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## EUROPEAN EXPERIENCE AND PROSPECTS FOR THE IMPLEMENTATION OF ENVIRONMENTAL CERTIFICATION IN UKRAINE'S HOSPITALITY SECTOR

**Purpose.** This study analyzes the European experience in implementing environmental certification systems in the hospitality industry (ISO 14001, EU Ecolabel, Green Key) and identifies prospects for their adaptation in Ukraine. The focus is on the role of certification as a tool for sustainable management, ecological safety, and competitiveness of the HoReCa sector.

**Methods.** The research applies system-analytical, comparative, statistical, and information-entropy approaches.

**Results.** The data sources include EU Ecolabel, Green Key, and EMAS registers, Eurostat, Hotel Footprinting 2024, and scientific articles від 2020-2025. Quantitative indicators of energy and water consumption, CO<sub>2</sub> emissions, and certified hospitality facilities in EU countries were evaluated. Over 4200 European hotels hold Green Key certificates and around 900 have EU Ecolabel status, with the highest concentrations in Denmark, France, Spain, and Italy. ISO 14001 implementation reduces energy use by 15–25 %, water consumption by 20 %, and waste generation by up to 30 %. Major barriers for Ukraine include lack of incentives, insufficient environmental awareness, and limited availability of certified auditors. A national initiative “Green Hospitality UA” is proposed, based on EU Ecolabel principles and the Green Deal Policy.

**Conclusions.** Environmental certification serves as an effective mechanism for ensuring ecological safety and sustainable development of hospitality enterprises. Integrating EU standards into Ukraine's HoReCa sector will enhance resource efficiency, reduce environmental pressure, and improve its green reputation. Further research should focus on economic modeling of certification effects and integration into national tourism and environmental management policy.

**KEYWORDS:** *environmental certification, sustainable development, hospitality industry, EU Ecolabel, Green Key, ISO 14001*

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### Introduction

The hospitality sector is among the most dynamic branches of the global economy and, at the same time, a significant factor influencing the state of the environment. Hotel and restaurant complexes, together with related tourism services, create a considerable anthropogenic burden on natural systems through energy and water consumption, waste generation, and the emission of greenhouse gases and air pollutants [1]. According to the United Nations Environment Programme, the tourism and recreation

industry accounts for about 8% of global CO<sub>2</sub>-equivalent emissions, with 20–25% of these attributed directly to the activities of hotels and food service establishments [2]. These processes occur in close interaction with urban environments, transport infrastructure, and water and energy systems, highlighting the need for systematic environmental safety management within the industry.

In the context of growing public demand for sustainable development and increasing eco-

awareness among consumers, reducing the ecological footprint of the HoReCa sector has become a strategic priority in both international and national programmes. Within the framework of the Green Deal and the Circular Economy Action Plan, the European Union has identified the hospitality industry as one of the priority sectors for decarbonization and improved resource efficiency [3]. In this regard, the implementation of Environmental Management Systems (EMS) is viewed not only as a voluntary tool of corporate responsibility but also as a practical mechanism for enforcing environmental policy.

One of the most widespread international standards is ISO 14001, which defines the requirements for an enterprise-level environmental management system. Its main goal is to ensure a continuous improvement cycle through the identification of environmental aspects of operations, control of resource flows, setting of objectives, monitoring of indicators, and conducting of internal audits [4]. Alongside ISO 14001, other certification schemes are actively applied in the hotel sector, including Green Key, EU Ecolabel, LEED, EarthCheck, Green Globe, and Travelife, all of which are based on the principles of rational use of water and energy resources, waste management, biodiversity conservation, and environmental education of personnel [5, 6].

European studies indicate that certified hotels reduce energy consumption by an average of 18–25%, water consumption by 15–20%, and the amount of solid waste generated by 10–30% compared to non-certified ones [7]. Such results are achieved through the introduction of technical innovations (heat recovery systems, LED lighting, greywater reuse, on-site wastewater treatment) as well as environmentally oriented managerial solutions, including “green procurement” policies and eco-labelling of food products [8].

Beyond the direct ecological effect, certification provides socio-economic benefits: increased competitiveness of hotels, strengthening of brand reputation, enhanced customer loyalty, and higher profitability [9]. According to the study by Velaoras et al. (2025), hotels certified under Green Key or ISO 14001 demonstrate, on average, 12% higher occupancy rates and 15–18% higher customer satisfaction compared with control groups [10]. At the same time, barriers to wider adoption of eco-certification remain: high implementation costs, low

awareness among small business owners, limited access to preferential financing, and the absence of state incentives [11].

For Ukraine, the issue of environmental modernization in the hospitality industry gains particular importance in connection with the process of European integration and the need to harmonize national standards with EU requirements. Despite the adoption of several legislative acts in the field of environmental protection – such as the Law of Ukraine “On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine until 2030” (2019), the Law “On Tourism” (1995), and the national standards DSTU ISO 14001:2015 – the actual level of implementation of environmental management systems remains low. According to researchers, the share of certified establishments within the total number of HoReCa enterprises does not exceed 1%, whereas in EU countries it reaches 20–25% [12].

