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**Green Logistics in Europe: A Sustainable Development Strategy Using
the Example of Germany**

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Abstract. The article examines the theoretical and practical aspects of implementing green logistics as a tool for advancing the concept of sustainable development in the European Union, using Germany as a case study. The relevance of the topic is determined by the fact that the transport and logistics



sector contributes significantly to the European Union's gross domestic product and employment, while simultaneously remaining one of the largest sources of greenhouse gas emissions.

The purpose of the study is to generalize the theoretical foundations of sustainable development, to analyze the regulatory impact of the European Green Deal, the EU Taxonomy, and the Corporate Sustainability Reporting Directive, and to assess the decarbonization practices of leading German logistics companies.

Methods. The methodological framework is based on methods of analysis and synthesis, the comparative method, graphical analysis, SWOT analysis, a systems approach, and the method of generalization.

Results. The article outlines the evolution of the sustainable development concept from the works of Thomas Malthus, Vladimir Vernadsky, Donella Meadows, Dennis Meadows, Gro Harlem Brundtland, and Herman Daly to contemporary ESG-based corporate strategies.

An original hierarchical model of sustainable logistics is proposed, illustrating the interrelationship between the United Nations Sustainable Development Goals, the European regulatory framework, ESG principles, corporate technologies, CO₂ emission reductions, and enhanced competitiveness.

The study includes a SWOT analysis of green logistics in Europe and a comparative assessment of its development in the European Union and Ukraine.

Practical solutions implemented by Hapag-Lloyd, DHL Group, and DB Schenker are analyzed, with particular attention to electric vehicles, biofuels, sustainable aviation fuel (SAF), hydrogen technologies, digitalization, and circular economy practices. The findings indicate that DHL operates more than 39,000 electric vehicles and aims to increase the share of electrified first- and last-mile transport to 66% by 2030; Hapag-Lloyd seeks to reduce greenhouse gas



emissions by approximately 33% by 2030; and the use of SAF and biofuels can reduce emissions by up to 80–90%.

A forecast for the development of green logistics through 2030, a system of key performance indicators (KPIs), and practical recommendations for Ukrainian enterprises are developed.

It is substantiated that the implementation of green logistics principles enhances resource efficiency, investment attractiveness, and the long-term competitiveness of companies.

Conclusions. The article argues that, Green logistics is a key instrument for implementing sustainable development principles in the transport and logistics sector. The experience of Hapag-Lloyd, DHL Group, and DB Schenker demonstrates that the use of electric vehicles, alternative fuels, digital technologies, and circular economy practices reduces greenhouse gas emissions and enhances operational efficiency and competitiveness. The proposed recommendations can be applied by Ukrainian enterprises to support decarbonization and integration into European supply chains.

Keywords: sustainable development, green logistics, ESG, European Green Deal, decarbonization, electric vehicles, alternative fuels, key performance indicators, Germany, European Union.

Зелена логістика в Європі: стратегія сталого розвитку на прикладі Німеччини

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Анотація. У статті досліджено теоретичні та практичні аспекти впровадження зеленої логістики як інструменту реалізації концепції сталого розвитку в країнах Європейського Союзу на прикладі Німеччини. Актуальність теми зумовлена тим, що транспортно-логістична галузь забезпечує значну частку валового внутрішнього продукту та зайнятості в ЄС, але водночас є одним із найбільших джерел викидів парникових газів.

Метою дослідження є узагальнення теоретичних засад сталого розвитку, аналіз регуляторного впливу European Green Deal, EU Taxonomy та Corporate Sustainability Reporting Directive, а також оцінка практик провідних логістичних компаній Німеччини щодо декарбонізації логістичних процесів.

Методи. Методологічну основу становлять методи аналізу та синтезу, порівняльний метод, графічний метод, SWOT-аналіз, системний підхід та метод узагальнення.

Результати. У роботі розкрито еволюцію концепції сталого розвитку від праць Т. Мальтуса, В. Вернадського, Д. і Д. Медоуз, Г. Г. Брундтланд та Г. Дейлі до сучасних ESG-стратегій бізнесу.

Запропоновано авторську модель ієрархії сталої логістики, яка відображає взаємозв'язок між Цілями сталого розвитку ООН, європейською нормативною базою, ESG-принципами, корпоративними технологіями, скороченням викидів CO₂ та зростанням конкурентоспроможності.



Проведено SWOT-аналіз зеленої логістики в Європі та порівняння стану її розвитку в ЄС та Україні.

Проаналізовано практичні рішення Narag-Lloyd, DHL Group та DB Schenker щодо використання електротранспорту, біопалива, SAF, водневих технологій, цифровізації та циркулярної економіки. Встановлено, що DHL експлуатує понад 39 тис. електромобілів і планує довести частку електрифікованого транспорту до 66% до 2030 року, Narag-Lloyd прагне скоротити викиди приблизно на 33%, а використання SAF і біопалива забезпечує скорочення викидів до 80–90%.

Розроблено прогноз розвитку зеленої логістики до 2030 року, систему ключових KPI та практичні рекомендації для підприємств України.

Обґрунтовано, що впровадження принципів зеленої логістики підвищує ресурсну ефективність, інвестиційну привабливість і конкурентоспроможність компаній.

