RESEARCH AND PRACTICAL SOLUTIONS FOR THE DEVELOPMENT OF RESOURCE-SAVING TECHNOLOGIES

Valeriy Leonov[1]

DOI: https://doi.org/10.30525/978-9934-26-651-5-5

Abstract. Natural changes in the planet's macroclimate parameters lead to force majeure events, accompanied by the destruction of natural ecosystems, biomes, man-made structures, and the destruction of the biosphere and humanity. The impact of natural factors is amplified by man-made factors. As a result, the destructive potential of climatic factors is increasing, leading to a climate crisis on the planet. Some experts refer to this phenomenon as the "greenhouse effect." *The subject of this research is to* identify possible causes of climate change on the planet, determine the factors influencing the climate crisis, analyze the quality and efficiency of green energy, particularly solar and wind power, compared to traditional hydrocarbon energy, and seek new solutions to the climate crisis within the framework of traditional hydrocarbon energy. *Research methods:* 1) computational and expert studies; 2) laboratory studies using ideal mixing and displacement units, flow-through and flow-through circulation designs; 3) certain fragments of scientific research were directly tested on real vessels under real sea voyage conditions. It has been established that man-made factors predominate over natural factors, and this trend is only increasing over time. Therefore, within the hydrocarbon energy sector, a transition from modern technologies to low-waste, resource-saving, and waste-free technologies is becoming both necessary and obvious. The world's oceans play a decisive role in shaping the planet's climate, leading to the climate crisis. Of the many problems associated with the deterioration of the quality and productivity of the world's oceans, three main problems caused by man-made systems are considered: 1) the problem of ballast seawater; 2) the problem of marine pollution by plastic waste; 3) the problem of marine pollution by oil-containing

[1] Doctor of Technical Science, Professor,
Kherson State Maritime Academy, Ukraine

compounds. Each of the above problems degrades the quality of the world's oceans and contributes to the development of the climate crisis. The scientific section demonstrates that the global community is effectively failing to take any effective measures to mitigate the negative consequences of the climate crisis, and the technical solutions implemented in practice are ineffective and have significant shortcomings. Based on our own scientific research, technical solutions are proposed for each of the above-mentioned problems, which collectively address issues of resource conservation, economics, and environmental protection. The role of the United Nations in addressing greenhouse gas emissions is limited to holding climate summits. Over the past 27 years (Kyoto-Paris-Baku), the summits' decisions have been virtually indistinguishable and have failed to address greenhouse gas emissions. This suggests the futility of climate summits, as well as the unnecessary financial costs of organizing and hosting them. The paper analyzes green energy, highlighting its shortcomings and lack of competitiveness compared to traditional hydrocarbon energy. Due to the depletion of natural resources, based on our research, we have proposed a raw material triad that includes carbon dioxide, nitrogen, and water vapor, on the basis of which we propose creating petrochemical, organic, and inorganic synthesis production facilities.

Introduction

Climate change on the planet is obvious. This is demonstrated, in particular, by the following examples: snow fell in the desert region of Saudi Arabia, flooding occurred in the United Arab Emirates, and the Arctic polar glaciers have melted by 70%, despite the fact that the climate is determined by the Arctic. It should be noted that, according to long-term observations, climate change is characterized by cyclical patterns. However, the frequency of these changes and their destructive potential have increased over time.

Climate change on the planet is associated with the "greenhouse" effect, with expert opinions on this issue diametrically opposed – from a categorical absence of a "greenhouse" effect to the presence of a "greenhouse" effect. The author of this section and his scientific team do not share these preferences, as there is no rigorous experimental evidence for either hypothesis. Existing climate change models are based solely on assumptions, the adequacy of which is extremely difficult to test on the

global scale of space and the planet. Based on his own research, the author attempts to navigate the current landscape of existing hypotheses.

The first section describes climate change issues and their impact on the environment, biosphere, and ecosystems. It is shown that man-made factors have a greater influence on climate change than natural factors.

Computational studies have established that the increase in atmospheric carbon dioxide concentrations is consistent with the increase in average annual atmospheric temperature over time. This may indicate the dominant role of carbon dioxide in the development of the greenhouse effect. Proposals for mitigating climate change are developed.