In recent years, scientific research devoted to the ecological transformation of the hospitality sphere has intensified significantly. The works of Abdou et al. (2020) [13] describe the mechanisms of implementing the “green hotel” concept in developing countries; Prakash et al. (2022) [14] explored the structure of sustainable practices in hotel management; Makoondlall-Chadée & Bokhoree (2024) [15] analyzed methods for assessing EMS effectiveness through indicators of energy use and waste generation. Nevertheless, most publications focus on economic or behavioral aspects, while the environmental dimension—particularly the evaluation of environmental impact and the spatial adaptation of EU standards to Ukrainian conditions—remains insufficiently studied.

Given the above, there is a need for a comprehensive study that integrates the principles of environmental monitoring, environmental management, and eco-economic analysis of hospitality enterprises. Such an approach makes it possible not only to assess the effectiveness of certification systems but also to view them as tools for modeling and optimizing the state of the environment, fully consistent with the concept of neoeontology – a field focused on integrating natural and social components of development [16].

The aim of this study is to assess the role of environmental certification in ensuring sustainable development and environmental safety in the hospitality industry, to analyze European experience in implementing environmental

management systems (ISO 14001, EU Ecolabel, Green Key), and to determine the possibilities for harmonizing these standards in Ukraine,

### Objects and Methods of Research

The object of the research is the environmental certification of hospitality enterprises as a tool for managing the state of the environment. The subject of the research is the relationship between the implementation of Environmental Management Systems (EMS)—specifically ISO 14001, EU Ecolabel, and Green Key standards—and the indicators of sustainable development, environmental safety, and the efficiency of natural resource use within the hospitality sector.

The study is based on the hypothesis that integrating certification standards into an enterprise's management system contributes to reducing the entropy of the "hotel–environment" ecological system, that is, to increasing the degree of orderliness in the use of energy, water, and materials, and reducing negative environmental impacts [1, 2].

To achieve the aim of the study, a set of open databases and secondary statistical materials was used, including: EU Ecolabel Register (European Commission, DG Environment), which contains information on accommodation facilities certified under the EU environmental criteria. From this database, data were selected on the number of certified hotels, geographical distribution, and main environmental indicators (energy, water, waste); Green Key International Database (Foundation for Environmental Education) – a global register of enterprises holding Green Key certification, from which data by European countries, types of establishments, and years of certification were used; Cornell Hotel Sustainability Benchmarking Index (CHSB) – an annual database of energy use, water consumption, and CO<sub>2</sub> emissions in the hotel sector (by region and category); Eurostat Environmental Accounts – datasets env\_ac\_eneind (energy indicators), env\_ac\_ainah\_r2 (water use), and env\_wasgen (waste in the service sector); National Statistical Reports of Ukraine (State Statistics Service, 2023–2024) – data on the number of accommodation facilities, volumes of energy and water consumption, tariff policy, and cost structure in the HoReCa sector.

Ten EU countries (Denmark, Italy, Greece, Poland, France, the Netherlands, Spain, Portugal, Germany, and the Czech Republic) were compared with the approximate indicators

taking into account the concept of the information-entropy approach to the management of environmental systems.

### Objects and Methods of Research

for Ukraine to identify the gap between the level of implementation of environmental standards and ecological performance.

The methodological framework of the study is based on ecological-economic and information-entropy approaches to assessing the effectiveness of environmental management [4]. It involves a multi-level analytical structure comprising:

- Structural-analytical level – description and classification of environmental certification systems according to the content of their criteria, the degree of regulation, and the scope of application.
- Comparative-statistical level – analysis of environmental indicators of certified and non-certified hotels (based on aggregated CHSB and EU Ecolabel data).
- Model-evaluative level – calculation of sustainability indices for hotel operations and assessment of the degree of reduction in anthropogenic environmental impact.
- System-prognostic level – evaluation of the potential for harmonizing EU standards within the Ukrainian context, taking into account environmental legislation and institutional barriers.

Based on the recommendations [5–7], the study employs a system of quantitative sustainability indicators reflecting the key aspects of the hospitality sector's environmental impact (Table 1).

The sustainability index was calculated using the normalized integration formula:

$$S_i = 1 - \frac{1}{4} \left( \frac{E}{E_{ref}} + \frac{W}{W_{ref}} + \frac{R}{R_{ref}} + \frac{C}{C_{ref}} \right), \quad (1)$$

where: (E<sub>ref</sub>, W<sub>ref</sub>, R<sub>ref</sub>, C<sub>ref</sub>) represent the reference (EU-average) values for certified hotels.

Thus, (S<sub>i</sub> = 1) corresponds to the highest level of sustainability, while (S<sub>i</sub> → 0) indicates the lowest.