Висновки. У статті стверджується, що зелена логістика є ключовим інструментом для впровадження принципів сталого розвитку в транспортно-логістичному секторі. Досвід Narag-Lloyd, DHL Group та DB Schenker демонструє, що використання електромобілів, альтернативних видів палива, цифрових технологій та практик циркулярної економіки зменшує викиди парникових газів та підвищує операційну ефективність і конкурентоспроможність. Запропоновані рекомендації можуть бути застосовані українськими підприємствами для підтримки декарбонізації та інтеграції в європейські ланцюги поставок.

Ключові слова: сталий розвиток, зелена логістика, ESG, European Green Deal, декарбонізація, електротранспорт, альтернативні види палива, KPI, Німеччина, Європейський Союз.



Problem Statement. Sustainable development is a key concept in the European economy. It is achieved through a balanced combination of economic growth, social responsibility, and environmental safety.

This topic is particularly significant for the transport and logistics industry. Logistics is a core sector of the European economy, accounting for approximately 8–12% of the GDP in a broad sense and about 5–7% in a narrower sense (specifically, transport and warehousing). Furthermore, it provides roughly 7–10% of total employment in the EU [1].

The industry is of strategic importance to the functioning of the internal market and international trade. Sea transport handles about 90% of external trade shipments, while road logistics accounts for nearly 75% of domestic freight. This massive scale is driven by the deep integration of EU economies, highly developed port infrastructure, and the operations of global logistics providers. Consequently, logistics is not merely an auxiliary function, but a fundamental pillar of the European economic system [2].

At the same time, this sector remains one of the largest sources of greenhouse gas emissions. This substantial environmental footprint makes it critical to implement sustainable development principles aimed at decarbonization, enhancing energy efficiency, and transitioning to eco-friendly technologies across logistics supply chains.

Analysis of recent research and publications. A significant number of foreign and Ukrainian scholars have explored the issues of sustainable development. The origins of the sustainable development concept trace back to leading international researchers, including D. Meadows, G. H. Brundtland, H. Daly, and R. Costanza. They established the theoretical foundations for a balanced integration of economic growth, social welfare, and environmental protection [3-6].



The further development of this concept is reflected in the works of numerous international and Ukrainian scientists, specifically J. Sachs, J. Elkington, M. Khvesyuk, B. Danylyshyn, L. Melnyk, O. Veklych, and V. Heyets. They investigated the mechanisms of greening the economy, resource efficiency, and ensuring the balanced development of society [7-12].

T. Malthus, in his work «An Essay on the Principle of Population», was among the first to highlight the limitations of land resources. He warned that population growth outpaces food production, and therefore humanity must consciously curb its consumption [3].

V. Vernadsky, in his essay «A Few Words About the Noosphere», emphasized that humans and nature are an inseparable whole. Since humanity has become a powerful geological force, its economic activities must be guided by reason and the laws of biosphere conservation [4].

Donella and Dennis Meadows utilized mathematical modeling as the authors of «The Limits to Growth report». They were the first to translate ecological concerns into precise figures and graphs, proving the destructiveness of uncontrolled capitalist growth [4].

G. H. Brundtland, in the report «Our Common Future, integrated ecology and economics into a single system», proposing the concept of sustainable development. The aim of this work was to meet the needs of the present generation without compromising the ability of future generations to meet their own needs, achieved through a balance of social justice, environmental safety, and economic growth [5].

H. Daly, in his books «Beyond Growth: The Economics of Sustainable Development and Steady-State Economics», detailed the concept of ecological economics and formulated his renowned principles of sustainable development [6].



It is these ideas that laid the foundation for the subsequent development of sustainable development policies at the global level, particularly within the UN and the European Union. Furthermore, they became the theoretical basis for modern corporate strategies that are actively being implemented in the economies of Europe and worldwide today.

Identification of previously unresolved parts of the general problem.

Despite a significant amount of scientific research dedicated to sustainable development, transport decarbonization, and the greening of logistics processes, the issues of comprehensively integrating the theoretical foundations of green logistics with practical mechanisms for their implementation at the level of leading European companies remain insufficiently explored. Special attention is required to systematize modern decarbonization tools, evaluate the economic impact of their application, and determine the possibilities of adapting Germany's experience for enterprises in Ukraine's transport and logistics industry.

The aim of the article is to investigate the theoretical and practical aspects of implementing green logistics as a tool for realizing the concept of sustainable development in European Union countries, using Germany as a case study, as well as to determine the possibilities of adapting the European experience for enterprises in Ukraine's transport and logistics sector.

To achieve this aim, the article outlines the following objectives:

1. To summarize theoretical approaches to interpreting the essence of sustainable development and green logistics.
2. To explore the evolution of the sustainable development concept and its transformation into modern corporate ESG strategies.
3. To analyze the regulatory framework for the green transformation of logistics in the European Union, specifically the provisions of the European Green Deal, the EU Taxonomy, and the Corporate Sustainability Reporting Directive.



4. To develop an original hierarchical model of sustainable logistics that reflects the relationship between the UN Sustainable Development Goals, European regulatory requirements, and corporate decarbonization tools.

