



# UTILIZING INNOVATIVE ENERGY-EFFICIENT TECHNOLOGIES IN THE PROFESSIONAL TRAINING OF FUTURE CONSTRUCTION INDUSTRY SPECIALISTS

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## Abstract

*The relevance:* of developing and implementing energy-efficient technologies in the modern construction industry is driven by Russia's ongoing energy-intensive war against Ukraine, which necessitates the formation of energy-saving behavior among all citizens and specialists and the implementation of energy-efficient technologies in all energy-consuming sectors of the domestic economy, one of which is construction.

*Aim:* To substantiate the importance of using modern building materials and innovative energy-efficient technologies in the professional training of vocational (vocational-technical) education students in the construction field to enhance energy efficiency, energy saving, and rational use of thermal energy in the modern construction industry of Ukraine.

*Methods:* Analysis of scientific sources, regulatory legal documents, and empirical data – to prove the importance of using modern building materials and innovative energy-efficient technologies in the professional training of vocational (vocational-technical) education students in the construction field; theoretical analysis, synthesis, and generalization – to form conclusions regarding the peculiarities of applying modern building materials and energy-efficient technologies in the educational process of vocational (vocational-technical) education institutions in the construction field.

*Results:* The main energy-economic indicators of Ukraine were identified and compared with those of other countries, revealing them to be negative (electricity consumption in Ukraine is 60%, while in France it is 40%, and in Great Britain – 35.8%); it was substantiated that the professional training of construction specialists requires familiarizing students with the problems and principles of sustainable development in construction (minimizing energy and material resource consumption during the construction and operation of building structures, reducing the negative impact of construction on the environment; comprehensive analysis of energy, environmental, economic, and socio-social issues of building construction, etc.).

*Conclusions:* It has been substantiated that to ensure the rational use of material and energy resources, increase energy saving in Ukraine's housing and communal sector, and strengthen its energy independence, it is necessary to include in the content of professional training for future construction industry specialists familiarization with innovative energy-saving technologies in construction (design of energy-efficient buildings, energy performance certificates for buildings, thermal modernization of the housing stock, use of modern thermal insulation materials, installation of energy-saving windows, application of energy-saving engineering technologies and heating systems), environmental characteristics of energy-saving technologies, principles of energy-saving measures, etc.

**Keywords:** *vocational education, vocational education institutions in the construction field, energy-saving technologies, energy-efficient competence, construction industry, sustainable development in construction, interactive learning, educational process, qualified worker, energy-efficient competence.*

**Introduction.** The construction industry in Ukraine is a significant consumer of energy resources. This sector consumes up to 50% of natural resources and over 40% of energy. Substantial energy expenditures are required not only for the construction of buildings but also for their subsequent operation. Old buildings currently demand excessive energy, making their operation a burden on Ukraine's modern fuel and energy complex. The construction of new facilities that do not meet energy-saving requirements further exacerbates the problem. To ensure the rational use of energy resources and enhance the energy efficiency of Ukraine's housing and communal sector, it is necessary to modernize the existing housing stock.

The main principles of sustainable development in construction involve minimizing energy and material resource consumption during the erection and subsequent operation of building structures, and reducing their negative impact on the environment. Familiarizing future construction specialists with these principles is currently a priority research direction in vocational pedagogy.

Therefore, the main criterion for a sustainable development strategy is innovation in the energy sector, increased energy efficiency in the domestic production sector, and enhanced efficiency of renewable energy sources. This underscores the relevance of incorporating energy-saving technologies into the professional training of future construction specialists, which is vital for strengthening Ukraine's energy independence and boosting the energy efficiency of its domestic construction industry.

**Research Sources.** The theoretical basis of this study comprises scientific and practical works by Ukrainian researchers on fostering an understanding of the importance of energy saving and developing energy-efficient competence in students. Among the ideas utilized in preparing this article, the following are noteworthy: the philosophy of a healthy environment (V. Barhiuk), ecological and economic aspects of energy saving in construction (M. Sanytskyi, O. Pozniak, O. Mazurak, Yu. Fedun), modern aspects of reconstruction and reinforcement of buildings and structures (Z. Blikharskyi, V. Saviovskyi); and the energy performance certificate of a building (V.

Hershkovych). An analysis was also conducted of textbooks actively used in the modern educational process to train future specialists for energy-efficient professional activities, including: energy-saving technologies in construction (M. Sanytskyi, O. Pozniak, U. Marushchak), fundamentals of technical operation of buildings and engineering systems (A. Havryliak), and others. The conducted analysis suggests the need to intensify scientific and pedagogical attention to the formation and development of energy-efficient competence among future specialists to accelerate the pace of Ukraine's reconstruction, strengthen its energy independence, and promote sustainable development.

