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# ON THE APPLICATION OF THE CONCEPT OF CIRCULAR ECONOMY TO ENSURE BALANCED SUSTAINABLE DEVELOPMENT OF THE NATIONAL LOGISTICS SYSTEM IN UKRAINE

***Hryhorak Mariia, Dzwigol Henryk, Kwilinski Aleksy, Trushkina Nataliia, Ovdiienko Oksana. "On the application of the concept of circular economy to ensure balanced sustainable development of the***

***national logistics system in Ukraine".*** *The evolution and preconditions of formation, challenges and factors for circular economy development are investigated in the article. Were analyzed and generalized the existing scientific approaches to the definition of "circular economy", which are conditionally systematized into 9 groups: section of economy, paradigm, strategy, model, system, ecological opportunity, recycling technology, tool of "green" economy, type of economic activity. It is proposed to consider the term "circular economy" from such aspects as: the modern paradigm of logistics systems' development; sustainable development strategy; sustainable business model of the national economy; economic model based on industrial waste recycling technology; logistics flow management tool, which is based on an integrated approach (integration of system, process, situational, functional); activities aimed at implementing a closed cycle of logistics flows to increase the level of the national economy environmental security.*

*Were was accomplished a statistical analysis of the national logistics system development in consideration of the environmental component. It was established that the "green" transformation of Ukrainian logistics system in a circular economy is not effective enough. This is due to the limited amount of funding for environmental protection and insufficient development of the industrial waste recycling system. These issues require the development of a set of appropriate institutional measures and the adoption of radical logistics decisions based on European best practices.*

***Keywords****:* national economy, logistics system, circular economy, sustainable development, strategy, paradigm, waste recycling, statistical analysis, conceptual approaches, systematization, effect.

***Григорак Марія, Джвігол Хенрик, Квілінський Олексій, Трушкіна Наталія, Овдієнко Оксана. "Щодо застосування концепції циркулярної економіки для забезпечення збалансованого сталого розвитку національної логістичної системи в Україні".*** *У статті досліджено еволюцію та передумови становлення, виклики та чинники розвитку циркулярної економіки. Проаналізовано й узагальнено існуючі наукові підходи до визначення поняття «циркулярна економіка», які умовно систематизовано за 9 групами: розділ економіки, парадигма, стратегія, модель, система, екологічна можливість, технологія рециклінгу, інструмент «зеленої» економіки, вид господарської діяльності.*

*Запропоновано термін «циркулярна економіка» розглядати з таких позицій, як: сучасну парадигму розвитку логістичних систем; стратегію збалансованого сталого розвитку; стійку бізнес-модель національної економіки; економічну модель, яку засновано на технології рециклінгу промислових відходів; інструмент управління логістичними потоками, який грунтується на комплексному (інтеграція системного, процесного, ситуаційного, функціонального) підході; діяльність, яку спрямовано на реалізацію замкнутого циклу логістичних потоків задля підвищення рівня екологічної безпеки національної економіки.*

*Виконано статистичний аналіз розвитку національної логістичної системи з урахуванням екологічної складової. Встановлено, що «зелена» трансформація логістичної системи України в умовах циркулярної економіки відбувається недостатньо ефективно. Це пов'язано з обмеженим обсягом фінансування сфери охорони навколишнього природного середовища та недостатнім розвитком системи рециклінгу промислових відходів. Ці питання вимагають розроблення комплексу відповідних інституційних заходів і прийняття кардинальних логістичних рішень з урахуванням передового європейського досвіду.*

***Ключові слова:*** національна економіка, логістична система, циркулярна економіка, сталий розвиток, стратегія, парадигма, рециклінг відходів, статистичний аналіз, концептуальні підходи, систематизація, ефект.

***Григорак Мария, Джвигол Хенрик, Квилинський Алексей, Трушкина Наталья, Овдиенко Оксана. "О применении концепции циркулярной экономики для обеспечения сбалансированного устойчивого развития национальной логистической системы в Украине".*** *В статье исследована эволюция и предпосылки становления, вызовы и факторы развития циркулярной экономики. Проанализированы и обобщены существующие научные подходы к определению понятия «циркулярная экономика», которые условно систематизированы по 9 группам: раздел экономики, парадигма, стратегия, модель, система, экологическая возможность, технология рециклинга, инструмент «зеленой» экономики, вид хозяйственной деятельности.*

*Предложен термин «циркулярная экономика» рассматривать с таких позиций, как: современную парадигму развития логистических систем; стратегию сбалансированного устойчивого развития; устойчивую бизнес-модель национальной экономики; экономическую модель, основанную на технологии рециклинга промышленных отходов; инструмент управления логистическими потоками, основанный на комплексном (интеграция системного, процессного, ситуационного, функционального) подходе; деятельность, которая направлена на реализацию замкнутого цикла логистических потоков для повышения уровня экологической безопасности национальной экономики.*

*Выполнен статистический анализ развития национальной логистической системы с учетом экологической составляющей. Установлено, что «зеленая» трансформация логистической системы Украины в условиях циркулярной экономики происходит недостаточно эффективно. Это связано с ограниченным объемом финансирования сферы охраны окружающей среды и развитием системы рециклинга промышленных отходов. Эти вопросы требуют разработки комплекса соответствующих институциональных мероприятий и принятия кардинальных логистических решений с учетом передового европейского опыта.*

***Ключевые слова:*** национальная экономика, логистическая система, циркулярная экономика, устойчивое развитие, стратегия, парадигма, рециклинг отходов, статистический анализ, концептуальные подходы, систематизация, эффект.