The second section analyzes the impact of UN-sponsored climate summits over the past 27 years. It is found that the resulting agreements are no different from previous ones, have no impact on the issues raised, the costs of holding the summits are unjustified, and holding them is pointless [1, p. 31]. The third section presents examples of the negative impact of man-made systems on the environment and biosphere. Practical recommendations are provided for reducing the environmental pressure of man-made systems on the environment, the biosphere and, ultimately, on climate change on the Planet.

1. Resource-Saving Technologies are the Path to Sustainable Development of Society

The idea of the mechanism of the "greenhouse" effect was first outlined in 1827 by Joseph Fourier in the article "Note on the temperatures of the globe and other planets", in which he considered various mechanisms of the formation of the Earth's climate. All most 200 years have passed since the planet's "greenhouse" effect (GE) model was proposed, and to date, no other possible mechanisms have been proposed that could be used to formulate the fundamental patterns of climate change and meteorological conditions on Earth. This is apparently due to the fact that constructing a mathematical model of the GE based on the GE mechanism requires rigorous experimental data obtained under global-scale conditions in the Universe, Space, and Earth. Obtaining the necessary data at this stage is virtually impossible. Climate change forecasts available in the literature are based on mathematical models without reference to rigorous concepts of a hypothetical climate changeж mechanism. Therefore,

it is difficult to assess the reliability, quality, and productivity of these forecasts [2, p. 159].

It should be noted that the opinions of experts, politicians, and the public regarding the existence of a prolonged greenhouse effect on the planet are polarized – from "there is no greenhouse effect" to "there is a greenhouse effect" on the planet. This is apparently primarily due to the lack of reliable experimental data on the causes of climate change on the planet and a rigorous theoretical justification for the mechanism of this phenomenon. One of these two possible points of view on the greenhouse effect was categorically voiced in October 2025 at the UN General Assembly, dedicated to the 80th anniversary of the UN, in a speech by US President Donald Trump. He declared that he would not recognize the "climate crisis," not adhere to greenhouse gas emission quotas, would abandon "green" energy, restore coal-fired power generation, and increase the use of "peaceful" nuclear energy.

In the work [1, p. 37] an attempt was made to explain climate change and the possible consequences of these fluctuations on the environment and biosphere of the Planet. It should be noted that climate change on the Planet is influenced by factors of a natural nature (NF)- volcanic eruptions, forest fires, hurricanes, sandstorms – and man-made factors (MMF). With a certain degree of error, it can be assumed that NF factors remain virtually unchanged over time, while MFF factors intensify over time for a number of reasons, for example, a sharp increase in the population of the Planet, the creation of new objects of man-made systems, an increase in the consumption of natural resource potential and, accordingly, an increase in the emission of material and energy waste from man-made systems. From this it can be assumed that MMF factors play a decisive role in climate change on the Planet (Fig. 1).

The relative index of factors determined by the ratio of the totality of factors of man-made systems to the totality of natural factors. Relative time is defined as the ratio of the current time to the approximate time when human impact on the environment was zero. An analysis of Figure 1 suggests that the contribution of man-made factors to climate change increases over time, while the contribution of natural factors stabilizes at approximately the same level. As a result of the combined influence of natural and man-made factors, their impact on climate change increases more than twofold

compared to natural factors. By us for the last 60 years an analysis [1, p. 35], researches, is conducted on the accumulation of dioxide of carbon – basic component of «greenhouse» gases on a planet. This period of time was accepted coming from that exactly he is characterized by the most intensive consumption of hydrocarbon raw material of unrenewable character (oil, natural gas, coal, slates) and, accordingly, most emission of dioxide of carbon in an atmosphere and environment. The results of researches are shown on a Figure 2.

