

Research Article

Formation and Implementation of Energy-Efficient and Low-Carbon Construction Solutions in Transition Economies: A Managerial and Institutional Analysis

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Abstract

The study is oriented toward a systematic interpretation of the institutional and managerial determinants that set the pace and shape the diffusion trajectories of energy-efficient and low-carbon solutions in the construction industries of transition economies. The empirical focus is built on a comparative review of regional cases in Central Asia (Kazakhstan, Uzbekistan), Southeast Asia (Vietnam), and the Western Balkans. The methodological foundation relies on integrating relevant statistical datasets produced by international organizations with an analysis of updated regulatory decisions and packages of lawmaking initiatives that define the framework conditions for “green” modernization in construction.

Within the discussion of public policy instruments, targeted incentive mechanisms are emphasized, including Kazakhstan’s model of administrative facilitation in the form of a “Green Corridor” and the formation of a new environmental taxonomy in Vietnam as an institution for classifying sustainable activities. In addition, the role of international financial institutions is examined as a catalyst for green finance markets and credit products that lower entry barriers for development projects with a reduced carbon footprint. At the same time, the analysis identifies a pronounced mismatch between declarative policy intentions and the operational effectiveness of implemented measures: the observed imbalance is associated with institutional gaps, a shortage of qualified personnel in energy auditing and sustainable design, and price and regulatory distortions in energy markets that prevent the proper monetization of energy efficiency.

As an applied outcome, managerial approaches are formulated for developer organizations, aimed—practically speaking, aimed again—at embedding ESG logic into corporate governance contours and shifting from linear resource-consumption models toward circular-economy practices across the design, construction, and operational stages of facilities. The set of conclusions shows that the low-carbon transformation of the construction sector in transition economies is not reducible to transferring technologies and equipment; a decisive condition is a deep restructuring of the architecture of state regulation and corporate governance systems, ensuring reproducible incentives, measurable effects, and institutional enforceability of adopted decisions. The material is of value to sustainable development specialists, representatives of regulatory bodies, and the research community working at the intersection of climate policy and construction economics.

Keywords:

energy efficiency, low-carbon construction, transition economies, institutional analysis, ESG transformation, green finance, decarbonization, Central Asia, Vietnam, Western Balkans.

Introduction

The global construction complex, including subsequent building operation, remains one of the most energy-intensive spheres of the world economy: in 2024–2025, it accounts for roughly 32% of global final energy consumption and around 34% of total direct and indirect carbon dioxide emissions [28, 29]. In transition economies—where the pace of urbanization and industrial expansion often outstrips the deployment of environmental and energy infrastructure—renewing and improving the efficiency of the building stock takes on the characteristics of a critical challenge for national security and long-run sustainable development trajectories. The specificity of the transition period—namely institutional volatility, high inertia of the fuel-and-energy balance with fossil sources still dominating, and the need to comply with climate commitments while maintaining economic momentum—creates a distinct context for designing and implementing low-carbon strategies [1].

The 2024–2025 interval emerged as a turning point for several jurisdictions considered in this analysis. Under the pressure of international agreements and the tightening requirements of global capital markets, the governments of Kazakhstan, Uzbekistan, and Vietnam shifted emphasis from declarative “green growth” frameworks toward applied managerial and financial instruments [3]. Vietnam provides a revealing example: by 2025, the country demonstrated a large-scale acceleration of institutional and market adoption of “green” standards, ranking 8th globally by the number of LEED-certified projects outside the United States [10]. This fact is interpreted as an indicator of the sector’s high receptivity to international norms when proportionate state support is in place [25]. The study’s **scientific novelty** is articulated through identifying a correlational link between the introduction of national “green taxonomy” systems and the effectiveness of attracting foreign direct investment into the construction sectors of transition economies [2, 3].