5. To conduct a SWOT analysis of green logistics development in Europe.

6. To examine the practices of leading German logistics companies, such as Hapag-Lloyd, DHL Group, and DB Schenker, regarding their use of electric transport, alternative fuels, digital technologies, and circular economy principles.

7. To evaluate the economic and environmental impact of implementing sustainable logistics based on companies' key performance indicators.

8. To compare the current state of green logistics development in the EU and Ukraine.

9. To formulate a forecast for the development of green logistics up to 2030.

10. To develop a system of key performance indicators (KPIs) and practical recommendations for the implementation of sustainable logistics principles by Ukrainian enterprises.

Fulfilling these objectives will help substantiate the significance of green logistics as a strategic factor in enhancing the environmental efficiency, investment attractiveness, and competitiveness of enterprises under the current conditions of European integration.

The scientific novelty of the study lies in systematizing modern trends in sustainable logistics and developing a comparative approach to evaluating the decarbonization practices of leading German logistics companies, such as Hapag-Lloyd, DHL Group, and DB Schenker. The article summarizes the interrelation



among the UN global Sustainable Development Goals, the EU regulatory framework, and corporate ESG strategies.

The practical significance of the obtained results lies in the opportunity for enterprises in Ukraine's transport and logistics industry to utilize the proposed approaches to develop decarbonization strategies, prepare ESG reporting, and adapt to the requirements of the European Green Deal.

Presentation of the main research material. A synthesis of theoretical approaches to sustainable development, an analysis of the European Union's regulatory framework, and an examination of the practical experience of leading logistics companies demonstrate a close interrelation among global strategic guidelines, regulatory mechanisms, and corporate decarbonization tools.

To systematize these interdependencies and visualize the sequential transition from international goals to specific economic outcomes, this study proposes an original hierarchical model of sustainable logistics. This model illustrates the relationship among the UN Sustainable Development Goals, the European Green Deal policy, the requirements of the EU Taxonomy and the CSRD, ESG principles, modern technological solutions in logistics, CO₂ emission reductions, and the enhanced competitiveness of enterprises (Fig. 1).

The proposed model demonstrates a sequential transition from global sustainable development goals to specific corporate solutions and the outcomes of their implementation, which shape the competitive advantages of logistics companies.

Next, we will examine the practical approaches to implementing sustainable logistics principles by leading European organizations.

In the European Union, sustainable development policy is implemented through a series of strategic and regulatory instruments that form a unified system for the ecological transformation of the economy [13].



Figure 1 Sustainable Logistics Hierarchy

Source: author(s)' own development



The European Commission has existed since the late 1950s and is one of the oldest institutions of European integration. It serves as the key executive body of the EU, developing and implementing sustainable development policies. It is the European Commission that initiates legislative acts in the field of climate neutrality, monitors their implementation by member states, and coordinates the realization of long-term strategies, particularly regarding emissions reduction and the green transformation of the economy [14].

The European Green Deal was officially presented by the European Commission in December 2019. The initiative was led by a team under the direction of Commission President Ursula von der Leyen. They introduced a comprehensive EU development strategy aimed at achieving climate neutrality by 2050. It entails reducing greenhouse gas emissions, transitioning to renewable energy sources, developing a circular economy, and improving energy efficiency across all sectors of the economy, including transport and logistics [15].

The EU Taxonomy Regulation was officially adopted in 2020 and began to be applied gradually from 2021. It is part of the European Green Deal's implementation. Its primary objective is to create a unified classification system for "environmentally sustainable" economic activities, establishing clear criteria of environmental compliance for businesses and financial institutions [16].

The Corporate Sustainability Reporting Directive (CSRD) was officially adopted in 2022 and is being gradually implemented from 2024. It represents an update and significant expansion of the previous Non-Financial Reporting Directive (NFRD). The main goal of this directive is to enhance the transparency, comparability, and reliability of corporate reporting regarding companies' impact on the environment, society, and governance [17].

The implementation of all the aforementioned EU initiatives and regulatory instruments - such as the European Green Deal, EU Taxonomy, and CSRD - creates a unified regulatory system for sustainable development that directly



affects business operations across all economic sectors. This is especially true for the logistics industry, which is critical to the functioning of the single European market but simultaneously has a substantial environmental footprint. That is why logistics has found itself at the center of the EU's green transformation as one of the priority sectors for decarbonization.

Alongside the opportunities for implementing green logistics in Europe, there are both strengths and prospects for development, as well as internal limitations and external risks. To systematize these factors, a SWOT analysis was conducted (Fig. 2).