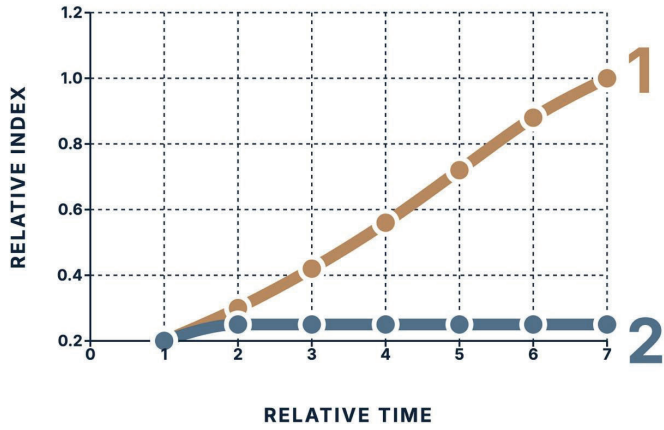

Figure 1. Dependence of the relative index on relative time: line 1 – man-made factors. line 2 – natural factors

Analyzing the data from the computational studies presented in Figure 2, we can conclude that the relationships between carbon dioxide accumulation in atmospheric air (line 2) and the increase in average annual atmospheric temperature (line 3) are virtually congruent. This finding may indicate that carbon dioxide is one of the main components of greenhouse gases responsible for the greenhouse effect. However, to validate this hypothesis, additional research is needed on other components of greenhouse gases, namely water vapor, hydrocarbons, dust (soot), nitrous oxide, and ozone, contained in atmospheric air. Only then can a conclusion be drawn as to which components of greenhouse gases are

responsible for the greenhouse effect. After this, technical solutions can be developed to reduce or eliminate emissions of these components of man-made systems. The emision of carbon dioxide, both general and only as a result of incineration, goes down in a row «coal → fuel oil → natural gas → hydrogen (down to zero). Technical suggestions, that will allow to bring down emission of dioxide carbon and, accordingly, bring down the action of «greenhouse» effect, are below given [3, p. 28; 4, p. 91].

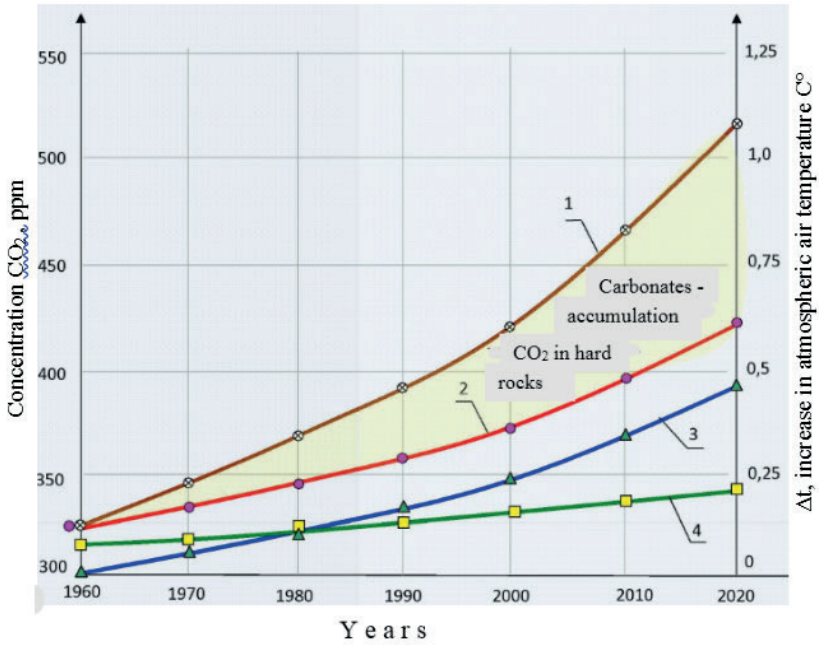

Figure 2. Change in the concentration of carbon dioxide and the average annual increase in atmospheric air temperature depending on time (years): Curve 1 – total anthropogenic CO_2 acculation; Curve 2 – anthropogenic accumulation of CO_2 in the atmospheric air; Curve 3 – average annual increase in atmospheric air temperature; Curve 4 – natural accumulation of CO_2 in the atmospheric air. Legend: ppm-parts per million, Δ t – the average annual increase in atmospheric air temperature

1. Development and realization of low-waste, resource-saving technologies, allowing to bring down formation of material wastes and, as a result, bring down the emission of dioxide of carbon.

