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INTRODUCTION

We are happy to invite you to get acquainted with the first issue of the new scientific and practical publication "Intellectualization of Logistics and Supply Chain Management".

We strongly believe that the launch of this magazine indicates the objective need to rethink a wide range of issues related to the development of theory and practice in logistics and supply chain management, awareness of the need to unite the scientific community and logistics practitioners, dissemination of modern knowledge and best practices for innovative development of the logistics services market.

The first issue of the magazine is published at a difficult time. The global coronavirus pandemic and the deep economic crisis have significantly worsened business activity in the world. Currently, global supply chains are collapsing, international trade is declining, and competition between global and regional logistics operators is intensifying. The most common thesis is that the world will never be the same again. Industry experts predict the emergence of new, more flexible and adaptive supply chain management strategies and approaches to logistics business process management. The trend towards collaborations, cooperation and unification of services is emerging, comprehensive proposals for clients are being developed. There is increasing talk about the need to build bimodal supply chains, which involves the development of different decision-making scenarios: the traditional approach - cost-effective efficiency, low risk, high predictability; a new approach "second mode" - rapid recognition of opportunities, adaptability, willingness to solve unexpected problems and look for new opportunities.

Radical transformations of the global and national markets for logistics services require appropriate scientific support. Logistics science has a special role to play in this process. Initiating the emergence of a new journal, we decided to focus on its coverage of problematic aspects of the formation and development of logistics systems at the micro, mezo and macro levels, supply chain management, digitization of logistics, methods and tools for optimizing processes in logistics and supply chains, sociopsychology relations and network interaction of enterprises using cloud technologies, artificial intelligence, e-learning, neural business process management systems, etc.

Therefore, we invite scientists, researchers and business representatives, as well as our colleagues from abroad, to cooperate and present the results of scientific research, to discus and debate on them, to work together to develop the scientific theory of logistics and promote mutual intellectual enrichment.

We hope that the new scientific publication will become a theoretical guide for young researchers and representatives of other fields.

HRYHORAK Mariia
Chief Editor

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ROLE OF ICAO CO2 EMISSIONS STANDARD FOR NEW AIRCRAFT IN CIVIL AVIATION SUSTAINABLE DEVELOPMENT PROCESS

Dmytro Bugayko, Anton Borysiuk, Nadia Perederii, Natalia Sokolova, Danylo Bugayko. "Role of ICAO CO2 emissions standard for new aircraft in civil aviation sustainable development process". *Achieving emissions reductions through technical standards is a fundamental element of ICAO's basket of* *measures to address aviation emissions. The sector remains the last major transport mode without vehicle emission standards, so the intensive CAEP work over the past years was an important opportunity for ICAO to deliver on its stated climate goals. The development of an aeroplane CO2 Standard was one recommended element within the ICAO Programme of Action on International Aviation and Climate Change, which was subsequently endorsed by the ICAO High-level Meeting of Member States. Following the agreement of a draft Annex 16 Volume III certification requirement1 at CAEP/9, the CAEP/10 work programme for WG3 included work items E.05 on an aeroplane CO2 emissions Standard and E.06 on interdependencies (Appendix A). These items were allocated to the CO2Task Group (CO2TG). The 36-State ICAO Council has adopted a new aircraft CO2 emissions standard which will reduce the impact of aviation greenhouse gas emissions on the global climate. Contained in a new Volume III to Annex 16 of the Chicago Convention (Environmental Protection), the aircraft CO2 emissions measure represents the world's first global design certification standard governing CO2 emissions for any industry sector. The Standard will apply to new aircraft type designs from 2020, and to aircraft type designs already in-production as of 2023. Those in-production aircraft which by 2028 do not meet the standard will no longer be able to be produced unless their designs are sufficiently modified.*

Keywords*:* air transport, emissions, regulation, standard, civil aviation sustainable development.

Дмитро Бугайко, Антон Борисюк, Надія Передерій, Наталія Соколова, Данило Бугайко. «Роль Стандарту ІКАО щодо викидів СО2 для нових літаків у процесі сталого розвитку цивільної авіації». *Досягнення скорочення викидів за допомогою технічних стандартів є фундаментальним елементом заходів ICAO щодо вирішення проблем негативного екологічного впливу авіації. Цей напрямок залишається головним аспектом, який потребує відповідних стандартів. Тому інтенсивна робота CAEP протягом останніх років стала важливою можливістю для ІКАО досягти заявлених кліматичних цілей. Розробка стандарту CO2 для літаків була одним із рекомендованих елементів Програми дій ICAO щодо міжнародної авіації та зміни клімату, яка згодом була схвалена Нарадою держав-членів високого рівня ICAO. Після погодження проекту Додатку 16 були визначені Вимога сертифікації Тома III1 на CAEP/9. Робоча програма CAEP/10 для WG3 включала робочі пункти E.05 щодо стандарту викидів літаками CO2 та E.06 щодо взаємозалежностей (Додаток A). Ці пункти були розподілені до робочої групи CO2 (CO2TG). Рада ICAO з 36 країн прийняла новий стандарт викидів CO2 від літаків, який зменшить вплив авіаційних викидів парникових газів на глобальний клімат. Інформація міститься у новому Томі III до Додатку 16 Чиказької конвенції (Захист навколишнього середовища), присвяченого вимірюванню викидів CO2 для літаків. Він є першим у світі глобальним стандартом сертифікації проектів, що регулює викиди CO2 для будь-якої галузі промисловості. Стандарт застосовується до нових конструкцій типів повітряних суден з 2020 року та до конструкцій типів літаків, які вже перебувають у виробництві, починаючи з 2023 року. Ті серійні літаки, які до 2028 року не відповідатимуть стандарту, більше не зможуть вироблятися, якщо їхні конструкції не будуть перероблені та достатньо модифіковані.*

Ключові слова: повітряний транспорт, викиди, регулювання, стандарт, сталий розвиток цивільної авіації.

Дмитрий Бугайко, Антон Борисюк, Надежа Передерий, Наталья Соколова, Даниил Бугайко. «Роль Стандарта ИКАО по выбросам СО2 для новых самолетов в процессе устойчивого развития гражданской авиации». *Достижение сокращения выбросов с помощью технических стандартов является фундаментальным элементом мер ICAO по решению проблем негативного экологического влияния авиации. Это направление остается главным аспектом, требующим соответствующих стандартов. Поэтому интенсивная работа CAEP в последние годы стала важной возможностью для ИКАО достичь заявленных климатических целей. Разработка* *стандарта CO2 для самолетов была одним из рекомендованных элементов Программы действий ICAO по международной авиации и изменению климата, впоследствии одобренной Совещанием государств-членов высокого уровня ICAO. После согласования проекта Приложения 16 были определены требования по сертификации Тома III на CAEP/9. Рабочая программа CAEP/10 для WG3 включала рабочие пункты E.05 по стандарту выбросов самолетами CO2 и E.06 по взаимозависимостям (Приложение A). Эти пункты были распределены в рабочую группу CO2 (CO2TG). Совет ICAO из 36 стран принял новый стандарт выбросов самолетами CO2, который снизит влияние авиационных выбросов парниковых газов на глобальный климат. Информация содержится в новом томе III к Приложению 16 Чикагской конвенции (Защита окружающей среды), посвященного измерению выбросов CO2 для самолетов. Она является первым в мире глобальным стандартом сертификации проектов, регулирующим выбросы CO2 для любой отрасли промышленности. Стандарт применяется к новым конструкциям типов воздушных судов с 2020 года и к конструкциям типов самолетов, уже находящихся в производстве, начиная с 2023 года. Те серийные самолеты, которые до 2028 года не будут соответствовать стандарту, больше не смогут производиться, если их конструкции не будут переработаны и модифицированы.*

Ключевые слова: воздушный транспорт, выбросы, регулирование, стандарт, устойчивое развитие гражданской авиации.

Introduction. The development of world civil aviation is accompanied by continuous technological progress and requires constant improvement in the field of control and reduction of the negative impact of CO2 emissions. Achieving emissions reductions through technical standards is a fundamental element of ICAO's basket of measures to address aviation emissions. The sector remains the last major transport mode without vehicle emission standards, so the intensive CAEP work over the past years was an important opportunity for ICAO to deliver on its stated climate goals. The article is a logical continuation of a number of publications devoted to the development of air transport sustainable development of Ukrainian scientists D. Bugayko [1 – 8], Y. Kharazishvili [1, 2, 4, 7], M. Hryhorak [2 – 3], Y. Ierkovska [5 – 6], O. Ovdiienko [3], V. Marchuk [3], V Lyashenko[4], V Sokolovskiy [4], V Baranov[4], Mariia Bahrii [6], Polish scientists (Z. Zamiar [2,7]), Azerbaijan Scientists F. Aliev [6], and scientists of other countries.

The purpose of the article is to provide structural analysis of CO2 emissions standard for new aircraft in civil aviation sustainable development process.

Presentation of the main results. *Global challenges of climate change.*

The problem of climate change is one of the most serious modern challenges of mankind. In September 2015, world leaders gathered at the United Nations (UN) and adopted the 2030 Agenda for Sustainable Development. It is an action plan aimed at achieving global sustainable development in economic, social and environmental directions, which ensures that no UN member country is left behind. The 17 sustainable development goals in the 2030 agenda can be used as guidelines for the coordinated development of UN member countries.

Sustainable development goal 13. Climate change. Urgent action to combat climate change and its impacts is a key priority for every responsible citizen or organization today. Therefore, the global ecological situation is actually getting out of control [9].

According to the latest figures from the Intergovernmental Panel on Climate Change, international and domestic aviation activities account for approximately 2% of global CO2 emissions. At the same time, the percentage of international aviation is approximately 1.3 percent of global CO2 emissions [3]. Therefore, the environmental component is a priority for the development of world civil aviation, which is constantly improving its actions in the following areas: combating climate change (CORSIA), aviation noise and emissions of CO_2, NOx..., environmental technologies and operation, ecological aviation fuel, and others. One of the effective tools for countering the trend on the part of civil aviation is the implementation of the new CO_2 standard for aircraft.

New CO_2 standard for aircraft.

Subsonic jet aeroplanes, including their derived versions, of greater than 5 700 kg maximum take-off mass for which the application for a type certificate was submitted on or after 1 January 2020, except for those aeroplanes of less than or equal to 60 000 kg maximum take-off mass with a maximum passenger seating capacity of 19 seats or less;

Subsonic jet aeroplanes, including their derived versions, of greater than 5 700 kg and less than or equal to 60 000 kg maximum take-off mass with a maximum passenger seating capacity of 19 seats or less, for which the application for a type certificate was submitted on or after 1 January 2023;

All propeller-driven aeroplanes, including their derived versions, of greater than 8 618 kg maximum take-off mass, for which the application for a type certificate was submitted on or after 1 January 2020;

Derived versions of non-CO_2-certified subsonic jet aeroplanes of greater than 5 700 kg maximum certificated take-off mass for which the application for certification of the change in type design was submitted on or after 1 January 2023;

Derived versions of non-CO_2 certified propeller-driven aeroplanes of greater than 8 618 kg maximum certificated takeoff mass for which the application for certification of the change in type design was submitted on or after 1 January 2023;

Individual non-CO_2-certified subsonic jet aeroplanes of greater than 5 700 kg maximum certificated take-off mass for which a certificate of airworthiness was first issued on or after 1 January 2028; and

Individual non-CO_2-certified propeller-driven aeroplanes of greater than 8 618 kg maximum certificated take-off mass for which a certificate of airworthiness was first issued on or after 1 January 2028 [10, 11].

The CO_2 standard for aircraft – key points

Reduces aircraft CO_2 emissions by encouraging the integration of fuel efficient technologies into aircraft design and development.

Ensures that older aircraft models end production in an appropriate timeframe or that manufacturers invest in technology to improve their efficiency.

The standard also ensures that new designs go beyond the highest fuel efficiency of today's aircraft. Is a challenging and robust standard that brings CO_2 emissions into the formal certification process that new aircraft need to pass in order to enter service.

Is a significant milestone for the sector: the first such standard for aircraft and is key to the sector's long-term commitment to reduce CO_2 emissions from aviation.

Is part of a basket of measures to deal with industry's climate impact which include improved operations, sustainable alternative fuels, better use of infrastructure and new technology (which the CO_2 Standard will support).

Is complementary to an agreement in September/October this year on a global market-based measure to cap the growth in aviation CO_2 emissions from 2020 and meet the industry's mid-term goal.

Was developed by the ICAO Committee on Aviation Environmental Protection (CAEP) over a six-year period through 26 meetings and some 700 papers and pieces of analysis by 170 aviation experts from governments, industry and environmental groups [10].

CO_2 differs fundamentally from ICAO's noise and NOx standards because fuel efficiency has always been a major aircraft design parameter whereas noise and (to a large extent) engine emissions abatement measures, are not in themselves inherent to building aircraft – at least until regulation was introduced. While those measures simply add costs, every fuel efficiency improving technology has both costs and savings [12].

Fuel efficiency is central to aviation's business and sustainable growth strategy — as evidenced by the huge gains in fuel efficiency over the decades. The formalization of a CO2 Standard for aircraft is an important part of the sector's overall basket of measures for climate action and is complementary to the significant work already underway in the sector: new aircraft and alternative fuels technology; optimizing operational procedures; and improved infrastructure.

The Standard will ensure that all newly-developed aircraft and engines incorporate the latest commercially-available proven technologies, mindful that no single technology can be applied across the entire range of new aircraft and engine models from small regional and business aircraft to the very large capacity long-range commercial aircraft.

The CO2 emissions of aircraft become part of the certification process, alongside safety compliance and noise measures, among other elements.

The establishment of the first global CO2 standard will allow monitoring and progress in the future towards achieving CO2 emissions reductions in line with research and development targets and technical feasibility.

How does the CO2 standard work?

The CO2 Standard focuses on cruise flight performance because the cruise portion of a flight is typically when the most fuel is consumed and the majority of CO2 is emitted.

It takes account of the 'transport capability' of the aircraft — i.e. what is transported and how far it is transported. These two elements, the payload and the range, are essential in the design of any aircraft. For each aircraft type, depending on its size and weight, the CO2 Standard defines a maximum metric value (fuel burn per flight kilometre) that may not be exceeded.

For each aircraft type, depending on its size and weight, the CO2 Standard defines a maximum metric value (fuel burn per flight kilometre) that may not be exceeded.

