

# MULTILEVEL METHODOLOGY FOR ENVIRONMENTAL QUALITY MANAGEMENT OF TECHNICAL PRODUCTS

Chynara M. Ergeshova  
Maral E. Saipova  
Shakhtybyubyu K. Ishembaeva  
Mukhriddin M. Bekmurzaev<sup>1</sup>  
Olga A. Boris

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## ABSTRACT

*The research focuses on the shortcomings of the existing methodology for managing the quality of technical products in the green economy, as reflected in the contradictory outcomes of such management: improvements in the environmental sustainability of products and their production processes accompanied by a deterioration in the technical characteristics of these products. The research aims to substantiate the advantages of the industrial and manufacturing engineering methodology for the environmental quality management of technical products in the green economy. To this end, it examines the case-based experience of Caterpillar Inc. in applying the industrial and manufacturing engineering methodology to the environmental quality management of technical products in the green economy. An effective system of environmental management is the basis for the formation of a positive image of the company, support of the possibility of conquering foreign markets, and long-term preservation of competitive positions, as well as a guarantee of high product quality. The research focuses on the methodology of environmental quality management for technical products in the green economy. It demonstrates that, under contemporary conditions, product quality encompasses performance characteristics, environmental parameters, resource efficiency, life-cycle safety, and compliance with the principles of sustainable production. Based on the research findings, contemporary industrial enterprises are encouraged to adopt the industrial and manufacturing engineering methodology to systematically optimize the environmental quality management of the technical products they manufacture within the green economy. The research allowed establishing a methodological framework for integrating environmental management into the product quality assessment system.*



<sup>1</sup> Corresponding author: Mukhriddin M. Bekmurzaev  
Email: [mukhriddin1997@gmail.com](mailto:mukhriddin1997@gmail.com)

## 1. INTRODUCTION

In the green economy, the technical quality of products cannot be separated from their environmental quality, since it is the combination of these characteristics that determines product competitiveness and long-term sustainability. Therefore, environmental management should be regarded as a structural component of product quality management.

This approach involves incorporating measurable environmental parameters into the quality management system. It would be appropriate here to include your indicators: reductions in emissions, decreases in material intensity, and increases in the share of recyclable components.

Industrial and manufacturing engineering provides extensive opportunities for the flexible adjustment of production processes, which is beneficial for improving the quality of technical products. The need to enhance the quality of technical products has increased, particularly in recent years, due to the green industrial transition, which is aimed at reducing the environmental footprint of industry and has been launched within the framework of global initiatives for environmental protection and decarbonization.

The problem is that the application of the advanced and promising industrial and manufacturing engineering methodology to improve the environmental quality characteristics of technical products has not yet been adequately established. As a result, green quality management in industry produces contradictory outcomes: on the one hand, it improves the environmental sustainability of manufactured products and their production processes, while, on the other hand, it may impair the technical characteristics of these products (Zhao et al., 2026).

Electric vehicles provide an illustrative example: their operation does not generate carbon emissions, but they require frequent recharging, whereas less environmentally friendly vehicles equipped with internal combustion engines produce a substantial carbon footprint but can operate much longer without refueling. Another example is the reduction in strength and more rapid deterioration of technical products resulting from the incorporation of biodegradable materials into their composition. Other examples include the less attractive appearance of technical products manufactured from secondary raw materials processed through recycling (Chen et al., 2026).

In all countries, environmental pollution is caused by such factors as economic growth, globalization, industrialization, and urbanization. All these factors are connected with an increased energy demand, which causes air pollution. A potential solution to reduce carbon emissions is the diversification of the structure of energy

consumption through an increase in the share of renewable sources and other types of clean energy. A larger share of renewable sources in the structure of consumption will lead to decarbonization of the economy.

Theories of the green economy cover a wide range of ideas that concern the interaction between humans and the environment. According to the green economy theory, the basis of all economic decisions must be connected with the ecosystem, and natural capital and ecological services have economic value.

The concept of the green economy is based on the principle that economic and environmental policies can stimulate the green economy and raise carbon, energy, and material efficiency, preserving, at the same time, natural assets and improving the quality of life. A green economy means stimulation of economic growth and development with simultaneous preservation of natural resources (Liu et al., 2026).