2. Extraction, concentration, collection, translation in the liquid aggregate state, storage and transporting of the liquefied dioxide of carbon.

3. Chemical conversion of dioxide carbon by the method of the catalytic hydrogenization in methanol and on the basis of methanol production of the plastic masses, urea-formaldehyde resins, hydrocarboxylic acids, fertilizers, pharmaceutical products, high-octane components of motor fuel, hydrogen, ethylene, protein-vitamin concentrate, hydrate inhibitor when mining of hydrocarbon gases.

In the Kherson State Maritime Academy (a scientific leader is professor Leonov V.Ye.) research, experienced and experienced-industrial works are conducted on development of resource-saving, ecologically safe technologies and use of nonhydrocarbon rawл material for providing of functioning of the manmade systems [5, p. 297; 6, p. 152].

Based on the results presented in Figure 1, it can be assumed that rapidly evolving factors of man-made systems are significantly contributing to climate change on the planet. Therefore, to reduce the impact of man-made factors and stabilize and mitigate the "environmental" crisis, we propose a consistent approach to addressing the "environmental" crisis in three areas:

1) developing resource-saving, waste-free technologies;

2) converting man-made systems to alternative, non-hydrocarbon energy resources;

3) further developing man-made systems using a raw material triad consisting of nitrogen, carbon dioxide, and water vapor – all of which are unlimited, low-cost, and environmentally safe.

We have introduced a criterion for the quantitative assessment of resource-saving technologies – the coefficient of performance (COP), %, which is determined by the ratio of the energy converted into the target product to the total energy converted into the target product and waste of technogenic systems.

Depending on the value of the COP, %, resource-saving technologies are conventionally divided into the following types [7, p. 19]:

1) modern technologies (15%);

2) low-waste technologies (45%);

3) resource-saving technologies (75%);

4) waste-free technologies (100%).

Purpose of resource-saving technologies [8, p. 119]:

1) reduce the consumption of non-renewable energy resources, reduce the load on class 3 resource reserves;

2) reduce ecological and economic damage to the environment, biosphere;

3) improve technical and economic indicators of man-made systems.

Provide examples of resource-saving technologies developed and implemented on an industrial scale. Particular attention should be paid to large-scale production of methanol according to the “short” scheme M-100 – 100,000 tons/year, integrated with the production of acetylene by the method of high-temperature oxidative pyrolysis of methane.

Thus, regardless of whether the concept of the "greenhouse" effect is accepted or rejected, the quality, productivity, and stability of the environment and biosphere are constantly deteriorating and degrading.

The "ecological" crisis depends on natural and man-made factors, with man-made factors playing a decisive role.

Technical solutions have been developed aimed at stabilizing and reducing the level of the "ecological" crisis.

Under the auspices of the UN, international "climate" summits are periodically held.

2. Analysis of the Productivity of Green Energy and the Feasibility of Holding UN Climate Summits

It should be noted that the climate summits held in Kyoto (Japan, 1997), Paris (France, 2015), Baku (Azerbaijan, 2024) were held. Over the analyzed period of time over the past 27 years, it should be noted that the quality of the environment, the biosphere is deteriorating, and their productivity is decreasing against the background of the growing population of the Planet [9, p. 227; 10, p. 357; 11, p. 9]. From a practical point of view, it is of interest to consider and analyze the final conclusion of the Paris Climate Summit, given below. The purpose of the agreement (according to Article 2) was to enhance implementation of the UN Framework Conference on Climate Change, in particular to keep the increase in global average temperature "well below" two (2) °C and to "make efforts" to limit the increase in

temperature to 1.5 °C. The feasibility of warming limits within 1.5-2°C is determined by the volume of national financial contributions, the practical implementation of man-made waste-free technologies and an increase in the share of Green energy. This is one of the main provisions of the final Paris Agreement and here it is necessary to take an action pause – how it is necessary to "make efforts" and most importantly to whom, in order to keep the increase in the global temperature of the Planet within two (2) °C, and in general is it possible to control the global temperature of the atmospheric air, and if possible, how, by what method?

