

3.2. PROFESSIONAL AND PRACTICAL TRAINING OF SPECIALISTS IN ENERGY-EFFICIENT CONSTRUCTION IN QUALITY ASSURANCE OF VOCATIONAL EDUCATION

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The chapter provides a theoretical and methodological analysis of education for sustainable development as a conceptual platform for modernizing the professional and practical training of specialists in energy-efficient construction. It has been substantiated that the transformation of the construction industry within the framework of the “green” economy and the post-war reconstruction of Ukraine requires integrating environmental, economic, and social components into the content of vocational education. The potential of competency-based, systemic, activity-oriented, and interdisciplinary approaches for developing the professional readiness of future specialists capable of implementing the principles of energy efficiency and resource conservation in practical activities has been demonstrated. The role of the dual form of vocational education, the digitalization of the educational process, and partnerships with employers as strategic factors in quality assurance of vocational education has been analyzed. The directions for modernizing educational programs, developing training and practical centers, updating the material and technical base, and improving the qualifications of teaching staff in accordance with European standards have been outlined. It has been proven that professional and practical training serves as an integrative link between the education system, the production environment, and the strategic goals of sustainable development, ensuring the readiness of competitive specialists for the reconstruction of Ukraine in line with the principles of energy efficiency.

Keywords: *education for sustainable development; professional and practical training; energy-efficient construction; competency-based approach; dual education; digitalization of education; quality assurance of vocational education*

Global trends in the transformation of the energy sector of the economy and the consistent implementation of sustainable development policies are driving systemic changes in the structure of social production and a profound transformation of the content of vocational education, particularly in the field of construction. The construction industry remains one of the largest consumers of energy resources and a significant source of greenhouse gas emissions, which determines its strategic role in achieving climate goals and ensuring the energy security of the state. Under these conditions, not only the technological base of the industry is being transformed, but also the content of vocational

education, which must ensure the training of specialists capable of implementing the principles of energy efficiency, resource conservation, and environmental responsibility in practical activities. In this context, the training of specialists in energy-efficient construction acquires not only professional but also pronounced socio-economic significance.

By the Resolution of the Cabinet of Ministers of Ukraine dated April 21, 2023, No. 373-r, the Energy Strategy of Ukraine until 2050 was approved. This document defines the long-term trajectory of the country's energy development in the context of the global energy transition and integration into the European economic space. It reflects the objectives of the European Green Deal and is based on the principles of a comprehensive approach to the formation and implementation of sustainable development policies for Ukraine's economy, including the energy sector. The goals set in the Strategy will be achieved through the development of modern and safe nuclear generation, renewable energy sources, and the modernization and automation of transmission and distribution systems. Particular emphasis is placed on improving energy efficiency as a systemic factor of economic competitiveness and national energy security. One of the main tasks of the Energy Strategy of Ukraine is the fulfillment of international commitments regarding energy efficiency (Ministry of Energy of Ukraine, 2023). In this context, the training of qualified personnel is considered a prerequisite for the realization of strategic objectives, since human capital ensures the practical implementation of innovative technologies in the construction and energy sectors. Thus, the issue of forming energy-efficient competence among future skilled workers in various sectors of the economy becomes particularly relevant for the post-war "green" reconstruction of Ukraine.

The implementation of strategic guidelines requires appropriate regulatory and institutional support. The National Recovery Plan (The Cabinet of Ministers of Ukraine, 2023) and the commitments arising from integration into the European Union serve as powerful drivers of reform. These documents shape the regulatory environment within which vocational education must be transformed in response to new economic and technological challenges. They define a dual vector of development: the restoration of damaged infrastructure and the modernization of the vocational education system in accordance with European standards. Therefore, the modernization of professional and practical training is not an optional direction of development but a strategic necessity in the context of post-war reconstruction.

At the same time, the Ukrainian system of vocational education is currently facing a number of limitations. An analysis of the current state reveals structural and content imbalances between labor market requirements and the actual capacities of educational institutions. Many institutions operate according to outdated curricula that do not reflect

modern energy efficiency requirements (Herasymyk-Chernova & Khomych, 2020). This results in a gap between the declared strategic objectives and the actual learning outcomes. At the same time, the lack of technical equipment, such as airtightness testing systems, thermal imagers, and other diagnostic tools, limits opportunities for practical training. The insufficient level of material and technical support reduces the potential for developing applied competencies and makes it impossible to simulate real production situations. In addition, teachers need to improve their qualifications to teach competencies that meet European standards. Thus, the problem of modernizing vocational training has a complex character and encompasses regulatory, content-related, technological, and personnel levels.