CO2 metric system to measure the aeroplane fuel burn

The intent of this CO2 metric system is to equitably reward advances in aeroplane technologies (e.g. propulsion, aerodynamics and structures) that contribute to reductions in aeroplane CO2 emissions, and differentiate between aeroplanes with different generations of these technologies. As well as accommodating the full range of technologies and designs which manufacturers can employ to reduce CO2 emissions, the CO2 metric system has been designed to be common across different aeroplane categories, regardless of aeroplane purpose or capability. An overview of the CO2 Metric System can be found in Figure 1 [13].

To establish the fuel efficiency of the aeroplane, the CO2 metric system uses multiple test points to represent the fuel burn performance of an aeroplane type during the cruise phase of flight. Specifically, there are three averaged (i.e. equally weighted) points representing aeroplane high, middle and low gross masses, which are calculated as a function of Maximum Take-Off Mass (MTOM). Each of these represents an aeroplane cruise gross mass seen regularly in service. The objective of using three gross mass cruise points is to make the evaluation of fuel burn performance more relevant to day-to-day aeroplane operations. The metric system is based on the inverse of Specific Air Range (i.e. 1/SAR), where SAR represents the distance an aeroplane travels in the cruise flight phase per unit of fuel consumed. In some aeroplane designs, there are instances where changes in aeroplane size may not reflect changes in aeroplane weight, for example when an aeroplane is a stretched version of an existing aeroplane design [13].

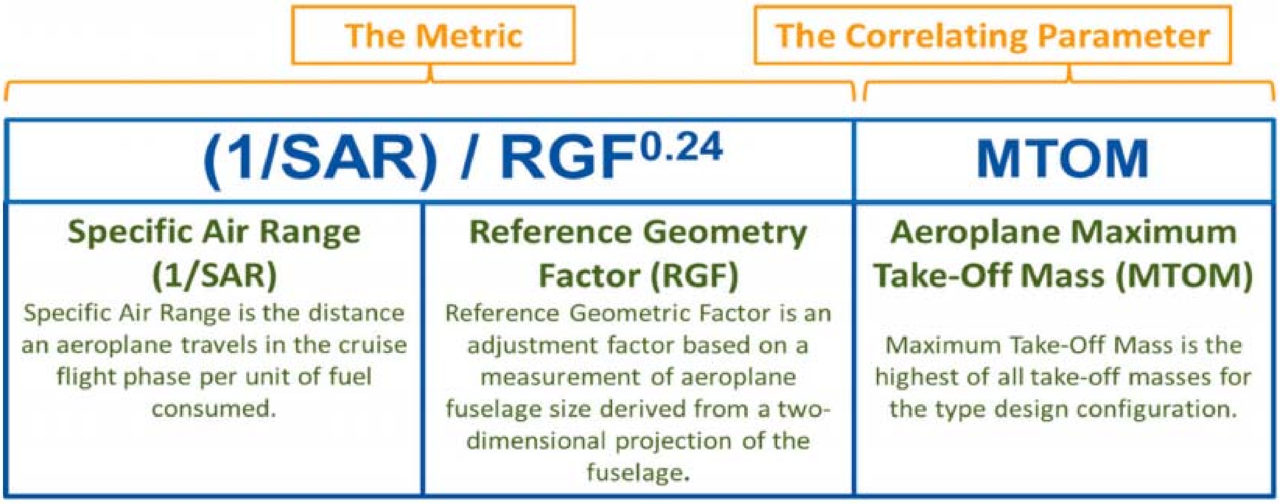

Figure 1 - An overview of the CO2 Metric System [7].

Source: 2016 Environmental Report - Aviation And Environment/ the CAEP/10 recommendation on a new ICAO AEROPLANE CO2 EMISSIONS STANDARD by Stephen Arrowsmith (European Aviation Safety Agency) and Laszlo Windhoffer (US Federalaviation Administration) ICAO, 2016 – P.112 – 114 [13].

To better account for such instances, not to mention the wide variety of aeroplane types and the technologies they employ, an adjustment factor was used to represent aeroplane size. This is defined as the Reference Geometric Factor (RGF), and it is a measure of aeroplane cabin size based on a two-dimensional projection of the cabin. This improved the performance of the CO2 metric system, making it fairer and better able to account for different aeroplane type designs.

The overall capabilities of the aeroplane design are represented in the CO2 metric system by the certified MTOM. This accounts for the majority of aeroplane design features which allow it to meet market demand. Based on the CO2 metric system, CAEP developed procedures for the certification requirement including, inter alia, the flight test and measurement conditions; the measurement of SAR; corrections to reference conditions; and the definition of the RGF used in the CO2 emissions metric. CAEP utilized manufacturers' existing practices in measuring aeroplane fuel burn in order to understand how current practices could be used and built upon for the new Standard [13].

Setting the regulatory limit

ICAO environmental Standards are designed to be environmentally effective, technically feasible, economically reasonable, while considering environmental interdependencies.

This involved defining an analytical space within which CAEP would work to investigate the options available. This included the development of options for the regulatory limit line, applicability options and dates, and all the associated assumptions which allowed the CAEP working groups to perform the cost - effectiveness analysis required to make an informed decision on the Standard at the CAEP/10 meeting. The foundation of the CAEP/10 recommendation on the CO2 emissions Standard was supported by this significant data informed process, involving input from ICAO member states and stakeholders.

The modeling exercise involved several analytical tools, including fleet evolution modeling, environmental benefits, recurring costs, non-recurring costs, costs per metric tonne of CO2 avoided, certification costs, applicability scenarios and various sensitivity studies to inform the decision-making process. This work allowed CAEP to conduct an analysis, with the aim of providing a reasonable assessment of the economic costs and environmental benefits for a potential, CO2 standard in comparison with a "no action" baseline [13]. The CO2 Standard regulatory limits can be found in Figure 2.

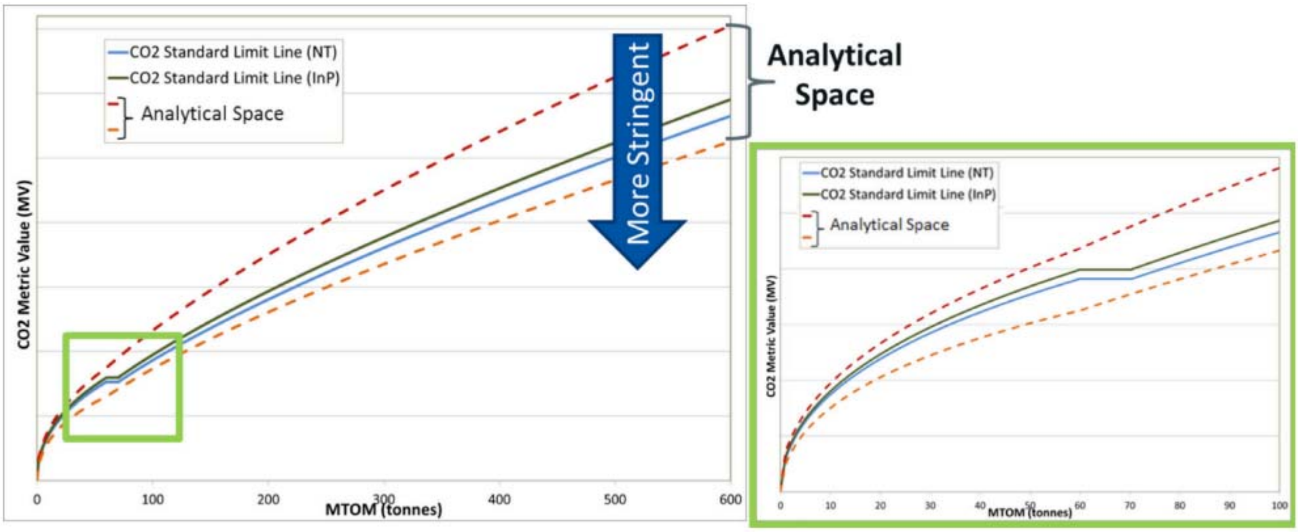

Figure 2 - The CO2 Standard regulatory limits

Source: ICAO'S CO2 standard for new aircraft, ICAO, 2017 [10].

Choices considered during the co2 standard work

– Ten Regulatory Limit Lines;
– Treatment of aeroplanes above and below 60 tonnes;
– New Type and In-Production applicability;
– Production cut-off; and
– Applicability dates of 2020, 2023, 2025 and 2028.

Conclusions. Each new generation of aircraft is roughly 15-20% more efficient than the model it replaces. The CO2 Standard mandates that these improvements continue.

However, the continuous development of new aircraft and engine technology, underpinned by the CO2 Standard, is only one part of overall aircraft efficiency improvements.

The aviation industry approach focuses on four pillars of climate action: reducing fuel use (and CO2 emissions) through new technology and alternative fuels; better operations of existing aircraft; and improvements in infrastructure. For all emissions that cannot be reduced through these pillars, a global market-based measure will be used to offset the remaining emissions in order to meet the targets set by the industry. The CO2 Standard will be reviewed as part of the regular cycle of ICAO's Committee on Aviation Environmental Protection (CAEP) [14].

At the same time, without diminishing the great importance of the introduction of this standard for the greening of global aviation transport, it is advisable to make some polemical remarks. From the point of view of the authors, its implementation will lead to further globalization of the aviation industry. Under such conditions, the most innovative manufacturers of aircraft and aircraft engines virtually monopolize the global aviation sales market. Under such conditions, other aviation equipment enterprises, in particular the Ukrainian enterprises «Antonov» and «Motor Sich», need to use proactive risk management procedures and plan mandatory changes in the design of aviation equipment. This will allow them to maintain a segment in the market and contribute to the greening of the industry.

The use of the CO2 Standard is a robust evolution of the sustainability toolkit for global, regional and national air transport. Regulation of the environmental component of the industry's work allows it to be a necessary component to achieve the United Nations Sustainable Development Strategic Goals.

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CONCEPTUAL PRINCIPLES OF THE "GREEN" TECHNOLOGIES INTRODUCTION IN THE LOGISTICS ACTIVITIES OF UKRAINIAN COMPANIES IN THE CONTEXT OF THE IMPLEMENTATION OF EUROPEAN ENVIRONMENTAL PROGRAMS

Sergiy Grytsenko, Lidiia Savchenko, Serhii Kryshtal. "Conceptual principles of the "green" technologies introduction in the logistics activities of Ukrainian companies in the context of the implementation of European environmental programs". *The article reveals the essence of the conceptual approach to "green" technologies in the logistics activities of enterprises. The concept of "green" technologies has been clarified as technologies that use environmentally safe production processes and supply chains in comparison with the production methods traditionally used at enterprises.*

The role and opportunities of Ukrainian environmental logistics in the European Green Deal have been studied. It has been established that the European Green Deal is a program of the European Union aimed at protecting the climate and the environment. This program is aimed at making the economies of the European Union countries more resource-efficient, canceling greenhouse gas emissions by 2050 and separating economic growth from the use of natural resources.

Currently, Ukraine is only planning to join the European Green Deal, declaring in the National Economic Strategy the intention to achieve climate neutrality by 2060.

The state and general trends of the development of strategic logistics infrastructure projects of Ukraine in the context of the implementation of the Green Deal and Digital Europe programs are analyzed. The Europian Green Deal is a dynamic instrument that is at the stage of formation.

The purpose of the article is the development of theoretical and methodological foundations, applied recommendations regarding the prospects of "green" technologies in the logistics activities of Ukrainian enterprises: their concepts and features of implementation within the framework of the European Green Deal and Digital Europe programs, "European Union for the Environment" (EU4Environment), development of sustainable logistics in Ukraine, features of application in specific logistics processes, problems and prospects, logistics strategy of Ukrainian enterprises.

The process of applying "green" technologies in supply chain management is analyzed. In the logistics chain, processes related to supply, production, warehousing, transportation and distribution are involved, therefore, logistics activities are focused not only on the internal business processes of the enterprise, but also have a significant impact on the environment and contribute to the emergence of negative environmental consequences.

In connection with the above, the concept of "green" (sustainable) supply chains, which provides for a minimal harmful impact on the environment during the implementation of logistics business processes, has recently become widespread.

Keywords*:* ecology, supply chains, logistics activity, environmental strategy, European Green Deal, transport logistics, decarbonization.

Сергій Гриценко, Лідія Савченко, Сергій Кришталь. «Концептуальні засади впровадження «зелених» технологій в логістичну діяльність підприємств України в контексті реалізації європейських екологічних програм». *У статті розкрито сутність концептуального підходу до «зелених» технологій в логістичній діяльності підприємств. Уточнено поняття «зелених» технологій як технологій, що використовують екологічно безпечні виробничі процеси та ланцюги постачання у порівнянні зі способами виробництва, що використовуються на підприємствах традиційно.*

Досліджено роль і можливості української екологістики в Європейському зеленому курсі. Встановлено, що Європейський зелений курс – це програма Європейського Союзу, яка направлена на захист клімату та навколишнього середовища. Дана програма націлена зробити економіку країн Європейського Союзу більш ресурсоефективною, анулювавши до 2050 року викиди парникових газів та відокремивши економічне зростання від застосування природних ресурсів.

На сьогодні Україна тільки планує приєднатися до Європейського зеленого курсу, проголосивши в Національній економічній стратегії намір досягти кліматичної нейтральності до 2060 року.

Проаналізовано стан та загальні тенденції розвитку стратегічних логістичних інфраструктурних проєктів України в контексті реалізації програм Green Deal і Digital Europe. Europian Green Deal - динамічний інструмент, що перебуває на стадії формування.

Метою статті є розробка теоретико-методичних основ, прикладних рекомендацій щодо перспектив «зелених» технологій в логістичній діяльності підприємств України: їх поняття та особливості впровадження в рамках Європейського зеленого курсу та програм Green Deal і Digital Europe, «Європейський Союз для довкілля» (EU4Environment), розвиток «зеленої» логістики в Україні, особливості застосування в конкретних логістичних процесах, проблеми та перспективи, логістична стратегія українських підприємств.

Проаналізовано процес застосування «зелених» технологій в управлінні ланцюгами постачань. В логістичному ланцюзі задіяні процеси, пов'язані з постачанням, виробництвом, складуванням, транспортуванням та розподілом, отже, логістична діяльність зосереджена не лише на внутрішніх *бізнес-процесах підприємства, але й здійснює значний вплив на навколишнє середовище та сприяє виникненню негативних екологічних наслідків.*

У зв'язку з вищенаведеним останнім часом набуває поширення концепція «зелених» ланцюгів постачань, що передбачає мінімальний шкідливий вплив на зовнішнє середовище при здійсненні логістичних бізнес-процесів.

Ключові слова: екологістика, ланцюги постачань, логістична діяльність, екологічна стратегія, Європейський зелений курс, транспортна логістика, декарбонізація.