The next question is why global temperature restrictions apply only to atmospheric air. Why doesn't the high UN conference introduce restrictions on the global temperature of the marine environment, the lithosphere, or the totality of the three shells of the Planet – atmospheric air, marine environment, lithosphere.

Therefore, the limitation on global air temperature adopted in the Paris Agreement is declarative in nature, since it is a priori impossible to implement, on the one hand, and on the other hand, without a sufficient evidence base and incomplete.

The next section of the final Paris Agreement concerns limiting man-made carbon dioxide emissions.

Here the following question arises: why is carbon dioxide taken as the dominant "greenhouse" effect out of the five known ones? After all, it is known that in terms of the intensity of the "greenhouse" effect, carbon dioxide is significantly inferior to water vapor, hydrocarbons, mineral and organic dust.

As a result, significant global financial costs will be spent on reducing carbon dioxide emissions from the prolonged action of technogenic systems, and the result of this action in terms of the "climate" crisis will tend to zero.

The parties to the Agreement declared that "carbon dioxide emissions should peak as soon as possible, will be possible."

To do this, parties to the Agreement needed to agree on a "set of rules" for carbon markets. In November 2024, the next COP-29 climate summit was held in Baku (Republic of Azerbaijan). It is of practical interest to consider the COP-29 Final Agreement, the main positions of which are listed below:

Position 1 – do not allow the average annual temperature of the Planet's atmospheric air to exceed 1.5 °C.

Position 2 – comprehensively and constantly reduce the emission of man-made carbon dioxide.

Position 3 – create a global carbon market, the purpose of which is to reduce the use of traditional hydrocarbon energy while increasing the share of "green" energy, while regulating the prices of these energy sources.

Position 4 – continuous, multi-level environmental education of the population of the Planet.

Position 5 – comprehensively and constantly use the energy of the sun and wind to produce "green" energy sources.

Let's analyze and consider the practical significance of the proposed measures in terms of improving the climate on the Planet separately for each position.

Position 1 – limiting the growth of the average annual temperature of the Planet's atmospheric air to no more than 1.5 - 2.0 °C, here it is appropriate to object, since the temperature of the marine environment has a greater impact on climate change compared to the temperature of the atmospheric air, here it is possible to accept as a criterion the limitation of the growth of the total temperature of the atmospheric air, the marine environment, the lithosphere, another question remains unresolved, how can we regulate the growth of the summative average annual temperature of the three shells of the Planet?

Position 2 – reducing the concentration of man-made carbon dioxide to almost zero beyond 2050, here the question naturally arises, why only carbon dioxide was chosen, in our opinion, in this case it is advisable to consider the joint participation of all components of "greenhouse" gases or choose the most significant in terms of their effect on the dynamics of the "greenhouse" effect.

Position 3 – the creation of a global carbon market, in our opinion, has no prospects, since hydrocarbon fuel markets have already been created and are effectively functioning, for example, the oil OPEC.

Position 4 – continuous, multi-level environmental education of the population, here it should be recognized that the four levels of environmental education at the present stage are optional, formal in nature, and the political decisions taken lead to negative consequences, for example, the disappearance of the Aral Sea, a unique bay on the Caspian Sea – Kara-Bogaz-Gol, the construction of a pulp and paper mill on the shore of Lake

Baikal, toxic and dangerous extraction of shale gas and other unreasonable political decisions.

Position 5 – the use of solar and wind energy for the production of energy resources is the main basis of "green" energy in the European Union.

In [2, p. 160] comparative characteristic of traditional hydrocarbon energy sources and solar and wind energy is given. It seems interesting to consider the negative characteristics of the use of solar and wind energy at the present stage, namely:

– the alienation of significant territories is required to place solar panels;

– high labor intensity in cleaning solar panels and their maintenance during normal operation;

– the service life of solar panels during their normal operation does not exceed 10-15 years, there is currently no commecial method for the disposal of used solar panels, while the toxicity of used solar panels is 400 times higher than the toxicity of spent nuclear fuel from nuclear power plants;

– the fragility of solar panels can lead to their premature destruction under mechanical impact, so in October 2024 in the state of Texas (USA) as a result of a powerful downpour with hail, solar panels were destroyed and a solar power plant was disabled, one has only to think about where the solid waste of solar panels will be sent, and alarming thoughts arise?

