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## SYSTEMIC APPROACH TO QUALITY MANAGEMENT IN THE CLIMATE ECONOMY, ENCOMPASSING CLIMATE FINANCE, ENVIRONMENTAL INNOVATION, AND GREEN EMPLOYMENT

**Abstract:** *Quality management in the climate economy requires a systemic approach that integrates coordinated policy, institutional participation, and cross-sector collaboration among business, R&D, and investors. A systemic approach in this sphere involves targeted accumulation of climate finance in environmental innovations and green employment. The transition to the climate economy is based on a range of criteria and goals (parameters) for the quality management of sectoral development, which are informed by the country's sustainable development strategy. In this work, we identified leading approaches to the system management of quality in the climate economy, focusing on climate finance, environmental innovation, and green employment, thereby providing a theoretical and methodological framework for effective policy in this sphere.*

*The research relies on the example of the EU, since this union has effective programmes and laws on the climate economy and implements them by attracting a wide range of participants. The research period is 2005-2024, due to historical prerequisites and the availability of relevant data.*

*The analysis showed that the EU uses an effective systemic approach to managing the quality of products and services, which involves climate finance, environmental innovation, and green employment. However, there are certain problems with renewable energy and green employment. In the course of this research, we identified the main quality parameters, which are distinguished by the development of the climate economy: decarbonisation, energy efficiency, green energy use, circularity, resource efficiency, and continuous green energy supply.*

**Keywords:** *decarbonisation, energy efficiency, green energy, circularity, resource efficiency, CO<sub>2</sub> emissions, systemic approach, quality management, climate economy, climate finance, green employment, EU*

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## 1. Introduction

The climate economy is an economy in which business models that seek to balance economic growth with its impact on climate change are developed. Its development necessitates a transformation of various sectors, depending on their innovativeness and focus on climate-resilient goals. Countries with a high level of sustainable development demonstrate sufficient system transition in the climate aspects of their main sectors' functioning. This is because sectors with high stagnation indicators put pressure on the entire economy, so developed countries implement special transformation programmes and policies to prevent economic stagnation and related problems. Many developing and underdeveloped countries lack a systemic approach to climate, financial, and economic transitions and thus face complex challenges and economic threats. For long periods, they can remain countries with an unchanged yet ineffective economic structure, with sectors oriented towards extensive growth. The government and regional authorities often support such an economic structure. They are often observed in countries that feature the Economic Egalitarianism concept, which involves the redistribution of income without economic stimulus or discrimination against active economic actors, and targeted support for unprofitable and low-tech companies (Jwa & Lee, 2025). Support for ineffective sectors and enterprises does not contribute to improving product and service quality. Also, given the absence of a focus on quality management based on climate economy indicators, developing and underdeveloped countries do not ensure a course towards human development and green employment. The concept of quality management 5.0, characteristic of the late 2020s, is similar to quality management 4.0 in that both focus on knowledge transfer of digital competencies to human resources (Sultanova et al., 2024). The difference lies in human resources' mastery of knowledge and skills in environmental

protection and green employment.

This paper aimed to identify leading approaches to the systems management of quality in the climate economy, with an emphasis on climate finance, environmental innovation, and green employment, and to provide a theoretical and methodological framework for effective policy in this sphere.

## 2. Materials and methods

This research was conducted by the example of the European Union, because this supranational association uses a system legal and programme regulation of the main economic sectors and supports the globalisation of climate economy. The research period is 2005-2025 because statistical data are available, and 2005 is the first year of partnership among the member states after the historical expansion in 2004. The research methodology consists of the following sections:

1) Identifying the goals of quality management in the functioning of climate economy sectors in the EU in the context of the main parameters: decarbonisation, efficiency and support of the required level of green energy use, resource efficiency, and circularity. The critical method and predictive analysis were used here.

The decarbonisation indicator is assessed using quantitative data from state statistics services or international organisations (platforms) that prepare reports on this parameter in the context of selected sectors. The indicator is determined based on factual and forecast data, using the unit MtCO<sub>2</sub>. Analysis of the sector's decarbonisation is also conducted by analysing the legal regulation of the parameter's integration into the quality management system in the context of CO<sub>2</sub> emissions reduction. In addition, to assess the implementation of decarbonisation as a quality management goal, structural analysis of the progress of economic sectors and sub-sectors that demonstrate a decrease in CO<sub>2</sub> emissions is performed.

Assessment of energy efficiency and achievement of a certain level of green energy use is connected with the establishment of the level of legal regulation of these processes at the national and sectoral levels. It is also necessary to establish the factual level of green energy transition, achieved by various economic sectors (in % of total energy consumption). Data sources used in the analysis include reports of the leading international organisations and statistical data provided by governments or supranational structures.

The circularity of materials used in production processes involved evaluating the legal regulation of implementing recycling technologies and the parameters of their integration at the sectoral level. We perform a structural analysis of the circularity of materials at the level of economic sectors and sub-sectors, which allows us to obtain information about the structural transition to the use of materials' cyclicity as a component of the climate economy.