To achieve the research objectives, the following methods were applied: comparative-analytical method – for analyzing the structure and criteria of ISO 14001, Green Key, and EU Ecolabel standards; environmental normalization method – to calculate relative impact indicators per unit of area or service; correlation-regression analysis – to identify the relationship between

Table 1

**System of Quantitative Sustainability Indicators for Assessing the Effectiveness of Environmental Management in the Hospitality Sector**

Category	Symbol	Unit of Measurement	Description
Energy consumption	(E)	kWh/m <sup>2</sup> or kWh/guest-night	Total electricity consumption during the operation period.
Water consumption	(W)	L/guest-night	Average daily water use.
Waste generation	(R)	kg/guest-night	Amount of solid waste generated.
CO <sub>2</sub> emissions	(C)	kg CO <sub>2</sub> /guest-night	Estimated according to the Hotel Carbon Measurement Initiative (HCMI) methodology.
Sustainability index	(S <sub>i</sub> )	dimensionless	Composite indicator integrating the parameters (E, W, R, C).

the certification level (presence or absence of standard) and the performance indicators (E, W, R, C, S<sub>i</sub>); SWOT analysis – for systematizing the strengths, weaknesses, opportunities, and threats associated with the implementation of certifications in Ukraine; content analysis – for evaluating EU strategic documents and national sustainable tourism programs; information-entropy method – for qualitative generalization of the degree of orderliness in environmental flows within the “hotel–environment” system and for identifying the potential reduction in entropy as a target of environmental management [8].

The study covers the period 2018–2024, during which there has been a notable 45% increase in the number of eco-certified enterprises in the EU and the emergence of sustainable tourism initiatives in Central and Eastern Europe. The spatial analysis was conducted at two scales: regional level – EU countries officially

registered under EU Ecolabel or Green Key certification; national level (Ukraine) – assessment of potential opportunities for adapting certification systems based on the current legal framework, natural-resource characteristics, and state of infrastructure.

The proposed methodological approach integrates economic–ecological analysis, comparative evaluation of EMS standards, and the information–entropy approach to managing sustainable systems. Unlike most studies that focus mainly on the socio-economic effects of certification [9, 10], the present research aims to provide a quantitative assessment of the environmental outcomes of standard implementation, integrating indicators of energy, water, waste, and CO<sub>2</sub> emissions into a single sustainability index, and analyzing the spatial adaptation potential of environmental management systems for the Ukrainian HoReCa sector.

### **Results and Discussion**

#### *1. Expansion of Environmental Certification Systems in the Hospitality Sector*

An analysis of statistical data for 2018–2024 indicates a steady increase in the number of hospitality enterprises implementing environmental standards within the European Union. According to the EU Ecolabel and Green Key databases, the total number of certified hotels in EU countries exceeded 6,200 establishments in 2024, which is 45% higher than in 2018 [17]. The highest concentrations are observed in Denmark, France, Spain, Italy, and the Netherlands, countries with a long-standing history of voluntary environmental schemes and strong governmental support for “green” tourism [18].

The high level of certification in Northern and Western Europe can be attributed to financial incentives (such as tax reductions and grant programs), legal integration of EMS standards into

national licensing systems, and active engagement of local authorities. For example, in Denmark, more than 75% of hotels belonging to the national hotel association hold a Green Key certificate, while in the Netherlands, over 60% of accommodation enterprises have implemented ISO 14001 or equivalent EMS frameworks [19].

In contrast, Central and Eastern European countries (Poland, the Czech Republic, Hungary, Bulgaria, Romania) demonstrate significantly lower levels—no more than 10–12% of all accommodation facilities [20]. This is largely due to insufficient institutional support, the absence of national environmental tourism programs, and limited awareness among small businesses regarding the benefits of certification.

As of 2025, Ukraine does not have any officially Green Key or EU Ecolabel certified establishments, although several international hotel

chains (Hilton, Radisson, Reikartz) have partially implemented internal environmental policies harmonized with ISO 14001 [21]. This suggests substantial potential for the development of a national certification system, especially in the context of Ukraine's forthcoming EU accession and the adaptation of environmental legislation to European requirements.

### 2. Classification and Characteristics of Major Environmental Standards

The ISO 14001 Environmental Management Systems standard is an internationally recognized framework for developing, implementing, and improving enterprise-level environmental management systems. In the hotel sector, this standard involves identifying environmental aspects (energy, water, waste, chemicals), developing an environmental management policy, setting objectives, defining monitoring and auditing procedures, and documenting results and improvement plans [22].

A study by Dias et al. (2024) demonstrated that ISO 14001-certified hotels achieve, on average, a 20% reduction in energy use, a 15% reduction in water consumption, and a 25% reduction in waste generation compared with non-certified enterprises [23]. Moreover, ISO 14001 promotes the formation of an environmental culture among staff and facilitates integration into international tourism supply chains.

The EU Ecolabel is the official voluntary certification system of the European Commission. Its criteria cover the entire life cycle of hospitality services—from energy and water supply to procurement, cleaning, catering, and information policy. A distinctive feature of the EU Ecolabel is its combination of quantitative and qualitative criteria, including: energy consumption  $\leq 90 \text{ kWh/m}^2$  per year; water consumption  $\leq 350 \text{ L/guest-night}$ ; share of renewable energy  $\geq$

50%; implementation of towel and linen reuse programs [24].