**Aim of the Article.** The aim of this article is to substantiate the importance of using modern building materials and innovative energy-efficient technologies in the professional training of vocational (vocational-technical) education students in the construction field to enhance energy efficiency, energy saving, and rational use of thermal energy in the modern construction industry of Ukraine.

**Research Methods.** The research methods include: analysis of scientific sources, regulatory legal documents, and empirical data – to prove the importance of using modern building materials and innovative energy-efficient technologies in the professional training of vocational (vocational-technical) education students in the construction field; theoretical analysis, synthesis, and generalization – to form conclusions regarding the peculiarities of applying modern building materials and energy-efficient technologies in the educational process of vocational (vocational-technical) education institutions in the construction field.

**Results and Discussion.** The primary objective of the energy policy of the European Union and Ukraine is to fulfill the obligations under the Kyoto Protocol. The excessive consumption of various types of energy (electricity, heating, water supply, gas supply, etc.) raises the most concern in both Ukraine and the European Union. To address this issue, it is proposed to construct buildings with low energy demands, partially utilizing renewable energy sources. Through effective changes in construction technologies, buildings can be constructed and renovated in accordance with economic, energy-saving, and ecological

requirements. By employing modern techniques and technologies in construction, heat loss can be reduced by 2-5 times, providing enormous energy-saving reserves.

To solve these problems, modern building materials, highly efficient technologies, and high-quality training of engineering and skilled workers are essential. The training of qualified workers for the construction industry with modern high-tech knowledge and skills is critically important, as these young, skilled workers can implement and realize ecological approaches in the construction industry. The integration of energy-saving technologies into the educational process helps in preparing qualified workers and junior professional bachelors who can effectively apply modern energy-efficient technologies amidst growing demands for energy efficiency, energy saving, and environmental safety in the construction sector.

Considering that Ukraine is in a state of prolonged destructive war, the training of qualified workers and junior professional bachelors, taking into account modern energy efficiency requirements, acquires strategic importance. The training of qualified workers and junior professional bachelors in vocational (vocational-technical) education institutions is carried out according to developed and approved standards, educational and educational-professional programs, the content of which is based on competency-based approaches. During the learning process, students develop a complex of key and professional competencies. Professional competencies are the ability of a qualified worker or junior professional bachelor, within their powers, to apply specially acquired knowledge, skills, and abilities, to demonstrate appropriate moral and business qualities for the proper performance of necessary tasks and duties, learning, and professional and personal development.

Every professional standard, educational, and educational-professional program includes ecological and energy-efficient competencies, which comprise the acquisition of knowledge on: the fundamentals of energy efficiency; regulatory and legal acts in the field of energy saving and ecology; the application and energy-efficient use of building materials and energy-saving equipment; methods of energy saving in enterprises; rules for waste sorting;

waste utilization, reproduction and preservation of natural resources; methods of environmental preservation and protection in professional activity and in everyday life.

Thus, ecological and energy-efficient competencies are closely interconnected and are important outcomes of modern professional training for youth. The development of educational programs that incorporate energy-saving technologies contributes to the high-quality professional training of skilled workers and junior professional bachelors for the construction industry, fostering a responsible attitude towards natural resources and their rational use without environmental pollution.

It is crucial to convey to future specialists that knowledge of energy-saving technologies and their application in professional activities forms the basis for implementing sustainable development principles in construction. The main directions and technologies, whose knowledge is of primary importance in the professional training of future specialists in the construction sector, include: designing energy-efficient buildings, energy performance certificates for buildings, thermal modernization of the housing stock, the use of modern thermal insulation materials, the installation of energy-saving windows, the application of energy-saving engineering technologies and heating systems, etc. (Haiduk, Herliand, Kulalaieva, Pivtoratska, & Piatnychuk, 2021, pp. 5-7).