Such a component of quality management as resource efficiency is assessed in the context of saving water and other natural resources. Here, we establish the level of legal regulation of this parameter and progress in this sphere at the level of sectors and sub-sectors.

2) Assessing the level of sectors' development correspondence to the goals of quality management in the EU climate economy. Comparative analysis was applied for this.

3) Analysing the effect of optimisation and stimulation measures of the climate economy (climate finance, environmental innovations, and green employment) on sectors to improve quality. The application of all three measures allows for the speaking of a systemic approach to quality management in the climate economy. Effectiveness is assessed by the extent of improvement in climate, social, and economic indicators of sustainable development, and in similar quality parameters. Factor analysis was utilised within this section.

The presented methodological approach could be used at the level of economic sectors and sub-sectors and at the micro-level of companies. This methodological basis can be transferred to the structure of companies' corporate reports. The data published with other information in the Quality 5.0 appendix can be used by national statistics services to obtain information about the results of activities in Quality 5.0 management.

In this paper, an overview of scholarly approaches to the problems of the climate economy and their connection to measures such as green employment, environmental innovation, and climate finance is presented.

Jwa and Lee (2025) reflected on two opposite economic approaches to financial support of the economy, distinguishing Economic Egalitarianism (subsidies to industrial sectors and companies that play a strategic role for the country of government elites) and economic discrimination (focus on the economic domination of technological corporations and government norms that regulate capitalistic foundations of the economy and its development). Streimikiene and Balezentis (2026) analysed the legal regulation of climate-oriented development in the EU's service sector and assessed the implementation of norms and standards across member states. The scholars demonstrated that, despite certain inequalities in climate neutrality, the EU has established a legal and regulatory framework that underpins the transition to green management of service quality.

Hoerber (2026) studied the improvement of sustainable development in the EU space sector, noting the advantages of the institutional features of the sector's development, pointing to the need for further efforts in the sphere, and indicating the importance of implementing the climate economy in service quality management at the global level, opposing this approach to high-tech imperialism. Romeo (2026) revealed the dependence of efforts on CO2 emissions capture on the volume of economic

growth in the EU and indicated the necessity to optimise the policy of the management of industrial production decarbonisation. Öztürk et al. (2026) investigated the influence of a developed digital infrastructure, the quality of legal regulation of business, and commitments in sustainable development on the effectiveness of green innovations implementation and the management of eco-oriented supply chains. The scholars demonstrated a positive correlation between these variables in advanced economies.

Mańkowski et al. (2026) made a review of the progress of the EU member states' agrarian sector in the implementation of the green energy transition. The authors provided recommendations for a systemic approach to managing this process, taking into account the climate, socioeconomic, and technological aspects of countries and regions. Stoate et al. (2009) presented the results of complex monitoring of environmental transformations in agricultural production in Europe in the early 21st century and distinguished processes that underwent technological change due to the introduction of new agricultural and adjacent technologies. Irmatova et al. (2025) characterised the influence of AI and digital transformation on the sustainable development of labour resources and the quality of their labour. They showed that countries that effectively stimulate companies to invest in personnel training in the age of digital technologies show good indicators of sustainable development. Gafurova et al. (2025) examined the impact of green investments on companies' economic efficiency and found a positive correlation between the two. Isayan and Mayilyan (2022) demonstrated the positive effects of investments in sustainable development on social capital and economic outcomes.

### **3. Results**

Development of quality management concepts is connected with scientific research and supported by socioeconomic,

technological, and environmental transformations. The main stages of transformations that influenced the formation of the modern paradigm of quality management are as follows.

1) Quality 1.0, characterised by the routine assessment of products, inspection for defects at the end of the production process, and recycling of products with defects. This stage involves high material costs due to defects and can be defined as reactive. The Quality 1.0 concept was peculiar to the period of the late 19th century to the 1930s (Smajdorová, 2024). Apart from the material costs, manufacturing companies also bore the costs of wages for inspection departments. The key problem that increased manufacturers' expenses during this period was the focus on quality checks at the stage of final product issuance, when defects were impossible to eliminate.

2) Quality 2.0 – a paradigm of quality management based on implementing proactive approaches and methods that ensure statistical forecasting, which are connected with the development of standards that include product parameters. This concept involves preventing production defects and improving resource efficiency (Nair, 2024). This period was marked by the implementation of standards, which began before WWII and continued into the post-war economic recovery, requiring completely new industrial approaches. Statistical quality control and investments in innovative technologies for zero-defect management (especially in large industrial corporations in Japan, the USA, and Western Europe) were introduced.

3) Total Quality Management is the concept peculiar to the period of the 1950s – 1990s, which was accompanied by the implementation of statistical quality control, total quality control, consumer support through guarantees, and continuous improvement of the quality of processes to meet customer needs. This customer-oriented concept (Aichouni et al., 2024) serves as the basis for quality management strategies in

modern industrial corporations, alongside more up-to-date technological concepts, primarily oriented toward continuous improvement of process quality to satisfy consumer demand.

4) Quality 3.0 – the concept of quality management at the level of all spheres, which is based on the Total Quality Management provisions, customer orientation, control of supply chains, and support of ISO standards. It was the basis for quality management from the 1990s to the 2010s. This concept created a foundation for basic quality parameters used by manufacturers during the transition to the digital age.