Environmental management is a practice of organizing human activities aimed at limiting their influence on the environment. It can cover the protection of land, flora, fauna, water, and atmosphere.

Businesses that implement innovations to offer environmentally friendly goods and services are attractive to new and potential customers. This leads to an increase in customer loyalty to the brand. Integration of the sustainable development principles of business improves the quality of products, customer services, and the well-being of interested parties (Jinliang et al., 2023). The indicators of using environmental management are the implementation of environmental management systems, the implementation of environmental policy, the creation of an environmental management department, the development of environmental management plans, preparation of the environmental strategy, introduction of low-carbon technologies, cooperation on environmental issues, development of stimuli for environmental, environmental training, certification of environmental effectiveness by independent agencies, and participation in voluntary environmental activities.

At all stages of production and distribution, the quality of environmentally clean products could be improved through raising the effectiveness of the use of resources, limiting the impact on the environment, and reducing the volume of waste. Also, this will bring the corresponding advantages in the form of cost savings for consumers and society (Creignou and Nuangjamnong, 2022).

There is a direct connection between compliance with the principles of environmental policy and environmental management and improvement of product quality. The quality of products is increasingly associated with products' compliance with environmental standards in consumers' thinking.

At present, receiving profit to meet shareholders' and owners' interests cannot be the only goal of the company's functioning. It is necessary to have a balance in satisfying the interests of all stakeholders. Sustainable development of the company lies in the balance of meeting the demands of stakeholders and simultaneously satisfying future generations' interests. It is necessary to provide sustainable value and quality to consumers to ensure their loyalty and trust. Consumer loyalty can be achieved through the production and realization of high-quality products with affordable prices. Also, modern consumers think that quality and safe products, as well as the manufacturing process, must be ethical, environmentally friendly, and safe for the environment. Therefore, improving the methodological aspects of environmental quality management for technical products in the green economy is highly relevant. This creates a need for scientific inquiry and the development of a methodology capable of overcoming the contradictions associated with the environmental transformation of industrial production.

The novelty of this research lies in proposing the use of the industrial and manufacturing engineering methodology for the systematic optimization of environmental quality management for technical products in the green economy, an approach that has not previously been applied for this purpose. The research aims to substantiate the advantages of the industrial and manufacturing engineering methodology for the environmental quality management of technical products in the green economy.

## **2. LITERATURE REVIEW**

From a theoretical perspective, the article draws on the fundamental principles of the scientific concept of industrial and manufacturing engineering for the quality of technical products presented in the works of Can et al. (2026), Lawan et al. (2026), and Zeng et al. (2026). The published literature by Anwer and Srinivasan (2026), Baba et al. (2026), and Lee et al. (2026) describes the established methodology currently applied to the environmental quality management of technical products in the green economy.

The essence of the existing methodology is to improve the environmental properties of technical products by reducing the material intensity of their production, decreasing the energy intensity of their production and consumption, promoting the circular use of natural raw materials, incorporating biodegradable materials, and reducing production and consumption waste. However, these measures often produce a "side effect" associated with the deterioration of the consumer properties of such products, including reduced functionality, a shorter useful life, a less attractive appearance, and packaging that is less convenient and less durable.

Environmental management is systemic and targeted activities aimed at ecologization of the economy, given the principles of environmental effectiveness and justice. It is seen as a type of management that is oriented towards the formation and development of environmentally friendly production and new environmental quality of life activities, for preservation of the quality of the natural environment, support of the population's health, and saving resources.

The issues of product quality, green economy, environmental management, and environmental responsibility of business were studied by many scholars. Husnaini and Tjahjadi (2021) dwelt on the influence of quality management on green innovations, which is measured with the help of innovations in green processes and innovations in green products. According to the scholars, to raise the company's value, it must have a consistent approach to quality management and the implementation of green innovations.

Zhang (2022) discussed internal mechanisms of environmental regulation to enhance product quality over the period of green transformation through expanding companies' capabilities in greenwashing and studied the interconnection between environmental regulation, behavior in greenwashing, and quality of products in the period of green transformation from the position of evolution.

