

3.3. EDUCATIONAL NEEDS AND RISKS IN TRAINING SKILLED CONSTRUCTION WORKERS WITHIN THE CONTEXT OF UKRAINE'S POST-WAR RECOVERY

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The section identifies the core principles of sustainable construction and defines their content. It outlines new expectations for construction industry professionals in the context of the sustainable development concept and the “Build Back Better” principle – a key pillar of Ukraine's post-war recovery. This principle emphasizes the creation of a qualitatively new environment based on modern standards rather than the mere restoration of destroyed objects. The article provides an overview of educational needs for training construction workers, categorized by key competencies, and explores pathways for their implementation within Ukraine. Priority areas for vocational training are defined, aiming to provide the professional knowledge and skills necessary for high-quality, energy-efficient construction with minimal environmental impact. Finally, the study examines the challenges and risks of addressing these educational needs in Ukraine's current climate and proposes strategies to overcome them.

Keywords: *sustainable construction, post-war recovery, Build Back Better, vocational training, energy efficiency, environment*

The future recovery of Ukraine following the destructive actions of the Russian Federation is fundamentally based on the approach of sustainable construction. Building for sustainable development involves the design and erection of energy-efficient structures using eco-friendly materials, which minimizes environmental impact throughout the entire life cycle of the building. This approach implements the principles of a circular economy, balancing economic efficiency, social responsibility, and environmental protection in accordance with modern EU standards. The primary goal of sustainable construction is to meet the needs of the present without compromising the ability of future generations to meet theirs (Borovyk et al., 2021, p. 51).

The key principle of Ukraine's post-war recovery – “Build Back Better” – envisages more than just repairing damage; it aims to create a qualitatively new environment based on contemporary standards that incorporate the goals and principles of sustainable development. This approach encompasses three main dimensions: environmental, economic, and social (Kisterskyi, 2023, p. 7). The environmental component signifies the reduction of emissions (decarbonization), the preservation of

biodiversity at the construction site, and the protection of ecosystems. The economic component involves the ability to evaluate a building's value through Life Cycle Costing (LCC), accounting not only for initial construction but also for substantial operational savings. The social component focuses on creating inclusive spaces (accessibility), ensuring comfort for residents, and providing safe working conditions for construction workers.

These core components of the “Build Back Better” concept define the fundamental principles of sustainable construction. These principles include the optimization of energy consumption by minimizing energy demand through insulation, passive design, and the transition to renewable sources. Furthermore, it emphasizes the conservation of resources and water by implementing water-saving systems – such as rainwater harvesting – and the rational use of building materials. Priority is given to the use of eco-friendly materials, specifically renewable (timber), recycled, or local materials with a low carbon footprint.

Waste minimization is achieved by applying circular economy principles, where materials are reused or recycled after dismantling. Additionally, the quality of the indoor environment is ensured through a healthy microclimate, natural lighting, high-quality ventilation, and the avoidance of toxic materials. Finally, the principles of durability and adaptability guarantee that buildings are designed to be easily repaired, modernized, or repurposed in the future.

In Ukraine, the implementation of these principles is coordinated through the adaptation of European standards, such as Nearly Zero-Energy Buildings (NZEB), and the advancement of green certification systems like LEED and BREEAM. These fundamental principles of sustainable construction dictate that the training of a modern construction worker can no longer be limited to basic tool proficiency. The Build Back Better (BBB) concept in Ukraine serves as the official state recovery strategy, focusing on the modernization of infrastructure using the latest standards of safety, energy efficiency, and inclusivity (Cilliers, 2023).

Consequently, the modernization of vocational training programs for the construction sector must prioritize several critical aspects. These include the integration of courses on energy-efficient design, green construction, and energy management. Furthermore, success in this field relies on close cooperation with the business community and the adoption of digital technologies in education, such as VR/AR simulations and software for analyzing building energy performance, while drawing on international expertise (Kupriyevych, 2025, p. 178).

For the construction industry, the Build Back Better concept signifies a transition from simple physical reconstruction to the creation of a qualitatively new environment based on European standards. This shift drives key transformations within the sector,

including the adoption of the circular economy, enhanced energy efficiency, digitalization, harmonization with EU regulations, and the principles of the New European Bauhaus. Each of these elements must be examined in detail to understand the necessary directions for transforming professional training.

The circular economy focuses on the recycling and reuse of construction debris, such as concrete and bricks, for new projects. As of 2026, Ukraine has already cleared over one million tons of rubble, which is being repurposed as a resource for new roads and foundations. Simultaneously, the transition to Nearly Zero-Energy Building (NZEB) standards significantly enhances energy efficiency. Although this shift increases construction costs by 10–40%, it remains critically important for the nation’s future energy independence.