The actualization of the problem of vocational education quality in the context of the “green” transformation of the economy necessitates a revision of approaches to the organization of professional and practical training. Scientific studies demonstrate that the implementation of the principles of integrated energy design requires the formation of interdisciplinary competencies among future specialists and the organization of team interaction already at the stage of vocational training (Brunsgaard et al., 2014). Thus, the traditional model of training, focused primarily on narrow-profile knowledge and the reproduction of technological operations, is gradually being transformed into a model based on a comprehensive vision of the building’s life cycle, beginning with concept and design and extending to operation, energy consumption monitoring, and renovation.

In a broader socio-economic context, transformational processes are confirmed by OECD analytical materials (2023), according to which the “green” economy requires flexibility from the vocational education system, modernization of educational standards, and the development of micro-qualifications related to energy efficiency, renewable energy sources, digital modeling, and resource management. Similar provisions are reflected in the documents of the European Commission on the implementation of the European Green Deal, where vocational education is considered a key instrument for shaping “green” skills for the labor market. In this context, professional and practical training functions not only as a component of the educational process but also as a strategic mechanism for ensuring the quality of vocational education, directly influencing the competitiveness of graduates and their ability to adapt to technological changes.

The European experience of “greening” vocational education demonstrates the effectiveness of integrating energy-efficient competencies into all educational components: professional-theoretical training, industrial practice, internships at enterprises, and the system of professional development for teaching staff. This approach ensures the systemic and consistent formation of professional competencies, as well as alignment between industry requirements and learning outcomes. An important condition

in this regard is the partnership of vocational education institutions with employers, the implementation of the dual form of education, and the use of modern equipment and digital tools for energy monitoring.

Therefore, the theoretical and methodological foundation of professional and practical training for specialists in energy-efficient construction is represented by competency-based, systemic, activity-oriented, and integrative approaches. Their combination ensures the formation of holistic professional readiness, which encompasses not only a set of knowledge and practical skills but also the ability for analytical thinking, interdisciplinary interaction, and decision-making that takes into account ecological and economic criteria. Under current conditions, professional and practical training must be oriented toward the formation of learning outcomes aligned with sectoral standards, the principles of sustainable development, and the needs of regional labor markets. Such a methodological framework makes it possible to consider professional and practical training as a key factor in ensuring the quality of vocational education in the context of the energy transition and the post-war reconstruction of Ukraine's economy.

In scientific research, the outlined issues find further specification at the level of defining strategic directions for the formation of energy-efficient competence. Thus, Kalenskyi (2025) substantiates that the training of future skilled workers in the construction industry should be carried out along several interrelated directions: the identification of methodological approaches, principles, and pedagogical technologies for the formation of energy-efficient competence; the modeling of pedagogical conditions for its establishment and development within the educational environment of the institution; and the design of the content and structure of energy-efficient activities of learners in the process of general vocational, professional-theoretical, and professional-practical training.

The analysis of the directions proposed by the researcher indicates the necessity of considering professional and practical training as a system-forming component of the educational process, within which the integration of theoretical knowledge and real production activities takes place. At the same time, the outlined theoretical approaches require specification at the level of content, forms, and technologies of organizing the educational process. Therefore, it is logical to move from methodological substantiation to the analysis of the practical component of training, which serves as the space for the implementation of the defined approaches. In this context, professional and practical training appears not as a separate component of the educational program but as an integrated mechanism for the formation of professional competence, within which knowledge is transformed into professional action.

Professional and practical training is a decisive factor in shaping the readiness of future specialists to perform professional functions in the field of energy-efficient construction. Its content must reflect modern technological processes, innovative materials, digital tools, and the requirements of energy legislation. This involves not only mastering technologies of insulation or the installation of engineering systems but also developing the ability to conduct energy analysis of facilities, evaluate the effectiveness of design solutions, and forecast their impact on the environment and the economics of building operation.

One of the leading directions in the modernization of practical training is the introduction of Building Information Modeling (BIM) technologies. The study by Alhamami, Petri, Rezgui and Kubicki (2020) confirms that adapted BIM training programs contribute to the formation of a systemic vision of building energy consumption, the optimization of design solutions, and the development of energy analysis skills. The use of BIM in vocational education makes it possible to integrate the technical, economic, and ecological aspects of construction into a single educational model, which corresponds to the integrative approach. Thus, the digitalization of vocational training functions not only as a technological innovation but also as a methodologically substantiated means of forming complex competencies.

Equally important is the introduction of the dual form of education and workplace learning, which implements activity-based and practice-oriented approaches. Dual education has long proven its effectiveness in many European countries, particularly in Germany, Switzerland, and Austria, and it holds significant potential for development in Ukraine. Given the economic and social challenges, especially in the construction sector, Ukraine requires flexible and effective methods of training specialists capable of addressing the pressing problems of the industry. The adaptation of dual education to Ukrainian realities will become an important step toward the modernization of vocational education and the improvement of employment opportunities for young specialists in the construction field.