Osmonalieva et al. (2025) disclosed the key features of using machine learning means in corporate information systems to ensure product quality management in climate-smart agriculture and demonstrated that directions for managing product quality in the conditions of using the leading methods and measures of climate-smart agriculture and corporate information systems based on machine learning in different countries and climate conditions can have various manifestations.

Ibraimova et al. (2025) proved the connection between the implementation of climate-responsible management information systems, aimed at raising product quality, and the effectiveness of their promotion in the market. The scholars also identified spheres that use management information systems with artificial intelligence tools for decarbonization, which contributes to product quality.

Wu (2023) researched the influence of environmental management and environmental innovations of companies on their productivity and revealed that environmental management and environmental innovations are interconnected and facilitate productivity. Ergasheva et al. (2023a) studied the development of robotized business in Russia and countries of Central Asia with compliance with ESG management principles for the development of the green economy and proved that the implementation of ESG management in robotized business can accelerate the transition to sustainable production. Ergasheva et al.

(2023b) considered the possibilities for ensuring ESG investing in the conditions of green economy development in Russia and countries of Central Asia, identified the main directions for investing, and stated that the green economy is one of the key directions for solving environmental problems. Busurmankulova et al. (2025) elaborated on the connection between using environmental aspects of product quality management with the help of corporate information systems and support of the sustainable development of the AI economy, and established the directions for the intellectualization of corporate information systems that contribute to an increase in product quality.

Liu (2024) dwelt on the impact of the implementation of agro-industrial and green technologies on market prices for agrarian products, with the emphasis on product quality and environmental awareness, and tried to show that improvement of product quality and satisfaction of the growing demand for eco-friendly agrarian products require more investments in the implementation of green technologies.

Building on the literature reviewed above, this article provides a comparative life-cycle assessment of technical products. The engineering component encompasses the technical parameters of production equipment, including energy intensity, emission levels, the degree of purification, and resource utilization indicators. Changes in these parameters resulting from the implementation of environmental measures are calculated, allowing the findings to be interpreted as an engineering and environmental analysis.

### **3.1 Case-Based Experience in Applying the Industrial and Manufacturing Engineering Methodology to Environmental Quality Management of Technical Products in the Green Economy**

Ecologization of quality management envisages the interconnection and mutual dependence of the systemic management of quality with compliance with environmental safety of products and the manufacturing process. It aims to meet the demands of the consumer, who believes that quality products and business processes of production and sales must be ethical and eco-friendly. Ecologization is connected with the issues of environmental and economic security of the company. There appears to be a need to create an economic system that would take the environmental factor into account in economic activities.

Environmental management and innovative activities have the same goal, but they use companies' resources in different directions. Environmental management focuses on the improvement of the company's managerial structure with the help of internal motivation or external support, while innovations directly affect the production process (Wu, 2023).

The initial stage of the development of environmental management in the world was the 1992 Specification for Environmental Management System, which was prepared by the British Standards Institute at the request of the Confederation of British Industry. The main goals of environmental management include the unification of the efforts of the government, the public, market infrastructure institutions, and economic subjects in the issues of environmental protection and rational use of natural resources; the minimization of negative anthropogenic impact on the environment from government and private structures and individuals; and the reduction of manufacturing costs due to modernization of the technological process.

According to the green economy concept, governments, businesses, and citizens are offered to develop balanced ways of development, which include stimulation of investments in natural capital, resolution of energy sector problems, and provision of eco-friendly food products, focus on land use, optimal distribution of limited resources, and improvement of resource management. The green economy model involves a harmonious combination of society's economic needs and the need for constant recovery and preservation of the environment. The green economy concept involves the resolution of different crises: financial, food, climate, fuel, water, etc.

Implementation of the environmental management system allows reaching economic, social, and environmental effects at different levels, especially at the level of the economic subject. This involves improvement of the region's environment due to agreement of the interests of all stakeholders and implementation of systemic, comprehensive, and targeted actions; an increase in investment attractiveness of the company due to upgrade of production processes and emergence of new products; enhancement of the marketing aspects of the company's activities; improvement of the image of companies, managers, and personnel as socially responsible and environmentally responsible subjects; rational use of natural resources; ordering of organizational, information & communication, financial, and eco-oriented activities of the company.

