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# MODERN PROBLEMS OF TRAINING FUTURE SPECIALISTS OF THE CONSTRUCTION INDUSTRY OF UKRAINE IN ENERGY-EFFICIENT TECHNOLOGIES

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**Abstract**

*Relevance*. The post-war reconstruction of Ukraine and the global transition to a green economy necessitate the implementation of energy-efficient technologies in the construction industry. The author notes that the problem of personnel training is systemic in nature, as vocational education often covers energy efficiency competencies fragmentarily, complicating the integration of information technologies. In this context, there is a growing urgent need to form a holistic approach to personnel training and the implementation of modern energy-efficient technologies at all stages of construction activity.

*Aim***:** to identify and characterize the modern problems of training future specialists of the domestic construction industry in energy-efficient technologies.

*Methods***:** theoretical (systematic literature review, content analysis, classification of barriers); empirical (analysis of reports from international organizations, comparative analysis of Ukrainian and European practices); analytical (generalization of results, interpretation of interconnections).

*Results***:** eight interconnected barriers have been singled out: the absence of a unified training system, the need for an interdisciplinary approach, a lack of practical skills, financial constraints, insufficient management support, difficulties in adapting materials, professional inertia, and excessive procedural regulation.

*Conclusions***:** the identified factors determine the low level of implementation of information technologies in construction (Building Information Modeling, BIM) and Cross-Laminated Timber (CLT) technology, which causes potential energy efficiency losses of up to 30%. Further improvement of the national standards framework, full scaling of dual education, and intensification of partnerships with the EU are recommended.

**Keywords:** *energy efficiency, construction industry, vocational training, implementation barriers, competencies.*

**Introduction**. The construction industry occupies one of the leading positions among energy consumers at the global level. According to the Global Alliance for Buildings and Construction (2024), the building and construction sector is responsible for approximately 37% of global energy consumption and 25–30% of $CO_2$ emissions. In Ukraine, the situation is particularly acute due to post-war reconstruction and dependence on imported energy resources, transforming energy-efficient technologies not merely into an innovation, but into a necessity for national security and sustainable development.

The relevance of the topic is conditioned by interconnected factors: global challenges of climate change and the UN Sustainable Development Goals

(SDG 7 and SDG 11) require a 50% reduction in energy consumption in buildings by 2030, which is reflected in the EU through the Energy Performance of Buildings Directive (EPBD), establishing minimum standards for the modernization and renovation of buildings (European Commission, 2024).

In the Ukrainian context, post-war reconstruction creates both unique opportunities and risks. The United Nations Development Programme in Ukraine (UNDP Ukraine, 2023) states that energy efficiency initiatives aim to reduce greenhouse gas emissions by strengthening institutional, administrative, and technical capacities in public institutions. The European Training Foundation (2025) emphasizes that the sector faces a shortage of skilled workers capable of working effectively with modern equipment and technologies of energy-efficient construction.

At the same time, the problem of personnel training is systemic in nature: vocational education often covers energy efficiency competencies in a fragmented manner, complicating the integration of technologies such as construction information technologies for modeling energy flows, as well as Cross-Laminated Timber (CLT) for energy-saving solutions (Kuzior et al., 2021). In this context, there is a growing urgent need to form a holistic approach to personnel training and the implementation of modern energy-efficient technologies at all stages of construction activity, including design, construction, and operation of structures.

The analysis of the source base made it possible to identify the main challenges for training future construction industry specialists in energy-efficient technologies. These are: the energy factor (high global energy consumption and Ukraine's critical dependence on imports, requiring personnel training for decarbonization and energy resilience); the educational factor (insufficient interdisciplinarity of programs globally and fragmentation of Ukrainian training, requiring standardization and updating of curricula); the technological factor (slow implementation of digital solutions and a low level of automation in Ukraine, exacerbated by resistance to innovation); and the political factor (global strategies—EPBD, Green Deal—set benchmarks, while the Ukrainian context is defined by the challenges of post-war recovery and dependence on international aid). In view of this, the training of future construction specialists must simultaneously take into account global trends and national limitations, forming competencies capable of ensuring the integration of energy-efficient technologies into the process of recovery and development of the construction industry.

