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CONTACTS

Phone: **+998 50 737 87 88**

Website: https://ist-journal.uz

Email: innovationist2025@gmail.com

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Editorial board:

CONTENTS

CONTENTS

CONTENTS

MECHANISMS FOR IMPROVING RESOURCE EFFICIENCY AND OPTIMIZING PRODUCTION COSTS IN THE CONSTRUCTION MATERIALS INDUSTRY

Utbasarov Doniyorjon Bakhtiyarovich
Tashkent University of Architecture and Civil Engineering
Assistant of the Department of Management

Abstract. This article examines the economic mechanisms for improving resource efficiency and optimizing production costs in enterprises operating within the construction materials industry. The relevance of the study is determined by the high resource intensity of construction materials production, which requires the intensive use of raw materials, energy, water, labor, financial resources, and technological capacities. In the context of increasing construction volumes, rapid urbanization, and growing demand for cement, concrete, bricks, gypsum, metal, polymer, and thermal insulation materials, inefficient resource utilization may contribute to higher production costs, increased waste generation, and additional environmental challenges. The purpose of the article is to provide a scientific substantiation of the mechanisms through which resource efficiency contributes to cost reduction, enhanced competitiveness, environmental safety, and sustainable industrial development. The study employs methods of systematic analysis, comparative analysis, economic-statistical analysis, grouping and classification, PESTEL analysis, cost analysis, and an ecological-economic approach. The findings demonstrate that the highest economic efficiency is achieved when raw material efficiency, energy conservation, water reuse, waste recycling, green technologies, ecological auditing, ISO 14001-based environmental management, digital monitoring, and an employee-oriented resource-saving culture are integrated into a unified enterprise management system. The practical significance of the research lies in the development of recommendations for construction materials enterprises aimed at reducing production costs, strengthening competitiveness, and supporting the transition toward a green economy.

Keywords: resource efficiency, construction materials industry, production cost optimization, resource-saving production, energy efficiency, green technologies, environmental management, ISO 14001, ecological audit, sustainable development.

Annotatsiya. Ushbu maqolada qurilish materiallari sanoati korxonalarida resurs samaradorligini oshirish va ishlab chiqarish xarajatlarini optimallashtirishning iqtisodiy mexanizmlari tadqiq etilgan. Tadqiqotning dolzarbligi qurilish materiallari ishlab chiqarishining yuqori resurs sig‘imi bilan izohlanadi. Mazkur jarayonda xomashyo, energiya, suv, mehnat, moliyaviy resurslar hamda texnologik quvvatlardan intensiv foydalaniladi. Qurilish hajmlarining ortib borishi, urbanizatsiya jarayonlarining jadallashuvi hamda sement, beton, g‘isht, gips, metall, polimer va issiqlik izolyatsiyasi materiallariga bo‘lgan talabning oshishi sharoitida resurslardan samarasiz foydalanish ishlab chiqarish xarajatlarining ko‘payishiga, chiqindilar hajmining ortishiga va ekologik bosimning kuchayishiga olib kelmoqda. Maqolaning maqsadi resurs samaradorligini oshirish orqali xarajatlarni kamaytirish, raqobatbardoshlikni kuchaytirish, ekologik xavfsizlikni ta’minlash hamda sanoatning barqaror rivojlanishini qo‘llab-quvvatlash mexanizmlarini ilmiy asoslashdan iborat. Tadqiqotda tizimli tahlil, qiyosiy tahlil, iqtisodiy-statistik tahlil, guruhlash va tasniflash, PESTEL-tahlil, xarajatlar tahlili hamda ekologik-iqtisodiy yondashuv usullaridan foydalanildi. Tadqiqot natijalari shuni ko‘rsatdiki, xomashyo samaradorligi, energiya tejamkorligi, suv resurslarini qayta foydalanish, chiqindilarni qayta ishlash, “yashil” texnologiyalar, ekologik audit, ISO 14001 standarti asosidagi ekologik boshqaruv, raqamli monitoring hamda xodimlarda resurslarni tejash madaniyatini yagona boshqaruv tizimiga integratsiya qilish eng yuqori iqtisodiy samarani ta’minlaydi. Tadqiqotning amaliy ahamiyati qurilish materiallari sanoati korxonalarida ishlab chiqarish xarajatlarini kamaytirish, raqobatbardoshlikni oshirish hamda “yashil iqtisodiyot”ga o‘tishni qo‘llab-quvvatlashga qaratilgan tavsiyalar ishlab chiqilganligi bilan izohlanadi.

