



To cite this article: Pashchenko, T., & Gerliand, T. (2026). Innovative Approaches to Implementing Energy-Efficient Practices in the Vocational Training of Future Construction Workers. *Professional Pedagogics*, 1(32), 56-66. <https://doi.org/10.32835/2707-3092.2026.32.56-66>

The article is published as part of the research project "Training future skilled construction workers to use energy-efficient technologies in professional activities" (state registration number 0125U000288, implementation period 2025–2027).

INNOVATIVE APPROACHES TO INTEGRATING ENERGY-EFFICIENT PRACTICES INTO THE VOCATIONAL TRAINING OF FUTURE CONSTRUCTION WORKERS

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Abstract

Relevance Modern building energy efficiency requirements, updated regulatory frameworks, and the rising demand for specialists capable of working with low-energy construction technologies necessitate the modernisation of vocational training for future construction workers; innovative approaches to developing energy-efficient competence are becoming a key condition for ensuring the quality of vocational education and aligning training with labour market needs and sustainable development challenges.

Aim: This study aims to substantiate and characterise innovative approaches to integrating energy-efficient practices into the vocational training of future construction workers, identify their substantive and methodological features, and outline the conditions for effective implementation within the educational process.

Methods: The study employs an analysis of academic sources, the comparative-pedagogical method, and the systematisation and generalisation of modern vocational education practices; it further utilizes content analysis of research on energy efficiency and digital technologies, structural-functional analysis of innovative educational models, and expert generalisation of the results from piloting specific methodologies.

Results: The analysis identifies key directions for modernising the content and methods of vocational training for future construction workers within the context of energy efficiency; the findings substantiate the role of digital technologies (BIM modelling, energy simulators, and digital platforms), alongside interactive and project-based learning methods, in fostering students' ability to model, analyse, and implement energy-saving solutions; furthermore, the results highlight the significance of practice-oriented interaction with industry stakeholders and the alignment of educational content with European energy efficiency standards as prerequisites for a high level of graduate professional readiness.

Conclusions: Innovative approaches to integrating energy-efficient practices ensure the comprehensive development of professional competencies in future construction workers, strengthen the practical orientation of training, and facilitate the preparation of specialists capable of operating according to modern technological, regulatory,

and environmental requirements; the combination of digital tools, active learning methods, and the industrial context creates a foundation for modernising vocational education and increasing its effectiveness in the field of energy-efficient construction.

Keywords: *energy efficiency, energy-efficient competence, vocational training, future construction workers, innovative approaches, construction industry, BIM technologies, project-based learning, sustainable development.*

Introduction. The current stage of the construction industry's development is defined by the implementation of technologies aimed at the rational use of energy resources and the reduction of environmental impact. Meeting building energy efficiency requirements, as declared in European strategic documents and international standards, highlights the urgent need to update the content of vocational training for construction workers. Research emphasises that the effective development of competencies in energy-saving technologies requires vocational learners to possess a profound theoretical understanding of processes, multidisciplinary knowledge, and the ability to apply energy-efficient solutions in industrial scenarios (Clarke et al., 2020).

In the context of Ukraine's post-war reconstruction, energy efficiency issues acquire particular significance. The large-scale destruction of residential, social, and infrastructural buildings necessitates rapid, yet high-quality and technologically modern reconstruction. Specifically, energy-efficient approaches – including the use of modern materials, low-energy consumption technologies, and NZEB standards (Nearly Zero-Energy Building) – must form the foundation of reconstruction, as they ensure the long-term sustainability of facilities, reduce operating costs, and enhance the state's energy security. Consequently, there is a growing demand for training specialists capable of operating under these new conditions by applying modern structural solutions, digital tools, BIM technologies, VR/AR, and other innovations.