An institutional reading indicates that in Central Asia and the Western Balkans, decarbonization rates are constrained by persistent structural barriers. In Uzbekistan, the housing stock remains extremely resource-intensive: energy use per square meter is nearly three times higher than comparable European benchmarks under similar climatic conditions [6]. The explanatory model is not limited to regulatory inertia and outdated construction standards; it also reflects systematic subsidies for energy tariffs that distort price signals and weaken the economic rationale for energy saving. In 2024, the volume of such subsidies in Uzbekistan was assessed at a level equivalent to 6.6% of GDP, reproducing an “inefficiency trap” and, at the same time, establishing the need for phased price liberalization as part of an exit strategy [6].

The purpose of the study is to conduct a comparative analysis of managerial models and institutional instruments that enable the formation of a low-carbon construction market under transition-economy conditions.

The working **hypothesis** asserts that technological modernization of buildings in the analyzed countries is derivative with respect to the priority of reforming energy subsidization and the adoption of digital procedures for verifying environmental data; without these components, comparability of results, investor confidence, and the manageability of climate effects remain difficult to secure [6, 17].

Materials and Methods

The study’s methodological framework is built on an interdisciplinary logic combining instruments from institutional economics, managerial analytics, and statistical modeling. The empirical base includes 2020–2025 datasets collected from three complementary groups of sources: reports of international energy and environmental agencies, analytical materials produced by development institutions and multilateral banks, and national legal acts and strategic documents specifying parameters of the “green” transformation of the construction sector [1, 6, 29]. In the present source system, this configuration is represented through materials such as the EBRD Transition Report 2024–25 and related country assessments, international energy-efficiency reporting, and country climate and development diagnostics, along with policy and market analyses that capture the practical evolution of taxonomies, finance, and sector governance [1, 4, 6, 29, 30].

The research procedure is organized as a sequence of three interlinked stages. The initial stage focused on comparing regulatory regimes and identifying differences in the architecture of requirements, including an analysis of standards for thermal transmittance coefficients (U-values) with attention to climate-zone variability and associated design operating conditions [5,

14, 23, 32]. The second stage shifted attention to the financial and organizational dimension, assessing the directions and configurations of flows channeled through green finance instruments, including administrative-investment schemes commonly framed as “Green Corridors,” as well as lending programs positioned to reduce barriers for low-carbon development projects [3, 24]. The final stage was devoted to diagnosing the gap between formal recognition of ESG alignment and actual performance recorded in operational indicators and non-financial reporting of corporate structures [17, 18]. Additional analytical depth is provided by incorporating the Western Balkans case, viewed through the lens of implementing the Green Agenda and its reporting architecture [9].

Results and Discussion

The institutional dynamics of recent years reflect a qualitative shift in transition economies—from fragmented initiatives toward the purposeful formation of regulatory contours for decarbonization. A core element of this emerging architecture is the taxonomy of “green” projects: a set of regulatory and methodological frameworks that codify measurable criteria of environmental acceptability and, by doing so, establish the rules of access to finance instruments and state support. In Vietnam, on July 4, 2025, Decision No. 21/2025/QD-TTg formalized a more specified set of environmental criteria applied to the verification of investment projects and to improving the comparability of declared sustainability effects [3]. In Kazakhstan, the managerial emphasis shifted toward procedural acceleration and the reduction of transaction costs: in August 2024, a Green Corridor system was initiated, oriented toward expedited facilitation of investment projects in renewables and infrastructure development [1, 6]. A comparison of these mechanisms makes it possible to structure institutional models and assess the maturity of regulatory instruments that determine the practical enforceability of the low-carbon agenda in the analyzed regions (see Table 1).

Table 1. Institutional instruments and indicators of decarbonization progress (compiled by the author based on [4, 10, 16, 17, 19, 22]).