Kalit so‘zlar: resurs samaradorligi, qurilish materiallari sanoati, ishlab chiqarish xarajatlarini optimallashtirish, resurs tejovchi ishlab chiqarish, energiya samaradorligi, “yashil” texnologiyalar, ekologik boshqaruv, ISO 14001, ekologik audit, barqaror rivojlanish.

Аннотация. В данной статье исследуются экономические механизмы повышения ресурсоэффективности и оптимизации производственных затрат на предприятиях промышленности строительных материалов. Актуальность исследования обусловлена высокой ресурсоёмкостью производства строительных материалов, предполагающей интенсивное использование сырья, энергии, воды, трудовых, финансовых ресурсов и технологических мощностей. В условиях увеличения объёмов строительства, ускорения процессов урбанизации, а также роста спроса на цемент, бетон, кирпич, гипс, металл, полимерные и теплоизоляционные материалы неэффективное использование ресурсов приводит к увеличению производственных затрат, росту объёмов отходов и усилению экологической нагрузки. Цель статьи заключается в научном обосновании механизмов, посредством которых повышение ресурсоэффективности способствует снижению затрат, укреплению конкурентоспособности, обеспечению экологической безопасности и поддержке устойчивого промышленного развития. В исследовании использованы методы системного анализа, сравнительного анализа, экономико-статистического анализа, группировки и классификации, PESTEL-анализа, анализа затрат, а также эколого-экономического подхода. Результаты исследования показали, что наибольший экономический эффект достигается при интеграции эффективности использования сырья, энергосбережения, повторного использования водных ресурсов, переработки отходов, «зелёных» технологий, экологического аудита, экологического менеджмента на основе стандарта ISO 14001, цифрового мониторинга и культуры ресурсосбережения персонала в единую систему управления предприятием. Практическая значимость исследования заключается в разработке рекомендаций для предприятий промышленности строительных материалов, направленных на снижение производственных затрат, повышение конкурентоспособности и поддержку перехода к «зелёной экономике».

Ключевые слова: ресурсоэффективность, промышленность строительных материалов, оптимизация производственных затрат, ресурсосберегающее производство, энергоэффективность, «зелёные» технологии, экологический менеджмент, ISO 14001, экологический аудит, устойчивое развитие.

INTRODUCTION

The construction materials industry occupies a strategically important position in national economic development, as it provides the material foundation for housing construction, industrial facilities, transport infrastructure, social infrastructure, and urban development. The production of cement, concrete, bricks, gypsum products, metal structures, polymer materials, insulation materials, dry mixtures, and other construction materials is directly associated with the expansion of the construction sector and the overall investment activity of the economy. At the same time, this industry is regarded as one of the most resource-intensive sectors because its production processes require substantial volumes of mineral raw materials, fuel and energy resources, water resources, transport services, labor resources, technological equipment, and financial capital.

In construction materials enterprises, inefficient resource utilization is reflected not only in the excessive consumption of raw materials and energy resources, but also in rising production costs, technological losses, waste generation, environmental payments, logistics expenditures, and equipment maintenance costs. Therefore, resource efficiency should be considered not merely as a technical or environmental measure, but also as an important economic mechanism for reducing production costs, increasing profitability, strengthening competitiveness, and ensuring long-term sustainable development.