Сергей Гриценко, Лидия Савченко, Сергей Крышталь. «Концептуальные основы внедрения «зеленых» технологий в логистическую деятельность предприятий Украины в контексте реализации европейских экологических программ». *В статье раскрыта сущность концептуального подхода к «зеленым» технологиям в логистической деятельности предприятий. Уточнено понятие «зеленых» технологий как технологий, использующих экологически безопасные производственные процессы и цепи поставок по сравнению со способами производства, используемыми на предприятиях традиционно.*

Исследованы роль и возможности украинской экологистики в Европейском зеленом курсе. Установлено, что Европейский зеленый курс – это программа Европейского Союза, направленная на защиту климата и окружающей среды. Данная программа нацелена сделать экономику стран Европейского Союза более ресурсоэффективной, аннулировав к 2050 г. выбросы парниковых газов и отделив экономический рост от применения природных ресурсов.

Сегодня Украина только планирует присоединиться к Европейскому зеленому курсу, провозгласив в Национальной экономической стратегии намерение достичь климатической нейтральности к 2060 году.

Проанализированы состояние и общие тенденции развития стратегических логистических инфраструктурных проектов Украины в контексте реализации программ Green Deal і Digital Europe. Europian Green Deal – динамичный инструмент, находящийся на стадии формирования.

Целью статьи является разработка теоретико-методических основ, прикладных рекомендаций по перспективам «зеленых» технологий в логистической деятельности предприятий Украины: их понятия и особенности внедрения в рамках Европейского зеленого курса и программ Green Deal и Digital Europe, Европейский Союз для окружающей среды (EU4Environment), развитие «зеленой» логистики в Украине, особенности применения в конкретных логистических процессах, проблемы и перспективы, логистическая стратегия украинских предприятий.

Проанализирован процесс применения «зеленых» технологий в управлении цепями поставок. В логистической цепи задействованы процессы, связанные с снабжением, производством, складированием, транспортировкой и распределением, следовательно, логистическая деятельность сосредоточена не только на внутренних бизнес-процессах предприятия, но и оказывает значительное влияние на окружающую среду и способствует возникновению негативных экологических последствий.

В связи с вышеприведенным в последнее время получает распространение концепция «зеленых» цепей поставок, предусматривающая минимальное вредное влияние на внешнюю среду при осуществлении логистических бизнес-процессов.

Ключевые слова: экологистика, цепи поставок, логистическая деятельность, экологическая стратегия, Европейский зеленый курс, транспортная логистика, декарбонизация.

Introduction. At the current stage of development, the consideration of logistics as one of the factors of environmental protection is gaining relevance, because logistics deals with the supply of raw materials to the enterprise, the movement of semi-finished products within the enterprise, the transportation of finished products to warehouses and the delivery of goods to customers. With the appearance in science of the concept of "green" logistics, which is based on resource-saving and environmentally safe processes and technologies, it began to be called ecological logistics (ecologistics) [1, p. 8].

As a result of the definition of the concept of "green" logistics (ecologistics), the concept of "green" technologies becomes clearer. Thus, green technologies can be called such technologies that use environmentally safe production processes and supply chains in comparison with the production methods used at enterprises traditionally.

Today, "green" technologies are used in the environmental, economic, technological and innovative spheres of state policy. They are applied when solving the issue of processing and disposal of waste, the implementation of alternative sources of electrical energy [2].

Environmentalism takes a leading place and plays an important role in the European Green Deal. The European Green Deal is a program of the European Union aimed at protecting the climate and the environment. The program is aimed at making the economy of the European Union countries more resource-efficient by canceling greenhouse gas emissions by 2050 and separating economic growth from the use of natural resources [3].

The European Union seeks to motivate other states by its own example. That is, by developing a "green" economy and "green" logistics in particular, the European Union will achieve stable economic growth and make the entire planet cleaner and safer. Today, Ukraine also seeks to develop "green" logistics, as it seeks to gain economic benefits from the global movement towards climate neutrality and to clean up the environment of the planet.

Therefore, the main task of environmental logistics is to ensure the minimization of damage to the environment due to restrictive conditions regarding the use of natural resources in the sphere of supply, production and sales.

For the development of "green" logistics at Ukrainian logistics enterprises, the enterprise itself must actively cooperate with state and local authorities, other enterprises and citizens who are final consumers of logistics services.

"Green" technologies must be implemented at each company taking into account the needs of customers of logistics services, their wishes and needs.

Today, the majority of Ukrainian logistics enterprises have joined the policy of decarbonization and implementation of the European Green Deal.

Analysis of recent research and publications. In the economic literature, a lot of attention is paid to the issue of "environmentalization" of logistics activities of enterprises [4-16].

Research also revealed ways to reduce the impact of logistics systems of enterprises on the environment.

However, the highlighted approaches to improving the greening of logistics activities of enterprises do not include prospects for the introduction of "green" technologies in the work of logistics companies of Ukraine, which requires further research.

The aim and task of the research: development of theoretical and methodological foundations, applied recommendations regarding the prospects of "green" technologies in the logistics activities of Ukrainian enterprises: their concepts and features of implementation within the framework of the European Green Course, Green Deal, Digital Europe and European Union for the Environment (EU4Environment), development of "green" logistics in Ukraine, features of application in specific logistics processes, problems and prospects, logistics strategy of Ukrainian enterprises.

Main material and research results.

Deterioration of the environment is a consequence of the intensive globalization process in international business. In order to survive, the economy must be reorganized in such a way that the industry is fully integrated with an efficient sustainable infrastructure and the introduction of "green" technologies into the logistics activities of enterprises [16].

The use of "green" technologies at enterprises is currently considered a new business philosophy based on a resource-saving concept, the implementation of which in the economy helps:

– reduce damage to the environment by means of restrictive conditions for the use of natural raw resources in the sphere of supply, production and sales;

– choose a rational vector of business development using "green" energy and its combination with traditional energy sources;

– activate creative development, strategic thinking of managers at various levels;

– carry out "green" restructuring of the enterprise and its meaningful functional support;

– optimize transport flows to meet the material and technological needs of production;

– alleviate the environmental crisis thanks to waste recycling;

– reduce costs from "freezing" of capital in the form of inventory due to environmentally-oriented business plans and coordination of business partnerships;

– activate innovative activities of enterprises during the implementation of environmental standards for production, packaging, storage and transportation;

– strengthen the competitiveness of business processes thanks to the use of environmentally friendly "green" technologies and energy- and resource-saving equipment;

– involvement of alternative energy sources to perform functions in the field of supply, production and sale of finished products;

– enrich the marketing information system of enterprises thanks to the formation of environmental information and environmental monitoring of logistics marketing networks;

– multiply the economic and social effect by applying a reduction in the cost of resources per unit of manufactured products or services, as well as to increase labor productivity in the logistics chain of creating added value;

– increase the investment attractiveness of Ukrainian entrepreneurship.

The problem of efficient processing of waste and its reuse requires special attention in Ukraine. An important aspect is also the improvement of the efficiency of the use of partially renewable energy resources (wood, water, land resources) and the gradual transition to "clean" energy sources.

The main environmental measures implemented in Ukraine include:

– reuse of containers, which reduces packaging costs;

– thermal insulation of warehouses, which increases the heat output of warehouses, reduces energy costs for heating;

– rejection of paper document circulation, which saves costs for paper, cartridges, electricity, printers, document archiving, and also stimulates the introduction of modern management systems;

– planning of optimal routes for transportation of finished products, reduction of idle time and reduction of fuel consumption, freight consolidation and use of railway transport [17, p. 284].

Thus, domestic enterprises should implement effective environmental methods and tools, taking as an example of transnational corporations such as Toyota, Xerox, Johnson & Johnson, Honda, Volkswagen, Hewlett-Packard, Casio, Sony, for which the key incentive is the desire to form socially responsible image of the company.

Taking into account the foreign experience of countries that also implement the Green Deal and Digital Europe programs in their own business activities will contribute to the effective integration of environmentalism at domestic enterprises of many industries. Therefore, logistics department specialists should:

– introduce "green" innovations into supply chains;

– ensure waste recycling;

– introduce energy and resource saving at the enterprise;

– choose suppliers focused on environmental strategy;

– to ensure the production of eco-goods and the provision of services that are not harmful to the environment;

– use ecological packaging and containers reduced in size and materials;

– control indicators of harmful emissions into the atmosphere [18, p. 213].

It is interesting to note that modern products of the IT industry, for example, ERP systems, which are actively and effectively used to manage internal and external resources of the enterprise, can solve the problems of logistics companies in terms of reducing a significant amount of paper waste, transport downtime, personnel costs, etc.

Thus, the development of strategic logistics infrastructure projects in the context of the implementation of the Green Deal and Digital Europe programs is a promising direction of activity for Ukraine today and should ensure a balance between the economy and environment.

The application of "green" technologies in supply chain management is implemented as follows:

1. Supply. Interaction with suppliers, which involves reducing iterations in supply chains, the possibility of supplying environmentally-friendly and safe materials, implementing recycling, reducing anthropogenic load on the soil during the storage of material resources and their transportation from suppliers.

2. Production. Minimization of the use of non-recyclable raw materials and packaging, use of energy-saving technologies, maximum reuse of production waste, recycling of waste, application of the latest technologies for the use of secondary raw materials.

3. Storage. Provision of environmentally safe storage technologies, thermal insulation of warehouses, which contributes to reducing energy costs for heating and reducing the overall burden on the environment.

4. Transportation. Planning of optimal routes, reduction of idle time in congested flows and reduction of fuel consumption, use of multimodal technologies, which will contribute to the reduction of harmful emissions into the atmosphere.

5. Distribution. Reduction of the volume of solid waste in the process of finished goods delivery, use of "green" packaging materials, selection of sales channels according to the criterion of impact on the environment.

In recent years, "green" technologies have become a newfangled trend among Ukrainian logistics enterprises, that is, such enterprises are increasingly using technologies that do not cause or minimize damage to the environment. The negative aspects of this process are associated with the increase in logistics costs due to the use of "green" technologies. However, despite this, in today's competitive market conditions, logistics enterprises have no other way out than to switch to "green" logistics in order to reach the international level, meeting European standards, to consolidate their own positions in the international market, in which the use of "green" technologies will soon become mandatory.

In order to save money, Ukrainian logistics companies, in particular Nova Poshta, Meest Express, Ukrposhta, Ukrkuryer and others, use the following "green" logistics measures:

– returnable packaging, which significantly saves costs for packing parcels and other shipments, especially large ones;

– thermal insulation of warehouses, which helps to save electricity for heating, and at the same time to pay less utility bills;

– rejection of paper document circulation, which leads to reductions in costs for paper, printers and electricity;

– rational planning of transportation routes, freight consolidation, use of rail transport for transportation, which leads to reduction of CO2 emissions into the air.

The Meest Express company has introduced a program for the absorption of greenhouse gases, which consists in financing the planting of forests and their care from funds in the amount of UAH 1 for each parcel paid by the client. The Nova Poshta company is expanding its own fleet of electric cars and plans to purchase electric cargo vans for transportation in order to reduce CO2 emissions. The Ukrposhta company is testing the delivery of parcels using drones.

Logistics companies of Ukraine have proven that reducing pollution and negative impact on the environment increases the company's competitiveness. Environmental pollution is currently considered an economic waste, as it is a consequence of the company's inefficient use of resources and irrational management.

One of the key signs of the modern development of the world economy is the tendency to expand the scale, intensifying the exchange and movement of goods, capital, raw materials, financial and labor resources. The increase in the pace of import and export operations, together with other forms of international cooperation, became possible thanks to the intensive development of the transport and logistics infrastructure, which is accompanied by an increase in the number of vehicles not only in the regional, but also in the global transport fleet.

The functioning of transport logistics is connected with the growth of consumption of material and energy resources and emissions of harmful substances, in particular greenhouse gases. The process of carbonization leads to a decrease in the content of hydrogen and oxygen and an increase in carbon in the atmospheric air. This leads to an increase in anthropogenic burden on the environment.

Therefore, the issues of "greening" of transport and decarbonization in order to increase environmental safety and reduce harmful ecological and economic consequences for the environment and human health are in the center of attention of the world community, demanding an urgent solution.

The analysis of economic, social and environmental relations in the "transport - environment" system allows to identify the factors of indirect negative impact at the following levels: legal, economic, environmental and social (Table 1).

Transport companies are forced to develop and apply effective approaches to resource and energy flow management, decarbonization of their activities in order to reduce ecological and economic damage caused to the environment, and ensure effective innovative development of transport activities in general.

Table 1 - Characteristics of the impact of transport logistics on the global ecosystem by groups of factors

Group of factors	Impact characteristics
Normative and legal	1. Weakness, imperfection of the environmental policy of the country, enterprise. 2. Outdated environmental requirements, regulations, standards that require revision for vehicles and transportation organization, etc.
Economical	1. Traffic congestion. 2. Excessive expenditure of material and energy resources.

End of Table 1

Group of factors	Impact characteristics
Ecological	1. Emissions of pollutants, including greenhouse gases. Global warming and climate change. 2. Consumption of non-renewable material and energy resources. 3. Generation of waste (tires, packaging, used lubricant). 4. Noise pollution. 5. Destructive impact on ecosystems, reduction of biodiversity, disappearance of certain species of plants and animals.
Social	1. Impact of pollution on human health and living conditions. 2. Increasing the danger on the roads (accidents). 3. Congestion of roads, which hinders passenger flow. 4. Destruction of green spaces and development of open space (logistics warehouses, hubs, etc.). 5. Accelerated moral and physical wear and tear of transport infrastructure facilities.

Source: compiled by the authors based on [19, p. 165, 20].

So, the set of indisputable facts about the negative effects of transport logistics on the environment, as well as additional economic advantages for transport companies, confirm the need for greening transport logistics. On the other hand, a detailed analysis of existing "green" practices, approaches and technologies has shown their contradictory nature regarding safety for the environment and human health. The assessment of the basic characteristics of logistics systems in the context of compatibility with environmental protection measures showed some discrepancy between economic and environmental results, which is commonly called the paradoxes of greening, including the decarbonization of logistics (Table 2).

The analysis of the existing negative effects of transport logistics on the environment and the economic advantages of greening transport activities explain the growing interest of manufacturers and society in the use and development of "green" technologies in transport logistics, its decarbonization.

However, some issues have not been studied yet due to the complexity and unpredictability of the consequences of their practical solution (paradoxes of "green" logistics). All this determines the need for a detailed study and further deepening of theoretical and practical provisions regarding the management of transport activities based on the principles of ecologistics and sustainable economic development.