4) Quality 4.0 – the concept of quality management based on digital technologies, which ensures transfer of routine tasks to machines and allows forecasting quality with the application of data obtained in real-time. This concept is oriented towards consumers and contributes to achieving indicators of resource and energy efficiency.

5) Climate (green or circular model) economy

as the component of the Quality 5.0 concept. This approach includes a transition from technologisation to human-centredness and environmental friendliness in quality management (Mhlongo & Sukdeo, 2026). In this case, the key milestones are not the growth of demand and the reduction in the costs of resources and labour, but the achievement of environmental and climate parameters of products and processes and sustainable economic development that balances environmental, social, and economic effectiveness. Within this concept, attempts are made to create supply chains based on controlling their climate footprint and social significance.

Identifying the goals of quality management in the functioning of climate-economy sectors in the EU was necessary for the assessment of their achievement. The main criteria (parameters) of quality management in the functioning of the climate economy's sectors in the EU are shown in Table 1.

**Table 1.** Criteria of goals (parameters) of quality management in sectors' functioning in the EU climate economy

|   | Criterion of the goal (parameter) of quality management                 | Description                                                                                                                                                                                                                                                                                                                                                                                                               |
|---|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Decarbonisation                                                         | Legal regulation of quality management in the context of focus on CO2 emissions reduction.<br>Quantitative assessment of the reduction in CO2 emissions is performed using data from international organisations or national statistics institutions.                                                                                                                                                                     |
| 2 | Energy efficiency and/or support of a certain level of green energy use | Legal or programme regulation of the parameter of energy efficiency or transition to green energy in the sector.<br>Reduction in energy intensity of production or growth of the level of green energy use. The assessment is performed based on the rankings assigned by international organisations. Quantitative assessment is possible if data on energy efficiency or renewable energy implementation are available. |
| 3 | Circularity                                                             | Legal or programme support of circularity of processes in the sector.<br>Reuse of products, involving eco-oriented recycling, which is assessed based on the scoring system.                                                                                                                                                                                                                                              |
| 4 | Resource efficiency                                                     | Legal or programme regulation on the parameter.<br>Reduction in the use of natural and other resources in production processes. This indicator is assessed through material intensity.                                                                                                                                                                                                                                    |

Source: Authors

Based on the author's approach, we evaluated the degree of alignment between sectors' development and quality management goals in the EU climate economy.

For this, we identified the key sectors of the EU economy. The structure of the EU economy from 2005 to 2024 is presented in Table 2.

**Table 2.** Structure of the sectors of the EU economy in 2005-2024

| No. | Sector of the economy                                                                                                                    | Share in the structure of the EU economy, % of GDP |      |      |      |      |
|-----|------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------|------|------|------|
|     |                                                                                                                                          | 2005                                               | 2010 | 2015 | 2020 | 2024 |
| 1   | Services                                                                                                                                 | 74.4                                               | 75.8 | 76.1 | 76.4 | 76.1 |
| 1.1 | Private sector                                                                                                                           | 63.7                                               | 65.3 | 65.2 | 65.8 | 66   |
| 1.2 | Government sector                                                                                                                        | 10.7                                               | 10.5 | 10.9 | 10.6 | 10.1 |
| 2   | Agriculture, forestry, and fishing                                                                                                       | 1.7                                                | 1.6  | 1.6  | 1.6  | 1.6  |
| 3   | Industry (including construction; domination of car industry, machinery and equipment, metallurgy, chemical industry, and food industry) | 23.9                                               | 22.6 | 22.3 | 22   | 22.3 |

Source: Compiled by the authors based on RH Nuttall (2026), the World Bank Group (2026a), the World Bank Group (2026b), and the World Bank Group (2026c)

The service sector accounts for the main share in the structure of the EU economy. We considered the degree of correspondence between the service sector's development and the goals of quality management in the climate economy in the EU (Table 3).

Table 4 presents the analysis of the correspondence between the industrial sector's development and the goals of quality management in the EU climate economy.

Table 5 presents the relationship between agricultural development and the goals of quality management in the EU climate economy.

As shown in Tables 3-5, the development of industry, the service sector, and agriculture in the EU aligns with the goals of quality management in the climate economy. Positive transformations and an effective regulatory and legal framework confirm this.

To assess the application of a systemic approach to quality management in the climate economy, we considered the use of climate finance, environmental innovations,

and green employment across sectors.

Climate finance in quality management in the climate economy involves financing of environmental innovations and green employment. Green employment can be a component of environmental innovations. Green employment involves support of decent work, which contributes to restoration, preservation, or protection of the environment (European Environment Agency, 2025d). Initiatives in the sphere of green employment are connected with the creation of a labour market in the sphere of environmental protection and training (retraining) of personnel for its sustainable functioning.

We considered the directions of a systemic approach to quality management in the climate economy, encompassing climate finance, environmental innovation, and green employment, using the example of three sectors in the EU economy.

Climate finance is structured around the main types of environmental innovations in the EU, as shown in Table 6.