In the context of Uzbekistan, the relevance of this issue is steadily increasing due to the rapid growth of construction activity, accelerated urbanization, the expansion of housing and infrastructure projects, and the growing demand for construction materials. According to official statistical data, the annual volume of construction works in Uzbekistan increased from 8,245.8 billion UZS in 2010 to 259,654.3 billion UZS in 2024. These indicators demonstrate a significant expansion of construction activity and, consequently, an increasing demand for cement, concrete, metals, gypsum, bricks, polymers, insulation materials, energy resources, water resources, and transport services. The data are based on the official Statistics Agency/SIAT indicator entitled “Volume of Construction Works (Annual),” measured in billion soums [1].

The transition toward a green economy further increases the importance of resource-efficient production. Uzbekistan has adopted several strategic documents aimed at supporting green growth, improving energy efficiency, ensuring the rational use of natural resources, and promoting environmental modernization. In particular, the Strategy for the Transition of the Republic of Uzbekistan to a Green Economy for 2019–2030 and the “Uzbekistan – 2030” Strategy establish an institutional framework for linking industrial development with resource efficiency and environmental responsibility.

The aim of this article is to provide a scientific substantiation of the economic mechanisms for improving resource efficiency and optimizing production costs in enterprises operating within the construction materials

industry. The object of the research is enterprises of the construction materials industry, while the subject of the research is the system of economic mechanisms aimed at enhancing resource efficiency and optimizing production costs [2].

LITERATURE REVIEW

The scientific literature on resource efficiency and production cost optimization can generally be divided into three major groups: foreign theoretical approaches, CIS scientific approaches, and national policy-oriented approaches related to the green economy and sustainable industrial development.

Foreign scholars frequently interpret resource efficiency as an important source of innovation and competitive advantage. Michael E. Porter and Claas van der Linde argue that the traditional perception of environmental regulation as a burden on competitiveness is incomplete. According to their approach, properly designed environmental regulations can stimulate innovation, reduce waste, improve productivity, and partially or fully compensate for compliance costs. This concept is highly relevant to the construction materials industry because stricter requirements related to energy consumption, emissions, waste management, and product quality may encourage enterprises to modernize production equipment, reduce technological losses, and introduce cleaner production technologies.

Stuart L. Hart developed the natural-resource-based view of the firm, which constitutes another important theoretical foundation. Hart emphasizes that pollution prevention, product stewardship, and sustainable development can become strategic sources of long-term competitive advantage. In the context of construction materials enterprises, this approach implies that reducing energy intensity, utilizing secondary raw materials, improving waste recycling systems, and introducing environmentally friendly product design should be regarded not only as environmental measures, but also as essential elements of strategic resource management [3].

Robert D. Klassen and Curtis P. McLaughlin establish a connection between environmental management and enterprise performance, arguing that effective environmental management positively influences the perceived future financial performance of firms. Their approach is particularly important for construction materials enterprises because ecological auditing, environmental monitoring, certification systems, and cleaner production technologies can reduce environmental risks, strengthen corporate reputation, and increase the attractiveness of enterprises to investors and major customers.

International standards also play a significant role in the scientific and practical understanding of resource efficiency. International Organization for Standardization standard ISO 14001 establishes requirements for the development, implementation, maintenance, and continuous improvement of environmental management systems. For construction materials enterprises, this standard is especially important because it enables the integration of resource consumption control, environmental risk management, waste monitoring, and corrective actions into the overall enterprise management system. The EMAS (Eco-Management and Audit Scheme) framework further expands this approach by emphasizing environmental performance improvement, reporting, auditing, transparency, and public accountability.

Scholars from the CIS countries generally examine resource efficiency in close connection with rational natural resource use, ecological-economic balance, state regulation, and production efficiency. Nikolai F. Reimers developed an approach to rational nature management that considers natural resources as limited economic and ecological assets that should be utilized within scientifically justified limits. This perspective is particularly relevant to the construction materials industry, where mineral raw materials, land resources, water resources, and energy constitute the primary production factors.