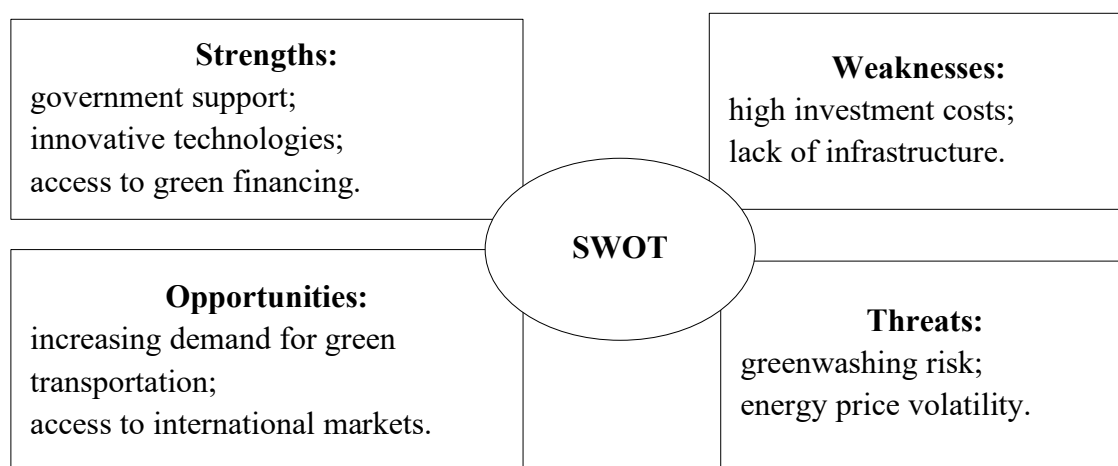


Figure 2. SWOT analysis of green logistics in Europe (author's development)

Source: author(s)' own development

The results of the SWOT analysis indicate that, despite the significant potential for the development of green logistics, there are challenges that require comprehensive managerial solutions and collaboration among the public sector, businesses, and academia.

Logistics encompasses the transportation, warehousing, and distribution of goods; simultaneously, it is one of the largest sources of greenhouse gas



emissions in the European Union. Overall, the transport sector generates approximately 25% of total EU greenhouse gas emissions.

Over 70% of these emissions come from road transport, which forms the backbone of freight logistics. Furthermore, transport remains the only major sector of the EU economy where emission levels still exceed the 1990 baseline figures, underscoring the complexity of its decarbonization (Figs. 3–5) [19].

The substantial consumption of fossil fuels remains a key driver of environmental strain, as the majority of transportation still relies on diesel and aviation fuels. Additionally, logistics operations generate vast amounts of packaging waste, exacerbating waste management challenges and highlighting the need to transition to circular economy models. Another notable issue is noise and air pollution, which is particularly severe along transport corridors, in ports, and around large logistics hubs, negatively impacting both the environment and public quality of life.

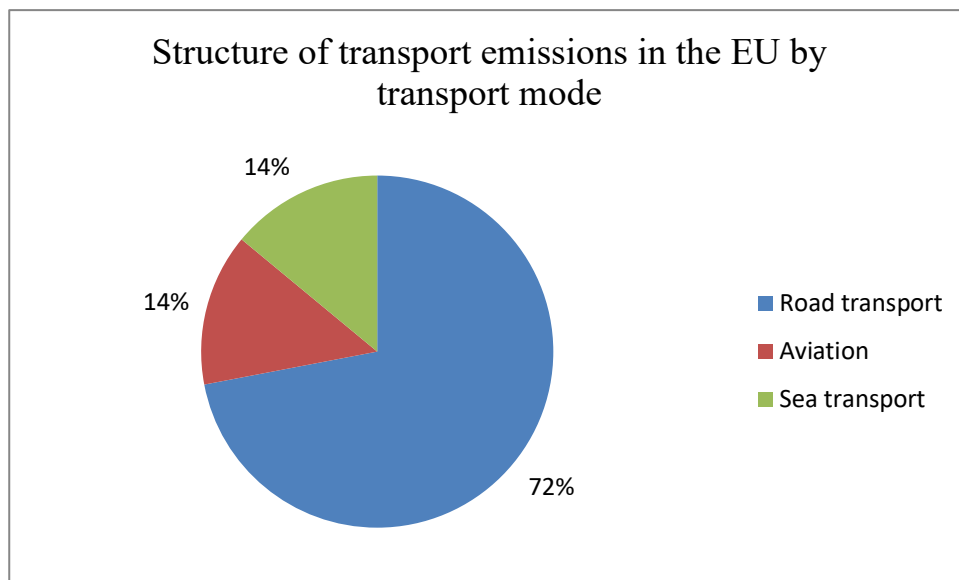


Figure. 3. Structure of transport emissions in the EU by transport mode

Source: compiled by the author based on analysis [19]