– the productivity of solar panels reacts sensitively to changes in meteorological conditions (fog, rain, snow), volcanic eruptions.

The disadvantages of wind power plants include the following:

– a source of infrasound radiation;

– the productivity of the plant depends on meteorological conditions (direction and strength of the wind);

– high "sail" of the propeller, which leads to their mechanical damage;

– a long payback period of the plant determines its unprofitability;

– death of birds;

– increased noise level.

For environmental reasons, Germany eliminated coal and nuclear heat generation and, together with the "voluntary" refusal to supply natural gas via Nord Stream 1,2, the basic energy of the FRG was reoriented towards "green" energy, in particular solar and wi. Thus, an analysis of the UN-sponsored climate summits held over the past 27 years has shown that the resolutions adopted are virtually identical and focus on three issues:

1) ensuring an increase in average annual atmospheric temperature within limits not exceeding 1.5-2.0°C;

2) reducing natural and man-made carbon dioxide emissions;

3) limiting the carbon market for energy resources and introducing carbon dioxide emission quotas.

It should be noted that the above conclusions have had no impact on the climate crisis, and the effectiveness of environmental summits is asymptotically approaching zero.

3. Development of Resource-Saving Technologies and Recommendations for Practical Implementation

3.1 Use of Ballast Water in Maritime Shipping

Ballast water is used during the transportation of light vessels, as well as to control the vessel's heel and stability to ensure the safety of sea passage. According to the International Maritime Organization (IMO), 12 billion tons of marine ballast water are processed annually worldwide during maritime transport operations. Concurrently with the processing and transportation of ballast water, various marine organisms are transferred across global waters and to destination ports. These microorganisms include pathogenic, toxic, and pathogenic organisms that cause human disease. According to the World Health Organization, 90% of cholera cases are caused by the transfer of ballast water.

This process of transferring alien organisms via ballast water is known as "marine invasion." The IMO directs all maritime transport vessels to exchange ballast water 200 nautical miles before arrival at their destination port. In this case, the problem of the transfer of pathogenic alien organisms to the marine environment remains unresolved. The problem of "marine invasion" can only be solved through complete neutralization and decontamination of ships' ballast water.

Physical and chemical methods for decontaminating ships' ballast water are known, including ultraviolet treatment, ultrasonic treatment, thermal treatment, inert gas treatment, treatment with chlorine-containing compounds, ballast water ozonation, and carbon dioxide treatment.

These ballast water treatment methods have advantages and disadvantages, and testing them under actual sea voyage conditions is required. In 2021, Master of Science (MSc) A.I. Grinberg, under the

supervision of Professor V.E. Leonov, completed and defended his master's thesis at the Kherson State Maritime Academy on the topic: "Research and Development of an Effective Process for the Treatment of Ship Ballast Water."

The thermal ballast water treatment system used on a real container ship, where the MSc served as the captain's chief mate, was chosen as the basic technology for ballast water treatment.

The system included a ballast water heating unit to 70 °C, consisting of a preheater for ballast water to 40°C using exhaust gases from the ship's propulsion system and a final heating unit to 70°C by burning fuel oil in a furnace.

Plate heat exchangers were used as the heat exchange equipment. Disadvantages of the basic technology:

1) clogging of the heat exchange surface on the exhaust side with sooty deposits, and on the ballast water side with silt and shellfish;

2) intermittent system operation due to clogging of the heat exchange surfaces, requiring system shutdowns for cleaning the heat exchange equipment;

3) additional fuel consumption for heating ballast water.

As a result of an analysis and summary of literary sources on the developed ballast water treatment and decontamination process, and an analysis of the deficiencies of existing methods, a concept for constructing an effective technology was developed, and laboratory studies were conducted.