The works of Viktor I. Danilov-Danilyan on sustainable development and ecological safety emphasize the necessity of coordinating economic growth with environmental restrictions and regulatory mechanisms. From this perspective, production cost optimization should be achieved through rational resource management, technological modernization, ecological regulation, and scientifically justified consumption standards, ecological regulation, and rational consumption standards.

Aleksey P. Butorin also made an important contribution to understanding the institutional aspects of resource efficiency through his studies on environmental management and state regulation of natural resource use. His approach demonstrates that enterprises are able to achieve higher levels of resource efficiency more effectively within a supportive regulatory environment characterized by clear standards, economic incentives, and institutional coordination.

The enterprise-level management approach proposed by Igor T. Balabanov is also significant because it links efficiency improvement, cost control, financial stability, and managerial responsibility within the enterprise management system. However, many CIS studies tend to examine resource efficiency either as an environmental issue or as a production-efficiency problem, whereas the integrated relationship between resource efficiency and production cost optimization in construction materials enterprises still requires deeper

methodological and practical development [4].

In the national context of Uzbekistan, resource efficiency is increasingly associated with the transition toward a green economy, energy efficiency improvement, sustainable industrial development, and production modernization. Official strategic documents emphasize the importance of increasing energy efficiency, reducing the resource intensity of the economy, introducing green technologies, and developing environmental management mechanisms. Consequently, the analysis of scientific literature and policy documents demonstrates that resource efficiency in the construction materials industry should be understood as an integrated economic mechanism that combines technological, financial, ecological, organizational, and institutional instruments [5].

RESEARCH METHODOLOGY

The study is based on a systematic and integrated methodological approach. Systematic analysis was employed to examine resource efficiency as a complex economic mechanism that integrates raw material utilization, energy consumption, water use, waste management, labor productivity, technological modernization, environmental costs, and production cost optimization. Comparative analysis was applied to evaluate international approaches, CIS theoretical perspectives, and national policy priorities related to resource efficiency and sustainable industrial development.

Economic-statistical analysis was used to assess the dynamics of construction activity in Uzbekistan and to substantiate the growing necessity for resource-efficient production mechanisms. Grouping and classification methods were applied to systematize the principal mechanisms of resource efficiency, including raw material consumption standards, energy auditing, water recycling systems, waste recycling technologies, green technologies, digital monitoring, ecological auditing, cost accounting, and employee motivation mechanisms.

PESTEL analysis was utilized to identify the political, economic, social, technological, environmental, and legal factors influencing resource efficiency and production cost optimization in construction materials enterprises. Cost analysis was employed to explain how excessive resource consumption contributes to increased production costs in the construction materials industry. In addition, the ecological-economic approach enabled the study to establish an integrated relationship between environmental management, production costs, competitiveness, and sustainable industrial development.

The following indicators may be used to assess resource efficiency and production cost optimization:

$$\text{Resource efficiency} = \frac{\text{Outputvolume}}{\text{Total resource consumption}}$$

This indicator demonstrates the volume of output produced per unit of total resources consumed.

$$\text{Material intensity} = \frac{\text{Material costs}}{\text{Output volume}}$$

This indicator reflects the amount of material cost required to produce one unit of output.

$$\text{Energy intensity} = \frac{\text{Energy costs}}{\text{Output volume}}$$

This indicator measures the share of energy costs in the production process.

$$\text{Waste recycling rate} = \frac{\text{Recycled waste}}{\text{Total generated waste}} \times 100\%$$

This indicator reflects the direct economic effect achieved through the implementation of resource-saving measures.

This indicator reflects the share of waste recycled or reused as a secondary production resource [6].

ANALYSIS AND RESULTS

Resource efficiency in the construction materials industry should be developed as a comprehensive enterprise-level management system. One of the primary mechanisms within this system is raw material efficiency. In the production of cement, concrete, bricks, gypsum products, metal structures, polymer materials, and insulation materials, raw materials constitute a substantial share of total production costs. Therefore, enterprises should introduce scientifically justified consumption standards, minimize technological losses, improve material balance systems, and increase the utilization of secondary raw materials. The implementation of these measures contributes to reducing the cost of purchased materials while simultaneously decreasing waste generation and improving production efficiency.