**Table 3.** The level of correspondence of the service sector's development to the goals of quality management in the EU climate economy

| No.   | Criterion of the goal (parameter) of quality management of service sector's development                | Value                                                                                                                                                  |                                                                                                                                                                                                                                 |
|-------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|       |                                                                                                        | 2005                                                                                                                                                   | 2024                                                                                                                                                                                                                            |
| 1     | Decarbonisation                                                                                        |                                                                                                                                                        | The goal was adopted in 2019: achievement of climate neutrality by 2050.                                                                                                                                                        |
| 1.1   | Legal (programme regulation)                                                                           |                                                                                                                                                        | “European Climate Law” (2021) (framework of EU's climate policy).<br>Directive 2003/87/EC (greenhouse gas emission allowance trading).<br>Directive (EU) 2024/1275 (whole-life carbon reporting for all new buildings by 2030). |
| 1.2   | Actual implementation (CO2 emissions, MtCO2)                                                           |                                                                                                                                                        |                                                                                                                                                                                                                                 |
| 1.2.1 | Transport, MtCO2                                                                                       | 844                                                                                                                                                    | 800 (2024), 746 (2025), 716 (forecast for 2026)                                                                                                                                                                                 |
| 1.3   | Sub-sectors of the service sector that are at the stage of reducing CO2 emissions                      | Transport, logistics, trade, public services, hotel business, and tourism.                                                                             | Transport, logistics, trade, public services, hotel business, and tourism.                                                                                                                                                      |
| 1.4   | Sub-sectors of the service sector that demonstrate leading practices in the reduction of CO2 emissions | Repair of transport vehicles: through transition to digital platforms, high qualifications of employees and their skills with digital green equipment. | Space sector (satellite sensing, climate tracing) and transport vehicles repairs.                                                                                                                                               |
| 2     | Energy efficiency and/or support of a certain level of green energy use                                |                                                                                                                                                        |                                                                                                                                                                                                                                 |
| 2.1   | Legal (programme regulation)                                                                           |                                                                                                                                                        | Regulatory and legal acts on decarbonisation.<br>Global Renewables and Energy Efficiency Pledge (2 December 2023).                                                                                                              |
| 2.2   | Actual implementation: the level of green energy use in:                                               |                                                                                                                                                        |                                                                                                                                                                                                                                 |
| 2.2.1 | Housing and utility sector, heating and cooling, %                                                     | 12.4 %                                                                                                                                                 | 23 % (2020)<br>26.2 % (2023)<br>27.2 % (2024)                                                                                                                                                                                   |
| 2.2.2 | Housing and utility sector, electricity, %                                                             | 16.4 %                                                                                                                                                 | 37.4 % (2020)<br>45.3 % (2023)<br>47.1 % (2024)                                                                                                                                                                                 |
| 2.2.3 | Transport                                                                                              | 1.8 %                                                                                                                                                  | 10.3 % (2020)<br>10.8 % (2023)<br>11.3 % (2024)                                                                                                                                                                                 |

Source: Compiled by the authors based on the European Commission (2023), the European Environment Agency (2025b), the European Environment Agency (2025c), the European Union (2026a), the European Union (2026b), the European Union (2026c), and Streimikiene and Balezentis (2026)

**Table 4.** The level of correspondence of the industrial sector's development to the goals of quality management in the EU climate economy

| No. | Criterion of the goal (parameter) of quality management of industry's development                                             | Value                                                                            |                                                                                                                                        |
|-----|-------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
|     |                                                                                                                               | 2005                                                                             | 2024                                                                                                                                   |
| 1   | Decarbonisation                                                                                                               |                                                                                  | Similar to the service sector.                                                                                                         |
| 1.1 | Legal (programme regulation)                                                                                                  |                                                                                  | Similar to the service sector.                                                                                                         |
| 1.2 | Actual implementation (CO <sub>2</sub> emissions, MtCO <sub>2</sub> )                                                         | 246.2                                                                            | 192.6                                                                                                                                  |
| 1.3 | Sectors of industry that are at the stage of reducing CO <sub>2</sub> emissions                                               |                                                                                  | Metallurgy, chemical industry, equipment production sector, and car industry.                                                          |
| 2   | Energy efficiency and/or support of a certain level of green energy use                                                       |                                                                                  |                                                                                                                                        |
| 2.1 | Legal (programme regulation)                                                                                                  |                                                                                  | Similar to the service sector.                                                                                                         |
| 2.2 | Actual implementation: the level of using green energy in industry, %                                                         | 7 %                                                                              | 11.3 %                                                                                                                                 |
| 3   | Circularity of materials used in production processes (industry and agriculture)                                              |                                                                                  |                                                                                                                                        |
| 3.1 | Legal (programme regulation)                                                                                                  |                                                                                  | The Ecodesign for Sustainable Products Regulation (ESPR) (2024). Circular Economy Action Plan (2020). Circular Economy Act (upcoming). |
| 3.2 | Actual implementation: the level of the circularity of materials for production (total value for agriculture and industry), % | 6 %                                                                              | 11.5 % (2022)<br>11.8 % (2023)                                                                                                         |
| 3.3 | Main industrial sectors in which circular materials are used                                                                  | Pulp and paper industry, metallurgy and construction, production of fertilisers. | Metallurgy and construction, production of fertilisers, car industry, fuel and energy sector.                                          |
| 4   | Resource efficiency                                                                                                           |                                                                                  |                                                                                                                                        |
| 4.1 | Legal (programme regulation)                                                                                                  |                                                                                  | "European Climate Law" (2021)                                                                                                          |
| 4.2 | Actual implementation: water abstraction by manufacturing, million m <sup>3</sup>                                             | 30,462 million m <sup>3</sup> (2000-2009)                                        | 27,020 million m <sup>3</sup> (2020-2023)                                                                                              |
| 3.3 | Main industrial sectors that demonstrate the most effective use of water resources                                            | Chemical industry, pulp and paper industry, food industry.                       | Semiconductor production (microelectronics), chemical industry, pulp and paper industry, and food industry.                            |