As a result, a technology for the sanitary disinfection of marine ballast water was developed, including the following stages:

1) preliminary and fine filtration of seawater from overboard seawater to remove silt and suspended solids;

2) synthesis of a pathogen destructor from seawater using a special technology protected by a Ukrainian patent (authors: Professor V.E. Leonov, Master's Degree Student A.I. Grinberg);

3) neutralization and disinfection of ballast water with the destructor (according to paragraph 2);

4) final treatment and disinfection of ballast water using ultraviolet radiation;

5) fine filtration of the disinfected ballast water to remove suspended solids.

The developed technology meets the requirements for the sanitary treatment of contaminated marine ballast water and is ready for practical implementation in the marine fleet. The main advantages of the developed marine ballast water disinfection technology compared to the standard disinfection technology are as follows:

1) clogging of equipment with silt and shellfish is eliminated;

2) the process is continuous, as no downtime for preventative cleaning of the equipment is required;

3) fuel consumption per unit is 550 times lower than with the standard technology.

It should be noted that the disinfected ballast water can be considered as a marketable product for other vessels.

Thus, the developed marine ballast water disinfection technology meets two crucial requirements: cost efficiency and environmental safety.

For the future, the following research and development projects in the field of preventing marine ballast water infestation are proposed:

1. Deep neutralization of marine ballast water using physicochemical methods.

2. Oil transportation from oil-producing regions of the Middle East to oil-poor regions, with return transportation to oil-producing regions, replacing natural fresh water as marine ballast [12, p. 12; 13, p. 65; 14, p. 201].

3. Research and development of ballast-free maritime cargo logistics using special-purpose vessels, using the rapidly developing region of Southeast Asia as an example [15, p. 7; 16, p. 70].

It is of scientific and practical interest to use natural fresh water, which has high energy and an ideal structure, instead of sea ballast. The main disadvantage of using natural fresh water instead of sea ballast is its contamination with hydrocarbons. However, this problem can be solved **using** water purification methods for hydrocarbons, as described in the textbook [17, p. 201].

3.2 The Impact of Plastic Waste on the World Ocean, the Environment, and, Consequently, Climate Change on the Planet

3.2.1 The Danger of Plastic Waste Pollution of the World Ocean

In November 2025, the 13th annual World Oceanographic Congress (WOC-2025) was held in Osaka, Japan, under the theme "A Sustainable

Future for Our Oceans." One of the most important criteria for this motto is improving the quality of the marine environment and biota, and increasing the efficiency of the "blue economy." One of the most significant instruments for achieving this criterion is the regulatory document MARPOL.

Tens of millions of tons of household and industrial solid plastic waste are dumped into the world's oceans annually. Problems arising in the ocean and the environment associated with marine plastic waste pollution include the following negative effects:

1) disruption of the natural water cycle due to reduced rates of evaporation and condensation of water vapor on the sea surface covered by plastic waste;

2) reduction in dissolved oxygen concentrations in the marine environment;

3) increased marine temperature in the area covered by plastic waste, which initiates a "greenhouse" effect;

4) pollution of the marine environment and the atmosphere by the degradation products of plastic waste.

The degradation and neutralization time of plastic waste in the marine environment varies from approximately 350 to 700 years, depending on the molecular weight of the plastic waste, pH, marine temperature, and the duration and intensity of solar radiation [18, p. 142]. Furthermore, new batches of plastic waste are constantly entering the world's oceans through wastewater and anthropogenic factors. From this, it's easy to determine how long it would take for the entire surface of the seas and oceans to be covered in plastic waste, which would spell the end of all life on the planet. Indeed, "islands" of plastic waste have currently formed in the waters of the Pacific and Atlantic Oceans, disrupting shipping, fishing, scientific research, geological exploration, and the extraction and transportation of mineral resources [19, p. 77; 20, p. 21].

The surface of plastic waste in the marine environment is used by algae, crustaceans, and their communities for their vital functions. The end product of these activities, the death of living organisms, is solid crystallized fragments attached to the surface of the plastic waste—the byproducts of their death. This increases the mass of plastic waste, reducing its buoyancy and, consequently, the formation of floating, suspended, and bottom-dwelling plastic waste. Each of these types of waste negatively impacts

the life of marine organisms, leading to a decrease in their productivity and biodiversity.