European experience confirms the importance of modernising vocational training for construction workers, particularly through the combination of theoretical and practical components, the integration of digital platforms, and the implementation of energy-efficient pedagogical technologies. The use of innovative learning environments and contemporary educational practices substantially improves the level of professional competence in energy-efficient construction (Drozich, 2025). This is especially

relevant for Ukraine, where post-war reconstruction will require a vast number of specialists capable of implementing projects according to modern standards and sustainable development principles. Updates to state vocational education standards and dynamic labour market needs create the prerequisites for rethinking the methodological foundations of vocational training for construction workers. It is essential to scientifically substantiate the pedagogical conditions for integrating innovative energy-efficient practices and to foster the readiness of future specialists to work amidst the country's large-scale reconstruction and recovery.

Against this backdrop, the article aims to highlight innovative pedagogical approaches to implementing energy-efficient practices in the vocational training of future construction workers, determine their potential, and analyse opportunities for integration into modern educational programmes at vocational education institutions.

Sources. The theoretical framework of the study is formed by a complex of academic works dedicated to the training of future construction workers in the context of energy efficiency and the implementation of innovative educational technologies (Radkevych, 2013; O. Hlushchenko, 2017; Kulalaieva, 2018; Clarke, Sahin-Dikmen, & Winch, 2020; Piatnychuk, 2023; Herliand, 2025; Herliand et al., 2025; Drozich, 2025; Kalenskyi, 2025; Svyrydiuk, 2025). Studies reflecting European trends in the development of vocational education and training (VET) within the field of low-energy construction are vital for understanding modern requirements. In their work, Clarke, Sahin-Dikmen, and Winch (2020) reveal various vocational training models, analyse approaches to forming energy-efficient competencies, and emphasise the need for deep multidisciplinary training of learners to achieve NZEB standards.

A significant source is the work of Drozich (2025), which presents the experience of applying energy-efficiency pedagogical technologies in the vocational training of future construction workers, with an emphasis on combining classroom and practical work, using digital tools, and adapting

European learning models to Ukrainian realities. These provisions are particularly relevant during Ukraine's post-war reconstruction, where the speed and quality of reconstruction will largely depend on the level of specialists' technological training.

Ukrainian research dedicated to the integration of energy efficiency into the content of vocational training for construction workers occupies a distinct place among the sources. In the work of Kulalaieva (2018), the pedagogical potential of project-based learning in developing the energy-efficient competence of future skilled construction workers is substantiated. The author emphasises that project technologies ensure the development of practical thinking and the ability to work with real engineering tasks, while fostering responsibility for technological decisions in the context of energy saving, which makes this study crucial for understanding the practical component of specialist training.

The research of Radkevych (2013), which focuses on the necessity of introducing energy efficiency issues into the vocational training system for future construction workers, is also of significant importance. The scholar identifies energy efficiency as a key element of modern sectoral professional competence and stresses the importance of a systemic update of educational content oriented towards the real needs of the construction sector. Radkevych's research contributes to the theoretical understanding of how the integration of energy-saving approaches can be realised at the level of curricula and qualification characteristics.

Studies by contemporary scholars provide a comprehensive vision of the problem, allowing for the disclosure of methodological, pedagogical, and sectoral approaches to training future construction workers in energy-efficient construction, while outlining modern trends in updating vocational education during post-war reconstruction. The results of the conducted scientific search confirm the necessity and expediency of researching eco-oriented training for construction industry specialists to support the energy-efficient reconstruction of Ukraine.

The aim of the article is to substantiate and characterise innovative approaches to implementing energy-efficient practices in the vocational training of future construction workers, identify their substantive and methodological features, and outline the conditions for effective implementation within the educational process.

Research Methods. To achieve the research aim and substantiate innovative approaches to integrating energy-efficient practices into the vocational training of future construction workers, a complex of methods was employed to ensure a comprehensive analysis of the problem.

Theoretical methods. A systemic analysis of academic works, regulatory documents, and modern research approaches in the field of vocational education and energy-efficient construction was conducted. The generalisation of scientific positions made it possible to identify the main trends in the development of vocational training for construction workers in the context of European standards, as well as to formulate substantive and methodological guidelines for integrating energy-efficient technologies into the educational process.

