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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 компаніїї 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.

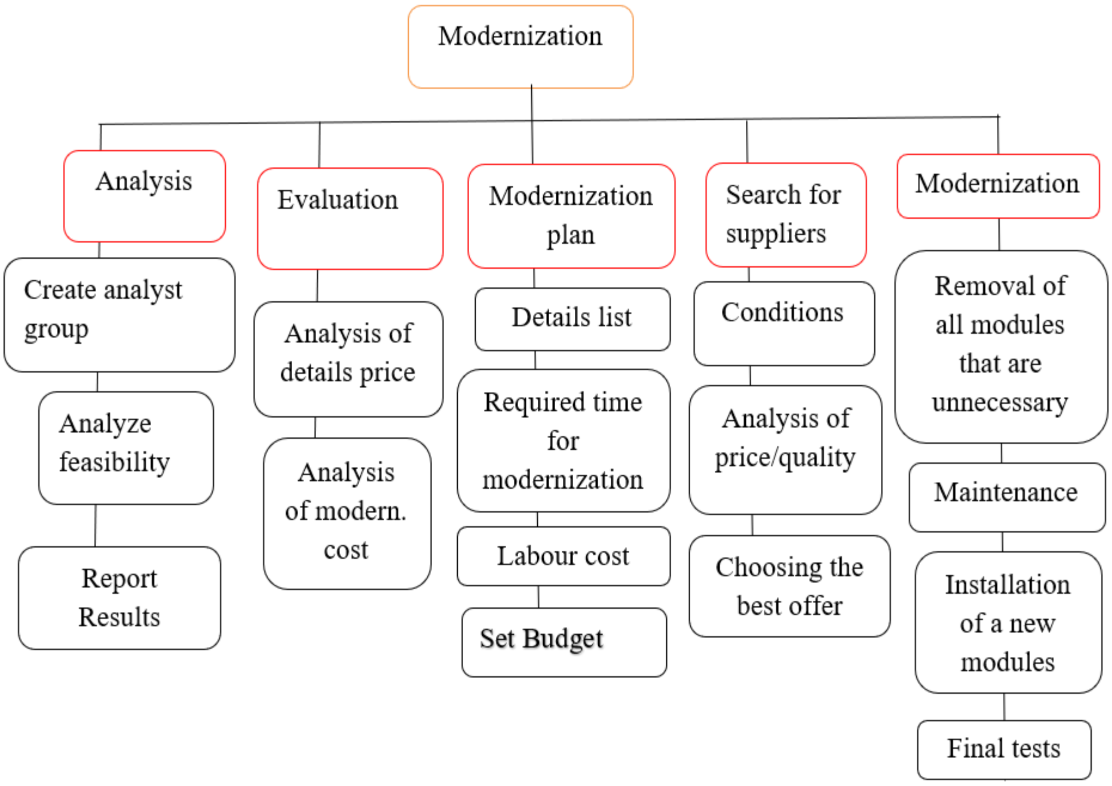

Figure 2 – Work breakdown structure of vessel modernization

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 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).