Energy efficiency represents another strategically important mechanism for optimizing production costs in the construction materials industry. Numerous technological processes within the industry, including crushing, grinding, drying, firing, pressing, heating, cooling, and internal transportation, are characterized by high energy intensity. In this regard, the implementation of energy audits, digital energy monitoring systems, heat-loss reduction measures, modernization of furnaces and electric motors, utilization of energy-efficient equipment, and integration of renewable energy sources can significantly reduce production costs and improve operational efficiency.

Furthermore, energy efficiency contributes not only to economic effectiveness, but also to environmental sustainability by reducing emissions, lowering fuel consumption, and improving the ecological performance of enterprises. Consequently, the integration of resource- and energy-efficient technologies into enterprise management systems creates favorable conditions for strengthening competitiveness, enhancing financial stability, and supporting sustainable industrial development [7] (Figure 1).

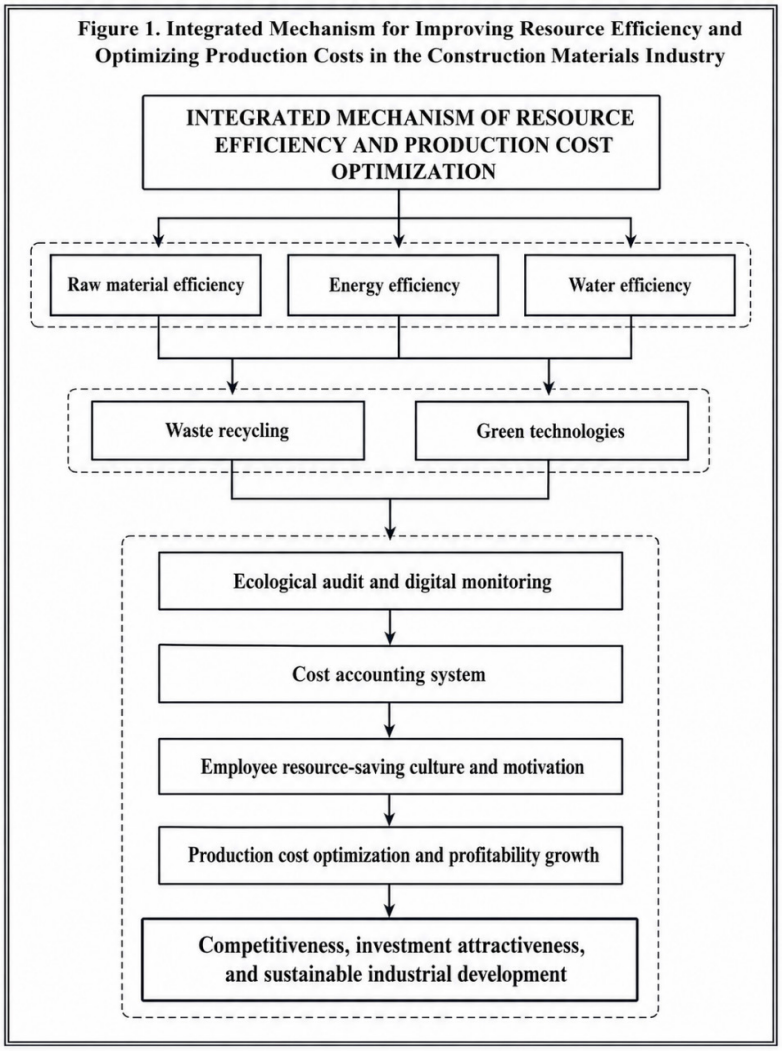

Figure 1. Integrated Mechanism for Improving Resource Efficiency and Optimizing Production Costs in the Construction Materials Industry

Water efficiency is particularly important in concrete production, equipment washing, cooling systems, dust suppression, and other technological processes. The introduction of closed-loop water supply systems, water reuse technologies, wastewater treatment mechanisms, and scientifically justified technological water-consumption standards contributes to reducing water losses and lowering operational costs. In regions where water scarcity is becoming increasingly significant, water efficiency serves not only as an economic mechanism, but also as an important factor ensuring production stability and sustainable industrial operation.