The experience of European vocational education offers practical models for adaptation. Dual training systems, where theoretical learning is combined with workplace practice, demonstrate how competencies can be strengthened through practical experience (Ertelt et al., 2021). Practical training should be carried out in conditions as close as possible to real production, which corresponds to the principles of dual education and workplace learning (Clarke et al., 2020). This approach ensures the combination of classroom learning with enterprise-based practice and contributes to the formation of applied competencies necessary for performing tasks such as building insulation, installation of renewable energy systems, and conducting energy audits.

At the same time, it is important to distinguish between the formal combination of work and study and the full-fledged dual form of education. In the first case, a learner may combine study with work episodically, which does not ensure the systemic formation of competencies. In contrast, the dual system provides for a structured integration of the educational process with professional activity, a clear distribution of responsibilities between the educational institution and the employer, the presence of mentorship, and a gradual immersion into the production environment. (Holyshev, 2025, p. 28). Such a model ensures the development of professional autonomy, teamwork, responsibility, and a culture of safe work. Research indicates that the implementation of the dual system contributes to increasing the employment rate of graduates, since their training corresponds as closely as possible to the real requirements of production.

The implementation of the dual form of education offers significant advantages for all participants in the educational process, especially in such a specific and practice-oriented field as construction. Learners gain the opportunity to apply theoretical knowledge in practice, work with modern equipment and technologies, develop professional identity, and increase competitiveness in the labor market. Construction companies, in turn, become involved in shaping the content of educational programs, which ensures their relevance in accordance with technological changes. Partnerships between educational institutions and industry, as well as the creation of workshops supported by manufacturers, demonstrate how effective cooperation can contribute to the development of digital technologies and the updating of educational materials (Esangbedo et al., 2024).

The dual form of education is a promising and effective model for training specialists in the construction industry, as it ensures synergy between theoretical learning and practical experience. However, its effectiveness largely depends on regulatory support, financial backing, the preparation of mentors in enterprises, and the readiness of vocational education institutions for organizational changes.

In the context of Ukraine, the problem of modernizing vocational training for construction specialists with consideration of the energy efficiency component acquires particular relevance in the conditions of post-war reconstruction. The restoration of residential, social, and industrial infrastructure must be carried out in accordance with the principles of energy efficiency, resource conservation, and ecological feasibility. This necessitates specialists of a new type (mobile, technologically prepared, and capable of working with digital tools) who will implement innovative solutions and act in accordance with European construction standards. In this regard, the development of a domestic network of training and practice centers, the modernization of the material and technical base of vocational education institutions, and the creation of laboratories for

energy auditing, energy modeling, and testing of energy-efficient technologies acquire special significance. However, the modernization of infrastructure is only a prerequisite. The decisive condition for ensuring the quality of professional and practical training is its integration with the real production environment and the professional standards of the industry.

The main features of the modern labor market for construction specialists are flexibility and high innovative dynamics. Under such conditions, employers increasingly define requirements not so much through a list of theoretical knowledge as through the expected modes of professional activity (skills, the ability to make independent decisions, readiness to act in non-standard production situations). Thus, this refers to a specific type of educational outcomes within the vocational training system, in which knowledge serves as a necessary but insufficient condition for achieving the proper quality of professional competence (Yershova, 2025b, p. 439). Therefore, the researcher's position is consistent with the competency-based paradigm of vocational education and reinforces the argument regarding the leading role of professional and practical training in shaping a competitive specialist.

The quality of vocational education should be considered as a systemic characteristic that reflects the degree of correspondence between learning outcomes and the requirements of the labor market, industry standards, and strategic guidelines of sustainable development. In this context, professional and practical training performs the function of a mechanism for verifying the competencies formed through their testing in conditions as close as possible to production. It is practice that makes it possible to identify not only the level of professional skills formation but also the learners' ability to make technically substantiated decisions, adhere to technological discipline, work in a team, and take responsibility for the result.

Analytical materials (European Union, 2015) emphasize that effective quality assurance systems in vocational education and training involve the active participation of employers at all stages of the educational cycle: from the development of professional standards and educational programs to the assessment of learning outcomes. This approach transforms the employer from the position of an external consumer of educational services into the status of a full-fledged partner and co-subject of quality assurance. The involvement of enterprises in conducting industrial practice, joint evaluation of qualification works, updating the content of training, and the expertise of educational programs creates conditions for objective monitoring of graduates' level of professional readiness.

Professional and practical training of specialists in energy-efficient construction performs a dual function. On the one hand, it ensures the formation of applied professional competencies necessary for carrying out specific production tasks. On the

other hand, professional and practical training serves as an indicator of the effectiveness of the educational process and the efficiency of quality management in vocational education institutions. Its effectiveness is determined by the degree of integration with the production environment, the systematic nature of partnerships with employers, the relevance of training content, the level of material and technical support, and the implementation of mechanisms for external and internal evaluation.