**Research sources.** The competency-based approach, which underlies the formation of energy efficiency competencies, integrates technical, economic, and environmental aspects into a holistic concept. The work of M. Ryghaug and K. Sørensen (2009) analyzes the problem of energy efficiency gaps in the construction industry caused by behavioral and organizational barriers. This work lays the theoretical foundations for understanding systemic obstacles influencing the implementation of energy-efficient practices. In the study by F. Mosannenzadeh et al. (2017), the concept is expanded by detailing the barriers to implementing smart energy city projects in Europe. The empirical approach of these studies revealed that the most frequent obstacles are related to planning and design stages, highlighting the importance of educational preparation at the early stages of transformation processes. Researchers A. Trianni et al. (2013) supplemented the picture by analyzing barriers to industrial energy efficiency in European foundries. Their research demonstrates that technological barriers are often intertwined with educational ones, creating complex challenges for industrial transformation.

Modern Ukrainian studies (Andriushchenko, 2019; Deineko, & Tsyplitsyna, 2019; Kuzior et al., 2021; Andrusiv et al., 2023) reveal the specifics of energy efficiency in the context of the transition to a circular economy and green transformation, emphasizing the critical importance of professional training for the successful implementation of sustainable practices. In 2017, G. Hochman and G. Timilsina (2017) conducted one of the most thorough studies of energy efficiency barriers in commercial and industrial firms in Ukraine. Empirical analysis revealed a lack of knowledge and skills as one of the most significant factors hindering the implementation of energy-saving technologies. Ukrainian scholars N. Kholod et al. (2018) expanded this research, focusing on overcoming barriers through policy reforms and emphasizing the role of

educational initiatives in creating a favorable environment for energy-efficient innovations.

Significant attention is paid to international experience as a tool for forming national educational programs: T. Kryvomaz et al. (2020) investigated the prospects for the development of green construction in Ukraine using the example of Poland, demonstrating the value of cross-border perspectives. The works of G. Kharlamova, S. Nate, and O. Chernyak (2016) examined renewable energy and Ukraine's energy security, emphasizing the role of education in ensuring energy independence. At the same time, modern international initiatives, particularly the programs of the International Energy Agency (IEA, 2024, 2025) and the European Commission (2024), demonstrate a comprehensive approach to competence development, combining technical training with economic analysis and environmental awareness.

**The purpose of the article** is to identify and characterize the current problems of training future specialists of the domestic construction industry in energy-efficient technologies.

**Research methods:** theoretical (systematic literature review, content analysis, classification of barriers); empirical (analysis of reports from international organizations, comparative analysis of described Ukrainian and European practices); analytical (generalization of results, interpretation of interconnections).

A systematic literature review was conducted according to generally accepted principles of selection, analysis, and synthesis of scientific sources, adapted for interdisciplinary research in the field of energy efficiency and vocational education. Data sources covered academic databases Scopus, Web of Science, and Google Scholar for the period 2013–2025, totaling 22 sources, including 15 academic articles, 7 reports from international organizations, and additional publications. The search was performed using keywords: "energy efficiency", "construction", "vocational training", "barriers", "Ukraine", "professional education". Source selection criteria included research on energy efficiency barriers in construction or related industries, analysis of educational approaches to specialist training, a focus on Ukraine or relevant international experience, as well as publication in peer-reviewed journals or authoritative reports. Works without empirical substantiation, without connection to educational topics, or with unavailable full texts were excluded. Analysis methods included content analysis with systematic coding of text data to identify the frequency of mentions of different types of barriers, comparative analysis contrasting Ukrainian and international practices, and classification involving the grouping of identified barriers by thematic categories.