Of particular importance for overcoming the economic crisis caused by the war is a more complete utilization of the experience of EU countries regarding sustainable construction. In the EU, energy-saving technologies and energy efficiency are key priorities, enshrined in the EU Energy Strategy until 2030. Its main goals include reducing greenhouse gas emissions, increasing the share of renewable energy, and enhancing energy efficiency. Educational programs for future specialists in Ukraine's construction sector should include familiarization with the strategic directions of energy saving and energy efficiency in the EU, planned for implementation by 2030. These include: a 40% reduction in greenhouse gas emissions (compared to 1990); a 27% increase in the share of renewable energy; a 27% increase in energy efficiency; the creation of a common energy market and a 15% increase in interconnectivity between EU

countries; and the development of infrastructure projects in the energy sector (Sanytskyi, Pozniak, & Marushchak, 2013, p. 9). Furthermore, energy-saving technologies used in the construction sector of EU countries deserve attention, such as: improving building thermal insulation (to reduce heat loss through walls, roofs, windows, and doors); installing energy-efficient equipment (using energy-efficient heating systems, lighting, household appliances); increasing the rational use of energy (economical use of light, water, heating, and other energy resources); utilizing renewable energy sources (installing solar panels, heat pumps, etc.); energy management (implementing energy consumption monitoring systems, developing energy budgets, and planning energy-saving measures); and energy auditing (assessing the energy efficiency of buildings and enterprises, identifying opportunities for energy saving).

To effectively introduce students to modern energy-saving technologies and develop the energy-efficient competence of future construction specialists, it is necessary to apply a number of scientific and pedagogical approaches in their training process.

Considering that energy efficiency is a complex and multifaceted phenomenon (S. Honcharenko, I. Ziaziun, P. Luzan), its study and implementation require the application of a systemic approach, which involves, for example, viewing a building structure as a single system where all elements are interconnected and influence each other. In the process of forming energy-efficient competence in future qualified workers and junior professional bachelors for the construction industry from the perspective of a systemic approach, it is necessary to: analyze the interconnections between different aspects of energy efficiency, its impact on ventilation systems, external and internal thermal insulation, heating systems, and electricity supply; optimize the building's energy system as a whole, i.e., adopt comprehensive solutions that ensure maximum energy efficiency of the entire building; clarify the building's construction year, and account for energy costs at all stages of the building's life cycle, from the production of building materials to waste disposal.

It is also important to apply the subject-activity approach (N. Aristova, O. Dubaseniuk),

which focuses on individualizing the process of forming energy-efficient competence in future qualified workers. It contributes to the personal development of students as active participants in learning, creating conditions for the maximum realization of their creative abilities through practical activity. According to the principle of unity, consciousness, and activity, it is active activity that shapes consciousness, which in turn determines the subsequent actions of the individual. Research by Ukrainian scientists (T. Herliand, N. Kulalaieva, T. Piatnychuk) convincingly demonstrates that the application of the subject-activity approach in the educational process of vocational education institutions opens up wide opportunities for the professional growth of students. Such an approach, by placing students at the center of the educational process, stimulates them to active participation, independence, and creativity.

Given the aforementioned problem, it is also necessary to consider the requirements of the technological approach (T. Ilyina, O. Piekhota), which forms the energy-efficient competencies of future qualified workers in the construction field and appears as a structured algorithm of logical actions within the educational process with a clearly defined final result. Pedagogical activity aimed at forming energy-efficient competence is considered as an educational technology – an integrated didactic system that includes principles, methods, pedagogical conditions, and means of controlling expected results. Therefore, the technological approach to learning involves designing and planning the educational process to guarantee the achievement of didactic goals.

We have also taken into account the requirements of the prognostic approach (T. Herliand, M. Koliada), which suggests that the formation of energy-efficient competence in qualified workers and junior professional bachelors in the construction industry should be oriented towards adaptation to future changes in production and technological processes. To this end, it is necessary to promptly use information about scientific and technical innovations, based on which vocational (vocational-technical) education institutions adapt their material and technical base, educational content, curricula, educational and

educational-professional programs to ensure quality training and professional development of pedagogical staff.

It is also important to note that energy efficiency is a field that requires knowledge in various areas, such as construction, energy, ecology, economics, law, and others. The educational process should include such components to ensure that future qualified workers and junior professional bachelors in the construction industry achieve an understanding of: the impact of the construction industry on the environment, assessing environmental consequences, and the rational use of various building materials and technologies; orientation in legislation and regulations in the field of energy saving, knowledge of requirements for energy certification of buildings, energy efficiency standards, and other regulatory documents.