The environmental strategy of logistics enterprises of Ukraine within the framework of the international program "European Union for the Environment" (EU4Environment) [22] is continuously developing through the use of environmentally safe materials for packing parcels, sorting garbage at branches, re-equipping the fleet, introducing electronic document flow, using modern and effective technologies for measurement of CO2 emissions of harmful substances into the air and other.

According to the goals of the international program "European Union for the Environment" Ukraine provides:

– increase national responsibility and speed up the greening of the economy of its state;

– increase environmental awareness of the population and its environmental education;

– implement the transition to "green" logistics and "green" economy, influence the recognition of this strategy by the population;

– implement resource-efficient and clean production methods at Ukrainian industrial enterprises;

Table 2 - Paradoxes of logistics greening

Indicator	Approach to achieving results	Paradox
Costs	- renewal of vehicles; - reducing the consumption of energy resources and/or their replacement (for example, replacing gasoline with gas fuel); - improvement and/or reduction of packaging material; - reduction of waste volumes	Environmental costs are mainly external, i.e. costs are incurred by third parties who are not involved in transport and logistics activities
Time/Flexibility	- integrated supply chains; - "Just-in-time" and "Door-to-Door" logistics concepts	The expansion of warehouse networks and/or the increase of areas for warehouse premises lead to the removal of additional land plots from general or agricultural turnover, an increase in the consumption of energy resources, and, as a result, an increase in the volume of emissions of harmful substances (CO_2, NO, etc.)
Warehouse networks	- development of transport and logistics networks (warehouses, hubs, etc.); - reducing the need for private warehouses	Localization of environmental impact around transshipment points. Increasing pressure on local communities

Source: compiled by the authors based on [21, p. 339-350].

– implement strategic approaches to the waste management process;

– support "green" reform in the economy;

– acquaint Ukraine and its population with the united market of "green" products and conduct its wide demonstration.

Regarding the practice of applying an environmental strategy within the international program "European Union for the Environment", it is worth noting that this program is most actively implemented by the Ukrainian company Meest Express, which began cooperation with the European Bank for Reconstruction and Development (EBRD) in the field of implementing a comprehensive system of environmental initiatives [23].

Interest in the development of ecology among companies, the government and the public is growing rapidly, especially because traditional logistics cannot meet the demands of modern society, but has a huge impact on the environment.

There are barriers to the implementation of environmental science, which are related to the environment: lack of necessary skills and technologies; lack of professional consultations; uncertainty of the result; participation of certifiers/verifiers; lack of resources; implementation and maintenance costs.

These barriers are also characteristic of Ukrainian enterprises. In particular, the low quality of Ukraine's transport infrastructure, which is present in all its components, becomes a significant obstacle to the use of more environmentally-friendly transport. The situation is complicated by insufficient interaction between different branches of the transport sector, low investment inflow, an outdated regulatory system and a high degree of wear and tear of fixed assets [24, p. 86].

Ukraine has an advantageous geographical location in Europe, as it is a transit country, and therefore it is obliged to have a high logistics potential with the introduction of "green" logistics measures, which is especially important in wartime.

Conclusions. The concept of "green" logistics includes: environmentally safe transportation and storage; resource conservation; personnel responsibility; introduction of IT technologies; waste minimization; waste recycling.

"Green" logistics is aimed at managing supply chains in order to minimize environmental, social, and economic damage and create additional value for the consumer through the use of resource- and energy-saving technologies.

In general, the implementation of "green" technologies in the work of logistics companies is completely economically justified, it increases the competitiveness of the enterprise, opens the way to international markets, attracts a larger number of consumers.

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MATHEMATICAL METHOD OF ASSESSING THE POTENTIAL USE OF LOGISTICS INFRASTRUCTURE

Mariya Hryhorak, Lesia Kostiuchenko, Oleh Harmash. «Mathematical method of assessing the potential use of logistics infrastructure». *The article reveals the content of the interpretation of the potential of logistics infrastructure concept. The main approaches to determining the logistics potential are described, on the basis of which a methodology for assessing its use is proposed. The purpose of the article is to research the components of the potential of logistics infrastructure objects and develop a mathematical model for its assessment. The author's understanding of the logistics potential of the logistics infrastructure is based on an integrated vision of the potential. Such integration has the form of a three-dimensional model with a "resources-abilities-competencies" coordinate system. The resource plane of such a model reveals the phenomenon of transformation of opportunities into abilities. In turn, abilities through their disclosure, consolidation and renewal with the help of training are transformed into competences.*

The proposed mathematical model of assessing the integral potential of the logistics infrastructure of the enterprise is performed taking into account its life cycle. This approach ensures the objectivity of the assessment of the integral potential. This can provide an assessment of the potential in view of three components that provide directions for the formation and use of logistics infrastructure facilities: resourceful (assessment of material or energy intensity), organizational (efficiency of management, coordination, etc.) and functional (functional infrastructure components, blocks, etc.). Each of these components is characterized by a set of parameters, the assessment of which reflects their compliance with a certain stage of the life cycle of the object under study. The correct selection of a group of parameters is important. In particular, such a group of *parameters can be: compliance as a complete set of necessary functions, operations, properties, etc.; excellence as a level of innovative development, informatization, digitization, etc.; usefulness as a level of specialization or versatility (capacity); relevance as a level of expediency, need for use, etc.; relevance as the possibility or suitability of being replaced by a similar means or resource. In this way, the integration of the potentials of individual elements of each direction of formation forms the overall potential of the logistics infrastructure object.*

***Keywords**:* logistics infrastructure, logistics infrastructure potential, potential application assessment method, potential assessment model, integrated logistics infrastructure potential.

Марія Григорак, Леся Костюченко, Олег Гармаш. «Математичний метод оцінки використання потенціалу логістичної інфраструктури». *У статті досліджено трактування поняття потенціалу логістичної інфраструктури. Описано головні підходи до визначення логістичного потенціалу на основі якого запропоновано методику оцінки його використання. Метою статті є дослідження складових потенціалу об'єктів логістичної інфраструктури та розробка математичної моделі його оцінки. Авторське розуміння логістичного потенціалу логістичної інфраструктури ґрунтується на інтегрованому баченні потенціалу. Таке інтегрування має форму тривимірної моделі з системою координат «ресурси-здатності-компетенції». Ресурсна площина такої моделі розкриває феномен перетворення можливостей в здатності. У свою чергу здатності через їх розкриття, закріплення й оновлення за допомогою навчання трансформуються у компетенції.*

Запропонована математична модель оцінки інтегрального потенціалу логістичної інфраструктури підприємства виконане з урахуванням його життєвого циклу. Такий підхід забезпечує об'єктивність оцінки інтегрального потенціалу. Це може забезпечити оцінку потенціалу з огляду на три складові, які забезпечують напрями формування і використання об'єктів логістичної інфраструктури: ресурсну (оцінка матеріало- чи енергоємності), організаційну (ефективність управління, злагодження тощо) та функціональну (функціональних інфраструктурних складових, блоків тощо). Кожна з цих складових характеризується сукупністю параметрів, оцінка яких відображає їх відповідність певній стадії життєвого циклу досліджуваного об'єкта. Важливим є правильний підбір групи параметрів. Зокрема, такою групою параметрів можуть бути: відповідність як повний набір необхідних функцій, операцій, властивостей тощо; досконалість як рівень інноваційного розвитку, інформатизації, цифровізації тощо; корисність як рівень спеціалізації/універсальності (дієздатності); актуальність як рівень доцільності, потреби у використанні тощо; значущість як можливість або придатність до заміни аналогічним засобом або ресурсом. Таким чином інтегрування потенціалів окремих елементів кожного напрямку формування утворює сукупний потенціал логістичного інфраструктурного об'єкту.

Ключові слова: логістична інфраструктура, потенціал логістичної інфраструктури, методика оцінки використання потенціалу, модель оцінки потенціалу, інтегральний потенціал логістичної інфраструктури.

Мария Григорак, Леся Костюченко, Олег Гармаш. «Математическая модель оценки реализации потенциала логистической инфраструктуры». *В статье исследовано видение понятия потенциала логистической инфраструктуры. Описаны основные подходы к определению логистического потенциала, на основании которого предложена методика оценки его использования. Целью статьи является исследование составляющих потенциала использования объектов логистической инфраструктуры, а также разработка математической модели его оценки. Авторское видение логистического потенциала логистической инфраструктуры основывается на интегрированном видении потенциала. Такая интеграция имеет форму* *трехмерной модели с системой координат «ресурсы-способности-компетенции». Ресурсная плоскость такой модели раскрывает феномен превращения возможностей в способности. В свою очередь способности средством их раскрытия, укрепления и обновления, а также обучения трансформируются в компетенции.*

Предложенная математическая модель оценки интегрального потенциала логистической инфраструктуры предприятия составлена с учетом его жизненного цикла. Такой подход обеспечивает объективность оценки интегрального потенциала. Это может обеспечить оценку потенциала с учётом трех составляющих, обеспечивающих направление формирования и использования объектов логистической инфраструктуры: ресурсная (оценка материало- или энергоемкости), организационная (эффективность управления, сплоченности и т.п.), функциональная (функциональных инфраструктурных составляющих, блоков и т.д.). Каждая из этих составляющих характеризуется совокупностью параметров, оценка которых отображает их соответствие определенной стадии жизненного цикла исследуемого объекта. Важным является правильный выбор группы параметров. В частности, такой группой параметров могут быть: соответствие в качестве полного набора необходимых функций, операций, свойств и т.п.; совершенство как уровень инновационного развития, информатизации, цифровизации и т.д.; полезность как уровень специализации/универсальности (дееспособности); актуальность как уровень целесообразности, потребности в использовании и т.п.; значимость как возможность или способность к замещению аналоговым средством или ресурсом. таким образом, интегрирование потенциалов отдельных элементов каждого направления образует совокупный потенциал логистического инфраструктурного объекта.

Ключевые слова: логистическая инфраструктура, потенциал логистической инфраструктуры, методика оценки использования потенциала, модель оценки потенциала, интегральный потенциал логистической инфраструктуры.

Introduction. The current stage of the development of economic relations in Ukraine is characterized by the emergence and development of new relations, the basis of which is the cooperation of producers, suppliers, users for the purpose of integrated management of business processes throughout the entire life cycle of products. Non-production factors have a greater impact on the economy of enterprises: sales, supply, service, the effective implementation of which is ensured by the maximum use of the logistics infrastructure potential. Therefore, today the research and development of methodology for assessing the potential of logistics infrastructure are gaining relevance.

Analysis of recent research and publications. The problems of managing the logistics infrastructure and directly defining the logistics potential were investigated in their works by such scientists as Hrytsenko S.I., Krykavskyi E.V. [4], Kovalev K.Yu., Levkovets R.P., Pashchenko Yu.E., Sokolova O.E. [5], Smerichevska S.V. etc. On the basis of their scientific developments, a range of issues regarding approaches to assessing the potential of logistics infrastructure facilities are also resolved. A fairly thorough analysis of the definition of the term "logistics potential" is presented in the publication [2]. Based on the results of the terminological analysis, the author identified different approaches to determining the logistics potential (see Table 1).

The purpose and objectives of the study. The purpose of the article is to research the components of the potential of logistics infrastructure objects and develop a mathematical model for its assessment.

Table 1 – Generalization of approaches to determining logistics potential

Approaches	Definition of logistics potential
Resourceful	the possibility of using resources for logistics operations and functions
Effective	the ability to ensure the achievement of the set goals of logistics activities
Effective and resourceful	symbiosis of resource and effective approaches

Source: developed by the authors on the basis of [3, p.281 – 284]

Basic material and results. In general logistics infrastructure is a set of elements that perform important logistics tasks and ensure the implementation of logistics processes [1; 2]. In other words, it is an integrated set of warehouse, transport, handling, packaging, information and financial infrastructure of the enterprise, which in the complex provide effective logistic service of the material flow according to the principle "from door to door" with minimal costs in accordance with the requirements of consumers. The given definition indicates the need for effective use of logistics infrastructure in the process of coordination and maintenance of supply chains, which also reinforces the relevance of the study of assessment parameters of this component of logistics.

The author's understanding of the logistics potential of the logistics infrastructure is based on an integrated vision of the potential. Such integration has the form of a three-dimensional model with a "resources-abilities-competencies" coordinate system. The resource plane of such a model reveals the phenomenon of transformation of opportunities into abilities. In turn, abilities through their disclosure, consolidation and renewal with the help of training are transformed into competences [2, c. 285]. The implementation of a complex of such opportunities takes place under the conditions of the implementation of business processes and self-organization processes and contributes to the creation of value for stakeholders. Based on such a position, it is possible to define the logistics potential as the ability of the logistics system to achieve its strategic goals in the most effective way in terms of time, quality and costs, taking into account the influence of factors of its internal and external environment.

Let's summarize the mentioned theoretical positions of various scientists regarding the definition of the economic essence and the conceptual model of logistics potential. Therefore, we offer an integrated vision in the form of a four-dimensional model with a "resources-capabilities-management system-competencies" coordinate system. In such a coordinate system, the resource plane reveals the phenomenon of the transformation of opportunities into abilities, and abilities through their disclosure, consolidation and renewal through training are transformed into competences. The realization of the specified opportunities complex takes place under the conditions of the implementation of business processes and self-organization processes and contributes to the creation of value for interested parties (stakeholders). The degree of satisfaction of the requests of various stakeholders from the result of the transformation of resources and the success of the logistics system functioning in general depend not only on the availability of resources, but also on the knowledge and skills to combine them into single technological and management processes, that is, on intellectual and human potential.

On the other hand, modern scientific developments of specialists in economics in general and logistics in particular pay little attention to the assessment of the use of potential capabilities of logistics infrastructure objects as a component of the logistics system in general. At the same time, there are often works devoted to the assessment of the investment or competitive potential of enterprises. The majority of authors are inclined to the opinion of the expediency of using integral potential, taking into account the life cycle of a certain enterprise or logistics system.

The formation of the mathematical model for assessing the integral potential of the logistics infrastructure of the enterprise is carried out taking into account the life cycle of its objects. This approach ensures the objectivity of the integral potential assessment approach. This can provide an assessment of the potential in view of three components that provide directions for the formation and use of logistics infrastructure facilities: resourceful (assessment of material or energy intensity) – ***R***, organizational (efficiency of management, coordination, etc.) – ***O*** and functional (functional infrastructure components, blocks, etc.) – ***F***. Each component is characterized by a set of parameters, the assessment of which reflects their compliance with a certain stage of the life cycle of the object under study. The correct selection of a parameters group is important. In particular, such a group of parameters can be (see Table 2):

– compliance (full set of necessary functions, operations, properties, etc.) – ***C***;

– excellence (level of innovative development, informatization, etc.) – ***E;***

– usefulness – level of specialization or universality (functionality) – ***U***;

– relevance (level of feasibility, need for use, etc.) – ***Re***;

– significance (possibility or suitability for replacement by a similar means or resource) – ***S***.

