on the Energy Performance of Buildings, adopted in 2002 and revised in 2010 (2010/31/EC), is a European Commission directive requiring member states to set minimum energy performance standards for new and renovated buildings. In addition, the directive requires each member state to implement energy performance certificates for buildings. The directive requires the calculation of the energy performance of buildings on the basis of a methodology that may vary regionally, but includes, in addition to thermal insulation, other factors of increasing importance, such as heating and air conditioning installations, the use of renewable energy sources and building design. Furthermore, according to the Directive, each Member State must ensure a uniform approach to this process, which will be carried out by qualified accredited experts whose independence must be guaranteed on the basis of objective criteria. The aim of this approach is to ensure a common "rules of the game" in terms of the Member States' attempts to ensure energy savings in the building sector and to help them ensure transparency of the energy performance of buildings to potential owners or consumers in the European real estate market.

Energy performance certification is an audit carried out by a qualified professional, which results in a decision. The building is assigned one of seven energy efficiency levels, and the results are necessarily entered in the Registry. Energy certificate – an electronic document in the prescribed form, which specifies the indicators and class of the building, the actual and design characteristics of the building envelope and engineering systems. Energy certificate - the result of energy audit containing a detailed calculation, with specific figures on the cost and payback. Certification is mandatory for all public authorities premises. The law of obligatory certification of buildings defines that the energy certificate serves as a tool for assessing energy efficiency and shows how many resources the building uses and the potential to minimize them. Rational indicators of consumption of thermal and electrical energy of the object in Ukraine is used the distribution into classes (Table 1).

Table 1

Indicators of heat and electricity consumption of the facility in Ukraine by class

Class	Residential Buildings		Public buildings		Hotels		Educational institutions	Kindergartens
	Number of floors		Number of floors		Number of floors			
	1–3	4 and up	1–3	4 and up	1–3	4 and up		
A	<66	<44	<[30]	<[21]	<60	<39	<[17]	<[28]
B	<119	<79	<[54]	<[38]	<109	<70	<[30]	<[51]
C	<132	<87	<[60]	<[43]	<121	<78	<[33]	<[56]
D	<165	<109	<[74]	<[53]	<151	<97	<[42]	<[70]
E	<198	<131	<[89]	<[64]	<181	<116	<[50]	<[85]
F	≤231	≤153	≤[104]	≤[75]	≤211	≤136	≤[58]	≤[99]
G	>231	>153	>[104]	>[75]	>211	>136	>[58]	>[99]

The energy efficiency label classifies buildings according to their energy consumption on a scale from A (low energy consumption, high energy efficiency) to G (high energy consumption, low energy efficiency).

Energy efficiency certificates can be divided into two categories based on the method of calculation: certificates based on calculated need and certificates based on measured consumption. That is, when certifying university buildings, one can choose between "demand" and "consumption" for all existing buildings since heating and hot water billing is based on consumption. To match the data obtained by calculating demand, the impact of weather conditions over the period of data collection (at least 3 years) should be adjusted to account for the climate factor. In addition, a single "reference climate" (Würzburg climate) should be used for certification and auditing, and the energy consumption data for heating should also be recalculated using the parameters of this climate.

The comprehensive calculation method is described in DIN V18599, which is in accordance with the standards of the European Committee for Standardization applied to prove compliance with the requirements of the Energy Conservation Ordinance and gives energy efficiency values for inclusion in Energy Performance Certificates drawn up on the basis of energy demand.

For the certification and audit it is necessary to consider the quality of the software, i.e. the correct transfer of the technical rules to the software, which is an important step in terms of the quality of the results.

CONCLUSION.

The proposed calculation methodology includes too many scenarios in the normal course of events (spare values), and is therefore too far from reality. Therefore, the problem arose of using a more reliable calculation methodology to determine the energy efficiency level of a university building. To solve this problem, consideration should be given to expanding the number of data to be entered into the program from 30 to 60 and reducing the number of parameters. The values of thermal and technical characteristics of the building envelope and individual elements, as well as the efficiency of the heating, cooling, ventilation and hot water supply systems should be determined according to the operational needs of each particular university building.

ACKNOWLEDGEMENT.

The author is grateful to the heads of higher educational institutions for their assistance in conducting this research.

ABBREVIATIONS:

%	Percentage
€	Euro
CMU	Cabinet of Ministers of Ukraine
EIB	European Investment Bank
ERRA	Energy Regulators Regional Association
EU	European Union

Fig.	Figures
HEI	higher education institution
IEE	Institute of Energy Saving and Energy Management
KNUTD	Kyiv National University of Technology and Design
MESU	Ministry of Education and Science of Ukraine
NTUU "KPI"	National Technical University of Ukraine "Kyiv Polytechnic Institute"
RES	Renewable energy sources
Sec.	Sector
UN	United Nations
UP	Ukrainian Parliament

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HOW TO CITE THIS ARTICLE
Hanushchak-Yefimenko, L. (2021). Energy certification and energy audit of higher education as a methodological tool to improve the energy efficiency of the university. *Management*, 2(34): 18–25. https://doi.org/10.30857/2415-3206.2021.2.2.