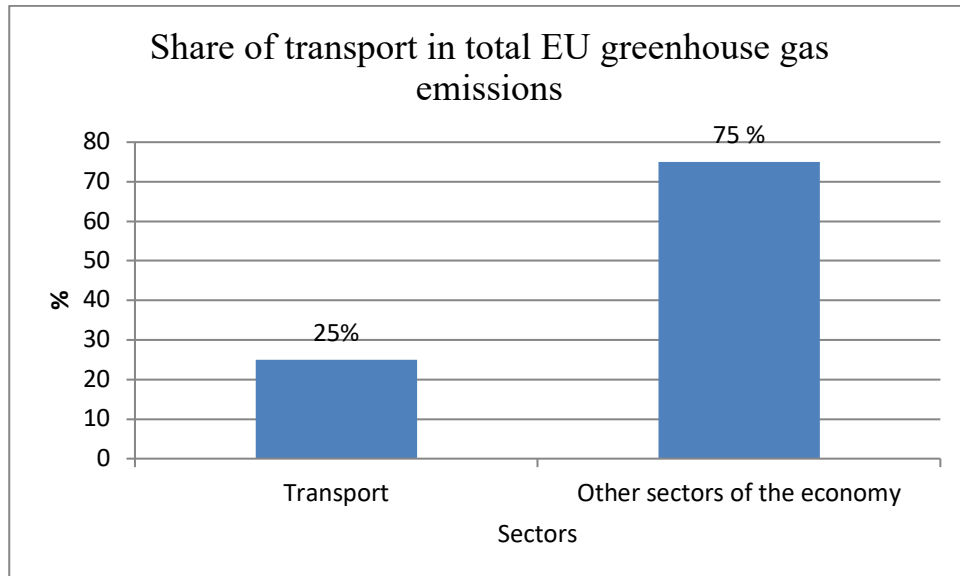


Figure. 4. Share of transport in total EU greenhouse gas emissions

Source: compiled by the author based on analysis [19]

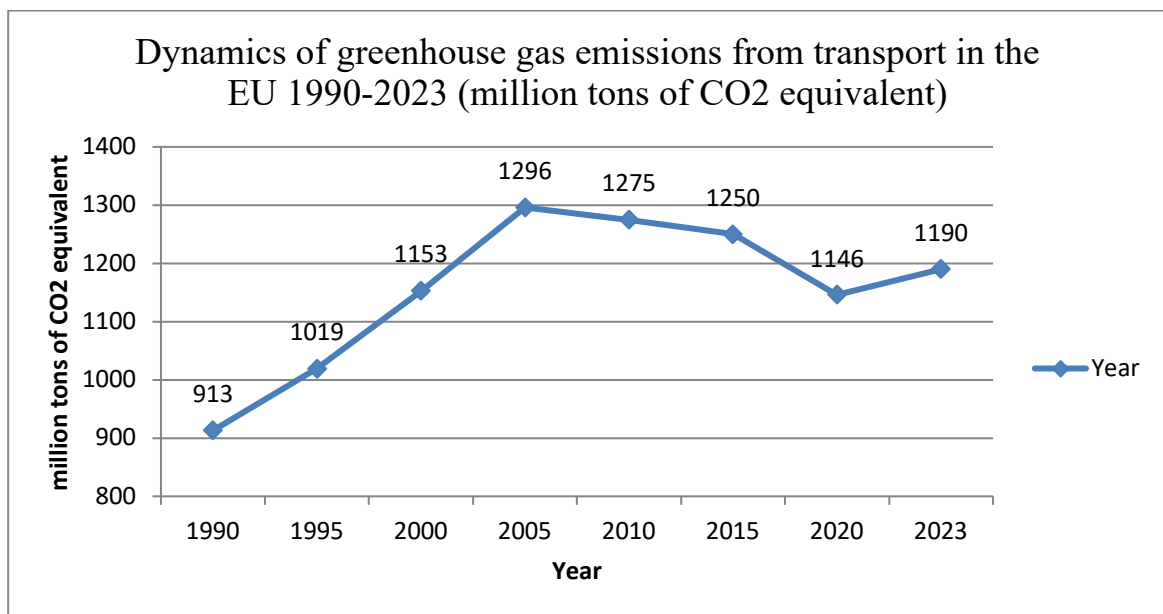


Figure. 5. Dynamics of greenhouse gas emissions from transport in the EU 1990-2023 (million tons of CO2 equivalent)

Source: compiled by the author based on analysis [19]

Germany holds a leading position in Europe in the field of sustainable logistics, combining innovation, digitalization, and green technologies. Major



logistics companies in the country have long transitioned from isolated "green initiatives" to comprehensive decarbonization strategies. Prominent among these are Hapag-Lloyd, DHL Group, and DB Schenker (Fig. 6).