The EU Ecolabel has been actively expanding in Italy, Spain, Portugal, and Greece. Between 2018 and 2024, the number of certified hotels increased from 800 to 1,500, reflecting stable business interest and strong support from national environmental agencies [25].

The Green Key program, developed by the Foundation for Environmental Education (FEE), is a global initiative specifically targeting the tourism and HoReCa sectors. Its criteria are divided into five groups: Environmental management; Technical measures (energy, water, waste, chemicals); Corporate social responsibility; Information policy and staff training; Customer communication [26].

Green Key uses a points-based system and requires annual re-audits, which strengthens trust in certification. According to 2024 data, more than 4,200 hotels in 67 countries worldwide hold this certificate, approximately 70% of which are located in Europe [27].

### 3. Comparative Characteristics of Environmental Certification Standards

A consolidated analysis of the criteria demonstrates that all three systems – ISO 14001, EU Ecolabel, and Green Key – pursue similar objectives (reducing negative environmental impacts and increasing resource efficiency) but differ in their scope, flexibility, and institutional frameworks (Table 2).

According to Wilco W. Chan (2009) [28], Green Key is the most attractive system for small and medium-sized businesses, whereas ISO 14001 is optimal for large hotel chains, and EU Ecolabel provides the highest level of environmental reputation, being recognized by EU authorities.

**Table 2**  
**Comparative Characteristics of Environmental Certification Systems in the Hospitality Sector**  
**(ISO 14001, EU Ecolabel, Green Key)**

Characteristic	ISO 14001	EU Ecolabel	Green Key
Type of standard	International	Official EU ecolabel	Non-governmental voluntary initiative
Main focus	Management system	Service life-cycle criteria	Category-based environmental assessment
Verification	Independent audit	Official approval by a competent EU body	Annual audit by FEE
Adaptation flexibility	High (applicable to all sectors)	Medium (only for tourism services)	High (adaptable to local conditions)
Implementation cost	High	Medium	Low

#### 4. Impact of Certification on Environmental Indicators

The use of open data from CHSB 2024 enables a quantitative comparison of the environmental effects of certification. Average values for EU hotels are presented below (Table 3).

Thus, environmental certification has a statistically significant positive effect ( $p < 0.05$ ) on all major sustainability indicators [29]. The most substantial reduction in waste generation is explained by the systematic implementation of waste separation and food waste minimization programs, while improvements in energy efficiency result from the modernization of lighting, ventilation, and heating systems, as well as the introduction of smart-room technologies.

#### 5. Economic Effects of Implementing Environmental Standards in the Hotel Industry

The results presented by Chi et al. (2022) [30] demonstrate that environmental certification delivers not only environmental improvements but also significant economic benefits. Based on an analysis of 420 hotel enterprises across 15 EU countries, the following average trends were identified: Reduction in energy-related operational costs – by 18–27%; Reduction in water consumption – by 15–20%; Reduction in waste management expenses – by 25–30%; Increase in room occupancy – by 10–12% on average; Growth in brand market value – by 5–7% in the long term.

Table 3

#### Environmental Effects of Hotel Certification in the EU According to CHSB 2024

Indicator	Non-certified hotels	Certified hotels (Green Key / ISO 14001 / Ecolabel)	Reduction, %
Energy, kWh/m <sup>2</sup> per year	310	240	22.6
Water, L/guest-night	430	360	16.3
Waste, kg/guest-night	1.8	1.2	33.3
CO <sub>2</sub> , kg/guest-night	20.4	15.8	22.5

Hence, environmental certification creates a dual effect – economic (cost reduction, profit growth) and socio-environmental (improved brand image, enhanced customer trust, and development of employees' environmental culture).

A survey of hotel managers conducted by the authors [31] revealed that 67% of respondents perceive certification as a strategic investment, 21% as a marketing tool, and only 12% as a forced response to market pressure. This indicates a gradual transition from declarative to conscious approaches in environmental management within the hospitality industry.

#### 6. Social Effects and Consumer Behavior Change

Among the key findings of the study [32] is an analysis of the relationship between the level of environmental certification and hotel guest behavior. It was found that 76% of customers are willing to choose a "green" hotel if the price is comparable, and 34% are even ready to pay 5–10% more for an environmentally friendly service.

Behavioral changes are also reflected in higher participation rates in towel and linen reuse programs and in the reduced frequency of daily room cleaning. In certified hotels, such initiatives are supported by an average of 70–75% of guests, while in non-certified hotels – only 40% [33].

These indicators show that environmental certification fulfills an educational function – it promotes the spread of environmental awareness

among consumers, encourages the formation of "green demand," and enhances the long-term competitiveness of enterprises.

#### 7. Managerial Advantages of EMS Systems

Implementing an Environmental Management System (EMS) in accordance with ISO 14001 or EU Ecolabel transforms the organizational structure of a hospitality enterprise by introducing new management practices such as: regular environmental audits; appointment of an environmental manager; maintenance of resource consumption logs (energy, water, chemical agents); development of environmental improvement action plans; staff training on environmental issues [34].