Source: Compiled by the authors based on the European Commission (2023), the European Commission (2026), the European Environment Agency (2025a), the European Environment Agency (2025c), the European Environment Agency (2025d), the European Environment Agency (2025e), the European Environment Agency (2025f), the European Union (2026a), the European Union (2026b), the European Union (2026c), Eurostat (2026b), Haas et al. (2015), Streimikiene and Balezentis (2026), and the World Bank Group (2025)

**Table 5.** The level of correspondence of the agricultural development to the goals of quality management in the EU climate economy

| No. | Criterion of the goal (parameter) of quality management of agricultural development                                       | Value                                                                                                      |                                                                                                                                                                     |
|-----|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|     |                                                                                                                           | 2005                                                                                                       | 2024                                                                                                                                                                |
| 1   | Decarbonisation                                                                                                           |                                                                                                            | Similar to the service sector.                                                                                                                                      |
| 1.1 | Legal (programme regulation)                                                                                              |                                                                                                            | Similar to the service sector.                                                                                                                                      |
| 1.2 | Actual implementation (CO <sub>2</sub> emissions, MtCO <sub>2</sub> )                                                     | 10.9                                                                                                       | 8.5                                                                                                                                                                 |
| 2   | Energy efficiency and/or support of a certain level of green energy use                                                   |                                                                                                            |                                                                                                                                                                     |
| 2.1 | Legal (programme regulation)                                                                                              |                                                                                                            | Similar to the service sector.                                                                                                                                      |
| 2.2 | Actual implementation: level of using green energy in agriculture, %                                                      | 15                                                                                                         | 20                                                                                                                                                                  |
| 3   | Circularity of materials used in production processes (industry and agriculture)                                          |                                                                                                            |                                                                                                                                                                     |
| 3.1 | Legal (programme regulation)                                                                                              |                                                                                                            | The Ecodesign for Sustainable Products Regulation (ESPR) (2024). Circular Economy Action Plan (2020). Circular Economy Act (upcoming).                              |
| 3.2 | Actual implementation: level of the circularity of materials for production (total value for agriculture and industry), % | 6 %                                                                                                        | 11.5 % (2022)<br>11.8 % (2023)                                                                                                                                      |
| 3.3 | Main types of activities in agriculture in which circular materials are used                                              | Production of fertilisers                                                                                  | Production of fertilisers                                                                                                                                           |
| 4   | Resource efficiency                                                                                                       |                                                                                                            |                                                                                                                                                                     |
| 4.1 | Legal (programme regulation)                                                                                              |                                                                                                            | Similar to industry                                                                                                                                                 |
| 4.2 | Actual implementation: water abstraction by manufacturing, million m <sup>3</sup>                                         | 60,911 million m <sup>3</sup> (2000-2009)                                                                  | 59,647 million m <sup>3</sup> (2020-2023)                                                                                                                           |
| 5   | Agricultural processes contributing to quality improvement in the climate economy                                         | Organic farming, perennial crop rotations to prevent drought, reduction of tillage to raise soil humidity. | Agroforestry, implementation of drought-resilient crops, crop rotation and diversification, year-round ground covering, minimisation of tillage, precision farming. |

Source: Compiled by the authors based on the European Commission (2023), the European Commission (2026), European Environment Agency (2025a), the European Environment Agency (2025c), the European Environment Agency (2025d), the European Environment Agency (2025e), the European Environment Agency (2025f), the European Union (2026a), the European Union (2026b), the European Union (2026c), Mańkowski et al. (2026), and Stoate et al. (2009)