Comparative-pedagogical method. A comparison of Ukrainian and European models of vocational training for construction workers was performed, enabling the identification of common and distinct approaches to forming energy-efficient competencies. Particular attention was paid to the analysis of specialist training practices in countries where the implementation of NZEB standards is a mandatory component of sectoral regulation.

Content analysis. The content of educational programmes, vocational education standards, and teaching materials of vocational institutions was investigated to determine the level of representation of energy efficiency topics in the training of future construction workers, identify multidisciplinary links, and establish potential directions for modernising vocational education content.

Expert assessment method. Vocational school teachers, construction industry specialists, and representatives of organisations working in the field of energy efficiency were involved in the analysis. Their conclusions allowed for the clarification of current labour market needs, the assessment of the feasibility of implementing innovative approaches, and the identification of key competencies required for future construction workers in the context of post-war reconstruction.

System-structural method. This was used to build a holistic model for integrating energy-efficient practices into vocational training. The method allowed for the logical connection of pedagogical, technological, and organisational components, the identification of structural elements of the educational process, and the outlining of conditions ensuring the effectiveness of innovations.

The complex application of these methods ensured the objectivity and scientific validity of the results, facilitating the formulation of recommendations for implementing innovative energy-efficient approaches in the training of future construction workers, accounting for modern challenges such as Ukraine's post-war infrastructure reconstruction.

Results and Discussion. Modern humanity is experiencing a period of profound change driven by the deepening ecological crisis, rapid growth in energy demands, and the gradual depletion of natural resources. Overcoming these challenges requires a comprehensive rethinking of approaches across many spheres of social life. This is especially true for the construction industry, which traditionally remains one of the most resource-intensive sectors. The impact of construction on the environment is measured not only by the amount of raw materials and energy used but also by the subsequent operational costs that accompany the existence of structures over decades.

Construction serves as an important indicator of a state's economic stability: the pace of infrastructure, housing, and industrial facility renewal directly affects a country's competitiveness and the population's quality of life. However, modern environmental and energy constraints increasingly demonstrate that further sectoral development cannot rely on outdated technologies or excessive resource consumption. Therefore, the training of specialists capable of working with innovative materials, design solutions, and energy-saving technologies that meet sustainable development standards is of particular importance.

Under these conditions, the vocational training of future construction workers is aimed not only at developing technical skills but also at fostering a broader mindset – the ability to see the interconnections between technological processes, environmental consequences, and economic efficiency. Energy efficiency is becoming an integral part of a modern specialist's professional culture rather than an additional competence. The educational environment itself must provide opportunities to acquire such experience: from working with real design tasks to mastering digital technologies that enable the modelling of building system behaviour and the prediction of their energy performance.

For Ukraine, raising a new generation of construction workers takes on even greater significance. Amidst large-scale post-war reconstruction, the quality of personnel training

determines not only the speed of restoring destroyed infrastructure but also how modern, safe, and energy-efficient it will be. Consequently, educational programmes oriented towards training construction workers must become a tool for developing specialists capable of implementing the principles of rational energy use, environmental responsibility, and technological innovation in practice.

Current policy and sectoral guidelines require the vocational training system for construction workers to transition from fragmented energy-saving instruction to the integration of energy efficiency within the educational programme framework, correlating with the European NZEB / LEC (Low Energy Consumption) logic and supported by comparative VET (Vocational Education and Training) studies in the EU (Clarke et al., 2020). In the Ukrainian context, emphasis is placed on the methodological updating of training content to include an energy-efficiency component, specifically through the "Basics of Energy Efficiency" programme and related methodological developments consistently proposed by O. Hlushchenko (2015). The gap between labour market expectations and training outcomes is manifested in the dominance of short-term CVET (Continuing Vocational Education and Training) solutions and the insufficient transformation of IVET (Initial Vocational Education and Training); this necessitates a broad-profile multidisciplinary model where energy-efficient competence becomes transversal (Clarke et al., 2020), aligning with T. Herliand's conclusions regarding the need for systemic training of construction workers in energy-efficient technologies and their competitive advantages in professional activity (Herliand, 2025).