Table 2 - The structure of the parameters of the assessment of the elements of the logistics infrastructure potential formation

Directions of formation		Evaluation parameters				
Component	Element	Compliance	Excellence	Usefulness	Relevance	Significance
Resourceful	$\forall r \in R$	C_r	E_r	U_r	Re_r	S_r
Organizational	$\forall o \in O$	C_o	E_o	U_o	Re_o	S_o
Functional	$\forall f \in F$	C_f	E_f	U_f	Re_f	S_f

Source: developed by the authors on the basis of [1]

Then, at a certain life cycle stage of the logistics infrastructure object, each potential element is a function of the corresponding evaluation parameters according to the following formulas:

$$\left.\begin{aligned} \forall o \in O : e_o = f_o(\mathrm{C}_o E_o U_o \mathrm{Re}_o \mathrm{S}_o); \\ \forall r \in R : e_r = f_r(\mathrm{C}_r \mathrm{E}_r \mathrm{U}_r \mathrm{Re}_r \mathrm{S}_r); \\ \forall f \in F : e_f = f_f(\mathrm{C}_f \mathrm{E}_f \mathrm{U}_f \mathrm{Re}_f \mathrm{S}_f). \end{aligned}\right\} \tag{1}$$

It is important to take into account that each of the above-described elements of the logistics infrastructure potential, in turn, is influenced by other elements. Thus, logistics infrastructure objects are characterized by dependence not only on the corresponding parameter estimates, but also on other adjacent elements of the logistics system and external conditions (see Table 3).

Table 3 - The structure of parameters influencing the level of elements potential

Directions of formation		Factor parameters		
Component	Element potential	Resource element	Organizational element	Functional element
Resourceful	$\forall r \in R$ p_r	$\forall r \in R$ e_r	$\forall o \in O$ e_o	$\forall f \in F$ e_f
Organizational	$\forall o \in O$ p_s	$\forall r \in R$ e_r	$\forall o \in O$ e_o	$\forall f \in F$ e_f
Functional	$\forall f \in F$ p_f	$\forall r \in R$ e_r	$\forall o \in O$ e_o	$\forall f \in F$ e_f

Conclusions. The structure of the parameters of influence on the level of potential by detailing the elements given in Table 2 produces the following conclusion. At a certain stage of the life cycle of a logistics infrastructure object, the level of potential of each individual element may have a different value. Since the directions of potential formation of individual evaluation parameters of its elements are related to the rest of the elements, and are influenced to varying degrees by external conditions. Mathematically, this dependence is a function of the corresponding parameters of other elements:

$$\left.\begin{aligned} &\forall f \in F : p_f = f_{p_f}(e_r, e_o, e_f), \forall r \in R, \forall o \in O; \\ &\forall o \in S : p_o = f_{p_s}(e_r, e_o, e_f), \forall r \in R, \forall f \in F; \\ &\forall r \in R : p_r = f_{p_f}(e_r, e_o, e_f), \forall o \in O, \forall f \in F. \end{aligned}\right\} \quad (2)$$

In this way, the integration of the individual elements potentials of each direction of formation forms the overall potential of the logistics infrastructure object. Thus, there is structure of formation potential factors in the table 4.

Table 4 – The structure of formation potential factors

Directions of formation		Factor parameters		
Component	Formation potential	Resource element potential	Organizational element potential	Functional element potential
Resourceful	P_R	$\forall r \in R$ p_r		
Organizational	P_O		$\forall o \in O$ p_o	
Functional	P_F			$\forall f \in F$ p_f

Then, at a certain stage of the logistics infrastructure object's life cycle, the overall potential of the logistics infrastructure object will correspond to the function of the corresponding parameters of the potentials of its elements:

$$\left.\begin{aligned} P_R &= f_P(p_1, p_2, \ldots, p_r, \ldots, p_R); \\ P_O &= f_P(p_1, p_2, \ldots, p_o, \ldots, p_O); \\ P_F &= f_P(p_1, p_2, \ldots, p_f, \ldots, p_F). \end{aligned}\right\} \qquad (3)$$

Therefore, the integrated set of potentials of individual formations forms the integral potential of the logistics infrastructure object. Within the defined stage of the life cycle, the integral potential of a logistics infrastructure object is a function of the corresponding parameters of the potential factors of its formation and has the following mathematical expression:

$$P_I = f_{P_I}(P_R, P_O, P_F) \quad \text{або} \quad P_I = \sqrt[n]{\prod P_n}, \qquad (4)$$

де $P_1 = P_R$; $P_2 = P_O$; $P_3 = P_F$.

Logistics infrastructure management in modern economic conditions is characterized by the presence of a large number of specific features and problems, the main ones of which are analyzed above. The given method of assessing the potential of the logistics infrastructure reflects a synergistic effect that significantly affects the final results of the performance of logistics functions. The proposed approach requires more detailed research, deeper analysis and the development of new models for evaluating the indicators of the use of infrastructure facilities suitable for practical use.

It should be added that for a qualitative assessment of factors affecting the realization of logistics potential at the macro level, it is advisable to take into account indirect effects. For example, such indirect effects are obstacles in the development of the logistics system within the limits of its market functioning. The main such obstacles include the imperfection or lack of state policy and state strategy, which affects the conditions of conducting logistics business and the possibility of realizing the logistics potential of the country. Therefore, an important subject of further research is the study of the methodology for assessing the logistics potential of the logistics services market, which is an important element of the national logistics system.

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GREENING OF THE MARITIME TRANSPORT PROCESS

Oksana Pozniak, Olexiy Antonov. "Greening of the maritime transport process" *The article is devoted to the study of the main trends in the greening of the maritime transport process. It has been proven that in order to reduce the negative impact on the environment, the contribution of each logistics company to the formation of ecological ecosystems must be systemic, and in order to ensure sustainable development, logistics companies must implement investment and innovative projects in various directions that help reduce the negative impact on the environment. This determines the main directions for the introduction of innovative technologies that can be implemented in the process of shipping in order to green the activities of a logistics company. Potential projects for the modernization of vehicles through their "greening" were studied to minimize the negative impact on the environment and maintain the competitive position of logistics companies. Detailed development and justification of the feasibility of implementing projects for a logistics company that supports the concept of sustainable development and implements the Green Business strategy has been carried out. The projects for the modernization of the transport infrastructure of a logistics company are analyzed, and the advantages, disadvantages, and potential for their development are identified, which involves the introduction of various "environmental" technologies, such as, firstly, the use of alternative fuel, namely liquefied natural gas, and secondly, the use of technology, which is based on wind energy, which gives a clear reduction in fuel costs and offers a more innovative solution; thirdly, the use of technology based on solar panels, innovative materials in the construction of ships. It is substantiated that each project has different entry barriers for implementation and initial investment, which determines the degree of risk and the possibility of implementing projects at different periods of the life cycle of a logistics company on the path to implementing the Green Business strategy. Using the methodology for evaluating the effectiveness of investment projects, the expediency of implementing each investment project is substantiated and a comparative description of the corresponding calculations is carried out. It is noted that "green" logistics has great potential for both a separate logistics company and the entire logistics ecosystem.*

Keywords*:* greening, shipping, modernization of vehicles, innovative technologies, sustainable development strategy, "green" logistics.

Оксана Позняк, Олексій Антонов. «Екологізація транспортного процесу в сфері морських перевезень». *Стаття присвячена дослідженню основних тенденцій екологізації транспортного процесу в сфері морських перевезень. Доведено, що для зменшення негативного впливу на навколишнє середовище вклад кожної логістичної компанії в формування екологічних екосистем має бути системним, і для забезпечення сталого розвитку логістичні компанії повинні реалізувати інвестиційно-інноваційні проекти різного спрямування, які сприяють зменшенню негативного впливу на зовнішнє середовище. Це визначає основні напрями впровадження інноваційних технологій, які можуть бути реалізовані в процесі морських перевезень з метою екологізації діяльності логістичної компанії. Досліджено потенційні проекти модернізації транспортних засобів шляхом їх «екологізації» задля мінімізації негативного впливу на довкілля та збереження конкурентних позицій логістичних компаній. Проведено детальну розробку та обґрунтування доцільності впровадження проектів для логістичної компанії, яка підтримує концепцію сталого розвитку та реалізує стратегію Green Business. Проаналізовані проекти модернізації транспортної інфраструктури логістичної компанії, визначені переваги, недоліки та потенціал їх розвитку, що передбачає впровадження різних «екологічних» технологій, таких як, по-перше, використання альтернативного палива, а саме скрапленого природного газу, по-друге, використання технології, яка заснована на енергії вітру, що дає однозначне зниження витрат на паливо та передбачає більш інноваційне рішення, по-третє, використання технології на основі сонячних панелей, інноваційних матеріалів в конструкції суден. Обгрунтовано, що кожен проект має різні вхідні бар'єри щодо впровадження і початкові інвестиції, що визначає ступінь ризику та можливість реалізації проектів в різні періоди життєвого циклу логістичної компанії на шляху реалізації стратегії «зеленого» бізнесу. Використовуючи методику оцінки ефективності інвестиційних проектів обґрунтовано доцільність реалізації кожного інвестиційного проекту та проведена порівняльна характеристика відповідних розрахунків. Зазначено, що у «зеленої» логістики є великий потенціал як для окремої логістичної компаніії так і для всієї транспортно-логістичної екосистеми.*

Ключові слова: екологістика, морські перевезення, модернізація транспортних засобів, інноваційні технології, стратегія сталого розвитку, «зелена» логістика.

Оксана Позняк, Алексей Антонов. "Экологизация транспортного процесса в сфере морских перевозок". *Статья посвящена исследованию основных тенденций экологизации транспортного процесса в сфере морских перевозок. Доказано, что для уменьшения негативного влияния на окружающую среду вклад каждой логистической компании в формирование экологических экосистем должен быть системным, и для обеспечения устойчивого развития логистические компании должны реализовать инвестиционно-инновационные проекты разного направления, способствующие уменьшению негативного влияния на внешнюю среду. Это определяет основные направления внедрения инновационных технологий, которые могут быть реализованы в процессе морских перевозок в целях экологизации деятельности логистической компании. Исследованы потенциальные проекты модернизации транспортных средств путем их «экологизации» для минимизации негативного влияния на окружающую среду и сохранение конкурентных позиций логистических компаний. Проведена подробная разработка и обоснование целесообразности внедрения проектов для логистической компании, которая поддерживает концепцию устойчивого развития и реализует стратегию Green Business. Проанализированы проекты модернизации транспортной инфраструктуры логистической компании, определены преимущества, недостатки и потенциал их развития, что предполагает внедрение различных "экологических" технологий, таких как, во-первых, использование альтернативного топлива, а именно сжиженного природного газа, во-вторых, использование технологии, которая основана на энергии ветра, что дает однозначное снижение расходов на топливо и предполагает более инновационное решение; в-*

третьих, использование технологии на основе солнечных панелей, инновационных материалов в конструкции судов. Обосновано, что каждый проект имеет различные входные барьеры по внедрению и начальным инвестициям, что определяет степень риска и возможность реализации проектов в разные периоды жизненного цикла логистической компании на пути реализации стратегии «зеленого» бизнеса. Используя методику оценки эффективности инвестиционных проектов, обоснована целесообразность реализации каждого инвестиционного проекта и проведена сравнительная характеристика соответствующих расчетов. Отмечено, что у «зеленой» логистики есть большой потенциал как для отдельной логистической компании, так и для всей логистической экосистемы.

Ключевые слова: экологистика, морские перевозки, модернизация транспортных средств, инновационные технологии, стратегия устойчивого развития.

Introduction. Transportation is the fastest growing source of emissions worldwide and now accounts for 17 percent of global greenhouse gas emissions - behind only the power sector. There are now more people and goods on the move than ever before, and each year hundreds of millions of vehicles pump huge amounts of greenhouse gas emissions into the atmosphere, driving the climate crisis. Between 1990 and 2019, annual transportation sector CO2 emissions increased by roughly 80 percent to a record high of 8.25 billion metric tons (GtCO2). Although global transportation emissions plummeted 12 percent in 2020 due to the outbreak of COVID-19, they are expected to have rebounded in 2021. In 2021, the reduction in the intensity of CO2 emissions in the world has slowed down and is 0.5%. In 2021, the intensity of EU CO2 emissions increased for the first time since 2010 [25].

Since transport and logistics companies are, on the one hand, one of the main participants in the global economy, and on the other hand, a rapidly growing source of environmental pollution, this leads to an increase in the responsibility of transport and logistics companies for the formation of ecosystems that will be more responsible in solving the problems of reducing the negative impact on the environment by greening the activities of both individual entities and the entire ecosystem as a whole. Moreover, greening should be systemic by introducing new approaches, principles, and technologies for conducting transport and logistics business based on the principles of sustainable development, greening, and implementing a green business strategy. The main results of the formation of this systematic approach can be to reduce the negative pressure on the environment, improve the image, profitability, and competitiveness of transport and logistics companies, and optimize supply chains. Consequently, research within the framework of this issue is relevant and continues to determine the direction of greening the activities of transport and logistics companies.

Analysis of recent research and publications. Nowadays, there has been an increase in attention to this issue. The analysis of research and publications made it possible to identify several areas in the field of greening transport and logistics activities. The first direction is the introduction of the foundations of greening for the formation of a system for ensuring the sustainable development of economic entities. Among the framework of this direction of research on this issue, it is possible to single out the scientific works of the following scientists such as Gurch L., Khmara L. [6], Hrechyn B.D. [8], Hryhorak M.Yu. and Varenko Yu.V.[9], Kobylynska T. [13], Korniyko J.R. and Valyavska N.O. [14], Sagaydack Yu., Kharchenko T. [22].

The second direction of research, which is devoted to the development of green supply chains, can be attributed to the works of the following scientists as Luthra, S., Garg, D., Haleem, A. [16], Rossolov, A., Lobashov, A., Kopytkov, D., Botsman, A. and Lyfenko S. [20], Vertakova Yu., Kazantseva A. and Plotnykov V. [26], Zaretskaia L.M. [30].

The third direction of research is closely related to the previous one and allows a more detailed study of the impact of individual modes of transport on ecologistics, determines the problems, and offers possible ways to solve the identified problems. The publication [23] systematizes the existing ways how to decrease the environmental load at the enterprise, in the country, and in the world, and identifies ways of greening the enterprise by using transportation means to transport goods from enterprises to customers using information systems and technologies.