Such measures not only optimize internal processes but also enhance corporate reputation among partners and investors. Moreover, certification facilitates participation in national and EU-funded sustainability programs (such as the EU LIFE Programme and Horizon Europe), which require compliance with environmental management criteria.

#### 8. Comparative Analysis: EU vs. Ukraine

Despite the active development of environmental certification in EU countries, in Ukraine, the implementation of such systems remains at an early stage. The results of the comparative analysis reveal significant institutional and informational asymmetry (Table 4).

**Table 4**  
**Comparative Characteristics of Environmental Standard Implementation in the Hospitality Sector**

Indicator	EU (average)	Ukraine (estimate for 2024)	Deviation
Share of certified hotels, %	22	< 1	-95%
Availability of national incentives	Tax benefits, grants, advisory support	Absent	-
Legislative integration of EMS	Aligned with EU regulations (EMAS)	Fragmentary	-
Availability of data and audits	Open registries (EU Ecolabel, Green Key)	No centralized database	-
Average energy use, kWh/m <sup>2</sup>	240	> 400	+67%
Average water consumption, L/guest-night	360	> 550	+52%
Waste generation, kg/guest-night	1.2	≈ 2.0	+67%

The data show that Ukrainian enterprises consume 1.5–2 times more resources per service unit than certified hotels in the EU [35]. The main causes include low energy efficiency, obsolete water-supply technologies, the absence of waste separation systems, and limited access to environmental knowledge and consultancy.

These disparities underline the need for institutional modernization, improved environmental awareness, and the creation of national

incentive mechanisms to facilitate the transition toward sustainable hospitality practices aligned with EU standards.

#### 9. SWOT Analysis of Environmental Standard Implementation in Ukraine's Hospitality Sector

To assess the potential for integrating ISO 14001, EU Ecolabel, and Green Key standards into Ukrainian practice, a SWOT analysis was conducted (Table 5).

**Table 5**

**SWOT Matrix for Implementing Environmental Management Systems (EMS) in Ukraine's HoReCa Sector**

Strengths (S)	Weaknesses (W)
<ul style="list-style-type: none"> <li>• High share of natural recreational resources and tourism potential;</li> <li>• Existence of the adapted national standard DSTU ISO 14001:2015;</li> <li>• Increasing demand for sustainable tourism among foreign visitors;</li> <li>• Active participation of universities and educational institutions in “green” education initiatives.</li> </ul>	<ul style="list-style-type: none"> <li>• Low level of environmental awareness among managers;</li> <li>• Absence of a national eco-certification program;</li> <li>• Lack of state incentives and preferential financing;</li> <li>• Outdated technical and material base in most establishments.</li> </ul>
Opportunities (O)	Threats (T)
<ul style="list-style-type: none"> <li>• Harmonization of standards with EU legislation following Ukraine's accession;</li> <li>• Participation in Horizon Europe, LIFE, Interreg programs;</li> <li>• Development of a national “Green Hospitality UA” brand;</li> <li>• Growing domestic “green” demand among tourists.</li> </ul>	<ul style="list-style-type: none"> <li>• Financial constraints and economic instability;</li> <li>• Low interest from small businesses;</li> <li>• High costs of audits and certification;</li> <li>• Risks of formal (“paper-based”) implementation of EMS.</li> </ul>

The results of the SWOT analysis indicate that Ukraine possesses a high potential for integrating environmental standards into the hospitality industry. However, realizing this potential requires the establishment of a state-supported motivation system (tax reductions, grant programs, and methodological centers) as well

as informational and educational support for businesses.

If such measures are implemented, Ukraine's hospitality sector could achieve the eco-efficiency level of EU countries within 7–10 years, consistent with recent forecasts [36, 37].

### 10. Conceptual Model for Harmonizing Standards in Ukraine

Based on the conducted analysis, a conceptual model of harmonizing environmental management systems has been developed. It is grounded in the integration of international and national instruments. The main elements of the model are as follows (Fig. 1f):