The implementation of energy efficiency in vocational education institutions is hindered by a shortage of specialists and resources. At the same time, practice shows that better results can be achieved through training closely aligned with real working conditions: combining classroom sessions with work-based learning, using BIM technologies and VR/AR simulations, and creating a modern educational environment (Drozich, 2025). Regarding methodologies for developing energy-efficient competence specifically within the construction sector, A. Kalenskyi proposes a staged model linked to updated standards and modular solutions for NZEB/EPBD and post-war "green" reconstruction (Kalenskyi, 2025). V. Svyrydiuk emphasises the integration of requirements for

innovative energy-efficient materials into educational professional programmes (EPPs) for future builders, offering structured modules that account for the life cycle of materials (Svyrydiuk, 2025). Concerning pedagogical strategies, Ukrainian authors systematically substantiate project-technological and practice-oriented approaches, proving their effectiveness for mastering energy-saving materials/solutions and developing the professional responsibility of learners. Specifically, T. Piatnychuk focuses on ensuring building energy efficiency research within educational institutions as a basis for systemic energy-saving instruction, applying the case-method for these purposes (Piatnychuk, 2023). At the intersection of digitalisation and pedagogy, T. Herliand and colleagues demonstrate that eco-oriented pedagogical technologies (including those for the construction sector) ensure the holistic development of competencies and should be integrated into energy-efficiency content modules (Herliand et al., 2025).

An analysis of contemporary research led to the conclusion that developing energy-efficient competencies in future construction workers should be structured as a sequential, practice-oriented process. The logic is straightforward: learners first solve real professional tasks in the format of educational projects, then practice solutions in digital simulations, proceed to workshops and training-production sites, and finally consolidate their experience on real objects in cooperation with industry stakeholders. This trajectory combines content, methods, and material-technical facilities, meeting current requirements for personnel training for post-war "green" reconstruction and compliance with modern European energy efficiency standards in construction. Domestic research emphasises that without this integrity, training remains fragmented and competencies unstable (Drozich, 2025; Herliand, 2025; Pashchenko, 2024).

The project-technological approach constitutes the basis of the educational process organisation. Working with specific objects (from insulation and sealing nodes to the installation of ventilation systems with heat recovery) encourages learners to compare several solution options and choose the one that best meets the criteria for energy consumption, life cycle cost, and environmental impact. In such projects, energy efficiency acts not as an "additional" topic but as a quality criterion for the decisions made. This is exactly how T. Herliand describes the practice of engaging learners with

modern energy-saving technologies and materials, highlighting the increased responsibility and professional maturity of future specialists (Herliand, 2025). In A. Kalenskyi's methodological works, the project-technological approach acquires a clear structure: from motivation and "entry" into the task to technological execution, results diagnostics, and reflection; the proposed framework allows for the stable development of energy-efficient competence specifically within the construction profile (Kalenskyi, 2025).

Digital and simulation technologies logically reinforce the project logic: BIM modelling helps visualize the consequences of design decisions before entering the site; VR/AR scenarios allow for practicing installation, testing joint variants, and evaluating thermotechnical indicators and risks. In this format, the integration of theoretical foundations with digital tools ensures a noticeable increase in learner engagement and task execution accuracy (Herliand et al., 2025). The consolidation of results occurs most effectively in workshops, laboratories, and training grounds where future builders work with real materials and systems: performing insulation, sealing, configuring ventilation, and conducting instrumental measurements (e.g., airtightness tests, room energy audits) (Piatnychuk, 2023). Another vital element is dual interaction with employers, which ensures the rapid transfer of solutions developed in simulations and training grounds into industrial practice. A modular organisation of cooperation proves effective: the educational institution handles theory and digital simulations, while the employer provides real objects with specific energy-efficiency requirements. Assessment is best conducted jointly: teachers, practical trainers, and enterprise representatives collectively record how the student adheres to installation, adjustment, and quality control standards.