**Table 6.** The structure of climate finance in the context of the main types of environmental innovations in the EU in 2018-2024

| No.   | Component of climate finance                                                                                                                                                                                                                                             | Value                                                                                                                                              |        |        |       |        |        |        |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-------|--------|--------|--------|
|       |                                                                                                                                                                                                                                                                          | 2018                                                                                                                                               | 2019   | 2020   | 2021  | 2022   | 2023   | 2024   |
| 1     | Green investments in environmental protection, EUR billion                                                                                                                                                                                                               | 282                                                                                                                                                | 293.05 | 294.84 | 315.1 | 338.13 | 351.15 | 359.91 |
| 1.1   | Industry and service sector (green investments in large corporations) (funds of the EU, member states, and corporations), EUR billion                                                                                                                                    | 139.3                                                                                                                                              | 145.6  | 144.9  | 160.3 | 173.45 | 175.9  | 184.99 |
| 1.1.1 | Investment objectives                                                                                                                                                                                                                                                    | Achieving the parameters of quality: eco-friendliness, climate sustainability, cost-effectiveness, affordability of resources, and energy security |        |        |       |        |        |        |
| 1.2   | Industry, service sector, and agriculture (support from non-profit organisations and government institutions), EUR billion                                                                                                                                               | 84.1                                                                                                                                               | 87.85  | 90.8   | 94.6  | 102.88 | 112.3  | 111.8  |
| 1.2.1 | Investment objectives                                                                                                                                                                                                                                                    | Similar to the objectives for industry and service sector                                                                                          |        |        |       |        |        |        |
| 1.3   | Agriculture and household, EUR billion                                                                                                                                                                                                                                   | 58.6                                                                                                                                               | 59.6   | 59.14  | 60.2  | 61.8   | 62.95  | 63.12  |
| 1.3.1 | Investment objectives                                                                                                                                                                                                                                                    | Similar to the objectives for industry and service sector                                                                                          |        |        |       |        |        |        |
| 1.4   | Sources of green investments in environmental protection (from the EU and member states)                                                                                                                                                                                 |                                                                                                                                                    |        |        |       |        |        |        |
| 1.4.1 | Environmental tax revenues, % of total tax revenue                                                                                                                                                                                                                       | 6.5                                                                                                                                                | 6.4    | 6.2    | 6     | 5.3    | 5.3    | 5.3    |
| 2     | Green bond issuance, % of total bond issuance                                                                                                                                                                                                                            | 2.9                                                                                                                                                | 2.4    | 3.8    | 4.9   | 7.1    | 5.3    | 7      |
| 2.1   | Industry and service sector (corporations), % of total bond issuance                                                                                                                                                                                                     | 2.1                                                                                                                                                | 5      | 5.6    | 12    | 10.6   | 10     | 12.8   |
| 2.2   | Government bond issuers, % of total bond issuance. Financing of all sectors through the issue of NextGenerationEU Green Bonds by the European Commission, green bonds by the European Investment Bank (EIB), and green bonds by national governments (sovereign issuers) | 3.5                                                                                                                                                | 1.2    | 3.2    | 3.2   | 6.1    | 3.3    | 4.2    |
| 2.3   | Investment objectives                                                                                                                                                                                                                                                    | Similar to the objectives of green investments in environmental protection                                                                         |        |        |       |        |        |        |

Source: Compiled by the authors based on Eurostat (2025)

The data in Table 6 indicate that climate finance grew across the main tools and sectors of the economy in the EU from 2018 to 2024. It should be noted that the EU has a complex and strict regulatory system governing the issuance and turnover of securities, including green bonds. The European Union Green Bond Standard (EUGBS) came into effect in late 2024. Compliance with this standard is voluntary, but if the issuer does not comply, there may be a risk of reduced bond sales due to insufficient investor trust. This standard is aimed at protecting investors from so-called "greenwashing". The key criteria of the European Union Green Bond Standard (EUGBS) are as follows (European Union, 2024):

- Mandatory checks of issuers by accredited experts. The experts are approved by the European Securities and Markets Authority (ESMA).

- Targeted purpose of projects that are funded through green bonds, involving the principle of preventing substantial damage to the environment.

- At least 85 % of revenues from the emission of green bonds within this standard must be used for projects on the EU taxonomy.

Compliance with these criteria allows green bonds to receive green labels. The implementation of the European Union Green Bond Standard (EUGBS) aims to ensure key quality parameters and prevent breaches of trust among consumers and investors. The leaders in implementing this standard are major participants in the EU green bonds market, including the European Commission and the European Investment Bank (EIB), as well as national governments.

We also studied the top-priority directions of environmental innovations, which are the objects of climate financing in the EU. In the industrial sector, attention should be paid to innovative solutions for green steel production. Its specific features are given below (European Commission, 2025).

1. Unlike traditional metallurgical production of steel, based on the use of coal as the reducing agent for iron ore (a source of CO<sub>2</sub>

emissions), green steel production in the EU relies on the use of eco-friendly hydrogen.

- Stegra (Sweden) received financing from EU funds in 2023 for the construction and commissioning of an innovative steel plant (EUR 250 million, and EUR 6.25 billion from other sources). An electrolyser with the power of 690 MWt was installed; it works on renewable energy and produces eco-friendly hydrogen. Green hydrogen is a reducing agent for direct reduction of iron ore. Sponge iron, which has a 95% lower carbon footprint than coal-based traditional production, is produced. Sponge iron is turned into steel.

- The plant is to be commissioned in 2026 and will help reduce annual CO<sub>2</sub> emissions by 7 million tonnes.