Digitalization, particularly through BIM (Building Information Modeling) technologies, allows for precise planning and can save up to 21% of costs during the construction phase (Demian et al., 2024). Project monitoring is facilitated through the DREAM ecosystem, ensuring transparency for international investors. This technological advancement is accompanied by harmonization with EU standards, specifically the transition to European regulations on construction products, such as Regulation 305/2011, and the certification of materials to ensure reliable quality and free export.

Furthermore, the New European Bauhaus (NEB) initiative integrates three core principles: sustainability, aesthetics, and inclusivity. Within the construction sector, the “Build Back Better” concept demands more than just manual labor; it requires a new generation of specialists. Consequently, professional training is currently undergoing a transformation across several key dimensions to meet these evolving requirements.

Mastering new technologies is a cornerstone of modern construction training in Ukraine, where workers must now move beyond traditional methods. This shift involves transitioning from paper blueprints to working with digital 3D models via BIM technologies, as well as installing advanced energy-efficient systems such as heat pumps, solar panels, and modern recuperation units. Furthermore, the emergence of 3D-printed construction – already evidenced by pioneer projects like the school in Lviv – creates a growing demand for specialized operators of construction 3D printers.

The reform of vocational education, driven by the state and international partners, is actively modernizing the learning ecosystem through several key initiatives. Modern educational and practical centers are being established within vocational schools, such as the Knauf or Siniat networks, to train dry construction specialists according to European standards. This is complemented by the expansion of dual education, where students spend 70% of their time gaining hands-on experience and earning wages at real construction sites. Additionally, short-term intensive programs lasting one to three

months have been launched to facilitate the rapid requalification of veterans and internally displaced persons (IDPs).

International certification and standards play a decisive role in this educational transformation. To work on projects funded by the EU or the World Bank, construction companies must ensure their personnel are trained in green building standards, such as BREEAM and LEED. Moreover, implementing occupational health and safety protocols aligned with EU directives is a critical requirement of the “Build Back Better” concept. This also includes specialized training in on-site waste management, focusing on the sorting and recycling of construction debris directly at the workplace. The following is a detailed overview of educational needs, categorized by the key modern competencies required of construction workers.

Technological Competencies (Hard Skills). Modern technological competencies for construction workers are transforming from basic manual labor to operating high-tech equipment and digital systems. This involves acquiring specialized knowledge and skills that enable qualified workers to build with high quality, energy efficiency, and minimal environmental impact. Key focus areas include robotics management, which entails training operators for concrete 3D printers, inspection drones, and robotic manipulators. Furthermore, workers must master energy-efficiency technologies, such as “passive house” construction, the precise installation of thermal insulation to eliminate cold bridges, and the setup of airtight window systems and air recuperation units. Additionally, renewable energy skills are becoming essential, covering the installation and maintenance of solar panels, heat pumps, and integrated smart home energy management systems. This technological shift also requires proficiency in innovative materials, including eco-friendly options like timber, hempcrete, and recycled materials, along with an understanding of their physical and chemical properties.

Environmental Competencies (Green Skills). According to the European Commission (Bianchi et al., 2022), green skills encompass the specialized knowledge and abilities aimed at reducing the negative impact of construction sites and future buildings on nature. These competencies include the professional installation of energy-efficient systems, such as solar arrays, heat pumps, and advanced ventilation with heat recovery. Achieving “passive house” standards also demands skills in airtight insulation mounting. Moreover, effective waste management is crucial, involving the on-site sorting of construction debris and knowledge of recycling methods for concrete, metal, and plastic. Water conservation skills, such as installing systems for rainwater harvesting and “greywater” reuse for industrial needs, are equally vital. Finally, environmental safety

requires a deep understanding of material toxicity (e.g., VOCs, formaldehydes) and the ability to handle them safely or replace them with non-toxic alternatives.

Economic and Management Competencies. This set of competencies includes the knowledge and skills necessary for efficient planning, financial analysis, strategic decision-making, and personnel management across all construction stages. A primary focus is placed on Lean Construction, which involves organizing the workplace to minimize waste in terms of time, materials, and effort. Furthermore, workers and supervisors must understand the baseline requirements of international certification standards such as LEED, BREEAM, or DGNB. A strong emphasis is also placed on the durability of structures and buildings; by prioritizing high-quality execution, workers extend the lifespan of constructions, thereby reducing the need for frequent repairs and lowering long-term costs.