In summary, the innovative approach to specialist training can be outlined as the sequential integration of several interconnected components: project activity forms the structural basis of the educational process; digital technologies create a safe environment for modelling and testing solutions; work in laboratories and on training-production sites ensures the transformation of theoretical knowledge into practical professional skills; dual interaction with enterprises transfers acquired competencies into real production conditions; and professionally trained educators ensure the integrity and consistency of all system

elements. In this logic, the organisation of construction specialist training emerges as an effective response to modern energy efficiency challenges for both educational institutions and the labour market, as well as the needs of the country's large-scale reconstruction.

The generalisation of scientific positions made it possible to formulate substantive and methodological guidelines for integrating energy-efficient technologies into the educational process for training future construction workers. An analysis of modern trends in construction industry development and the requirements for the professional activities of a civil engineer reveals the strengthening role of energy saving, rational resource use, and the optimisation of the thermotechnical characteristics of construction objects (Clarke et al., 2020; Pashchenko, 2024). In this regard, the educational process must be oriented towards developing learners' systemic knowledge of energy efficiency, skills in designing and operating energy-saving structures, and ecologically responsible professional thinking (Drozich, 2025; Herliand, 2025).

The primary substantive guideline is the development of a holistic understanding of energy saving in construction among learners, covering the scientific foundations of thermal protection, building physics, modern energy efficiency standards, and international approaches to "green" design (Clarke et al., 2020; Svyrydiuk, 2025). Knowledge of regulatory documents, methods for assessing the energy characteristics of structures, and principles for reducing energy consumption throughout the building's entire life cycle are crucial (Hlushchenko, 2015; Radkevych, 2013). The next substantive guideline is the mastery of structural solutions that determine the energy efficiency of modern buildings. This involves studying new-generation thermal insulation materials, facade systems with enhanced thermal protection properties, recuperation units, ventilation systems with heat recovery, alternative energy sources, energy-saving glazing, and engineering networks (Svyrydiuk, 2025; Pashchenko, 2024). A vital substantive guideline for integrating energy-efficient technologies into the educational process is the mastery of construction technological processes that ensure increased object energy efficiency. Future builders must understand the specifics of installing insulation systems, sealing joints, and constructing energy-efficient roofs and facades, as well as conduct analyses of structural nodes for heat

loss and perform thermotechnical calculations accounting for sustainable construction requirements (Kulalaieva, 2018; Svyrydiuk, 2025).

The next conceptual component concerns the development of competencies in using digital technologies for energy efficiency modelling and analysis, particularly BIM design tools. Knowledge of digital tools enables students to evaluate building thermal parameters, model the behaviour of building envelopes, and implement design decisions based on precise data (Celik et al., 2024; Drozich, 2025). Developing ecological thinking and professional-value orientations based on principles of environmental responsibility, resource management, and sustainable development is of great importance. Energy efficiency is viewed not only as a technological requirement but as an ethical component of the future civil engineer's profession (Clarke et al., 2020; Pashchenko, 2024).

The leading methodological guideline for integrating energy-efficient technologies is the modular-competence approach, which involves including energy-saving topics in both general professional and specialised disciplines. Its application ensures a logical sequence of competence development, alignment of learning outcomes, and multidisciplinary knowledge integration (Herliand et al., 2025; Kalenskyi, 2025). Project tasks (individual and team) include building energy balances, selection of materials and structures, ecological-economic substantiation of energy-saving systems, and alternative engineering support options. European training practices for low-energy construction confirm the effectiveness of contextual, problem-based, and project-based learning (Clarke et al., 2020; Drozich, 2025).