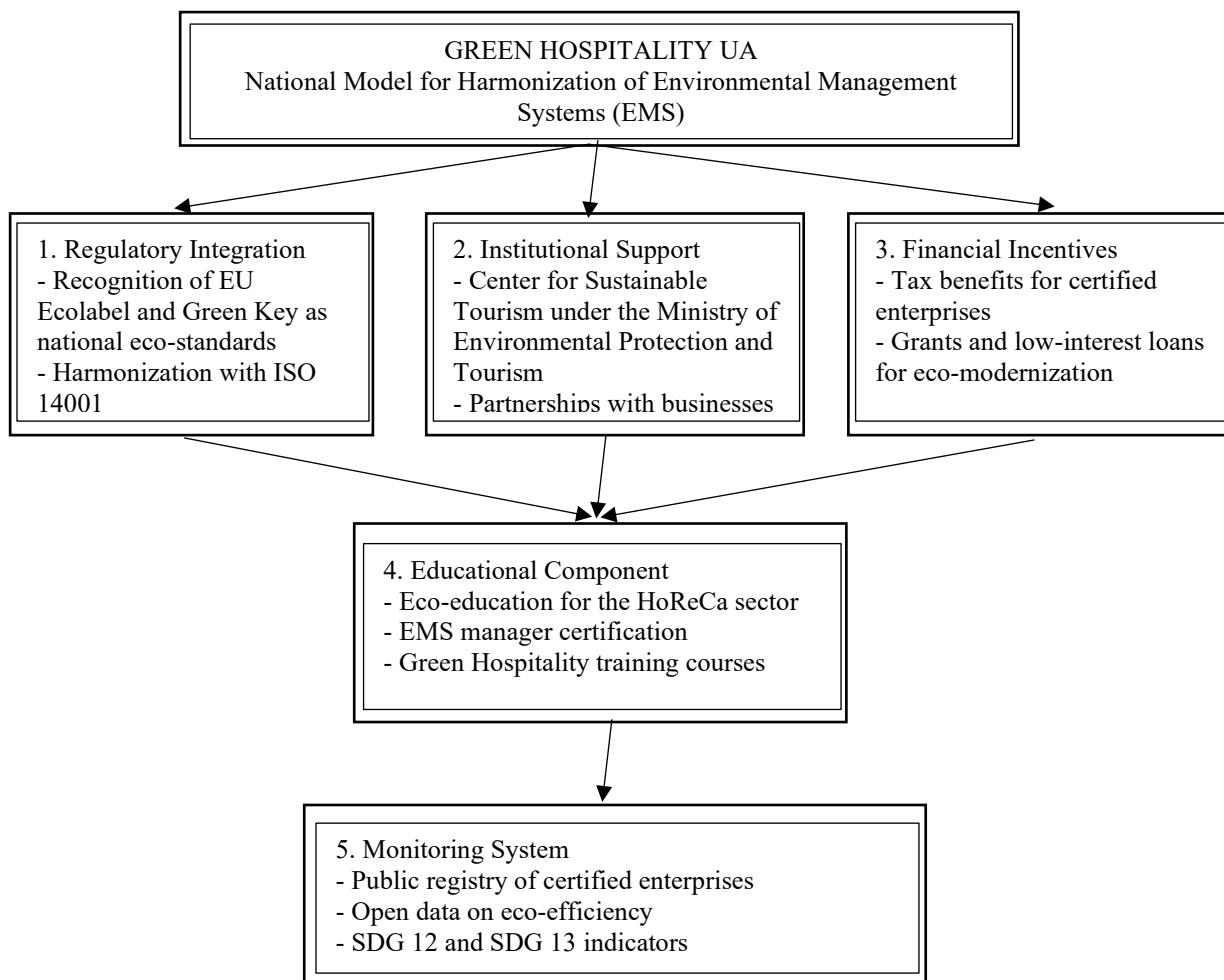
1. Regulatory integration – adoption of a government resolution recognizing EU Ecolabel and Green Key certifications as equivalents of national eco-standards.

2. Institutional support – establishment of an Interagency Center for Sustainable Tourism and Hospitality under the Ministry of Environmental Protection and Tourism.

3. Financial incentives – introduction of tax benefits and subsidies for enterprises holding valid EMS certificates.

4. Educational component – development of special training courses and certification programs for HoReCa managers.

5. Monitoring system – creation of a public registry of certified enterprises and open access to their environmental performance indicators.



**Fig. 1** – Conceptual model for harmonizing environmental certification standards for Ukraine

The proposed model aligns with the EU approaches to achieving the Sustainable Development Goals (SDGs), particularly SDG 12 “Responsible Consumption and Production” and SDG 13 “Climate Action”, and contributes to forming a national system of “green” competitiveness.

### 11. Eco-Entropic Interpretation of Environmental Certification Effects

The information–entropy approach to analyzing environmental certification is based on the assumption that any economic system operates within flows of energy, matter, and information, which may be either ordered or chaotic [38]. High entropy reflects uncontrolled resource consumption, waste generation, and inefficient process organization. Conversely, entropy decreases when a system

transitions to structured management, i.e., when policies, norms, and procedures are established to regulate resource use.

Formally, the level of environmental entropy in a hotel complex, denoted as ( $H_e$ ), can be described through the variance (uncertainty) of key indicators – energy (E), water (W), waste (R), and CO<sub>2</sub> emissions (C) – as follows:

$$H_e = - \sum_{i=1}^n p_i \ln p_i, \quad (2)$$

where ( $p_i$ ) represents the normalized proportion of each environmental flow (E, W, R, C) within the total resource circulation structure.

For non-certified hotels, the average entropy value ( $H_e$ ) equals 1.29, while for certified hotels, it decreases to 0.96, i.e., 25% lower, indicating a higher degree of system order [39].

Thus, implementing ISO 14001 or Green Key systems can be viewed as a mechanism of entropic self-regulation, where resource information (monitoring, reporting, control) reduces uncertainty and stabilizes the interaction between the enterprise and the environment.