Country / Region	Key regulatory act / mechanism	Status of taxonomy implementation	Volume of “green” investment (2025)	Primary market driver
Kazakhstan	Green Corridor System (August 2024)	Operational (through investment councils)	\$19 billion (greenfield projects)	State guarantees and procedural simplification
Uzbekistan	Resolution No. 673 (October 2025)	In progress (with GGGI support)	~ \$1.0 billion (EBRD credit line)	Tariff reform and ESCO market
Vietnam	Decision No. 21/2025/QD-TTg	Fully implemented	\$8.7 billion FDI (Q1 2025, +20%)	Exports and headquarters-level requirements
Western Balkans	Hamburg Declaration (2024)	Aligned with the EU Green Deal	Support via WBIF	Integration into the EU market and CBAM

A cross-reading of the results reflected in Table 1 indicates a stable regularity: jurisdictions that have built institutionally transparent and operationalized “green” taxonomies tend to exhibit markedly higher rates of international capital mobilization. The effect is most visible in the cases of Vietnam and Kazakhstan, where regulatory clarity regarding environmental eligibility reduces investment uncertainty, simplifies compliance verification, and thereby improves the predictability of project risk profiles [2, 3, 17]. By contrast, regions that remain in the phase of drafting framework legislation typically show weaker external financing dynamics, driven by elevated transaction costs, ambiguity in the interpretation of requirements, and limited verifiability of claimed sustainability outcomes [6, 17].

The technological configuration of low-carbon construction in 2024–2025 is shaped by a set of priority engineering and organizational-technological solutions, selectively adapted to climatic parameters, the structure of national energy balances, and the financial constraints of particular economies. Dominant directions concentrate on improving the thermal performance of building envelopes, deploying high-efficiency heating and cooling systems, expanding the on-site share of renewable energy, and using materials and design practices that reduce life-cycle carbon intensity in buildings [21, 22, 11, 33]. The overall structure of these solutions is visualized schematically in Figure 1.

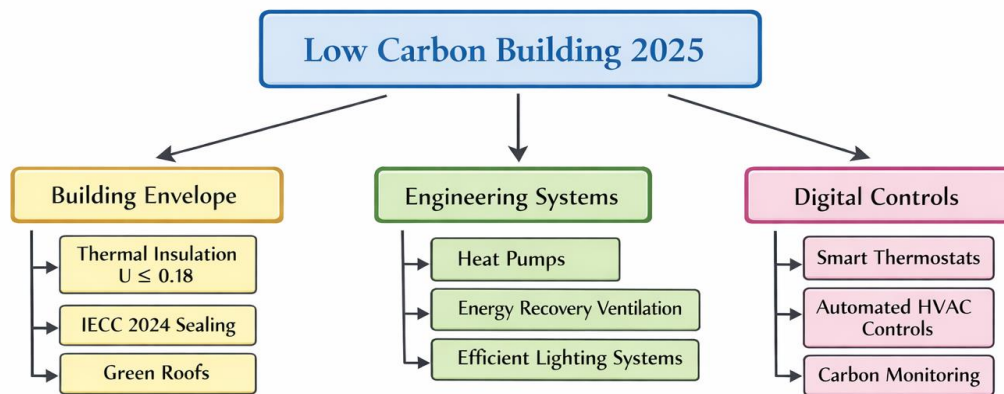


Fig.1. Priority technological solutions for low-carbon construction (compiled by the author based on [4, 10, 16, 17, 19, 22]).

The intensity of low-carbon solution deployment at the level of individual projects is captured most representatively through datasets of voluntary environmental certification, because such schemes reflect not only technological readiness but also the institutional capacity of a market to reproduce standardized practices over time. Vietnam, by 2025, entered the top ten LEED markets outside the United States, executing a rapid climb from 28th to 8th position within a two-year interval [10]. The consolidated portfolio of certified buildings reached 559 projects, indicating a material overperformance relative to previously stated public-policy targets and pointing to a high elasticity of the sector to international requirements when a supportive regulatory and financial environment is present [25]. In Central Asia, the EDGE system has tended to dominate: as of June 2024, 34 certified projects were recorded, and the prevalence of this standard is methodologically consistent with its emphasis on measurable resource savings and result comparability under conditions of data constraints and limited capital expenditures [27].

A comparative assessment of institutional effectiveness in decarbonization becomes substantially sharper when attention is directed to the stringency of building codes, particularly with respect to the thermal-technical parameters of envelope components. Requirements for thermal transmittance (U-values) function as an operationalized indicator of regulatory expectations regarding energy efficiency; they also set a lower bound for the quality of design solutions that can be considered acceptable. A comparison of requirements in transition economies and in developed markets, presented in Table 2, makes it possible to quantify the gap between current standards and target levels and to gauge the scale of forthcoming modernization—both in new construction and in programs aimed at upgrading the existing building stock [5, 14, 32].