Among the most popular pedagogical technologies that will contribute to ensuring students' deep understanding of modern energy-saving technologies and improving the practical application of energy-saving principles in the construction industry are: information, communication, and personal development technologies, interactive and problem-based learning, the project method, and others. Information technologies play an important role, enabling the use of specialized software for energy modeling of buildings, heating, ventilation, and air conditioning systems. Communication technologies involve organizing interactive seminars and webinars for participants and energy efficiency experts; creating a platform for exchanging experience between students, teachers, and social partners from construction companies; and virtual

trainers and simulators for practicing skills in designing and constructing energy-efficient buildings. The use of these technologies allows for the creation of an effective educational environment that fosters high-quality, in-depth knowledge, skills, and motivation in future builders for designing, constructing, and operating energy-efficient buildings.

**Conclusion.** To ensure the rational use of material and energy resources, enhance energy saving in Ukraine's housing and communal sector, and strengthen its energy independence, it is necessary to include in the content of professional training for future construction industry specialists familiarization with innovative energy-saving technologies in construction (designing energy-efficient buildings, energy performance certificates for buildings, thermal modernization of the housing stock, using modern thermal insulation materials, installing energy-saving windows, applying energy-saving engineering technologies and heating systems), ecological characteristics of energy-saving technologies, principles of energy-saving measures, etc. It is also essential to utilize the experience of EU countries, apply scientifically substantiated domestic pedagogical approaches (systemic, subject-activity, technological), and innovative pedagogical technologies (to familiarize students with modern energy-saving technologies and form energy-efficient competence in future construction specialists). This will enable significant progress in training specialists capable of practically implementing the construction of energy-saving, comfortable buildings with minimal environmental pollution.

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## ВИКОРИСТАННЯ У ПРОФЕСІЙНІЙ ПІДГОТОВЦІ МАЙБУТНІХ ФАХІВЦІВ БУДІВЕЛЬНОЇ ГАЛУЗІ ІННОВАЦІЙНИХ ЕНЕРГОЕФЕКТИВНИХ ТЕХНОЛОГІЙ

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### Реферат:

*Актуальність* розроблення і впровадження енергоефективних технологій в сучасній будівельній галузі зумовлюється продовженням енергетично виснажливої війни рф проти України, що потребує формування у всіх громадян і фахівців енергозаощадливої поведінки та впровадження енергоефективних технологій у всі енергозатратні галузі вітчизняної економіки, однією з яких є будівельна.

*Мета:* обґрунтувати важливість використання сучасних будівельних матеріалів та новітніх енергоефективних технологій у професійній підготовці здобувачів професійної (професійно-технічної) освіти будівельного профілю для посилення енергоефективності, енергозбереження, раціонального використання теплової енергії в сучасній будівельній галузі України.

*Методи:* аналіз наукових джерел, нормативно-правових документів та емпіричних даних – для доведення важливості використання сучасних будівельних матеріалів і новітніх енергоефективних технологій у професійній підготовці здобувачів професійної (професійно-технічної) освіти будівельного профілю; теоретичний аналіз, синтез та узагальнення – для формування висновків щодо особливостей застосування сучасних будівельних матеріалів та енергоефективних технологій в освітньому процесі закладів професійної (професійно-технічної) освіти будівельного профілю.

*Результати:* виявлено основні енергоекономічні показники України порівняно з показниками інших країн і з'ясовано, що вони є негативними (витрати електроенергії в Україні становлять 60%, тоді як у Франції – 40%, а Великобританії – 35,8%); обґрунтовано, що професійна підготовка фахівців будівельного профілю потребує ознайомлення здобувачів освіти з проблемами і принципами збалансованого розвитку у будівництві (мінімізація витрат енергії та матеріальних ресурсів у процесі спорудження та експлуатації будівельних конструкцій, зменшення негативного впливу будівництва на навколишнє середовище; комплексний аналіз енергетичної, екологічної, економічної та суспільно-соціальної проблематики зведення будівельних об'єктів тощо).

*Висновки:* обґрунтовано, що для забезпечення раціонального використання матеріальних і енергетичних ресурсів, підвищення енергозбереження житлово-комунального сектору України та посилення її енергетичної незалежності необхідно включити до змісту професійної підготовки майбутніх фахівців будівельної галузі ознайомлення з інноваційними енергозберігаючими технологіями у будівництві (проектування енергоефективних будинків, енергетичний паспорт будинку, термомодернізація житлового фонду, використання сучасних теплоізоляційних матеріалів, встановлення енергозберігаючих вікон, застосування

енергозберігаючих інженерних технологій та систем опалення), екологічними характеристиками енергозберігаючих технологій, принципами енергозберігаючих заходів тощо.

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**Ключові слова:** *професійна освіта, заклади професійної освіти будівельного профілю, енергозберігаючі технології, енергоефективна компетентність, будівельна галузь, збалансований розвиток.*

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