### 12. Environmental Optimization of the “Hotel–Environment” System

Based on the previous indicators, a generalized model of environmental optimization was developed, where the objective is to minimize the total environmental impact ( $I_e$ ) under economic feasibility constraints:

$$I_e = w_1 \frac{E}{E_{ref}} + w_2 \frac{W}{W_{ref}} + w_3 \frac{R}{R_{ref}} + w_4 \frac{C}{C_{ref}} \rightarrow \min, \quad (3)$$

where ( $w_i$ ) are the weighting coefficients of indicator significance (in this study: ( $w_1 = 0,35$ ;  $w_2 = 0,25$ ;  $w_3 = 0,20$ ;  $w_4 = 0,20$ )).

Calculations for 50 certified hotels demonstrated that resource use optimization is achieved through combined measures: 30–35% – energy-efficient technologies (heat pumps, heat recovery, LED lighting); 25% – water-saving equipment (aerators, dual-flush systems); 20% – reduction of food waste; 20% – transition to renewable energy sources [40].

After implementing this comprehensive strategy, the integrated sustainability index ( $S_i$ ) increases from 0.71 to 0.87, corresponding to a 22% reduction in total environmental impact.

### 13. Information–Energy Balance of the System

In terms of information ecology, the “hotel–environment” system can be viewed as an

open thermodynamic structure in a quasi-stationary equilibrium between consumed and returned resource flows. Environmental certification introduces a feedback loop in the form of information flow (audits, reporting, inspections), which regulates the energy balance.

This relationship can be schematically represented as:

Raw and energy flows → operational processes → emissions/waste → informational control (EMS) → corrective actions → new cycle with reduced losses.

Thus, the information flow acts as a negative feedback mechanism that stabilizes the system.

Calculations show that the energy efficiency coefficient ( $\eta_E = E_{out}/E_{in}$ ) in certified establishments reaches 0.84, compared to 0.68 in conventional hotels – an improvement of approximately 24%. This indicates that the system is approaching a state of minimal entropy [41].

### 14. Relationship Between Environmental Certification and Environmental Safety

Within the framework of the neoelectological approach, environmental safety is understood as a balanced state between economic activity and natural processes, ensuring ecosystem functionality and a comfortable human environment [42].

The results show that certification systems contribute to achieving this balance through: reduction of anthropogenic pressure on air, water, and soils; mitigation of pollution risks (particularly from cleaning agents and food waste); improvement of sanitary and hygienic conditions within facilities; enhancement of staff environmental competence; strengthening the socio-economic resilience of enterprises.

Together, these factors form localized nodes of increased ecological stability, positively influencing territorial systems – cities, resorts, and recreational zones. Thus, certified hotels become integral elements of the regional environmental safety system, characterized by reduced entropy and enhanced predictability of environmental processes [43, 44].

### 15. Model of Integrating Eco-Certification into the Sustainable Development Strategy

Based on the conducted analysis, a model linking environmental certification and the achievement of Sustainable Development Goals (SDGs) is proposed, encompassing three levels:

1. Micro level (enterprise) – implementation of ISO 14001, EU Ecolabel, or Green Key; internal monitoring and environmental reporting.
2. Meso level (region) – formation of networks of certified establishments as elements of “green tourism clusters.”
3. Macro level (state) – integration of EMS into national environmental safety and tourism policies.

The results of this study confirm that the implementation of environmental standards in the hospitality industry is an effective instrument for environmental management and a key driver of sustainable development. Through a comprehensive analysis of ISO 14001, EU Ecolabel, and Green Key, their common features, specific criteria, scope of distribution, and ecological and economic outcomes were identified. The main findings can be summarized as follows:

It has been established that environmental certification in the hospitality sector reduces energy consumption by 20–25%, water consumption by 15–20%, waste generation by 30–35%, and CO<sub>2</sub> emissions by 20–25% compared to non-certified enterprises. These results confirm the effectiveness of Environmental Management Systems (EMS) as practical mechanisms for mitigating anthropogenic pressure on the environment.

An eco-entropic model of certification impact has been developed, describing the reduction of uncertainty (entropy) in environmental flows through the structuring of informational and resource processes within the “hotel–environment” system. It was found that EMS implementation reduces entropy by approximately 25%, thereby increasing the orderliness and predictability of enterprise functioning.

Environmental certification produces a dual positive effect: environmental, through the reduction of the impact on natural systems; and socio-economic, through higher profitability, improved customer loyalty, enhanced corporate image, and better working conditions for staff.

A SWOT analysis of EMS implementation in Ukraine’s hospitality industry revealed that the main strengths include significant tourism potential, the existence of the adapted DSTU ISO 14001:2015 standard, and the interest of international hotel chains. The weak-

The model envisions phased development: from pilot regions (Odesa, the Carpathians, Podillia) to a national program “Green Hospitality Ukraine,” which could serve as an analogue to European initiatives such as Blue Flag or Eco-Tourism Label [45].

Implementation of this system will not only reduce environmental risks but also enhance the tourism attractiveness of regions, which is particularly important for Ukraine’s post-war economic recovery.

### **Conclusions**

nesses include the absence of state incentives, limited financing, and a low level of environmental management culture among business owners.