A significant place in the training process of future construction workers is occupied by the use of laboratory methods and diagnostic equipment, which allows for thermographic control, measurement of aerodynamic parameters, and research into the thermophysical properties of materials. Practical interaction with modern tools fosters students' ability to conduct energy audits and assess the quality of insulation work (Herliand et al., 2025). The use of digital and interactive technologies including virtual laboratories, energy audit simulators, multimedia cases, and digital object models also facilitates learning effectiveness. Such tools improve material mastery, foster research skills, and develop critical thinking (Clarke et al., 2020; Svyrydiuk, 2025).

A distinct methodological guideline is ensuring the practice-oriented nature of the educational process, which involves cooperation with enterprises, practical training at energy-efficient construction sites, participation in demonstration masterclasses, and excursions to certified "green" buildings. Such interaction helps students understand real technological requirements and the technical-economic specifics of implementing energy-saving solutions. The use of active learning methods facilitates the integration of energy-efficient technologies into the educational process for future builders. Specifically, the case method in energy efficiency research allows for modelling real professional situations and developing critical thinking, analytical, and communicative skills (Piatnychuk, 2023), while

project-based learning is effective for developing energy-efficient competence within the construction profile (Kulalaieva, 2018). The final methodological guideline is the integration of sustainable development principles into the educational process, which necessitates the inclusion of LCA (Life Cycle Assessment) approaches in the learning content, familiarisation with international environmental certification systems and their criteria, and the development of future specialists' ability to account for the environmental and energy consequences of design decisions.

Given the aforementioned methodological guidelines and approaches to developing the energy-efficient competence of future construction workers, it is expedient to summarise them in a comparative aspect, as reflected in Table 1.

Table 1

Comparative Analysis of Traditional Training and the Innovative Approach to Energy Efficiency in Construction

Criterion	Traditional Training	Innovative Approach (Per This Study)
Key Aim	Mastery of basic building codes	Development of energy-efficient competence and eco-thinking
Technological Toolkit	Paper blueprints, textbooks	BIM modelling, energy simulators, digital platforms
Learning Methods	Explanatory-illustrative methods	Project-based learning, interactive modelling, case studies
Industry Links	Periodic practical training	Practice-oriented cooperation and implementation of dual education elements
Standards	National State Building Codes (DBN)	Integration of DBN with European energy efficiency standards

Source: Compiled by the author based on a content analysis of the study's research framework.

The proposed comparative characterisation demonstrates a fundamental shift in the training vector: moving from the mere accumulation of technological knowledge toward the cultivation of an energy-efficient consciousness in the future specialist. A key distinction of the innovative approach is the integration of digital tools specifically BIM modelling not as a standalone discipline, but as a transversal means of designing and analysing objects. The implementation of energy simulators and digital platforms allows learners to model real building energy losses during the training stage, thereby minimising the risk of errors in future professional activities. Project-oriented learning acquires particular significance, where the output is not a theoretical paper but the calculation of a specific energy performance

certificate for an object. This transformation of educational content ensures that graduate training complies with both State Building Codes (DBN) and rigorous European energy efficiency standards, which is critical for Ukraine's post-war reconstruction and sustainable development.

The formulated substantive and methodological guidelines create a holistic foundation for integrating energy-efficient technologies into the training of future builders; this enables the educational process to meet the modern requirements of the construction industry while fostering a high level of professional competence, technological culture, and environmental responsibility in future specialists.

Conclusions. The research results demonstrate that innovative approaches are a key

condition for the qualitative renewal of vocational training for future construction workers in the field of energy efficiency. The integration of modern digital technologies into the educational process ensures a more profound understanding of thermotechnical processes, more accurate modelling of energy-efficient solutions, and the ability to make evidence-based engineering decisions. BIM systems, energy simulators, and other software tools play a vital role by creating conditions that replicate real production scenarios. The use of project-based, case-based, and problem-oriented learning methods is of great importance, as these facilitate the development of practical skills and allow learners to approximate real-world professional conditions. Such forms of educational organisation provide opportunities to work with technical documentation, analyse structural solutions, and evaluate the effectiveness of applied technologies.