**Problem statement.** The aggravation of modern environmental problems in the global world is mainly due to the use of the traditional economic model, which is no longer effective from an environmental point of view. Therefore, achieving a balanced sustainable operation of logistics systems at different levels requires launching both organization-managerial and green technologies, as well as innovative business models aimed at reducing the negative impact on the environment. This is in compliance with the concept of green growth proposed by the Organisation for Economic Co-operation and Development and the European Green Deal, which provides the solution of climatic problems, the reduction of greenhouse gas emissions, the the share of renewable energy sources increase. Ukraine has also joined the implementation of the European Green Deal.

As international experience shows, increasing the level of environmental safety of the national economy can be achieved by introducing conceptually new management tools based on integrated approaches (integration of system, process, situational, functional), concepts of "lean" production, sustainable development [1; 2].

Cirrently, leading scientists are conducting scientific discussions on the "green growth" concept implementation in order to preserve the environment and improve the economic activity of enterprises. The desire of companies to form an ecological image of consumers has contributed to the development of the sustainable logistics concept [3], which includes "green" components and considers economic, social and environmental activities in the context of logistics management.

Therefore, at present it is necessary to look for innovative tools and introduce qualitatively new approaches to the formation and development of logistics systems. The circular economy is one of the priority tools as one of the key instruments for developing and implementing the overall business strategy nowadays.

**Analysis of recent research and publications.** The term "green economy" was first mentioned in 1989 in a report by a group of leading economists for the government of the United Kingdom of Great Britain and Northern Ireland [4]. This concept became widespread during the global economic crisis of 2008-2009. Thus, in 2009 the UN Environment Program (UNEP) published a report "Global Green New Deal", which considered the goals, objectives, elements, incentives and directions of domestic policy, aimed at developing a green economy. The

green economy was mostly defined as a practical approach to achieving sustainable development.

Currently, the concept of green economy is being actively discussed by scientists, experts, businesses and non-governmental organization (NGOs). UNEP experts [5] formulate a green economy as an economy that improves human well-being and social justice and at the same time significantly reduces environmental risks and environmental deficits. According to this concept, the priorities of the green economy are, on the one hand, the support and restoration of natural capital; use of renewable energy and low-carbon technologies for fossil fuels; improving the efficiency of resource and energy use; formation of responsible behavior of city residents; transition to low-carbon mobility; and on the other hand, creating new jobs and improving social justice.

In the last decade, leading academics have studied attentively a new concept of economic development, called "circular economy". According to the concept's supporters, circular growth will help overcome the climate crisis and contribute to the development of an inclusive green economy. The definition of this type of economy was formulated in the study of the experts from Oxford University in 2019 [6], based on a series of interviews conducted with participants in the Platform for Accelerating the Circular Economy (PACE). Respondents generally agreed that a closed-cycle economy is a regenerative type of economy that aims to preserve the greatest possible value of products, their components and materials, whose growth is not stimulated and does not depend on the use of limited resources. In essence, this type of economy is seen as a new trajectory of society on the path of sustainability.

The evolutionary development of the circular economy took place in three main stages [7]: Stage I (1970-1990) - work with waste; Stage II (1990-2010) - environmental efficiency strategies; Stage III (approximately 2010 - present) - maximum conservation in an era of resource depletion.

The transition from industrial to post-industrial society in the 60's of XX century, which is based on technological progress and innovative model of development, led to the emergence of the concept of circular economy in the scientific literature. The concept of circular economy was put forward in 1966 by the American economist Kenneth Boulding and had a pronounced ecological character: "... human must find his place in the cyclical ecological system ..." [8]. Later, the concept began to acquire a more economic character [9].

Analysis of literature sources showed that the vast majority of researchers [7; 10; 11] uses while describing the basic principles of the circular economy the particle "re" (from Latin means "again", "once more"), which characterizes the basic essence of the circular economy. The circular economy was originally based on three main principles, called "3R": Reduce – Reuse - Recycle. But over time, they transformed into "9R": Rethink - Reduce - Reuse - Repair - Refurbish - Remanufacturing - Repurpose - Recycle - Recover.

A significant number of scientific publications are devoted to the identification of factors that hinder the development of the circular economy [12; 13; 14]. In [11] it is noted that the implementation of the circular economy concept in practice may be prevented by the following barriers:

– cultural (environmental culture of companies, lack of interest and awareness of consumers, activities based on a linear economy, interest in the chain of creation of the final value);

– regulatory (limited closed procurement, lack of global consensus, prohibition of laws and regulations);

– market (low quality materials, standardization, high investment value, limited funding of circular business models);

– technological (ability to supply high-quality refurbished products, insufficient scale of designed solutions demonstration,

lack of necessary data on the influence of factors).

N. Batova, E. Shershunovych, I. Tochytska [15] identified and systematized 5 groups of barriers to the development of a circular economy: socio-cultural, legislative, informational, technological and economic.

Socio-cultural barriers hinder the development of a circular economy given the differences in values and the level of environmental responsibility of society. Legislative barriers are demonstrated in the form of restrictions imposed by current legislation. Insufficient awareness of consumers and producers about the essence and principles, advanced experience and best practices of the circular economy create information barriers. Economic barriers are due to many factors, including the cost of circular innovations; lack of a clear methodology for assessing the economic efficiency of enterprises that use secondary resources; effective mechanisms of financial support and preferences from the banking system and the public sector. Technological barriers to the introduction of a circular economy are characterized by the lack of a clear logistics infrastructure of the system of collection, extraction and processing of secondary resources; lack of demonstration projects to work with new technologies, and as a consequence, concern about the quality of products made from secondary raw materials and waste [15].