A conceptual model for harmonizing European eco-standards (ISO 14001, EU Ecolabel, Green Key) in Ukraine has been proposed. It includes five key components: regulatory integration (recognition of European certificates); institutional support (creation of the Green Hospitality Ukraine center); financial incentives (tax reductions, grants); educational component (training programs for HoReCa managers); monitoring system (public registry of eco-certified facilities).

The developed provisions can be applied in state policy for sustainable tourism, particularly during the preparation of the National Strategy “Green Hospitality of Ukraine”; in university curricula for the fields of Hospitality and Restaurant Management, Management, and Environmental Safety; in the activities of professional associations (e.g., Ukrainian Hotel & Resort Association, Federation of Restaurateurs of Ukraine) for the development of sectoral eco-management standards; and in business consulting and environmental auditing during national implementation of ISO 14001 and Green Key systems.

For the first time in Ukraine’s hospitality sector, an information–entropy interpretation of environmental management has been proposed. It allows the certification process to be understood as a means of reducing entropy in an open economic–ecological system, thereby increasing systemic stability.

The implementation of EMS in the hotel and restaurant sector should be included among the priorities of Ukraine’s national environmental policy. It is necessary to establish financial and fiscal incentives (tax reductions, grants, low-interest loans for energy efficiency) and to introduce a state pilot program “Green

Hospitality Ukraine" to harmonize ISO 14001 and EU Ecolabel standards.

An important direction for the future is the development of educational and awareness programs to train specialists in environmental management for the service sector. It is also advisable to create a national open registry of enterprises certified under international eco-standards, with regular publication of environmental performance indicators.

Promising future research directions include: development of a regional environmental safety index for tourism areas; deepening the entropy-based analysis of resource flows in hotel operations; assessment of the impact of digital technologies (IoT, big data) on EMS efficiency; and modeling eco-economic risks associated with implementing sustainability standards in the context of post-war economic recovery.

### Conflict of Interest

The author declares no conflict of interest regarding the publication of this manuscript. Furthermore, the author has fully adhered to ethical norms, including avoiding plagiarism, data falsification, and duplicate publication.

The work does not use artificial intelligence resources.

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## ЄВРОПЕЙСЬКИЙ ДОСВІД І ПЕРСПЕКТИВИ ВПРОВАДЖЕННЯ ЕКОЛОГІЧНОЇ СЕРТИФІКАЦІЇ У СФЕРІ ГОСТИННОСТІ УКРАЇНИ

**Мета.** Аналіз європейського досвіду впровадження систем екологічної сертифікації у сфері гостинності (ISO 14001, EU Ecolabel, Green Key) та визначити перспективи їх адаптації в Україні. Особливу увагу приділено ролі екологічної сертифікації як інструменту управління сталим розвитком готельно-ресторанного бізнесу, підвищення його екологічної безпеки та конкурентоспроможності.

**Методи.** Використано системно-аналітичний, порівняльний, статистичний та інформаційно-ентропійний підходи.

**Результати.** Джерельну базу становлять офіційні європейські реєстри (EU Ecolabel, Green Key, EMAS), дані Eurostat, Hotel Footprinting 2024, а також наукові публікації Scopus і WoS (Velaoras et al., 2025; Abdou et al., 2020; Prakash et al., 2022). Здійснено аналіз кількісних показників енерго- та водоспоживання, викидів CO<sub>2</sub> та рівня сертифікації підприємств HoReCa у країнах ЄС. Встановлено, що у країнах ЄС понад 4200 засобів розміщення мають сертифікат Green Key, а близько 900 – EU Ecolabel; найвищі темпи поширення зафіксовано у Данії, Франції, Іспанії та Італії. Запровадження стандартів ISO 14001 дозволяє знизити енергоспоживання на 15–25 %, водоспоживання – на 20 %, утворення відходів – до 30 %. Виявлено основні бар’єри для України: відсутність економічних стимулів, низький рівень екологічної культури персоналу, нестача сертифікованих аудиторів. Запропоновано модель національної ініціативи «Green Hospitality UA», що базується на принципах EU Ecolabel та Green Deal Policy.

**Висновки.** Екологічна сертифікація є дієвим механізмом підвищення екологічної безпеки та сталого розвитку готельно-ресторанних підприємств. Адаптація стандартів ЄС в Україні сприятиме зменшенню антропогенного навантаження, зростанню енергоефективності й формуванню позитивного екологічного іміджу українського HoReCa-сектору. Подальші дослідження доцільно зосередити на економічному моделюванні ефектів екосертифікації та інтеграції її в державну політику туризму й екологічного менеджменту.

**КЛЮЧОВІ СЛОВА:** екологічна сертифікація, сталий розвиток, готельно-ресторанний бізнес, EU Ecolabel, Green Key, ISO 14001

### Конфлікт інтересів

Автор заявляє, що конфлікту інтересів щодо публікації цього рукопису немає. Крім того, автор повністю дотримувався етичних норм, включаючи plagiat, фальсифікацію даних та подвійну публікацію.

В роботі не використано ресурс штучного інтелекту.

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