Environmental management is closely connected with the national economy and forms the initial information about the necessity to use natural resources when solving the tasks of effective development of production. The emergence of new tasks of the rational use of natural resources and environmental protection is caused by the need for economic practice. The comprehensive program and targeted approach to the development of new forms of property and market economy reflect the interconnection between all parts of the nature use program.

In developed countries, the idea of implementing the system of environmental management in the practice of economic subjects' activities became popular in the 1970s against the background of the aggravation of environmental problems. The appearance of EMAS (Eco-Management and Audit Scheme) and ISO 14000 standards is considered the most important environmental initiatives at the international level.

Thus, the key principles of the green economy are harmonization of relationships in the system of "nature-human-production," proper agreement of economic, social, and environmental priorities; human protection from nature and destructive influence of society's production activities; support of favorable conditions for life activities in the current and future periods; guarantee of the growth of society's economic potential and its socio-cultural development in the conditions of environmental safety.

Transition to the green economy is possible only in the case of sustainable development of all sectors of industry and penetration of green technologies in production and consumption. Green production must develop in basic sectors (mining and chemical industry, energy sphere, machine-building, and transport sector) and high-tech sectors, which open new perspectives for eco-oriented modernization.

Improvement of product quality becomes a condition of reducing the number of products. Population growth requires the corresponding increase in production scales. This leads to a contradiction between quantitative and qualitative parameters of production in the conditions of the growth of expenditures. From the position of economic determinism, this phenomenon is unacceptable, for it leads to a slowdown of economic growth rates and a reduction of production effectiveness. However, this phenomenon has a right to exist from the position of socio-environmental expedience, for it creates conditions for the improvement of the population's quality of life and guarantees further development of society by the principles of environmental safety. The goal of the green economy is to form an effective environment for economic and social progress, which is based on the minimization of the negative impact on the environment and efficient use of natural resources, with preservation of decent living standards.

Environmental indicators in the structure of product quality indicators have a top-priority role in the conditions of achievement of the Sustainable Development Goals. Transition to support of these indicators involves the implementation of the principles of environmental management of product quality. Companies that declare environmental management, which helps achieve and raise product quality, use it as a component of marketing. They also declare their results in this sphere. This declaration can be realistic, but there are also many exceptions. It is difficult for a regular consumer to assess the fairness of the manufacturing

company that declares its environmental focus during production. Consumers interested in environmental consumption can assess manufacturing companies' orientation towards the factual parameters of the quality of manufactured products. Further on, an assessment of indicators for the determination of the level of environmental management in product quality management in the green economy is performed. This is done based on the analysis of sustainable development reports of the U.S. company Caterpillar Inc.

### **3.2 Lifecycle Environmental Engineering and Technical Product Parameters using Caterpillar Inc as a Case Study**

Caterpillar Inc. (CAT) manufactures a large range of products (mining and construction equipment, energy installations, clothing, footwear, etc.) and is ranked 3rd in the world by the volume of production waste generation (Sensoneo, 2025). The environmental indicator of product cyclicity is rather important in the system of product quality management of this company. Caterpillar Inc. has adopted green responsibilities and fulfills them during the design and production of goods. This is confirmed by the company's collecting waste for further recycling (own products and other types of industrial waste, which is further used after environmental recycling); modernizing its equipment to reduce the burden on the environment from disposal of obsolete equipment; creating products with a high or even 100% level of cyclicity (Table 1).