The study and generalization of the scientific literature shows that over the last decades of development of this scientific field, scientists have not come to a common and unambiguous interpretation of the term "circular economy". Many conceptual approaches to the consideration of the ecological component of the national economy are now proposed. This is due to the large number of established scientific schools, which have their own characteristics and approaches to theoretical and applied aspects of the development of concepts of green and circular economy. However, all the proposed formulations of the term "circular economy", as a rule, are generally accepted and have a broader meaning, without taking into account the specifics of the logistics systems functioning at different levels.

**Objectives statement.** The purpose of this article is to study the peculiarities of the national logistics system development considering the environmental component and justification of the need to develop the concept of a circular economy in Ukraine.

The methodological basis of the study is the scientific works of foreign and Ukrainian scientists on the problems of green economy, circular economy, environmental management, logistics management, formation and operation of logistics systems.

The research was conducted using general scientific methods: analysis and synthesis - to summarize existing theoretical approaches and provisions, scientific achievements on the development of the circular economy and greening of logistics systems, clarification of the terminology; classification - to systematize scientific approaches to the definition of "circular economy", which are proposed by various scientific schools; statistical analysis and comparison - to analyze the development of the national Ukrainian logistics system considering the environmental component; structural and logical generalization - to clarify the wording of the term "circular economy".

Statistics for Ukraine include: GDP at fixed 2010 prices; total costs (capital investments and current costs) for environmental protection, including in the field of transport and warehousing; budget expenditures for environmental protection; general expenses for protection of atmospheric air and climate, including in the sphere of transport and warehousing; investments in equipment and installations related to integrated environmentally friendly technologies; emissions' volumes of pollutants into the atmosphere from mobile sources of pollution; the amount of carbon dioxide emissions into the atmosphere from road transport; volumes of generated and utilized industrial waste.

These data are taken in the sections "Environment", "Transport", "Activities of enterprises" on the website of the State Statistics Service of Ukraine, as well as in the statistical compilations "Environment of Ukraine", "Activities of economic entities".

**Main material of the research.** In the scientific literature there are different views on the interpretation of the category "circular economy". As a rule, scientists identify it with the concepts of "circle economy", "cyclical economy", "renewable economy", "closed cycle economy", "green economy" and so on. A number of researchers think that the circular economy is a new stage in the development of the concept of sustainable development and the green economy in particular. On the other hand, much less often, it is considered as an independent direction in economic theory, which originated in the 1970s of XX century [16; 17]. E. Mishenin, I. Koblyanska [18] emphasize that the circular economy is not an analogue of the "green economy", but acts as an integral part of it, as well as a way to achieve sustainable development.

The following are the main interpretations of the concept of "circular economy", which are proposed by representatives of various scientific schools:

– sustainable development strategy aimed at improving the efficiency of materials and energy use [10];

– economic system based on business models that replace the concept of "end of life care" with reduction, alternative reuse, recycling and recovery of materials in the processes of production / distribution and consumption, thus functioning at the micro level (products, companies, consumers), meso-levels (eco-industrial parks) and macro-levels (city, region, nation and beyond) in order to achieve sustainable development, which means the formation of a quality environment, economic prosperity and social justice for the benefit of generations [11];

– complex multilevel system, the principles of organization of which differ significantly from the traditional linear economy [15];

– global economic model that separates economic growth and development from the consumption of resources [19];

– policy strategy aimed at reducing resource shortages and diminishing pollution [20];

– activities for the production, distribution and consumption of goods, which is based on the principles of saving various resources and materials, "waste-free economy" [21];

– way to solve problems of sustainable development of resources [22];

– implementation of a closed cycle of material flows in the economic system [23];

– the path to sustainable development [24];

– method of continuous economic development without creating significant environmental and resource problems [25];

– new trend, the basis of the "Fourth Industrial Revolution" [26];

– holistic concept that encompasses the actions of "reduction, reuse and processing" in the process of production, circulation and consumption [27];

– model of economic development with maximum use of resources and environmental protection [28];

– simple but convincing strategy aimed at reducing both the cost of primary materials and the production of waste by closing the economic and environmental cycles of resource flows [29];

– mutually beneficial philosophy according to which a "prosperous" economy and a "healthy" environment can coexist [30];

– space to address growing resource issues; the concept of separating the direct use of resources from economic growth [31];

– model of production and consumption of goods through closed material flows, which absorb the external effects associated with the receipt of primary resources and waste generation (including pollution) [32];

– solving a number of problems, such as waste generation, resource shortages and sustainable economic benefits [33];

– recovery or regenerative production system; integrated waste management process [34];

– economy that increases people's well-being and ensures social justice, significantly reducing risks to the environment [35];

– regenerative system in which the cost of resources and losses, emissions and leakages of energy are minimized by slowing down, closing and narrowing the material and energy cycles [36];

– economic model in which both the results and the actual processes of resource supply and production are planned and organized in such a way as to maximize human well-being and the efficiency of ecosystems [37];

– economic activity aimed at energy saving, regenerative environmentally friendly production, circulation and consumption [38];

– one of the tools for solving environmental problems to ensure a stable environmental future [39];

– philosophy of reusing and profiting from what was previously considered unnecessary and discarded within the triad of the traditional linear economy [40];

– economy based on the recovery of resources, the transition to the use of renewable energy sources and the processing of secondary raw materials [41];

– integral part of the expanded concept of "green" economy; the next stage of development of the "green" economy [42];

– sustainable development initiative, which aims to reduce linear material and production flows in the systems of production and consumption of society through the application of material cycles, renewable and cascading energy flows to the linear system [43];

– economic model, which is based on the principles of circular functioning of closed technological and biological cycles; an instrument of the green economy for the purpose of achieving sustainable development and achieving key goals [44].