Digital Skills in the modern construction sector involve a comprehensive transition to high-tech workflows. This includes proficiency in BIM modeling, where workers must be able to retrieve data from a Building Information Model directly on-site using tablets or Augmented Reality (AR) glasses. Furthermore, managing robotic systems has become essential, requiring skills in the maintenance and control of construction 3D printers that automatically erect building frameworks. This digital literacy is complemented by the use of cloud services, enabling real-time reporting and data exchange regarding project progress through shared digital platforms.

The evolution of **Material and Tool Technologies** demands a new level of technical expertise. Workers must now be skilled in handling innovative mixtures, such as low-carbon concrete, geopolymers, and composite materials. This is closely linked to the rise of modular construction, which involves assembling prefabricated blocks manufactured off-site – a process that requires extreme precision during installation. Additionally, the use of “smart tools” has become standard, including the operation of laser scanners for high-precision marking and drones for monitoring hard-to-reach areas.

Soft Skills and Safety form the foundational layer of professional competence. Critical thinking is paramount, as it grants workers the ability to make autonomous decisions when deviations from the project occur on-site. Moreover, safety auditing requires deep knowledge of contemporary occupational health and environmental safety standards, which are core requirements of modern construction protocols.

As previously noted, special emphasis in the training of construction workers must be placed on mastering digital tools and acquiring skills to manage automated systems. Robotics in construction involves the implementation of automated systems, robotic

mechanisms, and Artificial Intelligence (AI) to enhance the speed, accuracy, safety, and quality of building processes. The application of these technologies is transforming the traditional industry by introducing automation at every stage – from initial design to final interior finishing. The following sections provide an overview of the primary directions for the application of construction robotics.

The implementation of 3D printing in construction – using large-scale printers for concrete structures – significantly accelerates building processes. By employing robotic manipulators or gantry systems for layered concrete application, developers can create complex architectural forms, reduce material waste, and enhance construction speed. Similarly, automated bricklaying robots are capable of continuous operation, laying bricks much faster and with greater precision than human workers.

The integration of drones and scanning technologies allows for high-quality aerial photography, progress monitoring, and the inspection of hard-to-reach areas. For instance, robots such as Boston Dynamics' Spot perform autonomous laser scanning to create highly accurate BIM models. To support human labor, exoskeletons – wearable devices that safely enhance physical capabilities – are used to reduce fatigue and the risk of injury, proving especially effective during monotonous tasks, overhead work, or heavy lifting. Furthermore, autonomous machinery, such as excavators and bulldozers equipped with GPS and LiDAR, can perform earthworks according to a pre-set program without direct operator intervention.

Robotics also extensively covers finishing and demolition works. Specialized robots for painting, sanding, and tiling operate two to three times faster than humans while ensuring high-quality surface finishes. For hazardous tasks, robotic excavators and specialized machinery for concrete demolition and debris clearing function without a constant human presence. Additionally, automation is applied to assembly and inspection, utilizing robotic arms and platforms for erecting steel structures at heights, as well as UAVs, wheeled rovers, and robotic dogs to monitor construction sites.

The aforementioned trends in construction robotics confirm that vocational training is no longer about mastering manual tools but rather about learning to operate complex systems. Based on the capabilities of modern robotics, key training specializations can be identified. These include becoming a 3D printer operator, which involves preparing mixtures, loading digital STL files, and controlling the print head trajectory. Another vital area is drone piloting, requiring licenses for UAV operation in photogrammetry and laser scanning (with courses from companies like DroneUA being particularly relevant). Finally, specialists must master BIM data management using

software like Autodesk Revit or ArchiCAD to transmit precise coordinates directly to robots on-site, as well as mechatronics maintenance, providing the fundamental knowledge of hydraulics, sensors, and controller programming needed for rapid field repairs.

Key advantages of implementing robotic systems in the construction industry include a significant enhancement of occupational safety, as robots perform hazardous tasks at heights or in environments with structural collapse risks. High precision and quality are achieved by minimizing the human factor, ensuring ideal compliance with project specifications. Despite high initial investment costs, automation guarantees economic efficiency by reducing labor and material expenses in the long term, while the capacity for 24/7 operation substantially accelerates project delivery timelines.

In February 2026, the Kyiv National University of Construction and Architecture (KNUCA) inaugurated RoboLab – Ukraine's first specialized laboratory for construction robotics. The prospects of this field are directed toward full process automation, where machines can autonomously execute the entire construction cycle. Robotics serves as a critical tool for the Build Back Better (BBB) concept, enabling faster, safer construction with reduced waste – factors of paramount importance for Ukraine amidst labor shortages and large-scale destruction.