The article [15] considers the topical problem of the greening of railway transport in Ukraine and offers some solutions to this issue by ensuring efficient freight turnover, the development and integration of transport infrastructure into the international network, and the transition to a carbon-neutral economy in general.

The strategy, considered in [7], aimed to create a unified architecture of transport and logistics clusters with the introduction of intelligent transport systems that will ensure safety, mobility of traffic, reduce the negative impact on the environment from transport by monitoring the situation using navigation technologies and timely decision making, guarantees value innovation and market models for consumers of blue ocean. This becomes possible because transport and logistics clusters contribute to the probability of success: the creation of multimodal transport networks; replacement of carbon-emitting modes of transport; promotion of "green" modes of transport; increasing urban mobility and development systems of a network of parking zones and passenger terminals for transferring by individual transport to urban transport. Also, the problems of greening the different modes of transport were studied in [5,10].

And the last direction of research identifies the areas of greening in reverse supply chains. The article [3] notes that the use of a system with a closed production cycle requires the formation of new supply chains at the enterprise: from shops to warehouses of secondary raw materials; from warehouses of secondary raw materials to sorting shops and distribution of renewable materials; external supply chains from the enterprise to other enterprises, in case of non-compliance of the, received waste with the needs of the enterprise. This approach forms the ecologistics methods in the development of waste-free production of enterprises, taking into account limited resources and greening of industry. Other issues within this direction of research were considered in [21, 24].

Thus, it can be noted that the interest in this issue is huge and any new research that expands these boundaries leads to the emergence of new approaches, and methods for solving the problems of greening in the field of logistics and supply chain management.

Objectives statement. The purpose of this article is a theoretical study of the main trends in the greening of the maritime transport process and the implementation of these approaches in the activities of a transport and logistics company.

Basic material and results. By the latest official estimates, around 2-3% of global CO2 emissions come from shipping – equivalent to that of Germany – and they're projected to keep growing by 4% every year. And in addition to creating CO2, cargo ships release other harmful pollutants such as nitrous oxide (NOx) and sulfur oxide (SOx), which impact air quality and contribute to global warming [28].

With growing pressures from governments, regulatory bodies, and consumers, the shipping industry is undergoing a "green revolution" and re-thinking how it can move thousands of tons of cargo across the oceans without adding to global emissions. And, like many climate change solutions, the answers lie in adopting a combination of new measures, ranging from the highly technical – to the incredibly simple.

All participants in the process of organizing, managing, and, directly, executing maritime transportation should be involved in this process. All of them create an ecosystem of maritime transportation and distribute among themselves the responsibility for maintaining this ecosystem on the principles of greening. The state, represented by various government bodies, creates a legal framework for the "green" activities of business entities, creates a favorable investment climate for the introduction of "green" technologies in the activities of companies, and forms a "green" strategy for the state, which determines the responsibility of all business entities in its achievement. In addition, the state is implementing projects to form a transport and logistics infrastructure based on "green" technologies.

All participants in the marine transportation process, within the framework of the implementation of the Green Strategy, are involved in its implementation in their activities and can take part in strategic projects based on public-private partnerships. Consequently, a systematic approach is being formed to reduce the negative impact on the environment through the contribution of each logistics company to the formation of ecological ecosystems. This determines the main directions for the introduction of innovative technologies that can be implemented in the marine transport process in order to greening the activities of a logistics company.

There are several possible ways of greening the marine transport process of transport and logistics companies. Such methods include consideration of ecological supply chains as a competitive advantage of an enterprise, solving the problem of routing within an enterprise, energy saving in transport, carsharing by different companies, introduction of innovative modes of transport, energy efficiency in transport, calculation of optimal air routes in the world, optimization of transportation of goods from an enterprise to consumers [23]. Most of them are aimed at the modernization of ships using alternative fuel sources, since this is the main source of negative environmental impact. Potential projects for the modernization of marine ships through their "greening" by using different innovative technologies are presented in Table 1.

Table 1 - Potential projects for greening transport infrastructure of transport and logistics company

Name of a project	Transition to a more ecological fuel	Utilizing wind sails to decrease fuel consumption	Creation of electrically powered vessel
Goal	Choosing and implementing a more ecological and more profitable fuel instead of heavy oil.	Installing modern wind sails to decrease vessel fuel consumption and resulted harmful emissions	Creation of a marine vessel that utilizes electricity instead of fuel as a power source.
Content of project	Analyzing several types of fuel, choosing the best type by several indicators, and calculating the project profitability indicators.	Creation of Work Breakdown structure, setting the budget for modernization, calculation of profitability indicators.	Determining amount of energy vessel can storage and number of solar panels that can be installed; calculation of autonomy and profitability indicators
Predicted results	Reducing harmful emissions of the ship by 30-40%, a slight reduction in the cost of fuel.	Reducing fuel consumption of the ship by at least 10% and reducing the cost of operating the ship.	Zero emissions, significantly reduced ship operating costs and reduced vessel autonomy.

All these potential projects have their own advantages, disadvantages, and potential for their implementation, require different investments, and have different barriers to fulfillment.

The first project is aimed to transition to a more ecological fuel. Most ships use it as a fuel source so-called "bunker fuel" also known as "heavy fuel oil". Such fuel is considered of low quality but also low cost. The disadvantage of this type of fuel of course is that it is especially harmful to humans.

The use of bunker fuel is estimated to have caused 400 000 premature deaths and more than 14 million children's asthma cases yearly due to air pollution. On January 1, 2020, a new limit on Sulphur content in fuel oil came into force due to International Maritime Organization (IMO). This rule limits the amount of Sulphur in fuel to 0.5% mass by mass. A great improvement compared to the previous limit of 3.5% [11]. Despite this limitation, shipping air pollution is still a major problem and estimated to cause about 250 000 premature deaths and 6.4 million asthma cases yearly since 2020.

The following alternative fuel sources for shipping are possible:

1. Liquefied Natural Gas (LNG) – is a natural gas that has been cooled down to liquid form for ease and safety of non-pressurized storage and transport. Natural gas could be considered the least environmentally harmful fossil fuel because it has the lowest CO2 emissions per unit of energy and is suitable for use in high-efficiency combined cycle power stations. For an equivalent amount of heat, burning natural gas produces about 30 percent less carbon dioxide than burning petroleum and about 45 percent less than burning coal [4].

2. Hydrogen fuel. The main advantage of hydrogen is the possibility of being a zero-emissions fuel if produced from renewables. Furthermore, future hydrogen production capacity fits well with the anticipated energy transition to renewable power production on land.

3. Ammonia fuel. With an energy transition to renewables, ammonia will have the potential to become a carbon-free energy carrier with a higher density than hydrogen, and in principle technically feasible for the deep sea.

4. Bio-diesel is a renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease [2].

Each type of alternative fuel can be used for greening, so they need to be evaluated according to different criteria: type, energy density, volume and weight of fuel, emissions and price. The results are presented in Table 2.

Table 2 – Evaluation of different types of fuel by criteria

Name	Bunker Fuel	LNG	Hydrogen	Ammonia	Bio-diesel
Type	Fossil	Fossil	Renewable	Renewable	Renewable
Energy density (MJ/l)	33.4	21.2	9.55	12.8	14.6
Space taken	Medium	Above medium	Very large	Large	Above medium
Weight	Medium	Light	Very light	Heavy	Above medium
Emissions	Large	Medium	Very small	Very small	Small
Price	3.62$	2.2$	16$	4.16$	3.42$

Before choosing an alternative to bunker fuel, which is taken as standard - 1, it is necessary to compare these fuels with the standard based on the same criteria. The comparison results are presented in Table 3.

Table 3 - Comparing different types of fuel to Bunker fuel

	Bunker Fuel	LNG	Hydrogen	Ammonia	Bio-diesel
Type	Fossil	Fossil	Renewable	Renewable	Renewable
Energy density (MJ/l)	1	0.63	0.29	0.38	0.44
Space taken	1	0.67	0.33	0.67	0.83
Weight	1	1.33	1.67	0.67	0.83
Emissions	1	1.4	1.8	1.8	1.6
Price	1	1.41	0.23	0.85	1.06
Grade	5	5.44	4.32	4.37	4.76

Table 3 shows that grades below 1 mean fuel perform worse than bunker fuel, and grades above 1 mean fuel perform better therefore we can determine which fuel is better to use in the potential project.

According to the calculations currently, only LNG fuel has better overall performance compared to Bunker fuel; hydrogen takes fifth place, and this fuel takes up a lot of space, which is then mitigated by its almost non-existent weight, but the enormous price doesn't allow it to compete. Ammonia performs a bit better, and has a more reasonable price, unfortunately, it weighs and takes more space than usual fuel, and relatively low energy density affords it fourth place. Bio-diesel takes third place – it's a bit worse than bunker fuel in terms of weight and space but is a bit cheaper.

Thus, LNG fuel has a better price, comparable volumes, and weights, and is much better for the environment. Therefore, for the development of the first potential project related to the modernization of the vessels for transport and logistics companies, LNG fuel is chosen.

The first thing that needs to be calculated is the fuel cost for one medium-sized container ship. It is known that ships can take aboard 2 million gallons of fuel. Here both weight and space taken by fuel are important. Considering that bunker fuel and LNG are comparable in this department (LNG takes more space but is weightless) The indicator can be left the same for both fuels.

Next is energy density. It is known that ship consumes 63 000 gallons per day at top speed. The energy density of LNG is lower; therefore, ships will consume more fuel per day.

Calculating fuel expenditure per day for LNG fuel = 63 000 * 0.63 = 100 000 gallons per day. Calculating time until refuel for LNG fuel = 2 000 000 / 100 000 = 20 days.

And for Bunker fuel = 2 000 000 / 63 000 = 31 days.

Number of refueling per year for LNG fuel = 365/20 = 18.25 = 19 per year.

For Bunker fuel = 365/31 = 11.77 = 12 per year.

Calculating price of fuel for ship for 1 year for LNG fuel = 2 000 000 * 19 * 2.2 = 83 600 000$.

For Bunker fuel = 2 000 000 * 12 * 3.62 = 86 880 000$.

The annual benefit from the use of LNG fuel is 3,280,000 US dollars, which is a significant amount, provided that the transport and logistics company extracts it on its own, such as NYK Line.

NYK Line, the Japanese shipping company, has announced it has been placed on a prestigious climate change list, recognizing the company as one of the world-leading businesses at the forefront of tackling climate change. The NYK Group has commenced efforts to create a value chain for carbon-free society of the future.

The company has developed the concept of Green Business as a key element of its sustainable development strategy and is constantly implementing environmental projects aimed at reducing the negative impact on the environment. One of them is Sail GREEN a brand that emphasizes NYK's efforts to reduce GHG emissions through the transport of goods and contribute to the eco-friendly supply chains of customers, regardless of the mode of transport (e.g., by sea or land, through terminals, etc.) [19].

Realizing the importance of the implementation of such projects for the entire shipping ecosystem, the company develops collaboration with partners such as Clean Fuel Ammonia Association, Hydrogen Council, The Maersk Mc-Kinney Moller Center for Zero Carbon Shipping, Getting to Zero Coalition, Hydrogen Value Chain Development Council.

Therefore, the implementation of the proposed project support efforts to decarbonize not only the shipping ecosystem but also society as a whole.

The cost of modernization ship will roughly equal 15 million dollars, the price of engines will add another 7 million dollars, and we add 3 million dollars to a total expenditure as profit loss for the time of modernization and unpredictable factors. Therefore, the initial investment for changing fuel equals $25 million. The discount rate is set as the value of inflation - 4%. Cash flow (CF) is 3 280 000$ per year. The life of the project is set as ten years.

Based on the established data and using the investment analysis methodology, the effectiveness of the implementation of this project is conducted. The results of these calculations are presented in Table 4.

Table 4 – Calculation the efficiency of the first project

Year	1	2	3	4	5	6	7	8	9	10
CF ($ mln)	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28
r (4%)	0.962	0.925	0.889	0.855	0.822	0.79	0.76	0.731	0.703	0.676
PV($ mln)	3.16	3.03	2.92	2.80	2.70	2.59	2.49	2.40	2.31	2.22
Total PV ($ mln)										26.61
Initial investment ($ mln)										25.00
NPV ($ mln)										1.61
PI ($ mln)										1.06
DPP (years)										9.395
Year	1	2	3	4	5	6	7	8	9	10
CF($ mln)	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28
r (8%)	0.926	0.857	0.794	0.735	0.681	0.63	0.563	0.54	0.5	0.463
PV ($ mln)	3.04	2.81	2.60	2.41	2.23	2.07	1.85	1.77	1.64	1.52
Total PV ($ mln)										21.94
NPV ($ mln)										-3.06
IRR (%)										5.38

As can be seen from the calculations, the project has a very long discounted payback period, almost like the entire life cycle, therefore this is a big disadvantage of its implementation. But given that this is more likely not an economic project, but more of a socio-economic one, aimed at creating an environmentally friendly ecosystem, the transition to LNG fuel still has great potential. The overall potential results of this project would be: a decrease in harmful emissions, staying ahead of IMO regulations, and decreasing the cost of fuel.

Despite the fact that the development of an investment project implies the obtaining of economic benefits, the implementation of some targeted projects, such as environmental ones, provides, first of all, for obtaining social effects for the entire ecosystem.

An example of this project is presented in Figure 1.

Figure 1 – Example of implementation the investment project
"Transition to a more ecological fuel"

Despite the fact that the first project involves the use of an alternative type of fuel to ensure the process of sea transportation, namely, liquefied gas, which, unfortunately, firstly, cannot be called "clean", and secondly, it is also exhaustible, that is its stocks are also limited. Therefore, it is necessary to consider projects that can offer conceptual solutions to this problem, using "clean" and inexhaustible sources for the movement of goods in the process of maritime transport.

One such project is the use of wind energy as a pure, free, renewable energy source. Developments based on this concept have been carried out since 1924 by German engineer Anton Flettner. The first experiments with modern turbo sails began in 1980 by Jacques Cousteau. On August 2, 2008, Enercon launched the hybrid rotor vessel "E-Ship 1". It was used to transport the company's turbine products.

In 2018 Norsepower deployed rotor sails with the world's biggest shipping company Maersk. The Maersk Pelican has been fitted with two rotor sails, and later claimed to achieve 8.9% in fuel savings [18].