**Results and discussion.** The results of the analysis of the formed source base reveal eight key barriers hindering the effective training of future construction industry specialists in energy-efficient technologies:

1. *Lack of a unified training system.* Vocational education standards only partially cover energy efficiency, creating significant gaps in specialists' competencies. According to the International Energy Agency (IEA, 2025), standardization of curricula is necessary to ensure a systemic approach to education. At the same time, the European Training Foundation (ETF, 2025) points to a specific shortage of skilled workers in the energy-efficient construction sector in Ukraine. Ukrainian scholar K. Andriushchenko (2019) emphasizes that enterprise energy efficiency acts as a key factor in the country's economic development, requiring a systemic approach to education starting from basic vocational training. However, many educational standards do not include or only partially cover the formation of energy efficiency competencies, complicating the training of qualified specialists. As a result, there is no unified framework that would set a general trajectory for forming relevant competencies, leading to a disconnect between labor market requirements and educational programs.

2. *Need for an interdisciplinary approach.* Energy-efficient technologies require the close integration of technical, economic, and environmental knowledge. Research by F. Mosannenzadeh et al. (2017) demonstrates the success of smart energy city projects in Europe built on interdisciplinary cooperation and the integration of various fields of knowledge: technical, economic, environmental, and political. In this context, educational cases should encourage critical thinking and facilitate cooperation between different disciplines. Scholars A. Kuzior et al. (2021)

emphasize that green energy in Ukraine requires a comprehensive understanding of government requirements, societal needs, and technological trends, which is possible only under conditions of interdisciplinary education. Thus, the absence of systemic interdisciplinary training leads to a blurring of boundaries between knowledge and skills necessary for the effective implementation of energy-efficient solutions in the construction sector.

3. *Insufficient practical skills*. This is the most frequently mentioned limiting factor in relevant studies. Although Ukrainian commercial and industrial companies experience difficulties due to a lack of practical experience in applying energy-efficient technologies, similar problems exist in the international context. In particular, scientists G. Hochman and G. Timilsina (2017) note that a significant portion of specialists does not possess a sufficient level of knowledge and practical skills regarding the implementation of the latest energy-efficient technologies in construction, complicating their transition to real production conditions. According to European experience summarized in the study by A. Trianni et al. (2013), even in developed countries, industrial enterprises face similar challenges, indicating the universality of this problem. Thus, the mismatch between theoretical training programs and practical production requirements contributes to a low level of workforce readiness to implement energy-efficient technologies, reducing resource efficiency and innovation implementation in the construction process.

4. *Financial constraints.* In the study by L. Deineko and O. Tsyplitsyna (2019) on the opportunities and barriers of the Ukrainian industry's transition to a circular economy, it is emphasized that financial constraints play a central role in this process. The United Nations Development Programme (UNDP, 2023) states that high initial costs for training and implementing energy-efficient technologies constitute a key barrier for public buildings in Ukraine. An analysis of this problem is also reflected within the framework of the European Skills, Competences, Qualifications and Occupations (ESCO) program, aimed at overcoming relevant financial constraints by introducing innovative financial mechanisms. To effectively overcome financial constraints, systemic measures combining institutional and investment mechanisms are necessary. Within this strategy, innovative financial mechanisms offered by ESCO gain importance, oriented toward the modernization of educational programs and energy-efficient technologies in public buildings, as well as support for market participants at the initial stages of implementation.

5. *Insufficient management support*. The work of M. Ryghaug and K. Sørensen (2009) shows that the very absence of clear management support at the organizational structure level significantly reduces the effectiveness of energy efficiency measures in the construction industry. Researchers N. Kholod and M. Evans (2018) emphasize that overcoming energy efficiency barriers through policy reforms requires the active participation and support of governing structures at all levels.