M. Guryeva [44] proposes to group approaches to the interpretation of the concept of "circular economy" for the period of its formation as follows: the global economic model (2004); activity (2007); new trend 4.0 (2013); economic model (2015); production system (2016); economic activity, tool (2017); philosophy, economics (2018).

Based on the above, the existing scientific approaches to the definition of the term "circular economy" can be conditionally classified into 9 groups (Table 1).

Based on the generalization of the terminology on the selected topic and in accordance with various scientific concepts, it is proposed to consider the circular economy as an innovative approach to the organization of logistics processes, based on closed resource movement with minimal waste loss and maximum involvement of secondary resources in production systems [45].

Authors provide approach to the formulation of the term "circular economy", as a result of research [46-62], which consists in considering this concept from 6 positions:

– modern paradigm of logistics systems development;

– sustainable development strategy;

– stable business model of the national economy;

– economic model based on industrial waste recycling technology;

– logistics flow management tool, which is based on a comprehensive approach (integration of system, process, situational, functional);

– activities aimed at implementing a closed cycle of logistics flows to increase the level of environmental security of the national economy.

Table 1 - Theoretical approaches to the concept of "circular economy", which are proposed by representatives of various scientific schools

| Classification group | Scientific approach |
|---|---|
| Section of the economy | Closed cycle economics |
| | A resource-based economy |
| Paradigm | Philosophy of management |
| | The concept of economic development |
| Strategy | Sustainable development strategy |
| Model | Economic model in the context of globalization |
| System | Economic system with a closed cycle, which is based on R-principles |
| | Regenerative production system |
| Environmental opportunity | Alternative to the traditional linear economy |
| Recycling technology | Use of production waste |
| | Recycling |
| Tool | Tool of the "green" economy |
| | Tool for solving environmental problems |
| Activity | Economic activity |
| | Business activity |
| | Activities aimed at preserving the environment |

*Source: author's development*

The analysis shows that many companies around the world are already aware of the need to manage in a "new way", the transformation of economic models and the use of circular economy. Thus, 44% of companies in the top 100 on Fortune Global have chosen a strategy for the development of a circular economy. The leaders in this are the FMCG (Fast moving consumer goods) sector and the automotive industry. The transition to a circular model of the economy in companies in these areas of economic activity will help to reduce raw material costs, expand markets, improve brand reputation and dialogue with customers, increase their loyalty, create a competitive business model and more.

At the same time, the oil industry, financial services and health care are not yet so widely practiced in a closed cycle. Meanwhile, according to the report The Circularity Gap, which is presented annually at the World Economic Forum in Davos, only 9% of the materials in the world economy are reused.

It should be noted that analys of the development trends of the circular economy in the European Union, shows that each country has national characteristics of the implementation of this concept. For example, according to the Ecobusiness Group, Germany, with a strong industrial economy, has formed the basis of a circular economy through material flows and the availability of materials. The Netherlands has formed the basis on innovations in materials and business models. Finland is the first country in the world to develop a national roadmap for the transition to a circular economy. Scotland became the first country to join the Circular Economy 100 Club (CE100), created at the initiative of the Ellen McArthur Foundation, to stimulate cooperation and innovation for the development of the circular economy.

In the ranking of the circular economy in 2018, Germany ranks first in the number of patents related to the circular economy, more than twice ahead of France, which is on the second place (1260 patents against 542). The United Kingdom and Germany are the leaders in terms of "investment in the development of a circular economy".

Among the programs for financing innovative projects in Europe, there are many circular projects that provide them with large amounts of funding. Thus, one of the largest

investors in circular economy projects is the European Investment Bank (EIB). The EIB provides advisory assistance by assessing the possibilities of financing a specific circular project and selecting the best loaning terms. Projects that are too small to handle as stand-alone investment loans can be supported through intermediary credits.

Another major investor is the European Fund for Strategic Investments (EFSI), which provides investment in research and innovation, as well as supports small and medium-sized businesses. Within the framework of "InnovFin - EU Finance for Innovators", high-risk projects are financed provided that technological innovations are available in the circular project. In addition, all EU programs are complemented by investment at the national level through various instruments offered by national, regional and / or local development agencies (eg Teknologian Keskus, operating under the Ministry of Industry and Trade in Finland, Invitalia in Italy, Dutch Entrepreneurship Agency, etc.).

If to consider Ukraine, we can note that the "green" transformation of the national logistics system in a circular economy is not effective enough. Thus, according to the Ministry of Finance of Ukraine, the share of budget expenditures on environmental protection is insignificant, its' level in 2019 was only 0.7% of total state budget expenditures. This, in turn, does not meet the Sustainable Development Goals of 2016-2030. The share of total expenditures on environmental protection in total GDP is also negligible and amounted to 4.2% in 2019 (Table 2).