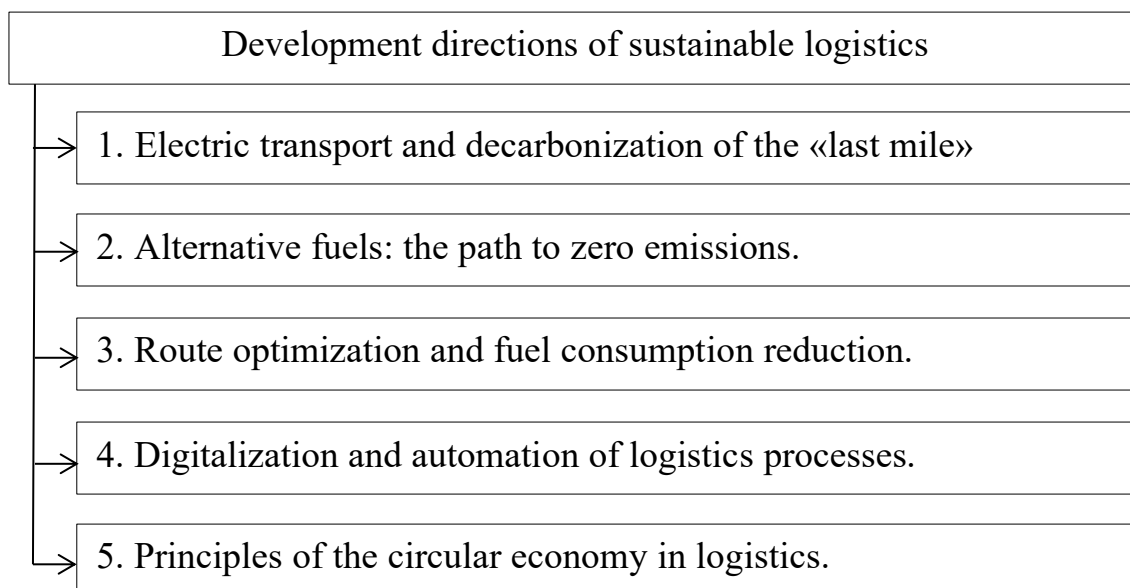


Figure 6. Development directions of sustainable logistics

Source: compiled by the author based on analysis [19]

1. Transport electrification is one of the key pillars of sustainable logistics.

DHL Group is an undisputed leader in integrating electric vehicles into urban delivery. The company is actively expanding its fleet of electric trucks, e-bikes, and micromobility solutions for last-mile delivery, particularly in European cities. This allows for a significant reduction in CO₂ emissions in densely populated areas.

DB Schenker is also actively rolling out electric trucks, particularly for regional freight. The company views electric transport as a component of multimodal logistics, combining it with rail transport.

Hapag-Lloyd employs electric transport indirectly, specifically within port infrastructure, by electrifying terminal operations and container handling equipment.



2. The transition to alternative fuels is a key element of logistics decarbonization.

Hapag-Lloyd actively tests and utilizes biofuels for container ships and invests in promising marine fuels of the future, namely green ammonia and methanol. This is a strategically vital direction for reducing emissions in maritime shipping, which is traditionally highly energy-intensive.

DHL Group focuses on aviation logistics, utilizing Sustainable Aviation Fuel (SAF) in collaboration with international partners. This approach helps reduce the carbon footprint of air freight, which is the most carbon-intensive segment of logistics.

DB Schenker actively uses biodiesel and HVO (Hydrotreated Vegetable Oil) while also testing hydrogen technologies for freight transport, which could mark a crucial milestone in the transition to zero emissions.

3. Modern logistics is impossible without digital optimization.

Hapag-Lloyd utilizes artificial intelligence systems for planning maritime routes and vessel speeds, particularly the "slow steaming" approach, which significantly reduces fuel consumption.

DHL Group uses real-time algorithms to optimize courier and freight routes, minimizing "empty runs" and increasing delivery efficiency.

DB Schenker develops multimodal solutions by combining road, rail, and sea transport to select the least energy-intensive routes.

4. Digital technologies form the foundation of the sustainable transformation of logistics.

DHL Group implements warehouse robotics, artificial intelligence for demand forecasting, and automated sorting centers, thereby improving the accuracy and speed of cargo handling.

DB Schenker utilizes IoT solutions for freight tracking and digital platforms for supply chain management.



Hapag-Lloyd develops digital services for customers, including real-time container tracking and transport efficiency analytics.

5. The circular economy is becoming an essential component of logistics strategies.

DHL Group is advancing reverse logistics, which is particularly vital for e-commerce, and is working on packaging optimization and the reuse of materials.

DB Schenker implements solutions for the recycling of industrial goods and the reuse of components within production chains.

Hapag-Lloyd focuses on container reuse and waste reduction in maritime operations, contributing to more efficient resource utilization. A comparison of sustainable development approaches, using Hapag-Lloyd and DHL Group as examples, is presented in Table 1.

Table 1. Comparison of approaches to sustainable development

Criterion	UN (SDGs)	EU	ESG approach	Logistics companies	Examples	Risks and challenges
				Hapag-Lloyd, DHL	Hapag-Lloyd, DHL	
Level of application	Global	Regional (EU)	Corporate-investment	Operational business level	Hapag-Lloyd maritime transport; DHL global delivery	Difficulty in harmonizing global standards between countries
Main goal	Global sustainable development	Climate neutrality	Company risk assessment	Decarbonization of logistics	Hapag-Lloyd - net-zero by 2045; DHL - net-zero by 2050	High cost of transition to «green» technologies
Nature of approach	Strategic	Regulatory	Analytical	Practical	DHL - GoGreen; Hapag-Lloyd - Ship Green	Regulatory pressure and compliance complexity
Specificity of requirements	Low	High	Medium	Very high	DHL - electric fleet; Hapag-Lloyd - LNG vessels	Technological limitations of alternative fuels



Main tools	SDGs	Green Deal, CSRD	SG ratings	Decarbonization technologies	DHL - SAF, electric vehicles; Hapag-Lloyd - biofuels	Lack of infrastructure for new technologies
Motivation	Global development	EU policy	Investment attractiveness	Competitiveness	DHL - delivery efficiency; Hapag-Lloyd - customer requirements	Competition between companies and the speed of market changes
Monitoring and evaluation	International indicators	Government control	ESG rating	Company KPIs	DHL - CO ₂ reduction; Hapag-Lloyd - reporting	Risk of greenwashing and reporting inaccuracies
Main focus	Balance of economy and society	Green transformation	Risk management	Practical decarbonization	DHL - electric delivery; Hapag-Lloyd - fleet modernization	Long payback period of investments

Source: authors' own development

The experience of leading German logistics companies demonstrates that sustainable development is a strategic necessity. Hapag-Lloyd is shaping the environmental future of maritime shipping through the adoption of alternative fuels and vessel optimization. DHL Group sets the benchmark for green urban and aviation logistics. DB Schenker is advancing multimodal and industrial solutions with a primary focus on decarbonization. Together, these companies form the bedrock of sustainable logistics in Europe and define global trends for industry-wide transformation.