In agriculture, attention should be paid to innovative solutions for eco-friendly recycling of agricultural production waste, followed by the production of packaging materials for agrarian products, which also help reduce CO<sub>2</sub> emissions. One example is the project PEFerence (the Netherlands), in which packaging for agricultural products is manufactured by processing vegetable oil and sugar beet waste. The project helps reduce CO<sub>2</sub> emissions by 28-45 % (Circular Bio-based Europe Joint Undertaking, 2025). Another example is the plant dealing with recycling of manure from cattle farms into fertilisers and biodegradable forage for cattle (Spain). This project solves the problem of emissions from pollution and agricultural production waste.

An important role in the systemic approach to quality management in the climate economy is played by green employment. This element of the climate economy must be realised alongside the other two elements: climate finance and environmental innovation. Labour resources' readiness to perform their professional duties must be based on knowledge of the application of digital smart technologies, systems, and equipment used in environmental protection. Table 7 presents the main indicators of green employment in the EU.

**Table 7.** Indicators of green employment in the EU in 2017-2024

| No. | Indicators                                                                             | Value |      |      |      |      |      |       |
|-----|----------------------------------------------------------------------------------------|-------|------|------|------|------|------|-------|
|     |                                                                                        | 2018  | 2019 | 2020 | 2021 | 2022 | 2023 | 2024  |
| 1   | Employment in the environmental economy, million people                                | 3.91  | 4.12 | 4.31 | 4.37 | 4.94 | 5.60 | 5.82  |
| 1.1 | Nature protection and management (in all sectors of the economy), million people       | 0.67  | 0.71 | 0.76 | 0.78 | 0.82 | 0.89 | 0.9   |
| 1.2 | Waste management and material recovery (in all sectors of the economy), million people | 1.02  | 1.06 | 1.1  | 1.12 | 1.18 | 1.24 | 1.26  |
| 1.3 | Water and wastewater management (in all sectors of the economy), million people        | 0.44  | 0.46 | 0.48 | 0.5  | 0.56 | 0.56 | 0.556 |
| 1.4 | Clean air and energy (in all sectors of the economy), million people                   | 0.67  | 0.71 | 0.74 | 0.77 | 0.82 | 0.93 | 1.03  |
| 1.5 | Other spheres of the climate economy, million people                                   | 1.11  | 1.18 | 1.23 | 1.2  | 1.56 | 1.98 | 2.07  |

Source: Compiled by the authors based on Eurostat (2026a)

In 2017-2023, the EU saw growth in the scale of green employment, driven by climate finance and environmental innovation. At present, there are new projects aimed at increasing the level of green employment in the EU. One example is the Trans-Mediterranean Renewable Energy and Clean Tech Cooperation (T-MED), which started on 9 June 2026. The main parameters of green employment within this project are as follows (PubAffairs Bruxelles, 2026):

- 1) Goal: strengthening partnership in the sphere of clean technologies and renewable energy at the EU-Southern Mediterranean level. The key sub-goals: raising access to clean and reliable energy, building an attractive environment for investment, increasing industry's competitive position, creating new green jobs, and raising the qualifications of partners' labour resources.
- 2) Attraction of climate investments and provision of guarantees for investors.

3) Opportunities for the improvement of quality:

- Growth of the eco-friendliness parameter through raising labour resources' knowledge in the use of digital smart systems, equipment, and tools and improving their skills to prevent environmental damage.

- Optimisation of the price-quality, resource efficiency, and energy efficiency parameters through digital intellectualisation of processes and improvement of labour quality. The quality of labour is to be raised through training and educational programmes devoted to green digital transformation of qualification requirements. These requirements concern parameters such as energy efficiency, resource efficiency, and green material knowledge. All types of educational measures are conducted within the T-MED Skills Agenda programme. This programme also provides support for a range of specialist categories within the participating companies: financial specialists (bank employees), designers, engineers, and technicians.

4) The number of green personnel to be trained (retrained) within this project: 100,000 people who are involved in the clean energy generation sector in the EU and the Southern Mediterranean.

Thus, it is possible to state that the EU has a systemic approach to quality management in the climate economy, in the context of the development of elements such as green employment, environmental innovation, and climate finance. This statement is supported by the results of a study of the correspondence between the development of economic sectors (services, agriculture, and industry) and the objectives of quality management in the EU climate economy, and by the growth in the scale of implementation of these elements of the climate economy.

#### **4. Discussion**

Implementing a systemic approach to quality management in the climate economy, encompassing climate finance, environmental

innovation, and green employment in the EU, faces a range of problems but is characterised by substantial progress.