Table 2 – Financial and economic indicators of development of the sphere environmental protection in Ukraine

| Year | GDP in fixed prices 2010 p., mln UAH | Total expenditures on environmental protection | | Budget expenditures on GDP | |
|---|---|---|---|---|---|
| | | mln UAH | share in the amount of GDP,% | mln UAH | share in the total budget expenditures,% |
| 2010 | 1079346,0 | 13128,1 | 1,2 | 2872,4 | 0,8 |
| 2011 | 1138338,0 | 18490,4 | 1,6 | 3890,7 | 0,9 |
| 2012 | 1141055,0 | 20514,0 | 1,8 | 5297,9 | 1,1 |
| 2013 | 1140750,0 | 20377,9 | 1,8 | 5594,2 | 1,1 |
| 2014 | 1066001,0 | 21925,6 | 2,1 | 3481,7 | 0,7 |
| 2015 | 961821,0 | 24591,1 | 2,6 | 5529,7 | 0,8 |
| 2016 | 985299,0 | 32488,7 | 3,3 | 6255,4 | 0,7 |
| 2017 | 1010173,0 | 31492,0 | 3,1 | 7349,3 | 0,7 |
| 2018 | 1043272,0 | 34392,3 | 3,3 | 8242,1 | 0,7 |
| 2019 | 1037299,1 | 43735,9 | 4,2 | 9731,1 | 0,7 |

*Source: compiled according to data [63, p. 195, 198].*

Analysis of statistical data shows that the share of current expenditures on air protection and climate change issue decreased in 2000-2020 by 4.9 percentage points or from 13.4 to 8.5% of total current expenditures on environmental protection. The share of current costs of waste management increased by 29.2 percentage points or from 10.7 to 39.9% (Table 3).

Table 3 - Dynamics of current expenditures for environmental protection

| Year | Total volume, mln UAH | Including on | | | |
|---|---|---|---|---|---|
| | | protection of atmospheric air and climate change issues | | waste management | |
| | | mln UAH | share, % | mln UAH | share, % |
| 2000 | 2618,4 | 350,4 | 13,4 | 279,2 | 10,7 |
| 2001 | 2903,7 | 305,1 | 10,5 | 327,4 | 11,3 |
| 2002 | 3080,1 | 416,2 | 13,5 | 402,9 | 13,1 |
| 2003 | 3361,9 | 444,7 | 13,2 | 477,1 | 14,2 |
| 2004 | 4152,2 | 606,5 | 14,6 | 746,7 | 18,0 |
| 2005 | 5313,6 | 877,4 | 16,5 | 925,5 | 17,4 |
| 2006 | 5172,4 | 826,7 | 16,0 | 1330,2 | 25,7 |
| 2007 | 6610,3 | 1141,9 | 17,3 | 1768,9 | 26,8 |
| 2008 | 8444,6 | 1349,9 | 16,0 | 2315,2 | 27,4 |
| 2009 | 8032,7 | 1035,2 | 12,9 | 1928,3 | 24,0 |
| 2010 | 10366,6 | 1314,8 | 12,7 | 2599,6 | 25,1 |
| 2011 | 12039,4 | 1475,4 | 12,3 | 3865,9 | 32,1 |
| 2012 | 13924,7 | 1341,5 | 9,6 | 4756,2 | 34,2 |
| 2013 | 14339,1 | 1415,8 | 9,9 | 4844,3 | 33,8 |
| 2014 | 13965,7 | 1238,6 | 8,9 | 5417,0 | 38,8 |
| 2015 | 16915,5 | 1519,8 | 9,0 | 6801,9 | 40,2 |
| 2016 | 19098,2 | 1760,6 | 9,2 | 6719,6 | 35,2 |
| 2017 | 20466,4 | 2104,3 | 10,3 | 7508,2 | 36,7 |
| 2018 | 24318,0 | 2897,7 | 11,9 | 8830,2 | 36,3 |
| 2019 | 27480,2 | 2963,9 | 10,8 | 10227,1 | 37,2 |
| 2020 | 28092,6 | 2375,8 | 8,5 | 11197,1 | 39,9 |

*Source: compiled on the basis of information materials of the State Statistics Service of Ukraine*

The share of total expenditures on environmental protection in the field of transport and warehousing decreased in 2012-2020 by 4.2 percentage points or from 6.2 to 2.0% of the total expenditures on environmental protection. During this period, there was a tendency to reduce the share of capital investment in the development of transport and warehousing by 47.6 percentage points or from 58.8 to 11.2% of the total expenditures on environmental protection in this area. The share of current expenditures on environmental protection in the field of transport and warehousing, respectively, increased by 47.6 percentage points or from 41.2 to 88.8% of the total expenditures on environmental protection in this type of economic activity (Table 4).