An important direction for environmental management of product quality is connected with the use of sustainable materials and supplies in production. Environmentally sustainable characteristics of materials and supplies ensure such indicators of product quality as energy efficiency (which leads to a reduction in energy resource consumption and greenhouse gas emissions), reduction in the use of materials and water in production, and biodiversity protection. The level of environmental friendliness of materials and supplies is assessed according to their influence on environmental and economic effectiveness. Some innovative environmentally sustainable materials, which are used within the focus on environmental management of product quality, have specific indicators in the sanitation and hygiene sector, the safety sphere, etc. We can note several examples of environmental management in the context of the effectiveness of using sustainable materials and supplies to raise product quality:

- Nike, Puma, and Adidas use eco-friendly wool obtained with the help of methods that are sparing for animals (Kellner, 2023). Nike performed a transition to the use of this eco-oriented method later, compared to other manufacturers of sportswear. This is because the method requires modernization of the process of materials certification. The year 2023 saw the final green transition, which reduced the

level of public dissatisfaction and influenced the popularization of Nike's products as eco-friendly. As of mid-2025, around 350 use the standard of environmental management (Responsible Wool Standard (RWS)), which contributes to the responsible management of production. Puma and Adidas are leaders in the transition to this standard. One problem during the transition was the necessity for the search and verification of wool manufacturers. However, the companies remained the leaders in sales of sportswear made of wool, among other materials. The volumes of sportswear sales of Puma were as follows: EUR 1687.5 million in 2018, EUR 1974 million in 2020, EUR 2517 million in 2021, EUR 2763 million in 2023, and EUR 2813 million in 2024 (Davies, 2025).

- Production and use of construction materials with high indicators in heat conservation, anti-

bacterial protection, and other quality parameters. The positions of environmental management in this direction consist of convincing consumers of the necessity of constructing buildings from materials with the given characteristics. This approach contributes to energy efficiency. Energy-efficient buildings are the final products, the environmental management of which quality depends on the demand and income level of final consumers. The global market of energy-efficient buildings grows constantly: while in 2024 it equaled \$135.6 billion, the forecast for 2025 is \$145 billion, and for 2029 – \$182 billion (The Business Research Private Ltd, 2025). The key construction materials for energy-efficient buildings are reflection and insulation materials, roofing materials with a high level of energy saving, and materials to produce energy-saving windows, doors, etc.

**Table 1.** Analysis of the effectiveness of environmental management of Caterpillar Inc. in the context of product quality management using industrial and manufacturing engineering methodology

|       | Indicator of effectiveness                                                                              | Value and characteristics of the indicator                                                                                                                                                                                                                                                                     |
|-------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | Types of waste subject to recycling with the use of eco-oriented technologies and equipment, including: |                                                                                                                                                                                                                                                                                                                |
| 1.1   | From the functioning of the administrative and production departments                                   | Since 2010, all waste that can be recycled at the company's equipment is to be collected.                                                                                                                                                                                                                      |
| 1.2   | Expired products:                                                                                       |                                                                                                                                                                                                                                                                                                                |
| 1.2.1 | In the company's storage or in the production and commercial departments                                | The company's products (including equipment) that are not subject to repairs or modernization are transferred to the corresponding departments for recycling                                                                                                                                                   |
| 1.2.2 | With consumers                                                                                          | Points of product waste collection. Transportation is covered by the company.                                                                                                                                                                                                                                  |
| 2     | Dynamics of change of the volume, metric tons                                                           | 2020 – 556000<br>2021 – 567000<br>2022 – 575000<br>2024 – 594000                                                                                                                                                                                                                                               |
| 3     | Revenue, \$ billion                                                                                     | 2020 – 41.7<br>2021 – 51<br>2022 – 59.43<br>2024 – 64.8                                                                                                                                                                                                                                                        |
| 4     | Waste recycled, %                                                                                       | 2020 – 90%<br>2021 – 89%<br>2023 and 2024 – 91%                                                                                                                                                                                                                                                                |
| 5     | Effectiveness of waste dynamics management                                                              | The growth of revenue exceeds the growth of the volume of waste.                                                                                                                                                                                                                                               |
| 6     | Waste intensity (volume of waste, metric tons / Revenue, \$ billion ratio)                              | Growth of this indicator is a sign of low effectiveness of the recycling policy, and vice versa.<br>2020 – 556000 metric tons / \$41.7 billion = 13<br>2021 – 567000 metric tons / \$51 billion = 11<br>2022 – 575000 metric tons / \$59.43 billion = 9.67<br>2024 – 594000 metric tons / \$64.8 billion = 9.1 |
| 7     | Intensity of disposal of unprocessed waste                                                              | 2020 – 1500 metric tons<br>2021 – 1100 metric tons<br>2022 – 1000 metric tons<br>2024 – 800 metric tons.                                                                                                                                                                                                       |
| 8     | Share of new products with 100% cyclicity and materials and resources with a low level of toxicity, %   | 2018 – 89%<br>2020 – 97%<br>2021-2024 – 100%                                                                                                                                                                                                                                                                   |
| 9     | Measures on product management with a lower level of recycling                                          | Focus on the creation of technologies and equipment for the modernization of products.                                                                                                                                                                                                                         |