Waste management and recycling generate a dual economic effect. On the one hand, waste sorting, recycling, and utilization contribute to reducing waste disposal and transportation costs. On the other hand, recycled waste materials may be reused as secondary raw materials, thereby decreasing the need for newly

purchased production resources. In construction materials enterprises, waste recycling may include the reuse of concrete waste, brick fragments, dust particles, slag, gypsum waste, packaging materials, and other production residues [8].

Technological modernization represents one of the central conditions for ensuring sustainable resource efficiency. The implementation of green technologies, automated production lines, digital sensors, cleaner production methods, dust and gas purification equipment, and intelligent monitoring systems enables enterprises to manage resource flows more accurately and efficiently. These technologies contribute to reducing technological losses, improving product quality, increasing labor productivity, and strengthening compliance with environmental standards.

Environmental management based on the ISO 14001 standard provides an institutional framework for systematic resource efficiency management. Through environmental policy development, planning, implementation, monitoring, auditing, corrective actions, and continuous improvement processes, enterprises are able to integrate resource-saving objectives into their everyday management systems. The EMAS framework further strengthens this approach by emphasizing transparency, environmental reporting, and external verification procedures.

Labor and organizational efficiency also play an essential role in achieving resource efficiency. Even advanced technologies cannot deliver the expected outcomes unless employees possess resource-saving behavior and a strong sense of environmental responsibility. Therefore, enterprises should develop employee training programs, internal regulations, motivation systems, and managerial accountability mechanisms. A resource-saving culture should become an integral component of overall corporate culture.

Financial and economic mechanisms include green financing instruments, investment incentives, environmental cost accounting, internal resource-consumption standards, performance-based management systems, and evaluation of the payback period of resource-saving investments. These mechanisms enable enterprises to justify investments in modern equipment, recycling systems, energy-efficiency technologies, and digital monitoring systems not as additional expenses, but as long-term sources of economic return and sustainable competitiveness [9].

Statistical Analysis

The expansion of construction activity in Uzbekistan creates a strong economic foundation for increasing the production of construction materials. At the same time, this growth significantly increases demand for raw materials, energy resources, water resources, labor, transport services, and technological capacities. Consequently, the statistical analysis of construction activity dynamics is important for substantiating the necessity of implementing resource-efficient production mechanisms in the construction materials industry [10] (Table 1).

Table 1

Dynamics of Construction Works in the Republic of Uzbekistan

Year	Volume of Construction Works, billion UZS	Growth Coefficient
2010	8,245.8	–
2015	25,423.1	3.08
2020	88,130.3	3.47
2021	107,492.7	1.22
2022	130,790.9	1.22
2023	222,935.8	1.70
2024	259,654.3	1.16

The data presented in the table indicate that the volume of construction works in Uzbekistan increased from 8,245.8 billion UZS in 2010 to 259,654.3 billion UZS in 2024, demonstrating an approximately 31.5-fold increase in nominal terms. Compared with 2015, the construction volume recorded in 2024 was approximately 10.2 times higher. These indicators confirm the significant expansion of construction activity and the corresponding increase in demand for construction materials, energy resources, water resources, transport services, and technological capacities.

The rapid development of the construction sector also intensifies the importance of implementing resource-efficient production mechanisms within the construction materials industry. In this regard, improving resource efficiency becomes an important factor for reducing production costs, strengthening industrial competitiveness, and ensuring sustainable industrial development. According to the official SIAT metadata, the indicator is identified as “Annual Volume of Construction Works,” measured in billion soums and prepared by the national

statistical authority [11] (Table 2).