The development of the dual form of education acquires particular importance, as it ensures the synchronization of theoretical learning with production activities. Such a model makes it possible to minimize the gap between educational outcomes and real professional requirements, increase learners' motivation, and facilitate their faster integration into the professional environment. At the same time, systematic interaction with social partners establishes shared responsibility for the quality of training and creates a foundation for the long-term development of the industry.

European experience convincingly demonstrates that practice orientation, flexibility of educational programs, and the continuous updating of training content in line with technological innovations ensure the competitiveness of graduates in the labor market. For Ukraine, in the context of large-scale infrastructure reconstruction, the implementation of energy efficiency standards in vocational education is not only an educational task but also a strategic factor of economic resilience and integration into the European space.

Thus, professional and practical training serves as an integrative link between the educational system, the production sphere, and the needs of sustainable societal development. Its quality is determined not only by the level of material and technical equipment but, above all, by the depth of partnerships with employers, the relevance of training content, and the ability of the educational system to respond promptly to technological changes. It is precisely through the modernization of professional and practical training that specialists are formed who are capable of implementing the principles of energy efficiency in practical activities and carrying out the reconstruction of the country on the basis of sustainable development.

In view of the above, it is advisable to carry out a systematic comparative analysis of approaches to professional and practical training of specialists in energy-efficient construction in the countries of the European Union and in Ukraine. Such an analysis makes it possible not only to outline differences in training models but also to identify structural elements that ensure the quality of vocational education in the context of the "green" transformation of the economy. The comparison is carried out according to the following key parameters: the training model, the organization of the practical component, the level of digitalization, quality assurance mechanisms, teacher training, infrastructure provision, and the strategic role in economic development (Table 1.1).

Table 1.1. Comparative Analysis of Approaches to the Professional and Practical Training of Specialists in Energy-Efficient Construction: The EU and Ukraine

Countries of the European Union	Ukraine
Training model	
Competency-based, interdisciplinary, and oriented toward the building life cycle.	A gradual transition from a traditional subject-based model to a competency-based one; requiring systematic integration of interdisciplinarity.
Practical component	
Developed dual education; compulsory workplace training; close cooperation with employers.	Active development of training and practical centers; cooperation with business is strengthening but remains fragmented.
Digitalization	
Integrating BIM as a standard of professional training; digital simulations and laboratories.	Gradual implementation of BIM in vocational education institutions; requires modernization of the material and technical base.
Quality assurance mechanisms	
Systems of internal and external quality assurance (EQAVET); involvement of employers in the development of standards.	Formation of an internal quality assurance system; integration of professional standards is ongoing.
Training of teaching staff	
Specialized professional development programs in “green” technologies.	The need for systematic professional development of teachers in energy-efficient technologies.
Infrastructure of practical training	
Energy-efficient educational campuses, demonstration buildings, and renewable energy laboratories.	Establishment of training and practical centers; modernization of workshops within the framework of national and international projects.
Strategic role in economic development	
A key element in the implementation of climate policy and decarbonization.	A strategic direction in the context of reconstruction and integration into the European educational space.

Comparative analysis demonstrates that in the countries of the European Union, professional and practical training of specialists in energy-efficient construction has a systemic character and is based on the integration of educational policy with climate and economic strategies. A distinctive feature is the clear coordination between educational institutions, employers, and state authorities, which ensures the alignment of learning outcomes with labor market needs. At the same time, the systemic nature of the European model is manifested in the coherence of regulatory frameworks, financial mechanisms for supporting vocational education, institutional partnerships, and the functioning of advanced quality assurance systems (in particular, in accordance with the principles of EQAVET). This creates a holistic educational environment in which professional and practical training is regarded as a key instrument for implementing climate and innovation policy.

In Ukraine, there is a positive dynamic in the modernization of vocational education, particularly through the establishment of training and practice centers and the updating of educational standards. However, the key challenges remain: insufficient level of digitalization; limited material and technical resources; the need for systematic professional development of teaching staff; and the necessity of deepening partnerships with employers.

Unlike the EU countries, where professional and practical training functions as a structured element of a unified ecosystem “education – labor market – climate policy”, in Ukraine the modernization process still has a predominantly project-based and phased character. This results in fragmented implementation of innovations and uneven development of vocational education institutions at the regional level. At the same time, the Ukrainian vocational education system has significant potential for integrating European experience, especially in the context of post-war reconstruction, which opens opportunities for the introduction of innovative energy-efficient solutions.

Thus, the results of the comparative analysis make it possible to consider the modernization of professional and practical training not as an isolated direction of reform, but as a component of the comprehensive transformation of the vocational education system, oriented toward ensuring quality, graduates’ competitiveness, and the strategic integration of Ukraine into the European educational and economic space.