Quality of products must be based on the complex and interconnected system of technical, organizational, economic, social, and motivational measures, which ensure the required level at all stages of production and consumption of products. Apart from observation of all necessary principles and rules, implementation of the green economy model, in connection with product quality, also involves an increase in the role of government and government bodies in economic and environmental regulation, cooperation between the government and business, creation of favorable conditions for development of business based on new environmental technologies and standards, government support of socially and environmentally responsible companies, and support of the activities of non-profit environmental organizations, as well as formation of conditions for the development of population's environmental culture.

Based on the examination of Caterpillar Inc.'s case-based experience in applying the industrial and manufacturing engineering methodology to environmental quality management of technical products in the green economy, this methodology was found to be highly effective because it enables simultaneous improvement in both the environmental and technical quality characteristics of industrial products.

### 3.3 Methodological Approaches to Improving Environmental Quality Management of Technical Products

In the context of the green economy, environmental quality management of technical products requires a multilevel methodology based on the principles of industrial and manufacturing engineering. A technical product is considered an object with a complete life cycle encompassing design, production, operation, maintenance, and disposal. At each stage, environmental quality parameters are established, including specific emissions, resource efficiency, toxicity, the share of recyclable components, and ecosystem impacts. These parameters are incorporated into the quality management system alongside traditional technical and economic indicators.

The methodological framework provides for the identification of critical environmental control points, the selection of measurement and monitoring methods, the development of corrective action procedures, and the use of continuous improvement tools. An integrated environmental product quality index is introduced to rank alternative engineering solutions according to their contribution to achieving green growth and sustainable development goals. The inclusion of this methodology in the article demonstrates that the approach extends beyond merely declaring environmental sustainability and instead involves systematic engineering efforts to manage the environmental dimension of quality.

A technical model is proposed to describe the impact of green technologies on the quality of energy products. The model represents each innovation as a change in the structure of the technological chain, such as replacing the type of fuel, adding a catalyst, or modernizing the storage system, and links this structure to four groups of quality indicators.

An integrated technical sustainable quality index,  $Q_{green}$ , is introduced and defined as the weighted sum of the normalized values of these indicators:

$$Q_{green} = w_1E + w_2(1 - Em) + w_3(1 - Re) + w_4R$$

where  $E$  is energy efficiency in normalized form;

$Em$  is normalized emissions;

$Re$  is normalized resource intensity;

$R$  is reliability;

$w_i$  is the weights assigned according to priorities, for example, an emphasis on decarbonization.

Baseline values of these parameters are established for conventional technologies in the fuel and energy sector, while expected and actual values are specified for green innovations. The change in the index  $\Delta Q_{green}$  and its sensitivity to each component are then calculated. For the practical application of the authors' model, it is recommended to use a "life-cycle environmental quality loop for technical products" framework.