"OceanBird" is an ongoing project that is scheduled to come into service in 2024. The ship will be fitted with 5 telescopic modern windsails and promises to achieve 10 knots speed with an emission decrease of above 90% [12].

Thus, the second proposed project " Utilizing windsails to decrease fuel consumption " aims to achieve a significant reduction in fuel consumption and, therefore, to reduce harmful emissions.

The modern windsails offer a great opportunity to contribute to green logistics, while at the same time decreasing fuel costs. From the analysis of the gathered data, we can conclude that the Panamax class vessel will require from 4 to 5 modern sails and will be able to reduce its fuel consumption by 10-12%.

Unlike the previous variant where vessels could be modernized with relatively little effort, installing turbosails will require capital changes. For the purpose of modernization of a ship, it is recommended to create a work breakdown structure. Work Breakdown Structure is a deliverable-oriented breakdown of a project into smaller components. A work breakdown structure is a key project deliverable that organizes the team's work into manageable sections. Initially, it serves as a planning tool to help the project team plan, define and organize the scope with deliverables. The WBS is also used as the primary source of schedule and cost estimate activities. But, its biggest contributions to a project are it's used as a description of all of the work and as a monitoring and controlling tool.

The work breakdown structure of a modernization of a Panamax-class vessel with turbosails is shown in Figure 2.

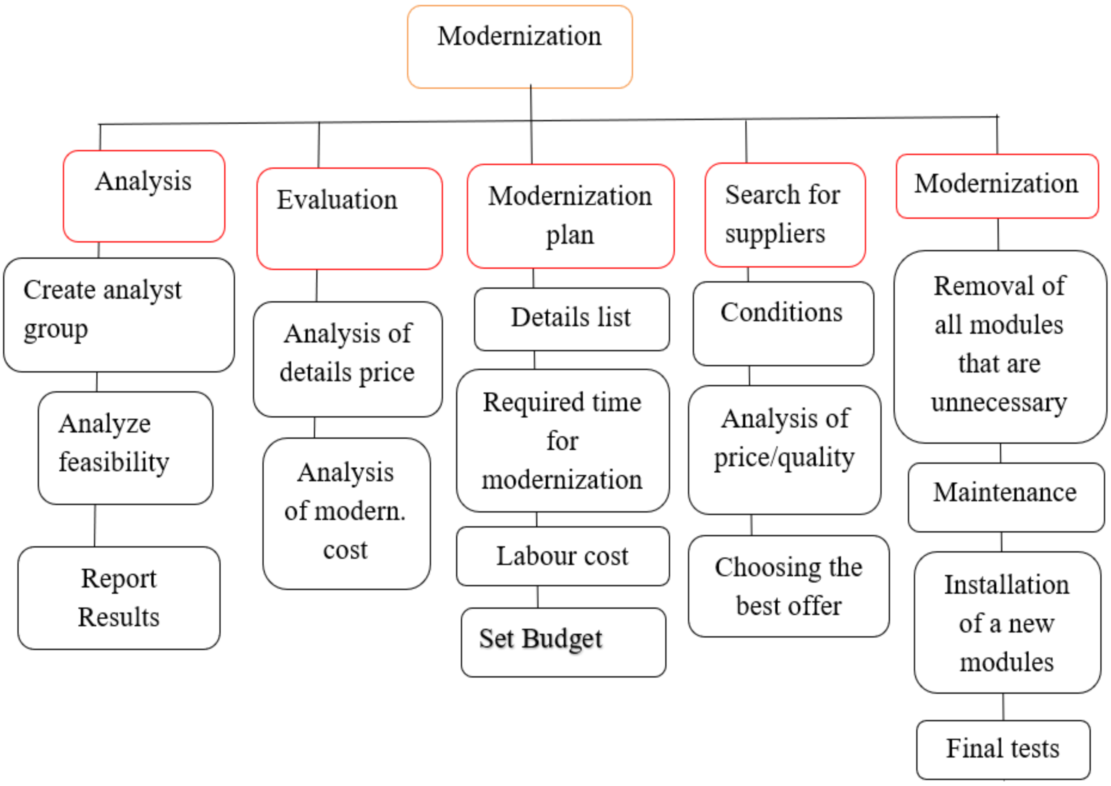

Figure 2 – Work breakdown structure of vessel modernization

Let's explain the work breakdown structure of vessel modernization in more detail.

Analysis – first we have to check that the idea is valid. For this purpose, the company needs to execute the following steps:

1. Analyze other cases of installation of modern windsails, their results, and the profitability of the projects by creating of analyst group. For this purpose, will be created an inspecting group of 5 analysts researched the idea of turbosails, based on the results of other companies' experiments.

2. Analyze feasibility: when the analysts have an idea of what turbosails are capable of, they can roughly judge whether is it possible to modernize companies' vessels and receive profit in the future.

3. Report results: the results of the analysis are noted and reported to supervisors, who then, based on gathered data and company conditions, decide either

to entertain a more serious investigation or scrap the idea.

Evaluation is another big group of action in WBS that requires a more detailed evaluation based on project analysis. It consists of two main steps:

1. Analysis of detailed price. The turbosails are a relatively new project with few companies having experience building them. Contact companies such as Norsepower, Enercon, and Wärtsilä to learn more about the capabilities and costs of turbo sails and accessories.

2. General analysis of all modernization efforts. The price for the implementation of new equipment, the price for equipment for modernization, price of dry docks is calculated. The end result is once again reported to supervisors who make the final decision to go forward with the project or not.

Modernization plan is another big group of action in WBS that suggests creating a detailed plan of modernization efforts. It includes the following information necessary for the implementation of the project, namely:

1. Details list that includes information about what we have to procure, comparing purchasing costs, efficiency, and reliability of suppliers.

2. Required time for modernization: knowing which details we have to procure and the scope of work we can evaluate the length of time required by modernization.

3. Labour cost: calculating the salary of our specialists and estimating the number of personnel required for the implementation of the project, the possibility of additional hiring of specialists is carried out in this stage.

4. Budget: after we are sure of the scope of work, a budget is set for the entire modernization effort.

The next big group of action in WBS is Search for suppliers – turbosails. For this project components and support equipment for turbosails is likely to be custom created for the company vessel. While there are only a few companies in the world that have experience in such projects, choosing among them is still required. That choice is based on the following data:

- Conditions: company limits the list of choices by introducing conditions that are required such that turbosails creation should be within the relevant budget part and the specific capability of turbosails must be achieved.

- Price/Quality analysis: our conditions are not really hard so we can safely presume that we still have the list of possible suppliers. Analysts rate them by chosen criteria and sort the list by company priorities.

- Choosing the best offer: based on the list of possible supplier's choice is made.

Modernization - finally, you can proceed to the modernization itself. Firstly, this is disassembly, we need to establish a place in the hull where future turbosails will stand, find a place for their auxiliary equipment and install the necessary software.

Maintenance: while engineers have full access to the ship, complete maintenance and check-up are required. Nobody wants to waste millions on a project that will fail simply because of rust that cannot be easily seen, or failed machine.

Assembly: after commissioned turbosails arrive, they will need to be installed, and then the hull should be fixed and prepared for the final tests.

Final testing: the upgrade is complete, but to make sure everything is in order, the company will conduct extensive testing of the vessel to find out its improved performance and possible problems.

The calculation of the project efficiency is based on the budget for the modernization of the company's ship which mainly identifies, first of all, the costs of the project

The average salary of an analyst per month is $6,000.

The company has hired a full team of five analysts who will work for four months.

Therefore, the analyst team's budget is - 6,000 * 5 * 4 = $120,000.

Of course, the company will need a lot of engineers who will be engaged in

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dismantling the hull and installing turbosails, and maintenance.

The company plans to hire about 100 workers to reach a reasonable completion date of 6 months.

The average salary of employees will be $3800 per month. Among them are 5 senior shipbuilders with a monthly salary of $6500.

Therefore, the budget for workers is (3800 * 95 + 6500 * 5) * 6 = $2,361,000.

Next comes the maintenance budget. The cost of servicing a Panamax class container ship is $9,000,000.

Finally, the cost of turbo sails. Considering that the company wants to reduce fuel consumption by 12%, the company's vessel will have no less than four turbosails.

The company decided to order them from Norsepower for $10,000,000 each.

Therefore, four turbo sailboats will cost $40,000,000.

The total budget set for the upgrade is 120,000 + 2,361,000 + 9,000,000 + 40,000,000 = $51,481,000.

This budget is considered our initial investment.

With turbosails installed, the ship will consume 12% less fuel than before the upgrade.

A Panamax-class vessel can hold 2 million gallons of fuel and consumes 63,000 gallons per day when traveling at top speed.

The fuel price per gallon is $3.62.

Time to replenishment - 2,000,000 / 63,000 = 31 days.

Replenishments per month - 365/31 = 12 times.

Fuel price per year = 2,000,000 * 12 * 3.62 = $86,880,000.

12% of annual fuel consumption = 86,880,000 * 0.12 = $10,425,600.

The price of fuel per year after modernization is - 86,880,000 - 10,425,600 = $76,454,400.

So, the initial data for calculating NPV, DDP and PI are determined.

The initial investment is our budget - $51,481,000.

Annual cash flow - the price of reducing fuel consumption by 12% - $ 10,425,600

The discount rate is equal to the world inflation rate - 4%.

The life of the project is once again set at 10 years.

Based on the established data and using the methodology of investment analysis, an assessment of the effectiveness of the implementation of this project is carried out. The results of these calculations are presented in Table 5.

Table 5 – Calculation the efficiency of the second project

Year	1	2	3	4	5	6	7	8	9	10
CF ($ mln)	10.43	10.43	10.43	10.43	10.43	10.43	10.43	10.43	10.43	10.43
r (4%)	0.962	0.925	0.889	0.855	0.822	0.79	0.76	0.731	0.703	0.676
PV($ mln)	10.03	9.64	9.27	8.91	8.57	8.24	7.92	7.61	7.325	7.04
Total PV ($ mln)										84.56
Initial investment ($ mln)										51,481
NPV ($ mln)										33.08
PI ($ mln)										1.643
DPP (years)										6.09
Year	1	2	3	4	5	6	7	8	9	10
CF($ mln)	10.43	10.43	10.43	10.43	10.43	10.43	10.43	10.43	10.43	10.43
r (18%)	0.847	0.718	0.609	0.516	0.437	0.37	0.314	0.266	0.225	0.191
PV ($ mln)	8.83	7.49	6.35	5.38	4.56	3.86	3.27	2.77	2.35	1.99
Total PV ($ mln)										46.8
NPV ($ mln)										-4.64
IRR (%)										15.61

The example of this project is presented in Figure 3.

Figure 3 – Example of implementation investment project "Utilizing windsails to decrease fuel consumption"

The third project involves the introduction of technology that is already widely used in the automotive industry - the use of solar panels. In recent years, electrical cars become increasingly popular. The cars are clean and use electricity instead of fuel for power, which considering the ever-rising prices for fuel is a definite advantage.

So, the question is, why when electric cars proved themselves most effective, yet the creation of large electric-powered marine vessels is a distant project for now? The answer is simple – battery space. Ships use a lot of fuel and would need a lot of electrical power to move. The batteries to keep the ship running will take a lot of space and currently, there is no infrastructure to recharge them in mass.

Yet the world's first all-electric cargo ship is already building. A European company, Yara Fertilizer of Norway, designed a fully electrically powered ship that will transport its products around the country and eliminate 40,000 trips normally made by diesel trucks.

While relatively small by current standards, Yara's electric model can still haul 3,200 tons of cargo over a distance of 30 nautical miles [29].

The main limitations of today's lithium batteries are their size and weight; they're generally too heavy and bulky to power large-scale container ships while leaving enough space for the required cargo. But at least initially, we're likely to see batteries powering small ships over short distances and continue to gain momentum as batteries become smaller, lighter, and cheaper.

Proof of the battery development's continued progress lies in the recent statement from Danish shipping company Maersk which announced the trials of a new 600-kilowatt-hour battery, the size of a shipping container [1].

Still providing power to ship only by the way of batteries is, well not impossible but severely limiting. Then the question: Is there a way to produce electricity during an ocean voyage? And the answer is simple: Yes. Theoretically, a small wind-powered power station could be installed on the ship, but this would be inefficient, and practically turbosails will be better.

But what about solar energy? It doesn't require much space, it can provide additional power, and is a tested technology. Of course, it is weather depended on the extreme, but it is not required to work constantly at max power, just to augment the ship's power reserves.

In July 2021 bulker owner and operator, Berge Bulk launched a pilot test to trial the maritime application of solar technology. The test is being carried out on Berge K2, the company's 262,600 dwt Capesize ore carrier [17].

According to Berge Bulk, the test installation produces ~100 kilowatts of electrical power, which is fed into the main electrical grid on the ship to supplement the bulk carrier's diesel alternators. Following the pilot test, the Berge Bulk company plans to evolve trial, increasing number of solar panels to produce 1000 kilowatts.

This test shows that using solar panels to supplement the diesel generators are feasible and have a lot of potential for the future.

For this project an amount of energy that can be stored on the ship should be calculated, the number of solar panels that can be installed on the vessel and their comparison. The result of this project should be almost completely green vessel without harmful emissions with major economic benefit as electricity is a much cheaper source of energy than fuel.

Let's start by calculating the number of batteries that electric-powered vessels will require.

For this purpose, a Maersk has created a battery with a space of 600kwh will be used.

The size of the battery is identical to the size of a standard 20-feet shipping container.

The dimensions of such container, and therefore the battery is 6.1 meters in length, 2.44 meters in width, and 2.59 meters in height. The volume of such a battery will equal 33.2 cubic meters.

Panamax class ship can carry 2 000 000 gallons of fuel. To fill one cubic meter with fuel we will need 264.17 gallons.

Therefore, volume of fuel company vessel can carry – 2 000 000 / 264.17 = 7570.8 cubic meters.

Now we can calculate how many batteries we can use on the ship.

7570.8 / 33.2 = 228.04 = 228 batteries.

The amount of energy stored therefore equals 228 * 600 = 136 800 kWh.

Now we should calculate how quickly this power will be used.

Bunker fuel has an energy density of 33.4 mega joules per gallon.

1 mega joule are equal to 0.278 kWh.

Energy density of 2 000 000 gallons of fuel in kilowatts = 33.4 * 2 000 000 * 0.278 = 18 570 400 kWh.

The Panamax-class ship uses 63 000 gallons of fuel per day.

Energy density of 63 000 gallons of fuel in kilowatts equals - 33.4 * 63 000 * 0.278 = 584 967 kW/h.

Determining how long can travel Panamax-class vessel with 228 batteries installed – 136 800 / 584 967 = 0.234 of a day or 5.6 hours. This is certainly not enough.