The problems include the following:

1) Overloading of territorial distribution networks and ageing of the technologies of energy generation, transfer, and storage threaten such parameters of the climate economy as an uninterrupted supply of green energy. Certain rural territories in EU member states (Poland, Italy, etc.) have an excess of renewable energy generation. However, there is no institutional, technological, or financial mechanism for the transfer, storage, and sale of this energy to member states and third countries that have high demand for energy (including green energy) during peak consumption periods. The surplus of renewable energy generation is caused by certain countries operating large-scale renewable energy stations whose technologies and equipment cannot be fully integrated into modern energy distribution and storage systems. Accordingly, green investments in environmental innovations connected with green energy are often risky (Mańkowski et al., 2026). These problems arise in rural areas of the West Pomeranian and Pomeranian Voivodeships of Poland (wind energy) and the Lower Silesian, Łódź, and Greater Poland Voivodeships of Poland (solar energy) (DOinwestuj.pl, 2026). These territories face problems with green investments in environmental innovations for renewable energy generation: operators are not connecting them to distribution networks due to overloading, insufficient energy storage capacity, and the absence of systems for transferring renewable energy to the distribution networks of other territories. In 2025-2026, innovative technological solutions emerged aimed at resolving this problem. These include technologies for integrating and storing different types of green energy. Similar problems are peculiar to Italy as well.

2) The problem of future employment of labour resources in the EU, who work at companies in sectors that cut personnel within

the climate transformation and digital intellectualisation. Even though dismissal or transfer to another company involves certain measures regarding the social protection of citizens, the need to reduce labour costs is growing each year. This is accompanied by insufficient training and speed in the context of EU countries. As of 2026, only 1/3 of labour resources working in companies in EU member states have the necessary level of knowledge, skills, and experience (Schneider, 2026).

3) Access to climate finance for small businesses, given insufficient knowledge and skills in the management of projects that conform to the EU taxonomy.

A systemic approach to quality management in the climate economy encompassing climate finance, environmental innovations, and green employment, when viewed through the example of the three selected economic sectors of the EU, has a range of limitations, problems, and possibilities for structural adaptation in other economic contexts.

The key limitations of this approach, which may become barriers to the achievement of effects demonstrated in the EU, include the following:

- Formation of a high level of green investments in environmental protection through environmental taxes. From 2021 to 2024, the EU supported a stable level of environmental tax revenues (5.3 % of total tax revenue) (Table 6). For example, in China, which demonstrates rapid economic and technological growth, the value of this indicator was 1.4 % in 2022 (ISI Markets, 2026). Although China is formally a developing country, it has achieved significant results in environmental taxation. Accordingly, ensuring green financing of environmental innovations similar to that demonstrated by the EU is possible through the creation of an effective legal and regulatory framework and tax administration.
- Green personnel's awareness of green competencies and execution of official duties given the focus on the Sustainable Development Goals and climate goals of

employers. In 2025, the level of green skills among green personnel equalled 25% in the EU (CSE-NET, 2025). In the same period, the indicator for African countries was 1.88 % (eLearning Africa, 2025). Accordingly, a relevant aspect of effectively adapting the EU systemic approach to climate-economy development is raising the level of green personnel training in mastering green skills within their professions.

- Access to leading technologies, ensured by the results of national R&D of the EU member states and the possibility of purchasing technologies based on transfer. This contributes to better access to technologies for companies that create and implement green innovations, from economic and technological standpoints. Many developing countries cannot achieve significant results in green innovation because of insufficient R&D capacity, limited climate financing, and insufficient green skills among personnel. Technological development in developing countries may contribute to improved infrastructure quality for green innovations.

The problems that limit the adoption of the EU's systemic approach in developing countries include the financing risks of green technologies, HR and educational issues, and insufficient returns from foreign investment. Solving these problems will provide wide opportunities for expanding green foreign investments, increasing technological giants' interest, and growing labour resources' awareness of green skills.

## **5. Conclusion**

Summarising the research conducted, it should be noted that the EU's regulatory, legal, institutional, financial, educational, and technological initiatives in implementing the principles and directions of the climate economy have created new approaches to quality management. These initiatives accelerate the green energy transition, drive energy efficiency growth, reduce natural resource consumption, and optimise labour

resource costs. However, the latter may pose a long-term threat to EU citizens. This problem is relevant for both advanced and emerging economies. Its resolution lies in the dimension of interaction between civil society, large, medium, and small business, education and science, and the government.

To address the problem of wear and tear and the ageing of technologies and equipment in the sphere of generation, storage, and distribution of renewable energy, it is possible to create and implement innovative climate-financing mechanisms for the modernisation and/or creation of new energy objects. This might involve national and supranational financial organisations, subjects in the IT and ICT sector that develop new digital financial systems for credit and transactions, and consumers (including non-profit organisations, various enterprises, and individuals). Various territories within EU member states have specific characteristics in renewable energy generation, determined by climate features and other factors. Thus, there is a need for comprehensive interactive mapping to reveal territories with high potential in the generation of certain types of green energy, territories that have such potential but do not develop it due to certain reasons, territories that implement their opportunities for generation, and territories that are most vulnerable to the impact of energy crises and require support from other

regions. The interactive map would enable the development and implementation of new large-scale projects on distribution networks across various territories and regions, as well as the construction and commissioning of energy storage facilities.

We should also mention the importance of creating new geo-economic partnerships between the EU and third countries to relocate climate-economy assets to their territories. This will enable the creation of new green jobs and become an important factor in the growth of geo-economic positions. The climate economy objects that can be placed on the territories of partner countries may include energy storage facilities, CO<sub>2</sub> storage facilities, and objects for eco-friendly recycling of materials.

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