Table 4 - Dynamics of total expenditures on environmental protection in the field of transport and warehousing

| Year | Total volume, mln UAH | including in the field of transport and warehousing | | Including | | | |
|---|---|---|---|---|---|---|---|
| | | | | capital investments | | current expenses | |
| | | mln UAH | share, % | mln UAH | share, % | mln UAH | share, % |
| 2012 | 20514,0 | 1262,6 | 6,2 | 742,1 | 58,8 | 520,5 | 41,2 |
| 2013 | 20377,9 | 691,6 | 3,4 | 197,6 | 28,6 | 494,0 | 71,4 |
| 2014 | 21925,6 | 330,0 | 1,5 | 78,0 | 23,6 | 252,0 | 76,4 |
| 2015 | 24591,1 | 303,8 | 1,2 | 59,0 | 19,4 | 244,8 | 80,6 |
| 2016 | 32488,7 | 824,9 | 2,5 | 96,7 | 11,7 | 728,2 | 88,3 |
| 2017 | 31492,0 | 575,4 | 1,8 | 65,3 | 11,3 | 510,1 | 88,7 |
| 2018 | 34392,3 | 742,3 | 2,2 | 168,2 | 22,7 | 574,1 | 77,3 |
| 2019 | 43735,9 | 819,0 | 1,9 | 64,0 | 7,8 | 755,0 | 92,2 |
| 2020 | 41332,2 | 807,4 | 2,0 | 90,1 | 11,2 | 717,3 | 88,8 |

*Source: compiled according to data [63, c. 191, 194, 198].*

The share of current expenditures on environmental protection in the field of transport and warehousing decreased in 2012-2019 by 1.2 percentage points or from 3.7 to 2.7% of total current environmental expenditures. The share of expenditures on air and climate protection in the field of transport and warehousing decreased by 1.6 percentage points or from 2.4 to 0.8% of the total costs for all types of economic activity. At the same time, the share of expenditures on air and climate protection in the field of transport and warehousing decreased by 3.1% in the total current expenditures on environmental protection in this area or from 6.1 to 3% (Table 5).

Table 5 - Dynamics of current expenditures on environmental protection in the field of transport and warehousing

| Year | Total volume, mln UAH | including in the field of transport and warehousing | | of which the expenditures on the air and climate protecting, mln UAH | including in the field of transport and warehousing | |
|---|---|---|---|---|---|---|
| | | mln UAH | share, % | | mln UAH | share, % |
| 2012 | 13924,7 | 520,5 | 3,7 | 1330,8 | 31,9 | 2,4 |
| 2013 | 14339,1 | 494,0 | 3,4 | 1411,1 | 29,0 | 2,1 |
| 2014 | 13965,7 | 252,0 | 1,8 | 1234,6 | 22,6 | 1,8 |
| 2015 | 16915,5 | 244,8 | 1,4 | 1512,6 | 60,3 | 4,0 |
| 2016 | 19095,2 | 728,2 | 3,8 | 1755,4 | 32,4 | 1,8 |
| 2017 | 20466,4 | 510,1 | 2,5 | 2086,9 | 31,8 | 1,5 |
| 2018 | 24318,0 | 574,1 | 2,4 | 2897,7 | 26,7 | 0,9 |
| 2019 | 27480,2 | 755,0 | 2,7 | 2963,9 | 22,4 | 0,8 |

*Source: compiled according to data [63, c. 172, 192, 198].*

According to the State Statistics Service of Ukraine, the share of capital investment in air protection and climate change increased in 2010-2020 by 1 percentage point or from 41.3 to 42.3% of the total capital investment in environmental protection. The share of capital investments in waste management increased by 4.7 percentage points or from 17.2 to 21.9% (Table 6).

Table 6 - Dynamics of capital investments in environmental protection

| Year | Total volume, mln UAH | Including on | | | |
|---|---|---|---|---|---|
| | | protection of atmospheric air and climate change issues | | Waste management | |
| | | mln UAH | share, % | mln UAH | share, % |
| 2010 | 2761,5 | 1139,9 | 41,3 | 475,6 | 17,2 |
| 2011 | 6451,0 | 2535,6 | 39,3 | 1183,9 | 18,4 |
| 2012 | 6589,3 | 2462,7 | 37,4 | 730,5 | 11,1 |
| 2013 | 6038,8 | 2411,9 | 39,9 | 713,9 | 11,8 |
| 2014 | 7959,9 | 1915,1 | 24,1 | 784,0 | 9,8 |
| 2015 | 7675,6 | 1422,9 | 18,5 | 737,5 | 9,6 |
| 2016 | 13390,5 | 2502,8 | 18,7 | 2208,7 | 16,5 |
| 2017 | 11025,5 | 2608,0 | 23,7 | 2471,0 | 22,4 |
| 2018 | 10074,3 | 3505,9 | 34,8 | 1182,0 | 11,7 |
| 2019 | 16255,7 | 4276,7 | 26,3 | 5754,3 | 35,4 |
| 2020 | 13239,6 | 5595,3 | 42,3 | 2899,8 | 21,9 |

*Source: compiled on the basis of information materials of the State Statistics Service of Ukraine.*

In 2012-2019, the share of capital investments in environmental protection in the field of transport and warehousing decreased by 10.9 percentage points or from 11.3 to 0.4% of the total capital investment in environmental protection for all types of economic activity (Table 7).