6. *Difficulties in adapting teaching materials.* Regarding the difficulties of adapting teaching materials, the International Energy Agency (IEA, 2024) points to the rapid development of technologies as the main reason for difficulties in their adaptation: traditional approaches to curriculum development cannot keep pace with technological innovations, as well as the significant volume of available but not always high-quality information, requiring extensive work from instructors and learners to select relevant content. Polish scholar T. Kryvomaz et al. (2020) emphasize that prospects for green construction development require the constant updating of curricula in accordance with modern technological solutions, reinforcing the need for a systemic approach to updating educational materials in the context of the circular economy and energy efficiency.

7. *Professional inertia.* Among industry barriers, professional inertia is also highlighted, particularly resistance to change among professionals accustomed to traditional approaches and technologies. Ukrainian scholars G. Hochman and G. Timilsina (2017) found that psychological barriers related to resistance to change represent a serious obstacle to the implementation of energy-efficient technologies in Ukrainian firms. Research by Ukrainian scientists U. Andrusiv et al. (2023) showed that the effective use of Ukraine's fuel and energy resources requires not only technical solutions but also cultural changes within the

professional community. Thus, a notable role is assigned to changes in corporate culture and professional values, which must support the implementation of technological innovations and energy-efficient practices.

8. *Bureaucratic procedures.* Regarding bureaucratic procedures, the European Commission (2024) in its Energy Performance of Buildings Directive notes the presence of regulatory barriers as a significant obstacle to the rapid implementation of energy-saving technologies. Examining issues of renewable energy and security for Ukraine, scientists G. Kharlamova, S. Nate, and O. Chernyak (2016) emphasize that complex bureaucratic procedures slow down not only technological innovations but also the development of relevant educational programs. Thus, ensuring a faster and sustainable implementation of the circular economy and energy efficiency in the Ukrainian construction industry requires considering the interaction between regulatory reforms, financial instruments, workforce capacity development, and the adaptation of curricula to technology dynamics.

Thus, the study identified eight barriers of a systemic nature in the context of teaching energy-efficient technologies in the construction industry. The analysis of the problem highlights the necessity of applying a systemic approach to teaching energy-efficient technologies in construction, combining curriculum updates, provision of practical experience, overcoming financial and personnel constraints, and interdisciplinary cooperation to overcome complex challenges.

The review results indicate the critical importance of practice-oriented approaches and economic support for educational initiatives. The interconnection between the identified barriers forms a cascading system of obstacles, where successfully overcoming one challenge often depends on effectively resolving another. For example, the lack of a unified training system directly impacts the formation of interdisciplinary competencies and, consequently, the quality of energy-efficient solutions in practice, creating a chain of limitations in translating existing knowledge into actionable innovative approaches.

Particular attention is drawn to the domestic trend, which partially aligns with global trends but has specific features related to post-war recovery. While European countries (Mosannenzadeh et al., 2017; Trianni et al., 2013) direct their efforts toward improving existing systems, Ukraine has a unique opportunity to build a new vocational education system by integrating global best practices while taking local realities into account. In this context, the experience of international support programs (UNDP, 2023; ETF, 2025), demonstrating the effectiveness of targeted initiatives to overcome specific barriers, is especially valuable.

The identified barriers have a cascading impact on the entire construction industry of Ukraine: insufficient personnel training leads to a reduction in the quality of energy-efficient solutions, reduces energy saving potential by up to 30%, slows down the pace of post-war reconstruction, and lowers the competitiveness of Ukrainian construction companies in the international market.

The research results are directly linked to achieving the Sustainable Development Goals: SDG 4 (Quality Education), SDG 7 (Affordable and Clean Energy), and SDG 11 (Sustainable Cities and Communities). Overcoming the identified barriers is a prerequisite for the successful implementation of Ukraine's obligations under the Paris Agreement and the European Green Deal.