The implementation of sustainable logistics principles yields not only environmental benefits but also substantial economic advantages for companies. The key performance indicators for leading German logistics firms are presented below (Fig. 7).

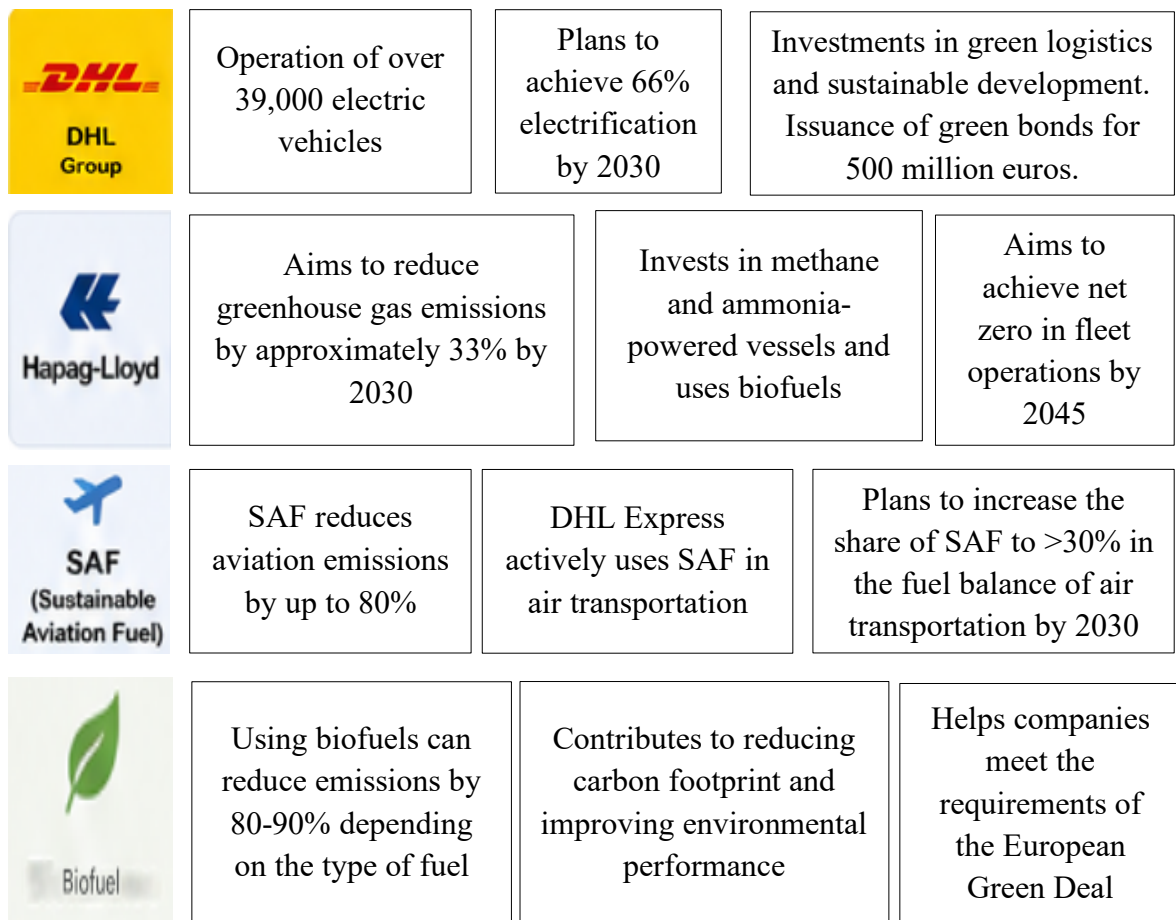


Figure 7. Economic effect of implementing sustainable logistics

Source: authors' own development

These figures demonstrate that investments in sustainable technologies pay off through reduced fuel costs, enhanced operational efficiency, improved brand reputation, and broader access to international markets.

In Ukraine, the implementation of sustainable logistics is currently in its early stages. Adapting the German experience can facilitate the modernization of transport infrastructure, the reduction of the carbon footprint, and the integration of Ukrainian companies into European supply chains (Table 2).



