

SUSTAINABLE LOGISTICS: TRANSPORT SOLUTIONS TAKING INTO ACCOUNT ENVIRONMENTAL LIMITATIONS

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Анотація

У доповіді досліджено роль транспортної логістики у забезпеченні сталого розвитку економіки та розглянуто сучасні транспортні рішення з урахуванням екологічних обмежень. Проаналізовано вплив транспортних операцій на навколишнє середовище та визначено ключові проблеми, пов'язані з викидами парникових газів, шумовим забрудненням і енергоспоживанням. Розглянуто способи зменшення негативного екологічного впливу через оптимізацію маршрутів, впровадження екологічно чистих транспортних засобів та застосування цифрових технологій управління перевезеннями.

Ключові слова: сталий розвиток; транспортна логістика; екологічні обмеження; оптимізація маршрутів; цифрові технології; екологічно чистий транспорт.

Abstract

The report examines the role of transport logistics in achieving sustainable economic development and analyzes modern transport solutions considering environmental constraints. The impact of transport operations on the environment is evaluated, with attention to greenhouse gas emissions, noise pollution, and energy consumption. Methods to reduce environmental impact through route optimization, implementation of eco-friendly vehicles, and use of digital transport management systems are considered.

Keywords: sustainable development; transport logistics; environmental constraints; route optimization; digital technologies; eco-friendly transport.

Modern transport logistics requires a comprehensive approach to assessing transportation efficiency, which includes not only economic but also environmental indicators (Table 1).

Table 1 – Comparative environmental characteristics of different modes of transport

Type of transport	CO ₂ emissions, g/t·km	Energy consumption, MJ/t km	Noise level, dB	Notes on environmental friendliness
Automobile	120–150	2,5–3,0	70–85	High route flexibility, but high emissions when transporting over long distances
Railway	20–30	0,8–1,2	60–70	Energy efficient for long-distance mass transportation
Water	10–25	0,5–1,0	55–65	Lowest energy consumption per ton of cargo, depending on the navigation season
Aviation	500–600	10–12	75–90	High emissions and energy consumption, used for urgent cargo
Pipeline	5–15	0,3–0,5	50–60	High stability and efficiency for liquid and gaseous cargoes, limited versatility

One of the key areas of greening transport logistics is the optimization of routes and cargo flows. Rational route planning allows you to reduce empty runs, reduce fuel consumption and reduce emissions of harmful substances. Thus, in urban distribution, the use of route optimization algorithms allows you to reduce

delivery time by 20–30% and simultaneously reduce CO₂ emissions. The use of multimodal transportation, combining road, rail and water transport, is especially effective. Rail transport provides economical transportation of large volumes over long distances, water transport minimizes energy consumption in mass transportation, and road transport guarantees door-to-door delivery and fast service of small-batch cargo.

An equally important area is the use of environmentally friendly and energy-efficient transport. The use of electric and hybrid cars, vehicles running on hydrogen or biofuels allows you to significantly reduce emissions of CO₂, nitrogen oxides and particulate matter into the atmosphere. This is especially true for large cities and industrial regions, where the transport sector is the main source of pollution. In addition to environmental benefits, the introduction of such modes of transport helps reduce operating costs, increase energy efficiency of transportation and extend the life of vehicles.

The digitalization of transport processes is of great importance in modern logistics. The use of transport management systems (TMS), GPS monitoring, automated route planning and analytical platforms allows you to quickly adjust transport schedules, avoid congestion and increase the transparency of logistics processes. Such digital solutions contribute to accurate forecasting of transport needs, optimization of cargo flows and cost reduction, while simultaneously reducing the environmental burden on the transport system. For example, the integration of GPS systems with dynamic route planning programs allows you to reduce the mileage of empty vehicles and reduce total CO₂ emissions by 15–25% on large logistics routes.

Particular attention is paid to rail and water transport, which are more environmentally friendly and energy efficient. Rail transport provides high load capacity and stability of long-distance transportation, while the level of emissions per ton of cargo is significantly lower than that of road transport. Water transport allows moving large volumes of cargo with minimal energy consumption and reduces the load on the road network. The use of combined routes that combine different modes of transport allows optimizing logistics parameters, reducing costs and ensuring a more sustainable operation of the transport system.

An equally important factor is state support for environmental innovations in transport, which provides financial incentives for enterprises that introduce energy-efficient and emission-free vehicles, preferential taxation and the development of infrastructure for alternative fuels. Harmonization of national standards with international environmental standards allows enterprises to integrate into global logistics chains and adhere to high standards of environmental safety.

Thus, the integration of environmental principles into transport logistics ensures the simultaneous combination of economic efficiency, social responsibility and environmental safety, which is a key condition for the implementation of sustainable development of logistics systems and increasing the competitiveness of enterprises in the long term.

Conclusions

The integration of environmental principles into transport logistics is a necessary condition for sustainable economic development. Route optimization, the introduction of environmentally friendly transport and the use of digital technologies allow reducing the negative impact on the environment and increasing the efficiency of transportation. State support and harmonization of national legislation with international standards create conditions for the safe and sustainable functioning of transport systems.

LITERATURE

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