An important limitation of the study is the use of exclusively secondary sources without primary data collection from Ukrainian specialists. In future research, it is advisable to involve empirical surveys of construction industry representatives, educational institutions, and government bodies to validate and refine the identified barriers, which will strengthen confirmed conclusions and provide a more grounded basis for formulating policies and educational programs oriented toward the industry's real needs.

**Conclusions.** The study of domestic sources made it possible to ascertain that the training of future construction industry specialists in Ukraine faces complex challenges—from Ukraine's energy dependence and personnel shortages to the slow implementation of modern energy-efficient technologies in the construction industry and the fragmented inclusion of modern energy-efficient technologies in educational programs for future specialists. Combined with the needs of Ukraine's post-war recovery, this requires updating the content of education and forming competencies in future

construction industry specialists capable of ensuring the active implementation of modern energy-efficient technologies in professional activities.

The analysis of the source base allowed outlining the key problems of preparing future construction industry specialists for work with energy-efficient technologies under conditions of Ukraine's post-war reconstruction. The most critical are the deficit of practical skills and financial constraints, which is confirmed by both Ukrainian and foreign studies. At the same time, the country's reconstruction process opens an opportunity to create a qualitatively new system of vocational education that can integrate global best practices and avoid the mistakes of gradual, evolutionary development of educational systems. Overcoming the identified barriers requires a comprehensive approach including: development and implementation of modern educational standards; active participation in European educational programs; involvement of international organizations' experience; and cultural transformation of the professional community. Without systemic and coordinated work in all directions, there is a risk of losing up to 30% of energy efficiency potential during the reconstruction process, which may cause significant economic losses and reduce the competitiveness of the national construction industry.

In the future, it is planned to conduct a survey among construction industry specialists to clarify specific needs and the existing level of practical skills in energy-efficient technologies, as well as to identify key barriers hindering their implementation.

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# СУЧАСНІ ПРОБЛЕМИ НАВЧАННЯ МАЙБУТНІХ ФАХІВЦІВ БУДІВЕЛЬНОЇ ГАЛУЗІ УКРАЇНИ ЕНЕРГОЕФЕКТИВНИМ ТЕХНОЛОГІЯМ

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**Реферат:**

*Актуальність.* Повоєнна відбудова України та глобальний перехід до зеленої економіки зумовлюють потребу впровадження енергоефективних технологій у будівельній галузі. Автор зазначає, що проблема підготовки кадрів має системний характер, оскільки професійна освіта часто фрагментарно охоплює компетентності з енергоефективності, що ускладнює інтеграцію інформаційних технологій. У цьому контексті зростає нагальна потреба у формуванні цілісного підходу до підготовки кадрів і впровадження сучасних енергоефективних технологій у всіх ланках будівельної діяльності.

*Мета:* виявити й охарактеризувати сучасні проблеми навчання майбутніх фахівців вітчизняної будівельної галузі енергоефективним технологіям.

*Методи:* теоретичні (систематичний огляд літератури, контент-аналіз, класифікація бар'єрів); емпіричні (аналіз звітів міжнародних організацій, порівняльний аналіз українських і європейських практик); аналітичні (узагальнення результатів, інтерпретація взаємозв'язків).

*Результати:* виокремлено вісім взаємопов'язаних бар'єрів: відсутність єдиної системи навчання, потреба в міждисциплінарному підході, нестача практичних умінь, фінансові обмеження, недостатня підтримка керівництва, труднощі адаптації матеріалів, професійна інерція та надмірна зарегламентованість процедур.

*Висновки:* виявлені чинники зумовлюють низький рівень впровадження інформаційних технологій у будівництві (Building Information Modeling, BIM) і технології перехресно-ламінованого брусу (Cross-Laminated Timber, CLT), що спричиняє потенційні втрати енергоефективності до 30 %. Рекомендовано подальше вдосконалення національної рамки стандартів, повне масштабування дуальної освіти та активізація партнерства з ЄС.

**Ключові слова:** *енергоефективність, будівельна галузь, професійне навчання, бар'єри впровадження, компетентності.*

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