Table 2
Main Mechanisms for Improving Resource Efficiency in the Construction Materials Industry

Mechanism	Content	Expected Economic Effect
Raw material consumption standards	Establishment of scientifically justified consumption standards for cement, sand, gravel, gypsum, metal, polymer, and other materials	Reduction of material losses and production costs
Energy audit	Assessment of energy consumption across production stages and technological equipment	Identification of excessive energy losses and reduction of energy-related costs
Water recycling systems	Implementation of closed-loop water circulation and wastewater treatment systems	Reduction of water consumption and water-related operating costs
Waste recycling	Sorting, recycling, and reuse of production and construction waste	Lower waste disposal costs and reduced dependence on primary raw materials
Green technologies	Introduction of energy-efficient, low-waste, and environmentally safe technologies	Cost reduction, innovation development, and compliance with environmental standards
Digital monitoring	Real-time monitoring of energy, water, raw materials, fuel, and waste flows	Faster managerial decision-making and prevention of excessive resource consumption
Ecological audit	Assessment of environmental risks, waste flows, and resource utilization	Improved control over environmental costs and ecological risks
Employee motivation	Development of training programs, internal regulations, and incentives for resource-saving behavior	Improved labor discipline and reduction of operational losses
Cost accounting	Separation and analysis of material, energy, water, waste, and environmental costs	More accurate and effective production cost optimization decisions
ISO 14001-based management	Integration of environmental objectives into enterprise management systems	Continuous improvement of resource efficiency and environmental performance

This statistical trend demonstrates that the rapid expansion of construction activity, if not supported by resource-efficient production mechanisms, may create additional economic and environmental pressures requiring effective management solutions for the construction materials industry. As construction volumes continue to increase, demand for cement, concrete, bricks, metal structures, gypsum products, polymer materials, insulation products, energy resources, water resources, transport services, and labor resources also rises substantially. If enterprises continue to rely primarily on traditional resource-intensive production methods, such growth may result in higher raw material consumption, increasing energy expenditures, greater technological losses, and a considerable rise in production costs. Consequently, the production cost of construction materials may increase, affecting the profitability of enterprises and the economic efficiency of construction projects.

At the same time, the expansion of production activities without effective waste management systems, recycling mechanisms, ecological auditing, and digital monitoring technologies may intensify environmental pressure. In particular, the growth of construction and industrial waste, excessive utilization of natural resources, increased fuel and electricity consumption, and rising emissions highlight the importance of strengthening ecological sustainability within the sector. Therefore, the observed growth in construction activity should be interpreted not only as an indicator of economic development, but also as an important signal emphasizing the necessity of actively introducing resource-saving technologies, energy-efficiency measures, closed-loop water systems, waste-recycling mechanisms, and ISO 14001-based environmental management systems within construction materials enterprises.

It should also be emphasized that the statistical indicators presented above are expressed in nominal values. Consequently, the growth reflected in monetary terms indicates not only the real expansion of construction activity, but also the influence of price fluctuations, inflationary processes, and rising costs of materials, labor, transportation, and energy resources. Therefore, for a more accurate assessment of the real dynamics of the construction sector, these indicators should additionally be analyzed using price deflators. Such an approach

enables researchers to distinguish actual physical growth in construction output from nominal growth caused by price changes. This is particularly important for evaluating the real impact of construction-sector expansion on resource consumption, production costs, and the necessity for resource-efficient industrial modernization [12] (Table 3).