Table 7 - Dynamics of capital investments in environmental protection in the field of transport and warehousing

| Year | Total volume, mln UAH | including in the sphere of transport and warehousing, mln UAH | Share in total capital investment,% |
|---|---|---|---|
| 2012 | 6589,3 | 742,1 | 11,3 |
| 2013 | 6038,8 | 197,6 | 3,3 |
| 2014 | 7959,9 | 78,0 | 1,0 |
| 2015 | 7675,6 | 59,0 | 0,8 |
| 2016 | 13390,5 | 96,7 | 0,7 |
| 2017 | 11025,6 | 65,3 | 0,6 |
| 2018 | 10074,3 | 168,2 | 1,7 |
| 2019 | 16255,7 | 64,0 | 0,4 |

*Source: compiled according to data [63, c. 189, 191].*

During the study period, the share of investments in equipment and installations related to environmentally friendly technologies in the field of transport and warehousing decreased by 18.2 percentage points or from 21.7 to 3.5% of the total investment. The share of investments in integrated technologies for air and climate protection in the field of transport and warehousing decreased by 22.8 percentage points or from 44.2 to 21.4% of the total investment. At the same time, the share of investments in complex technologies for the protection of atmospheric air and climate in the field of transport and warehousing increased by 29.5 percentage points or from 60.9 to 90.4% of the total investment in equipment that is associated with environmentally friendly technologies in this area (Table 8).

Table 8 - Dynamics of investments in equipment and installations, which are associated with integrated environmentally friendly technologies

| Year | Total volume, mln UAH | including in the field of transport and warehousing | | Of these, investments for the protection of atmospheric air and climate, mln UAH | including in the field of transport and warehousing | |
|---|---|---|---|---|---|---|
| | | mln UAH | share, % | | mln UAH | share, % |
| 2012 | 3714,8 | 806,6 | 21,7 | 1112,2 | 491,5 | 44,2 |
| 2013 | 3233,9 | 191,7 | 5,9 | 1094,2 | 142,7 | 13,0 |
| 2014 | 4638,2 | 70,8 | 1,5 | 428,5 | 11,0 | 2,6 |
| 2015 | 4952,2 | 49,2 | 1,0 | 436,0 | 10,0 | 2,3 |
| 2016 | 7783,7 | 82,0 | 1,1 | 528,9 | 25,4 | 4,8 |
| 2017 | 4183,4 | 47,5 | 1,1 | 300,1 | 12,0 | 4,0 |
| 2018 | 3519,4 | 125,7 | 3,6 | 514,1 | 114,0 | 22,2 |
| 2019 | 3519,4 | 121,9 | 3,5 | 514,1 | 110,2 | 21,4 |

*Source: compiled according to data [64, c. 134].*

During the period 2010-2020, the volume of emissions of pollutants into the atmosphere from mobile sources of pollution decreased by 30.1%, and their share in the total emissions of pollutants increased by 6.2 percentage points or from 38.1 to 44.3% (Table 9).

Table 9 - Emissions volumes of pollutants into the atmosphere from mobile sources of pollution

| Year | Total volume, mln UAH | including mobile sources of pollution, thousand tones | Share in total emissions of pollutants,% |
|---|---|---|---|
| 2010 | 6678,0 | 2546,4 | 38,1 |
| 2011 | 6877,3 | 2502,7 | 36,4 |
| 2012 | 6821,1 | 2485,8 | 36,4 |
| 2013 | 6719,8 | 2424,7 | 36,1 |
| 2014 | 5346,2 | 1996,2 | 37,3 |
| 2015 | 4521,3 | 1663,9 | 36,8 |
| 2016 | 4686,6 | 1608,5 | 34,3 |
| 2017 | 4230,6 | 1645,7 | 38,9 |
| 2018 | 4121,2 | 1612,9 | 39,1 |
| 2019 | 4108,3 | 1648,8 | 40,1 |
| 2020 | 4017,3 | 1778,7 | 44,3 |

*Source: compiled according to data [63, c. 26, 28].*

The amount of pollutant emissions into the atmosphere from mobile sources of pollution per capita increased in 2016-2020 by 13% or from 37.7 to 42.6 kg. This was due to an increase in emissions of carbon monoxide by 12.8% (from 28.8 to 32.5 kg), nitrogen dioxide - by 18.4% (from 3.8 to 4.5 kg).

As the analysis shows, the total volume of air emissions from road transport decreased in 2010-2019 by 28.3% or from 2313.8 to 1659.5 thousand tons. The volume of carbon dioxide emissions into the air from road transport increased by 13.4% or from 1782.7 to 2021.1 thousand tons [63, p. 26, 28].

There is a negative trend in the development of waste recycling in Ukraine. Thus, according to the State Statistics Service of Ukraine, the amount of generated waste increased in 2019 compared to 2010 by 4.5%. At the same time, the total amount of waste accumulated during operation in specially designated places and facilities increased by 16.5%. Meanwhile, the volume of recycled waste decreased by 25.5%, and the volume of disposed waste in specially designated places and facilities - by 23.3%. The share of recycled waste in the total amount of generated waste decreased in 2010-2019 by 9.8 percentage points or from 34.3 to 24.5% (Table 10).

Table 10 - Dynamics of indicators that characterize development waste recycling systems in Ukraine

| Year | Waste generated volume, mln t | Recycled waste volume, mln t | Volume of waste disposed of in specially designated places and objects, mln t | The total amount of waste accumulated during operation in specially designated areas and facilities, mln t |
|---|---|---|---|---|
| 2010 | 422,5 | 144,9 | 311,6 | 13219,9 |
| 2011 | 443,8 | 153,4 | 251,4 | 14372,1 |
| 2012 | 446,7 | 143,1 | 263,6 | 14856,6 |
| 2013 | 445,3 | 146,7 | 264,7 | 15111,6 |
| 2014 | 355,0 | 109,3 | 203,7 | 12205,4 |
| 2015 | 312,3 | 92,5 | 152,3 | 12505,9 |
| 2016 | 295,9 | 84,6 | 157,4 | 12393,9 |
| 2017 | 366,1 | 100,1 | 169,8 | 12442,2 |
| 2018 | 352,3 | 103,7 | 169,5 | 12972,4 |
| 2019 | 441,5 | 108,0 | 238,9 | 15398,6 |

*Source: compiled according to the section "Environment" on the official website of the State Statistics Service of Ukraine.*

**Conclusions.** Thus, the statistical analysis shows the need to implement the principles and tools of the circular economy as a concept of sustainable development of the national logistics system in Ukraine.