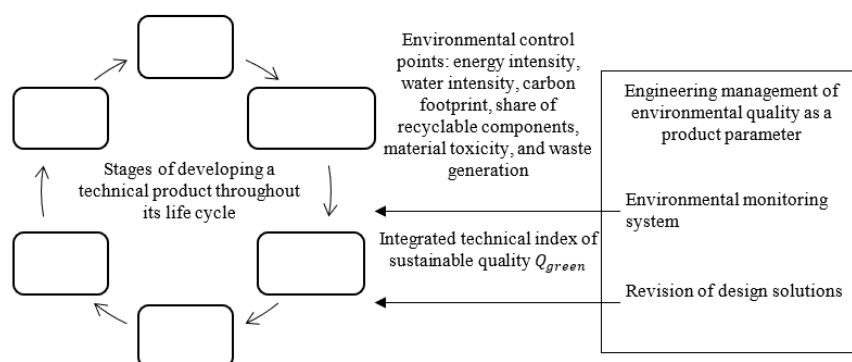


**Figure 1.** Life-cycle environmental quality loop for technical products

Source: Developed by the authors

Figure 1 illustrates the stages of design, material procurement, production, operation, maintenance and repair, and disposal. Environmental control points are specified for each stage, including energy intensity, water intensity, carbon footprint, the share of recyclable components, material toxicity, and waste generation. Feedback is established through an environmental monitoring system and the adjustment of design solutions. The proposed framework demonstrates that environmental quality is an engineering-manageable product parameter rather than merely a marketing characteristic.

The practices of Caterpillar and major global manufacturers of sporting and industrial goods demonstrate that environmental parameters are increasingly being integrated into QMS and assessed as part of overall product quality. This applies both to waste recycling and to the design of products with greater circularity and lower material intensity. In international engineering practice, the green transition is gradually becoming a source of competitive advantage, as environmental performance is directly linked to resource efficiency, life-cycle costs, and brand sustainability.

#### **4. DISCUSSION**

This research contributes new scientific findings to the literature of Can et al. (2026), Lawan et al. (2026), and Zeng et al. (2026) and supplements the fundamental principles of the scientific concept of industrial and manufacturing engineering for the quality of technical products with a new proposition regarding the feasibility of applying the industrial and manufacturing engineering methodology to the environmental quality management of technical products in the green economy.

Unlike the existing methodology described in the publications of Anwer and Srinivasan (2026), Baba et al. (2026), and Lee et al. (2026), the proposed industrial and manufacturing engineering methodology does not entail the “side effect” associated with improving the environmental properties of technical products at the expense of their consumer properties. Instead, it makes it possible to preserve and even improve these properties, including functionality, useful life, the attractiveness of product appearance, and the convenience and durability of packaging.

In the short-term and mid-term, humanity will face serious challenges: climate change, loss of biodiversity, growth of inequality, etc. These systemic global crises cannot be solved in isolation, because they are all interconnected. Innovative solutions in the environmental sector help reduce the negative impact of economic activities on the environment and ensure the rational use of natural resources. These solutions contribute to an increase in the effectiveness of production, a reduction of emissions, and an optimization of energy use. Implementation of innovations in the

environmental spheres is determined by new standards for companies and consumers, which stimulate the formation of a more balanced and environmentally responsible society.

The main goal of environmental management is the protection of the environment, preservation of life forms, and support of sustainable development for future generations. In practice, this may mean the reduction of the carbon footprint, protection of endangered species, and support of the use of renewable energy sources. Environmental management interacts with business, science, and law. It involves understanding how business strategies must change given environmental restrictions, the principles of sustainable development, and the public approval of environmental services and products.

A green economy should be treated as an innovative and strategic way of development of global, national, and regional economies, with the main priorities being the achievement of environmental and social goals aimed at reaching sustainable economic growth. A green economy is a part of sustainable development and involves the harmonious co-existence of economic and social systems and the environment. Manufacturing of environmentally friendly products is possible only through the systemic implementation of green technologies at all stages of production.

An effective system of environmental management allows the company to react to modern challenges, support the effective innovative processes, and receive additional profit. In the case of the implementation of ecologization of the company’s activities, it must develop an environmental policy to prevent the negative impact on the environment. Here, it is necessary to mention the procedures of standardization and certification, which are used in environmental management, to find the correspondence to the current norms, rules, standards, and parameters of product quality and procedures on the development of the systems of integrated systems of management. There is a direct connection between observation of the principles of environmental policy and environmental management and improvement of product quality. More and more consumers associate product quality with compliance with environmental standards. Thus, in line with Chen et al. (2026), Liu et al. (2026), and Zhao et al. (2026), it is substantiated that the green economy plays an increasingly important role in shaping national economies. The process of the economy’s ecologization is accompanied by the implementation of resource-saving and energy-saving technologies and a decrease in pressure on the environment, growth of demand for organic products and investing in the green economy, changes in the employment structure, improvement of the quality of life, enhancement of living standards, and growth of product quality.