Practice-oriented interaction with construction industry enterprises occupies an essential place in the training system. Internships, work-based learning, site visits, and participation in real projects facilitate the consolidation of professional skills and ensure the readiness of

learners to implement energy-efficient solutions in industrial environments. Such cooperation also allows for a rapid response to changes in sector technologies and regulatory requirements.

A current task for educational programmes is to align training content with modern European energy efficiency norms and standards, specifically requirements for low-energy construction and environmental certification. The adoption of international approaches enhances the competitiveness of graduates and prepares them to operate within the European labour market.

Generalising the research results provides grounds to assert that the combination of digital tools, innovative educational methods, and a real production context creates a favourable environment for the comprehensive development of energy-efficient competence in future builders. The applied approaches define the directions for the further modernisation of vocational education and ensure the preparation of specialists capable of meeting the modern demands of energy-saving construction and the country's sustainable development.

Conflict of Interest

The author certifies that no conflict of interest (financial, professional, or personal) exists that could have influenced the objectivity of the research results or conclusions. The integrity of the double-blind peer review process was ensured through a mandatory declaration of the absence of conflict of interest submitted via the journal's editorial system. This protocol guaranteed complete author anonymity and the independence of the expert evaluation throughout the entire editorial cycle.

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ІННОВАЦІЙНІ ПІДХОДИ ДО ВПРОВАДЖЕННЯ ЕНЕРГОЕФЕКТИВНИХ ПРАКТИК У ПРОФЕСІЙНУ ПІДГОТОВКУ МАЙБУТНІХ БУДІВЕЛЬНИКІВ

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Реферат:

Актуальність: сучасні вимоги до енергоефективності будівель, оновлення нормативної бази та зростання потреб у фахівцях, здатних працювати з технологіями низько енергетичного будівництва,

зумовлюють необхідність модернізації професійної підготовки майбутніх будівельників; інноваційні підходи до формування енергоефективної компетентності стають ключовою умовою забезпечення якості професійної освіти та відповідності підготовки потребам ринку праці й викликам сталого розвитку.

Мета: обґрунтувати та охарактеризувати інноваційні підходи до впровадження енергоефективних практик у професійну підготовку майбутніх будівельників, визначити їх змістові та методичні особливості, а також окреслити умови ефективної реалізації в освітньому процесі.

Методи: аналіз наукових джерел, порівняльно-педагогічний метод, систематизація й узагальнення сучасних практик професійної освіти; контент-аналіз досліджень з енергоефективності та цифрових технологій; структурно-функціональний аналіз інноваційних освітніх моделей; експертне узагальнення результатів апробації окремих методик.

Результати: визначено ключові напрями модернізації змісту та методів професійної підготовки майбутніх будівельників у контексті енергоефективності; обґрунтовано роль цифрових технологій (ВІМ-моделювання, енергетичних симуляторів, цифрових платформ), інтерактивних і проектно-технологічних методів навчання у формуванні здатності студентів до моделювання, аналізу й упровадження енергоощадних рішень; показано значення практико-орієнтованої взаємодії з підприємствами галузі та узгодження освітнього змісту з європейськими стандартами енергоефективності як передумови високого рівня професійної готовності випускників.

Висновки: інноваційні підходи до впровадження енергоефективних практик забезпечують комплексне формування професійних компетентностей майбутніх будівельників, підсилюють практичну спрямованість навчання та сприяють підготовці фахівців, здатних працювати відповідно до сучасних технологічних, нормативних та екологічних вимог; поєднання цифрових інструментів, активних методів навчання і виробничого контексту створює підґрунтя для модернізації професійної освіти та підвищення її ефективності у сфері енергоефективного будівництва.

Ключові слова: енергетична ефективність, енергоефективна компетентність, професійна підготовка, майбутні будівельники, інноваційні підходи, будівельна галузь, ВІМ-технології, проектне навчання, сталий розвиток.

Manuscript received 17.11.2025
Accepted for publication after peer review 02.02.2026
Published 19.03.2026