One of the most prominent aspects of reconstruction is 3D Construction Printing (3DCP). Instead of prolonged wall erection, a printer “prints” them within a few days, as demonstrated in Lviv during the construction of Europe’s largest primary school. This technology allows for material savings of up to 20–30% and the creation of complex, energy-efficient forms that are difficult to implement manually. The subsequent phase involves demining and site preparation, where remote-controlled machines and scanner drones become indispensable. Modern Ukrainian and foreign developments, such as the GCS-200, allow for the safe clearance of up to 3000 m² of territory per hour, operating at distances of up to 1500 m from the operator.

LIDAR technology plays a key role in damage assessment by creating precise 3D maps of objects and detecting hidden defects. Simultaneously, automation of various trades is being implemented directly on construction sites: painting robots (e.g., Canvas) ensure flawless wall finishing, while exoskeletons assist workers in lifting heavy loads, thereby reducing injury rates. For laser scanning and progress monitoring within the DREAM system, quadruped robots such as Boston Dynamics' Spot are utilized.

Particular attention is paid to robotic demolition and recycling, which allows for the safe dismantling of structures and the reuse of up to 90% of materials. Small remote-

controlled demolition machines, such as Brokk, operate in hazardous zones inaccessible to humans, while AI-driven automated lines identify and separate concrete, metal, and brick. This approach not only accelerates debris clearance but also minimizes waste and CO₂ emissions, transforming construction rubble into resources for new roads and foundations.

Preparing qualified workers for the construction sector remains one of the most critical challenges for Ukraine's recovery in the coming years. The primary risks in meeting educational needs are linked to the demographic crisis, the misalignment of educational programs with modern requirements, and various institutional barriers. As of early 2026, the dominant challenge for the construction industry is a critical labor shortage, which has already surpassed the 30% mark. It is projected that the rapid increase in housing and infrastructure reconstruction will only widen this gap, as the demand for a skilled workforce significantly outpaces the current market supply.

The situation is further complicated by a technological gap resulting from Ukraine's full transition to European quality standards for construction products starting in 2026. There is a tangible risk that a significant portion of the workforce will not have enough time to master the skills required to work under new EU regulations and with modern materials. A separate and pressing issue is the acute shortage of specialists capable of implementing BIM technologies and operating automated management systems or robotic equipment.

Simultaneously, the educational sphere is undergoing a complex institutional transformation as vocational education institutions transition into the status of municipal non-profit enterprises. This reform carries the risk of losing experienced teaching staff due to the difficulties management faces in adapting to new market conditions. At the same time, the problem of practical training remains fragmented; despite the targeted modernization of workshops by international partners, most institutions still suffer from a lack of modern machinery and equipment.

The general context of the industry's development in 2026 is defined by demographic and security factors. The continuation of military actions remains the primary systemic risk for businesses, triggering a further drain of human capital abroad. Such conditions make long-term planning for youth training programs and the stable development of the construction sector extremely difficult.

To mitigate the identified risks, several priority areas have been established. First, the synchronization of education with market demands through Dual Education is paramount. This model allocates 30% of the curriculum to theoretical studies at colleges

and 70% to paid practical training on actual construction sites. Furthermore, public-private partnerships aim to establish specialized training centers directly within major construction firms or material manufacturing companies, such as Knauf and Henkel.

The mastery of Green and Smart Technologies represents a second critical pillar. This includes specialized training in energy modernization, focusing on the installation of heat pumps, solar panels, and advanced insulation systems. Simultaneously, the integration of BIM (Building Information Modeling) technologies is essential. As noted by BIMCommunity (n.d.), the use of digital twins by designers and site foremen allows for the minimization of technical errors and the reduction of corruption risks throughout the project lifecycle.

To address the immediate labor shortage, a strategy of Rapid Retraining (Micro-credentials) has been introduced for cases where a traditional 3–4 year degree is not feasible. This approach utilizes short-term intensive programs (3–6 months) tailored for veterans, internally displaced persons (IDPs), and career changers. Additionally, the system prioritizes the validation of informal learning, providing official certification for skills acquired through self-teaching or prior work experience abroad.

Inclusivity and psychological support are being integrated as foundational standards to ensure the needs of veterans and persons with disabilities are not ignored. This involves establishing “barrier-free” standards – such as ramps, wide passages, and tactile paving – as a mandatory basis for all construction rather than an optional add-on. Psychosocial adaptation is also being incorporated into curricula to build resilience, alongside the “feminization” of construction trades. According to Yershova (2025a), gender equality in the labor market ensures equal rights, opportunities, and significance for both women and men in all spheres of public and professional life.