## 5. CONCLUSIONS

The advancement of scientific knowledge achieved in this article is attributable to the authors' innovative conclusion that the industrial and manufacturing engineering methodology is preferable for the environmental quality management of technical products in the green economy, as it eliminates inherent contradictions in such management, thereby making it more effective and more attractive to industrial enterprises. In the context of globalization, sustainable production and green economy become the decisive aspects for ensuring the modern development of countries and the global economic system. A green economy is the key direction in national strategies of countries where measures to save resources and reduce carbon emissions are necessary for the achievement of sustainable development.

Environmental management is a complex approach to environmental protection. It includes strategies of natural resources protection, reduction of pollution, preservation of ecosystems, and support of sustainable development. This sphere covers the development of policies, monitoring of the environment's quality, and implementation of measures on environmental protection, and the growth of public awareness of ecological problems. Human needs must be balanced with the long-term health of the plant, ensuring a sustainable future for nature and society.

The goal of environmental management is the improvement of the quality of human life. It involves the mobilization of resources and the government's measures in building strategies for the use of natural resources. Environmental management uses systemic analysis and conflict resolution strategies to distribute losses and benefits from the activities. Environmental management is a critically important tool for ecologization of economic activities, for it contributes to the implementation of innovative technologies and improvement of managerial processes. According to the principles of environmental management, all subsystems

and components of the economic subjects must guarantee environmental protection from their negative effects.

The quality of products could be raised due to the system of quality management, which includes certification of the quality management system, implementation of the HACCP system (Hazard Analysis Critical Control Point), modernization of production, improvement of personnel qualification, and control over production safety.

Introduction of the system of environmental management allows for transition from control over the level of pollution due to industrial activities and prevention of excessive pollution to the concept of sustainable development, which envisages the balance between the satisfaction of modern needs of humanity and the needs of future generations. Environmental management, including environmental management of product quality, can become an effective tool for solving the problem of sustainable development and help future generations to fully satisfy their demands. This is especially relevant in the conditions of population growth, urbanization, and the growth of pollution and waste. Implementation of environmental management can create preconditions for ecologization through education, information policy, and solving the problems of environmental protection.

Based on the research findings, contemporary industrial enterprises are advised to transition to the industrial and manufacturing engineering methodology for the systematic optimization of environmental quality management of the technical products they manufacture in the green economy.

The scientific and methodological developments proposed in this research are of practical significance because the transition to a more advanced methodology for managing the quality of technical products in the green economy, based on industrial and manufacturing engineering, will make the environmental transformation of industrial operations and products more attractive and widespread, thereby supporting and accelerating the green industrial transition.

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**Chynara M. Ergeshova**

Osh Technological University named  
after M.M. Adyshev,  
Osh,  
Kyrgyzstan  
[ergeshova\\_2019@mail.ru](mailto:ergeshova_2019@mail.ru)  
ORCID 0000-0001-5946-5951

**Maral E. Saipova**

Osh Technological University named  
after M.M. Adyshev,  
Osh,  
Kyrgyzstan  
[maral.saipova@mail.ru](mailto:maral.saipova@mail.ru)  
ORCID 0009-0008-0953-5366

**Shakhtybybyu K. Ishembaeva**

Osh Technological University named  
after M.M. Adyshev  
Osh,  
Kyrgyzstan  
[shahtybyby@gmail.com](mailto:shahtybyby@gmail.com)  
ORCID 0000-0002-0243-836X

**Mukhriddin M. Bekmurzaev**

Mukhriddin M. Bekmurzaev  
Tashkent State University of  
Economics,  
Tashkent,  
Uzbekistan  
[mukhriddin1997@gmail.com](mailto:mukhriddin1997@gmail.com)  
ORCID 0009-0008-8212-1856

**Olga A. Boris**

North-Caucasus Federal University,  
Stavropol,  
Russia  
[parakhina\\_o@mail.ru](mailto:parakhina_o@mail.ru)  
ORCID 0000-0002-6245-9250

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