Table 2. Comparative analysis of U-values in building codes (compiled by the author based on [12, 13, 14, 15, 25, 26, 27]).

Element / Standard	United Kingdom (Building Regs 2025)	European Union (EPBD Revision 2024)	Uzbekistan/Kazakhstan (design norms 2024)	Vietnam (QCVN 09:2017)
Walls	0.18	0.15	0.30–0.45	0.45–0.60
Roof	0.15	0.10	0.20–0.30	0.35
Windows	1.2–1.4	1.0	1.8–2.0	2.5–3.0
Airtightness	5.0 m ³ /h (Passivhaus)	1.01 L/s	Not standardized	Not standardized

A synthesis of Table 2 yields a conclusion of practical significance: normative levels for thermal-performance parameters in the transition economies under consideration lag by roughly a factor of two behind the requirements applied in the European Union [32]. This gap implies that a substantial share of buildings commissioned under the current regulatory contour may become functionally and economically outdated by 2030, because the tightening of climate policy and the evolution of financing standards will, almost inevitably, raise the energy-efficiency “acceptability threshold” [17, 29]. The downstream consequence is the accumulation of deferred demand for deep renovation, associated with rising capital costs and the risk of locking the building stock into a higher-carbon pathway over an extended horizon [19, 20].

At the level of corporate governance, the low-carbon transition in 2024–2025 is increasingly mediated through ESG standards that operate simultaneously as a tool for strategizing and as a “language” for communication with capital markets. In Vietnam, 34% of foreign companies have already implemented localized ESG strategies, and 20% allocate more than 5% of budget resources to sustainable development goals—an arrangement that signals the formation of relatively stable internal contours of prioritization [18]. At the same time, a material deficit of verifiability is evident: 75% of companies positioning themselves as “sustainable” do not disclose auditable non-financial reporting, which increases the probability of greenwashing and reduces investor trust in declared outcomes [18]. In Kazakhstan, the institutional impulse associated with the launch of the Green Corridor manifested as a factor improving the investment climate and was accompanied by growth in foreign direct investment into fixed capital, indicating the sensitivity of capital flows to lower administrative barriers and to more predictable project-support procedures [1, 16].

The impact of institutional reforms on real-sector parameters is revealed especially clearly in the Kazakh case, where the introduction of new state-support mechanisms was accompanied by a reallocation of investment flows toward environmentally oriented directions, forming preconditions for a more resilient structure of capital formation and for accelerated decarbonization projects [16, 17].

Below, Figure 2 presents the dynamics of “green” investment in Kazakhstan.