Table 2 Comparison of the state of sustainable logistics in Germany and Ukraine

Indicator	Germany	Ukraine
Regulatory framework	Strict environmental standards, EU Taxonomy, CSRD, state support	Legislation is being formed, there are no mandatory ESG standards for most companies
Infrastructure	Developed network of railway, port and intermodal terminals, electric charging infrastructure	Limited infrastructure, worn-out fixed assets, insufficient number of charging stations
Energy	Active transition to RES, >95% of electricity in DHL from renewable sources	Share of RES is growing, but dependence on fossil fuels remains high
Technologies	Wide use of AI, IoT, automation, eco-transport	Local and fragmented technology implementation
Financing	Access to green financing, subsidies and soft loans	Limited access to green financing instruments
CO2 emissions in logistics	Systemic emission reduction, decarbonization targets by 2030–2050	Absence of systemic targets, high emission intensity

Source: authors' own development

Ukraine's transition toward green logistics models requires robust government support, infrastructure investment, the development of a regulatory framework, and active collaboration with European partners.

By 2030, green logistics will become the industry standard for all companies operating within the European market. The primary development vectors will include transport electrification, the use of alternative fuels, large-scale digitalization, and increasingly stringent ESG reporting requirements (Fig. 8).

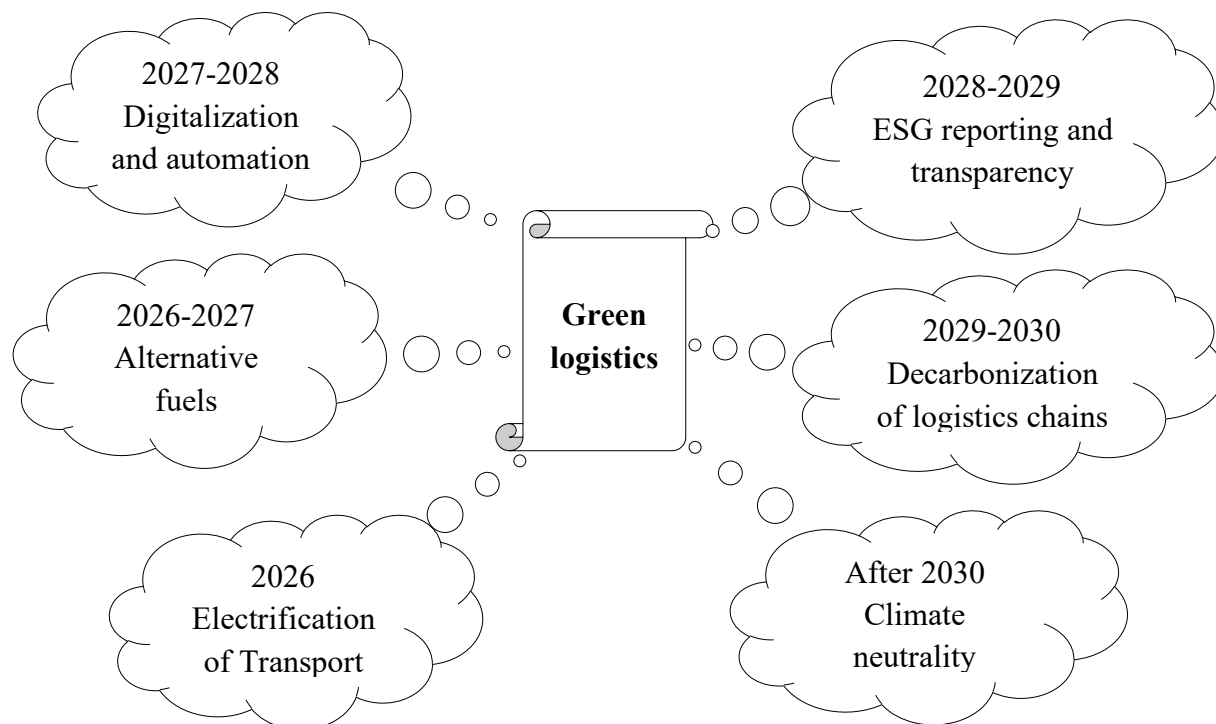


Figure 8. Forecast of green logistics development until 2030

Source: compiled by the author based on analysis [19]

Key performance indicators (KPIs) are used to assess the effectiveness of implementing sustainable development principles (Table 3).

Table 3. Key KPIs of sustainable logistics

KPI	Target value by 2030
CO ₂ per tonne-kilometre	↓20-50%
Share of electric transport	up to 66%
Share of SAF in the fuel balance of air transport	>30%
Use of renewable electricity	up to 100%
Share of recycled packaging materials	>80%

Source: authors' own development

Based on the conducted research, the following recommendations are proposed to accelerate the transition to sustainable logistics:

1. Expand the use of electric transport. Increase the share of electric vehicles in urban and regional logistics and focus on infrastructure development.



2. Invest in SAF, HVO, and hydrogen technologies. Transition to alternative fuels by supporting pilot projects and strategic partnerships.
3. Implement AI and IoT for route optimization. Utilize digital technologies to reduce fuel consumption, travel time, and emissions.
4. Develop circular logistics. Increase resource reuse, optimize packaging, and enhance reverse logistics operations.
5. Improve the transparency of ESG reporting. Ensure data openness and integrate ESG principles into core strategies and business processes.

The implementation of these recommendations will help enhance corporate competitiveness, reduce environmental footprints, and facilitate integration into the European and global logistics space.

In conclusion, green logistics is transforming from a purely environmental initiative into a key driver of competitiveness, investment attractiveness, and strategic resilience for companies in the global economy.

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