From a macroeconomic point of view, a circular economic investment strategy may lead to a 10% reduction in the cost of raw materials and a 7% increase in GDP in the European Union in 2030 compared to the usual business model [65]. However, such a leap in development undoubtedly requires strategies that focus on the specific potential of the economy, as well as the appropriate infrastructure and administrative capacity. An important long-term opportunity for a circular economy is to reduce direct and indirect environmental costs. Direct costs are associated with waste management. However, indirect costs for the use of natural resources are also relevant. Globally, an international group of resource experts under the United Nations Environment Program estimates that these costs are up to USD2.4 trillion. [66].

In addition, it should be emphasized that the development of a circular economy contributes to the social effect through job creation. According to a study by the European Commission [67], depending on how waste is treated, a different number of jobs can be created: for 10 thousand tons of used products can create one job for incineration, six jobs - for disposal, 36 jobs - for waste recycling and up to 296 jobs for their recovery and reuse.

It is worth taking into account the best European experience, for example, in Finland, where practical solutions of the closed-loop economy are effectively implemented. The essence of the transition is to rethink value chains and develop new business models. Currently, there are several solutions developed by experts from the Finnish innovation fund Sitra, which help accelerate the transition to a circular economy [68]. These include:

– product-service systems and sharing models;

– ways of values to the sphere of food;

– sustainable delivery models (efficient delivery models and logistics operations play a crucial role in the implementation of circular economy solutions. RePack company offers reusable packaging solutions that minimize air transportation costs. Koepala offers sophisticated lunch boxes that are flat for storage and transportation and can be assembled in packaging products of various forms, all of which have turned the potential of the circular economy into real market results);

– roadmaps for carbon-neutral industries (important for Finland's future industrial development; for example, a € 300 million investment in a battery cluster creation and the first multifunctional textile recycling center in Northern Europe to handle 10% of textile waste; resource efficiency and recycling Betolar creates value by converting construction industry waste into concrete-like building materials with a carbon footprint of up to 90% less than conventional concrete);

– education on the development of the circular economy.

In conditions of fierce competition, domestic companies are implementing the mechanism of the circular economy in their economic activities through various strategies and tools, including:

1) Design of the future - is the production of products where traditional materials can be replaced by renewable or recycled.

This optimizes the use of resources and reduces the amount of waste in the production process. For example, Adidas has made sneakers with 100% recycled materials. One type of material is used in production and it is not used. General Electric uses 3D printing to prepare parts to save material.

2) Special use and virtualization are already common for many business models. Uber, BlaBlaCar, Airbnb are examples of this approach. From the Ukrainian examples of the Oh My Look! Brand, which is being transformed from dress rental services into a virtual subscription wardrobe offer.

3) Strategy "goods as a service" - replacement of the traditional model of selling goods for the sale of services. A classic example is Rolls Royce, which has built a market that customers have enjoyed for more than 60 years. The company offers customers in the aviation industry instead of buying aircraft engines to use 'Power-by-the-Hour' service that predicts paying for engine use a fixed rate for 1 year of operation. To service the service approach, the engine life cycle is increased by 25%. Another example is the successful subscription of a Volvo car. The customer can choose the model through the website and form a subscription with fixed monthly payments. This model is an alternative to leasing or buying a car.

4) Autonomous use in production (already used in the use of products or as components that become part of new products). Yes, Canon is once again accepting end-of-life products and using components in new devices without using the functional characteristics of the materials. This approach is part of Dell, which uses secondary materials for the production of spare parts. The Michelin Group is returning to the production process of 17 million tons of used car tires.

5) Reuse in consumption - when by optimizing service companies can increase the life cycle of products. For example, the eBay marketplace offers damaged, but fully functional devices on a special site at reduced prices.

The reuse strategy also offers to sell and buy used products. In Sweden, there is a special supermarket Retuna, the range of which consists of "second-hand" things.

6) Industrial symbiosis and recycling of production waste - can significantly increase business efficiency. The first example of symbiosis in the concept of circular economy is considered to be the project in Kalundborg (Denmark). There, the participating companies united the principle of interaction, when the waste of production of one business becomes a resource for another. At the same time, economic costs and greenhouse gas emissions are reduced. The consortium includes Denmark's largest oil refinery, owned by energy giant Equinor, the pharmaceutical company Novo Nordisk, the city's municipal water and heating company, a waste management operator and others.

Ukraine also has examples of efficient use of resources in the production process. For example, Myronivsky Khleboproduct is building biogas complexes for poultry waste processing and energy production. Obolon Concern sells beer by-products to agricultural companies, which become animal feed. Special tanks for heat recovery from freeze equipment are installed in the Silpo supermarket chain to meet the need for a hot water supply.

In further scientific researches, it is planned to analyze and generalize the international experience of "green" transformation of logistics systems in the conditions of the circular economy, substantiate and develop conceptual provisions for the formation and operation of "green" supply chains in the context of the circular economy

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