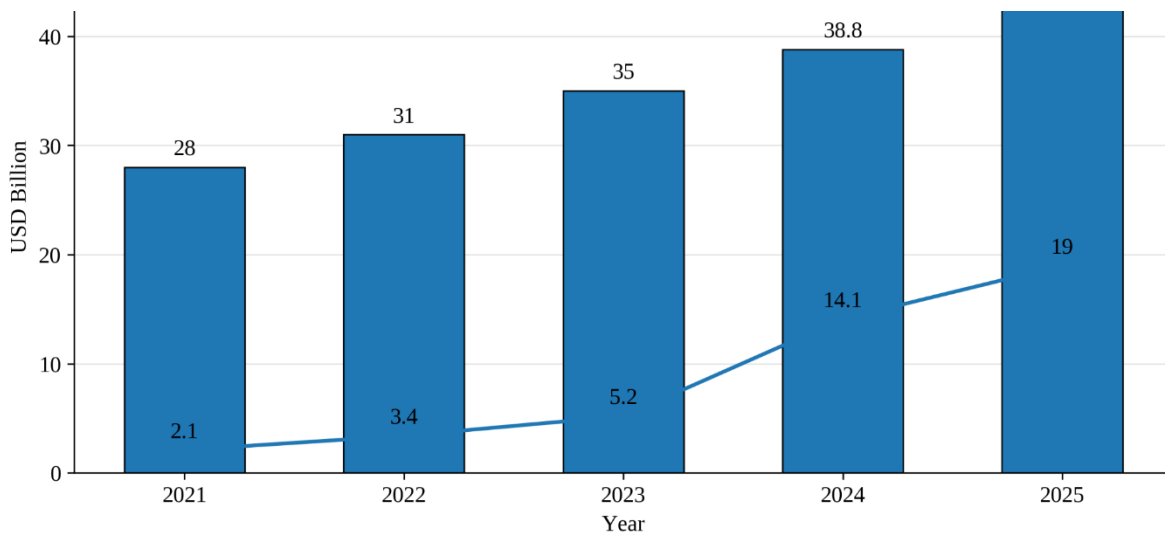


Fig.2. Dynamics of “green” investment in Kazakhstan (compiled by the author based on [16, 17]).

Despite the positive trajectory, the decarbonization process continues to face a layered hierarchy of constraints that slows the diffusion of innovation. These barriers are complex in nature and, in practice, require a coordinated managerial response rather than isolated technical fixes [1, 6, 17].

A critical element of the managerial analysis concerns how economic effects are distributed among the main market participants. A clearer view of who captures benefits—and who carries costs—makes it possible to design more effective interaction strategies and to reduce coordination failures across the value chain (see Figure 3) [17, 19].