Finally, Digitalization and Transparency serve as the primary safeguards against corruption and the use of substandard materials. Key measures include training specialists to operate within the Unified State Electronic System in the Construction Sector (USESCS) and implementing anti-corruption compliance. By embedding ethical standards and legal literacy into the educational process, the industry aims to foster a new generation of professionals committed to high-quality, transparent reconstruction.

The strategies mentioned above represent the priority areas for training construction workers, which is critical for rebuilding the country according to the Build Back Better (BBB) concept. This concept serves as a key principle for Ukraine's recovery, implying that we must not merely repair what was destroyed but create qualitatively new objects according to modern standards, sustainable development requirements, and the

“smart city” philosophy (Yershova & Bazhan, 2020, p. 71). It is crucial to emphasize that without the preparation of skilled “blue-collar” workers – those who directly bring construction projects to life – any green strategy will remain only on paper (Mayboroda, 2025b, p. 182).

Addressing the current educational needs of Ukraine's construction industry requires the widespread implementation of the dual education model. This approach allows for a harmonious combination of theoretical training in vocational institutions with intensive practice directly on construction sites, where modern principles of sustainable construction are already being actively applied.

Alongside formal systemic education, the creation of a network of competence centers, for example, based on energy-efficiency hubs, plays a vital role. These centers should facilitate short-term retraining courses, allowing experienced professionals to quickly master specific innovative technologies, such as the installation and maintenance of heat pumps.

A vital strategic step is the integration of international certification programs into the educational process. Implementing curricula with results recognized across the EU is becoming critically necessary in the context of Ukraine's future large-scale reconstruction. This will ensure that the qualifications of Ukrainian specialists meet the requirements of international donors and will help attract foreign investment to the industry.

Several educational and professional initiatives are already operational. At the state level, the Ministry for Communities and Territories Development conducts training on planning resilient and barrier-free cities. Public projects include the “Green Reconstruction of Ukraine” practical course for specialists aiming to implement sustainable approaches, and the “Reskilling Ukraine” project, which offers courses for construction project administrators with an emphasis on digital tools like Microsoft 365 and Project. Additionally, industry associations such as the Confederation of Builders of Ukraine (CBU) coordinate efforts between business and education to overcome labor shortages and implement new skills.

According to Kupriyevych et al. (2025), current educational opportunities for training construction workers in the context of sustainable development in Ukraine focus on integrating environmental standards, energy efficiency, and accessibility into the learning process. In the system of professional and higher education, particular attention is given to specialty 192, “Construction and Civil Engineering”. Colleges and universities, such as KNUBA, are actively adapting their curricula to teach modern high-

tech skills. This includes the implementation of energy-saving technologies and eco-oriented training, which teaches future specialists methods for minimizing environmental impact and the use of eco-friendly building materials.

Additionally, specialized programs and courses allow for deeper knowledge in niche areas of sustainable development. For instance, the Schneider Electric Sustainability School offers free online courses on energy management and environmental regulations. The International Sustainability Academy (ISA) provides training for professionals on ESG factors, climate responsibility, and sustainable management. Basic sustainability programs for businesses and the general public are also available through online platforms like VUM online and UNDP resources.

A vital component is professional development and practical training aimed at inclusive reconstruction. The Ministry for Communities and Territories Development, in cooperation with the UNECE, organizes training sessions on planning barrier-free and resilient cities, which is critically necessary for modern construction. The Institute of Innovative Education at KNUBA conducts regular advanced training courses for industry specialists, while the Confederation of Builders of Ukraine, together with trade unions, offers free training in the field of construction and reconstruction, ensuring the market is supplied with personnel ready for future challenges.

Conclusions: The “Build Back Better” concept is a key principle for Ukraine's recovery, which involves not just repairing what was destroyed, but creating a qualitatively new environment based on modern standards. This concept is rooted in the fundamental principles of sustainable development and sets a range of requirements for training specialists in Ukraine's construction industry. Post-war reconstruction is a massive challenge that requires not only funding but also a fundamental change in approaches to professional training. Risks such as specialist shortages, skill gaps, and outdated technologies could critically slow down the process. The training of construction workers is no longer limited to tool proficiency; it now encompasses the integration of environmental standards, energy efficiency, and accessibility into the educational process. As the industry evolves rapidly and the demand for construction workers remains high, training occurs at multiple levels: vocational education institutions, international organizations and foundations, building material manufacturers, industry associations, NGOs, and online learning platforms.