Table 3
PESTEL Analysis of Factors Affecting Resource Efficiency and Cost Optimization

Factor	Direction of Influence	Managerial Implication for the Enterprise
Political	Green economy policies, state programs, and environmental priorities	Align enterprise strategy with national green economy objectives
Economic	Energy prices, raw material costs, subsidies, green investments, and environmental payments	Treat resource-saving investments as instruments for long-term cost optimization
Social	Consumer demand for environmentally responsible products, public expectations, and employee culture	Strengthen ecological reputation and develop an internal resource-saving culture
Technological	Digital monitoring, automation, recycling technologies, and cleaner production methods	Modernize production processes to minimize technological losses
Environmental	Resource scarcity, waste accumulation, emissions, and ecological risks	Introduce preventive environmental and resource-saving measures
Legal	ISO 14001, EMAS, environmental legislation, certification, and reporting requirements	Develop compliance-oriented and audit-based management systems

The results of the study demonstrate that resource efficiency in the construction materials industry should not be regarded solely as an environmental measure. Rather, it represents a strategic economic mechanism that directly influences production cost reduction, profitability growth, competitiveness, investment attractiveness, environmental safety, compliance with international standards, and long-term sustainable development.

The greatest effect is achieved when several resource-efficiency mechanisms are implemented simultaneously and in an integrated manner. Scientifically justified raw material standards contribute to reducing material losses; energy auditing and digital monitoring systems decrease fuel and electricity costs; closed-loop water systems minimize water losses; waste recycling reduces disposal expenses and dependence on primary raw materials; green technologies improve productivity and environmental compliance; ecological auditing strengthens managerial discipline; and employee training programs support the formation of sustainable resource-saving behavior in everyday production activities.

The relationship between state environmental policy and enterprise strategy is also highly significant. State policy establishes regulatory frameworks and economic incentives, while enterprises transform these conditions into practical production and management decisions. When green investments, ecological cost accounting, tax incentives, environmental standards, and certification requirements are effectively coordinated, construction materials enterprises can transition from passive compliance toward proactive resource-efficient development.

ISO 14001 and EMAS are particularly important because they institutionalize resource efficiency within enterprise management systems. These frameworks enable enterprises to transform separate technical measures into a continuous management cycle consisting of planning, implementation, monitoring, corrective action, and continuous improvement. In this context, resource efficiency becomes not merely a temporary cost-reduction initiative, but a stable and strategic component of long-term enterprise development [13].

CONCLUSION AND RECOMMENDATIONS

Improving resource efficiency and optimizing production costs in the construction materials industry represent strategically important economic objectives. The study demonstrates that construction materials enterprises operate under conditions characterized by high resource intensity, growing market demand, increasing production costs, and strengthening environmental requirements. Therefore, resource efficiency should be integrated into enterprise management as a comprehensive system that combines raw material utilization, energy efficiency, water management, waste recycling, technological modernization, financial mechanisms, labor productivity, ecological auditing, and digital monitoring technologies.

Based on the results of the study, several practical recommendations may be proposed. First, construction materials enterprises should gradually introduce environmental management systems based on the ISO 14001 standard and strengthen ecological auditing mechanisms. Second, enterprises should develop scientifically

justified technical and economic standards for raw material, energy, and water consumption for each category of products. Third, energy auditing and real-time digital monitoring systems should be implemented to identify excessive resource losses and improve operational efficiency.

In addition, waste recycling systems and the utilization of secondary raw materials should be expanded as effective mechanisms for reducing both waste disposal costs and material consumption costs. Closed-loop water supply systems and cleaner production technologies should also be introduced in water-intensive technological processes to improve production sustainability and resource efficiency.

Enterprises should further develop ecological cost-accounting systems that separately reflect material costs, energy costs, water-related costs, waste-management expenses, environmental payments, and the economic effects achieved through resource-saving measures. Employee training programs, motivation systems, and the development of a resource-saving corporate culture should also be strengthened, because organizational behavior directly influences the practical effectiveness of technological modernization and environmental management initiatives.

Finally, resource-efficiency indicators should be integrated into strategic enterprise management, investment planning processes, and performance-evaluation systems. This approach would allow enterprises to evaluate resource-saving measures not merely as short-term operational improvements, but as long-term strategic investments that contribute to sustainable industrial development.

In general, resource efficiency in the construction materials industry should be regarded not only as a technical or environmental requirement, but also as a strategic economic mechanism for reducing production costs, increasing competitiveness, strengthening environmental responsibility, and supporting long-term sustainable industrial development.

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