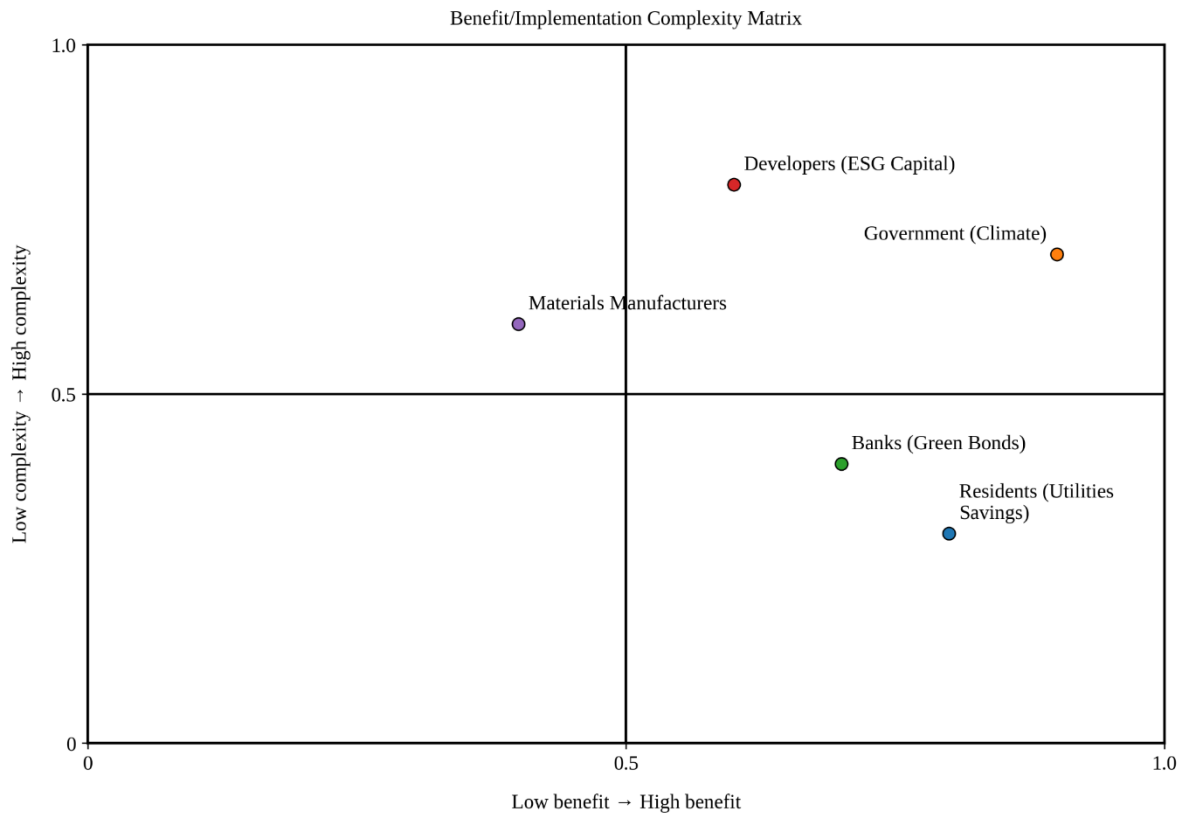


Fig.3. Stakeholder matrix of low-carbon construction (compiled by the author based on [17, 19]).

The results indicate a marked heterogeneity in the stages of institutional and market maturity across transition economies, and this heterogeneity largely determines the dominant trajectories of low-carbon transformation. Vietnam is characterized by a configuration that can be described as “export pressure,” in which foreign direct investment—and the requirements embedded in global supply chains—functions as a disciplining force for the development sector, pushing firms toward the adoption of LEED-aligned practices and documentation routines [2, 10, 25]. In Central Asia, by contrast, a model of “state dirigisme” is more visible, where effectiveness depends on the capacity of public authorities to correct price signals through tariff liberalization and the reduction of cross-subsidization [6, 16]. In 2024–2025, Uzbekistan launched reforms to gas and electricity pricing, and this was accompanied by a 40% reduction in the payback period for building-insulation measures [6]. Based on the identified trends and the diagnosis of current constraints, a forecast of the evolution of the low-carbon construction market in transition economies through 2030 is presented (see Table 3).

Table 3. Market development forecast through 2030 (compiled by the author based on [7, 8, 13, 31])

Parameter	Expected trend (2026–2030)	Forecast value	Necessary condition
Share of green buildings	2.5× growth	15–20% of new commissioning	Mandatory EPC
Carbon price	Integration into materials	\$35–50 per t CO ₂	Launch of ETS
Digitalization	BIM-based operations	40% of large projects	National BIM standards
Green jobs	Rising demand for energy auditing	>50,000 jobs	Reform of technical education

The forecast values underline that a shift toward a mass market for environmentally preferable housing is feasible only if climate policy is synchronized with reforms in digitalization and vocational education.

Conclusion

The managerial and institutional assessment conducted in this study supports the conclusion that in 2024–2025 transition economies, taken as a whole, have formed a minimally sufficient baseline contour of infrastructure enabling the launch of building decarbonization processes. Illustrative cases include the effectiveness of Kazakhstan’s Green Corridor mechanism, associated with mobilizing approximately \$19 billion in investment, and Vietnam’s accelerated integration into the global architecture of “green” standards, expressed in reaching 8th place worldwide in LEED-related rankings outside the United States. Together, these cases point to a high degree of institutional plasticity in the markets and an ability to rapidly adapt project and investment practices to ESG requirements when clear eligibility rules, verifiable criteria, and predictable facilitation procedures are in place.

At the same time, a set of systemic constraints continues to limit the transition from isolated successes to a stable decarbonization trajectory. Among the key barriers are ongoing fossil-fuel subsidization, which distorts price signals and weakens incentives to invest in energy efficiency, as well as a regulatory gap in building codes that locks in lower minimum requirements for thermal and energy performance. Under conditions of tightening international climate frameworks and rising expectations in capital markets, this lag converts into a risk of accelerated functional obsolescence for the building stock being commissioned today and into the accumulation of deferred obligations for deep renovation.

Achieving climate neutrality by 2050 implies a shift from predominantly voluntary certification regimes toward mandatory implementation of Zero Emission Building standards, establishing a unified regulatory “floor” for carbon performance. A necessary companion is the institutionalization of MRV (monitoring, reporting, verification) systems, which make it possible to ensure data comparability, auditability of claimed effects, and policy controllability grounded in measurable metrics rather than declarative commitments.

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