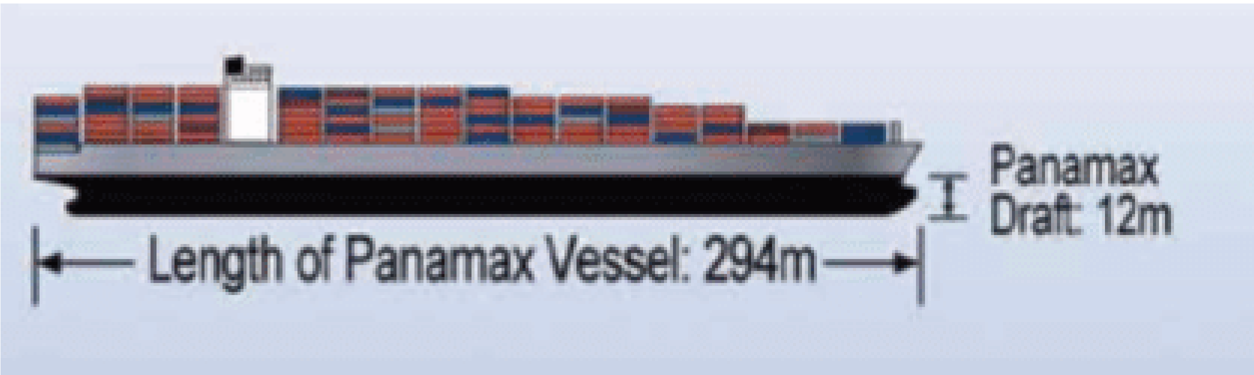

Figure 4 – Length of Panamax class vessel

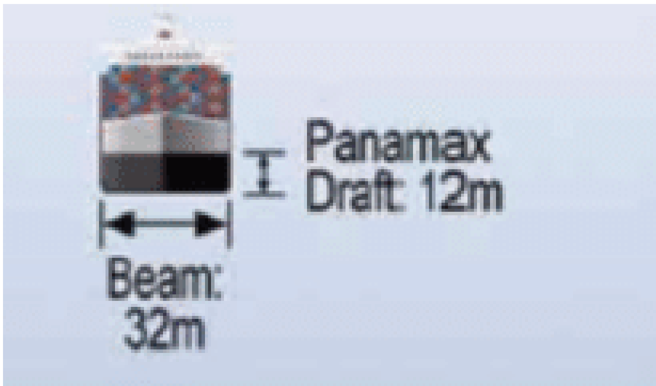

Figure 5 – Width (Beam) of the Panamax class vessel

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.

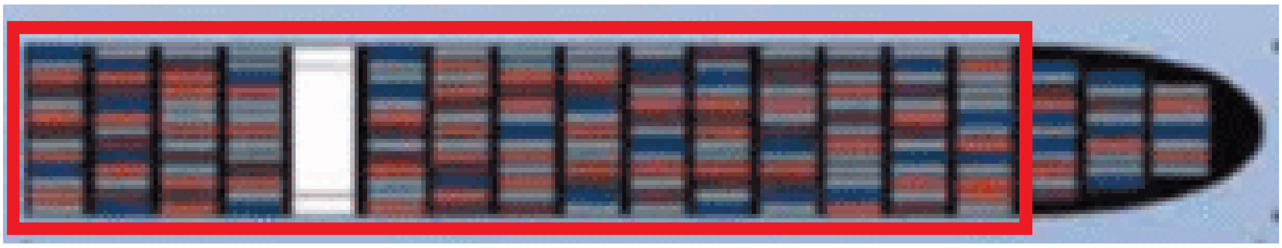

Figure 5 – Area of solar panel installation on Panamax class vessel

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.

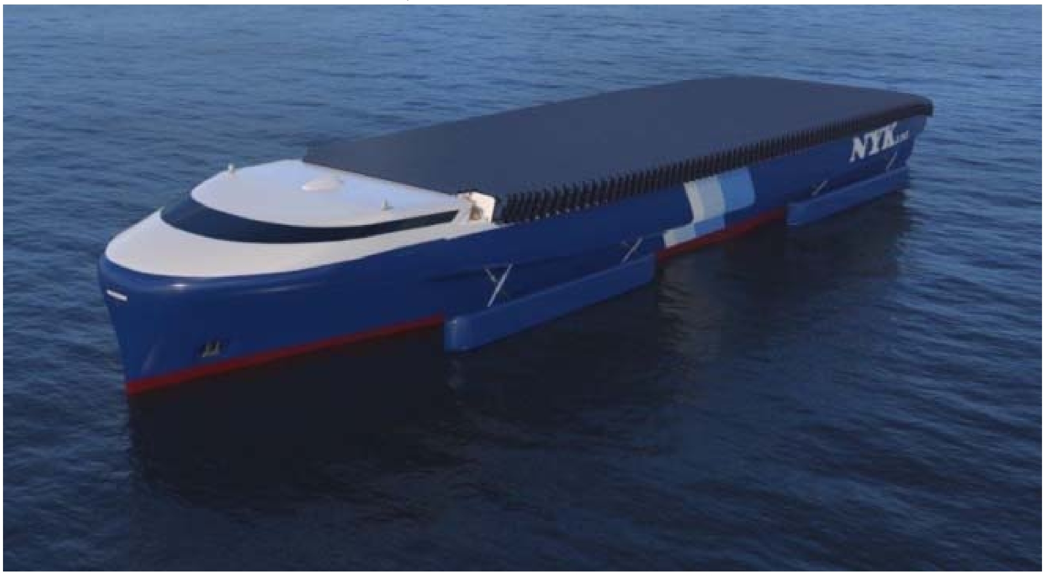

Figure 6 – Example of implementation investment project "Creation of electrically powered vessel"

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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