Even if decreased the cargo capacity of the vessel is by a fifth, the resulting 1228 batteries will have only 736 800 kilowatts of energy stored, enough for a day and a quarter of travel - 30 hours.

In 30 hours, the Panamax class ship can journey 690 knots or 1278 kilometers.

Just a bit more than the distance from New York to Chicago – 1144.6 kilometers.

The calculations show that such a vessel will be unsuited for long journeys, but can be used for transportation in relatively close distances such as operating in the Black Sea, along the European coast where there are plenty of places to recharge, or for example making deliveries from Japan to China.

Before abandoning the idea of a large fully powered electrical ship let's make a price comparison.

Price of fuel per gallon - 3.62$.

Time until refill – 2 000 000 / 63 000 = 31 days.

A number of refills – 365/31 = 12 per year.

Yearly price of fuel = 12 * 2 000 000 * 3.62 = 86 880 000$.

Price of electricity per kWh – 0.118$.

Time until recharge – 736 800 / 584 967 = 1.26 days.

Number of recharges – 365/1.26 = 289.6 = 290 per year.

Yearly price of electricity = 290 * 736 800 * 0.118 = 25 213 296$.

But it should be noted that electric-powered vessel carries only 80% of the standard Panamax class ship. Therefore, ships will require 25% time to carry the same cargo and will therefore burn 25% more energy.

Thus, 25 213 296 * 1.25 = 31 516 620$.

Despite all the disadvantages of an electrically powered vessel, the one thing it absolutely tops is operation costs. It will be more than 50 000 000$ cheaper to use electricity instead of fuel.

Solar panels use sunlight as an energy source to generate DC electricity, so the top of a ship is the logical place to install them. Considering that cargo ships are mostly rectangular in shape, it is easy enough to calculate the usable area for installing a ship's solar panels. To do this, we need the length of the ship (Fig. 4) and the width, or breadth of the ship (Fig. 5).

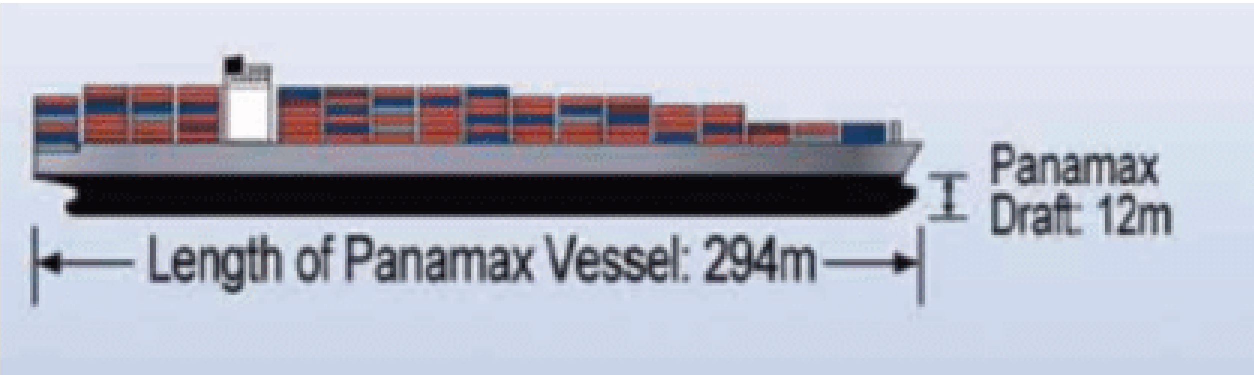

Figure 4 – Length of Panamax class vessel

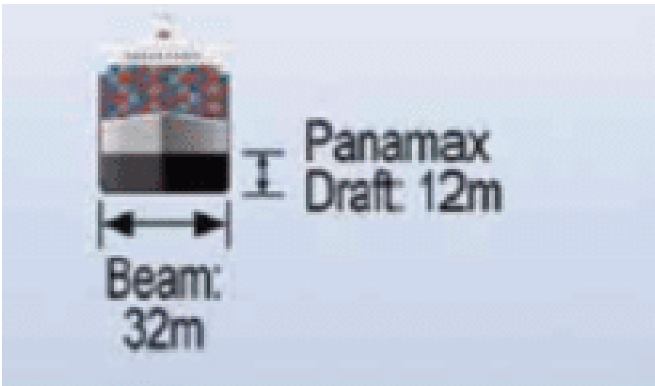

Figure 5 – Width (Beam) of the Panamax class vessel

But the solar panels are not being able to install on the bow of the ship. This limits the installation area, as shown in Fig. 5.

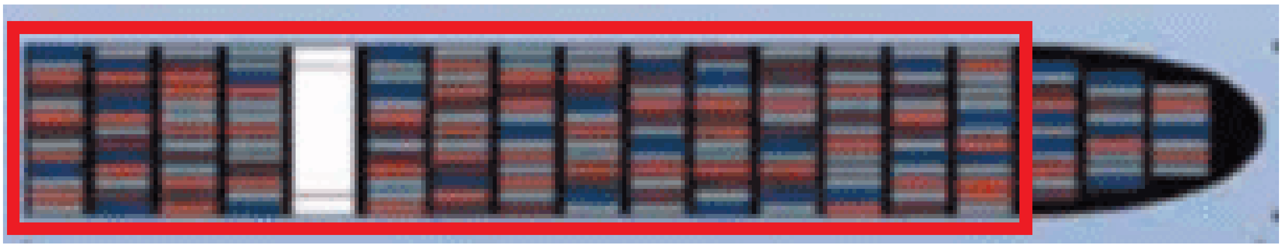

Figure 5 – Area of solar panel installation on Panamax class vessel

The length of the installation area is 230 meters.

The width of the installation is the same as the ship – 32 meters.

Then useful area for solar panel installation = 230*32 =7360 square meters.

To decide which solar panels are more profitable to install on the vessel several samples and compared their characteristics were taken into account (Table 6).

Table 6 – Comparison of performance of solar panels

Solar panel power	1kWh	5kWh	12kWh	17kWh	20kWh	30kWh	36kWh	40kWh
Area, m2	5	26	62	83	99	145	176	191
Amount on vessel	1472	283	118	88	74	50	41	38
Generated yearly per unit, kwh	1100	6504	15300	22966	26239	39430	49225	50712
Total generated yearly, kwh	1619200	1840632	1805400	2021008	1941686	1971500	2018225	1927056
Cost per unit, $	845	4188	8029	10650	12173	16635	18985	20865
Total cost, $	1243840	1185204	947422	937200	900802	831750	778385	792870

As can be seen from Table 6, due to the difference in the amount installed, the cost of the panels decreases the higher their power. At the same time amount of electricity generated varies. The peak is reached by the solar panels of 17-kilowatt power. Yet 36-kilowatt powered solar panels generate almost the same amount of power per year, only about 3000 kilowatts less, while at the same time being significantly cheaper. Therefore, on our ship will be installed 36-kilowatt powered solar panels. They will produce additional 2 018 255 kW/h per year for the price of 778 385 dollars.

The price of electricity is 0.118 dollars per kWh.

Therefore, our solar panels will generate 238 150 dollars per year.

That means they will become profitable after the time of 3.3 years.

Now that the extreme potential of electric power is clear let's determine the amount of investment required.

Our vessel will require 1228 batteries, the size of a shipping container. These batteries are new on the market and therefore the price is steep.

Considering the number of batteries ordered the price can be negotiated down to 95 000$ per battery. Total battery cost = 1228 * 95 000 = 116 660 000 $.

In this project, the largest modernization effort is required as our vessel switches completely from fuel to electricity. The cost of modernization is predicted in the area of 75 000 000$.

The cost of solar panels is 778 385$ + 10% for installation efforts brings as to 778 385 + 77 839 = 856 224$.

Total cost of creating fully electrically powered ship equals to – 116,660,000 + 75,000,000 + 856,224 = 192,516,224$.

The predicted profit of such investment is all the amount of money the company managed to save from the cost of fuel, counting of course our own expenses such as electricity cost and electricity generated by solar panels – 86 880 000 – 31 516 620 – 238 150 = 55 125 230$.

The discount rate remains equal to the rate of global inflation – 4%.

The life of the project is set as 10 years.

The results of calculation the efficiency of this project are presented in Table 7.

Table 7 – Calculation the efficiency of the third project

Year	1	2	3	4	5	6	7	8	9	10
CF ($ mln)	55.13	55.13	55.13	55.13	55.13	55.13	55.13	55.13	55.13	55.13
r (4%)	0.962	0.925	0.889	0.855	0.822	0.79	0.76	0.731	0.703	0.676
PV($ mln)	53.002	50.97	49.01	47.12	45.31	43.56	41.89	40.28	38.73	37.24
Total PV ($ mln)	447, 113 363									
Initial investment ($ mln)	192, 516 224									
NPV ($ mln)	254, 593 363									
PI ($ mln)	2.322									
DPP (years)	4.30									
Year	1	2	3	4	5	6	7	8	9	10
CF($ mln)	55.13	55.13	55.13	55.13	55.13	55.13	55.13	55.13	55.13	55.13
r (18%)	0.781	0.61	0.477	0.373	0.291	0.227	0.178	0.139	0.108	0.085
PV ($ mln)	43.05	33.63	26.29	20.56	16.04	12.51	9.81	7.66	5.95	4.68
Total PV ($ mln)	180, 203 625									
NPV ($ mln)	- 12, 316 375									
IRR (%)	26.89									

A fully electrically powered ship certainly seems impressive on paper, but it should be noted that it has rather big disadvantages, which is why its development only began. The necessity of such a big ship as Panamax class is for example questionable. Still this project promises immense benefits if properly realized.

The example of this project is presented in Figure 6.

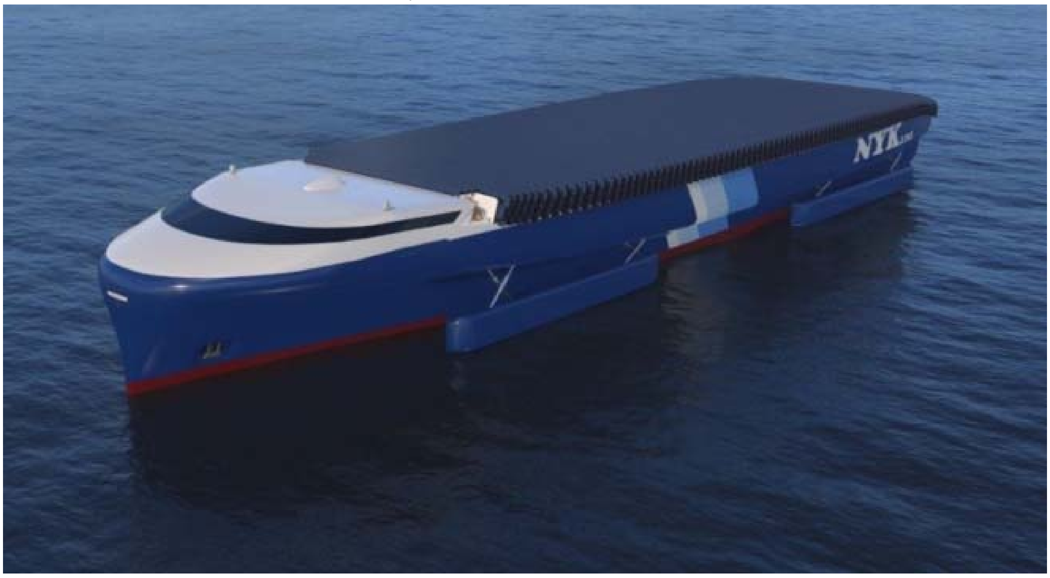

Figure 6 – Example of implementation investment project "Creation of electrically powered vessel"

In order to compare the economic efficiency of potential investment projects, Table 8 summarizes the main results of the calculations.

Table 8 – Comparison of potential investment projects

Name of a project	Transition to a more ecological fuel	Utilizing windsails to decrease fuel consumption	Creation of electrically powered vessel
Initial Investments	25 000 000$	51 481 000$	192 516 224 $
Net Present Value (NPV)	1 603 752$	33 079 999$	254 593 336$
Discounted Payback Period (DPP)	9.395 years	6.09 years	4.305 years
Profitability Index (PI)	1.064	1.64	2.32
Internal Rate of Return (IRR)	5.39%	15.61%	26.89%
Time until refill (autonomy)	20 days	34 days	1.26 days
Volume of modernization	Minor	Moderate	Capital

As can be seen from Table 8, each of the proposed projects has its own advantages and disadvantages, barriers to implementation, which are reflected in the above calculations and indicators.

Changing fuel on a cargo ship is the least expensive but also offers the longest payback of the three projects. Its advantages are relatively fast upgrade times and easy access to fuel. The use of LNG fuel will reduce the harmful emissions of a dry cargo ship by at least 30%. And, of course, replacing one fossil fuel with another means fuel shortages as a future problem for the company. For now, you can ignore the slight loss of ship autonomy.

The second project - the use of modern windsails to decrease fuel consumption - is more expensive with an initial investment of $51,481,000, but will pay off faster. This project requires a moderate modernization period, but in addition to increasing profits, it loses to the first project in terms of environmental impact - harmful emissions will decrease, as well as fuel consumption, by 12%.

The third project - the use of electricity instead of fuel, certainly looks interesting. The advantages of such a project, of course, are greater profitability, reduction of harmful emissions to zero, and the technical possibility of generating a small amount of energy during the flight. This means that, theoretically, this ship will be able to move without recharging at all, but, of course, only for small distances per year. Unfortunately, there are more disadvantages: the initial investment is the largest of all three projects, extremely limited autonomy, and certain infrastructure problems (since many ports in the world are not ready to offer recharging such a large amount of energy). at the moment) solar panel power generation depends on weather conditions and finally reduced cargo space.

The proposed projects expand the possibilities of greening the process of marine transportation, and provide a practical range of projects that can be implemented in transport and logistics companies that support a sustainable development strategy based on green business strategies.

Conclusions. The article considers project proposals for the introduction of methods for greening the activities of a transport and logistics company, namely energy saving in transport, energy efficiency in transport, the introduction of innovative modes of transport, the use of alternative fuels. All this was combined under the auspices of the transport and logistics company's vehicle modernization projects in order to reduce harmful emissions into the atmosphere. To substantiate the economic feasibility of introducing the proposed projects, the methodology of investment analysis and project management tools were used. Considering that in order to form a sustainable development of a transport and logistics company, as a main participant in the shipping ecosystem, it is necessary to introduce greening projects, the article offers practical tools for implementing a green business strategy.

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