3.2.2. Solutions to the Plastic Waste Problem.

The main solutions to this problem are listed below:

1) eliminating the use of plastic for packaging materials, containers, and utensils in industry and everyday life;

2) switching to paper and glass instead of plastic;

3) switching to the reuse of paper and glass products.

Currently, the share of recycled plastic waste globally does not exceed 10%. Plastic waste recycling technology includes collecting, sorting, cleaning, shredding waste, high-temperature melting of the shredded material, film stretching, and manufacturing the necessary products. As a result, products obtained through recycling are more expensive than those made from virgin plastic, which is unprofitable for businesses. Therefore, the problem of plastic waste recycling remains unresolved. It is advisable to seek new methods for recycling plastic waste that will produce substances with a higher production cost than virgin plastic. As shown above, pollution of the marine environment with plastic waste leads to an increase in the temperature of the marine environment, disrupts the natural water cycle on the planet, and the end products of the decomposition of plastic waste are unsaturated hydrocarbons – ethylene, propylene, which are among the main components of "greenhouse" gases. All these factors, caused by pollution of the world's oceans with plastic waste, contribute to the acceleration of the development of the "greenhouse" effect on the planet.

The work [2, p. 158] analyzes the activities of international organizations under the auspices of the UN in the context of preventing the "greenhouse" effect on the planet. The activities of these organizations are reduced to holding regular climate summits, developing final agreements to counter the "greenhouse" effect on the planet and allocating funds for the implementation of activities provided for in the final agreements. An analysis of climate summits over the past 27 years has found that the resulting agreements are virtually indistinguishable from each other, and the recommendations arising from the agreements adopted are unsuitable for practical implementation [21, p. 36].

Thus, it can be concluded that pollution of the world's oceans and environment with plastic waste negatively impacts the quality and productivity of the environment and the biosphere, and could ultimately lead to the collapse of civilization on the planet. The current situation only exacerbates the already catastrophic state of the world's oceans. We have proposed specific solutions to this problem, and other approaches to saving the planet are also possible. The future of the planet depends on the decisions made in the near and long term [22, p. 192].

3.3 Development of an Integrated Marine Facility for the Disposal of Oil-Containing Water

Pollution of the marine and ocean environment with petroleum products and oil poses a serious threat to the environment and the biosphere for the following reasons:

1. Low-boiling hydrocarbons contained in oil, with a boiling point of 25-85°C, evaporate into the atmosphere, and since they are components of greenhouse gases, it can be assumed that this enhances the greenhouse effect.

2. High-boiling hydrocarbons contained in oil, with a boiling point of 85-250°C, form a rainbow film on the sea surface, "floating" in the depths of the marine environment and sinking, covering the bottom surface. The decomposition time of these hydrocarbon groups, depending on their boiling point and molecular weight, ranges from 50 to 150 years. The danger of marine pollution with oil and petroleum products for the environment and biosphere is obvious from the above [23, p. 248].

The main sources of hydrocarbon pollution of the marine environment are:

– discharge of oil-containing water (OCW) from ships – accidental, after tanker flushing;
– ship collisions, berthing, groundings;
– wastewater from man-made systems.
– emergency oil discharges resulting from tanker wrecks.
– natural oil discharges from oil field faults.

Cleaning up OCW is a rather complex technical task, characterized by high capital investment, energy and material resource consumption, and cleaning costs.

This section aims to develop a mobile, efficient, self-propelled unit for cleaning and recycling OCW, which will reduce damage to the marine environment and improve the economic performance of the voyage.

The self-propelled unit is designed to receive hazardous waste from ships and to clean up marine waters from accidental discharges of oil and petroleum products (Fig. 3).

The stages of the hazardous waste treatment and disposal process implemented on the self-propelled unit are:

1) separation (section A), with an α1 purification rate of 25-35%;

2) pressure flash flotation (section A), with an α2 purification rate of 70-85%;

3) HC adsorption on a unique sorbent (section A). Sorbents have been developed for the absorption of hydrocarbons (HC) from the surface of the marine environment. 1 g of sorbent absorbs 50 g of HC. A Ukrainian patent has been obtained for the sorbent formulation and production method.

4) regeneration of the saturated HC sorbent.

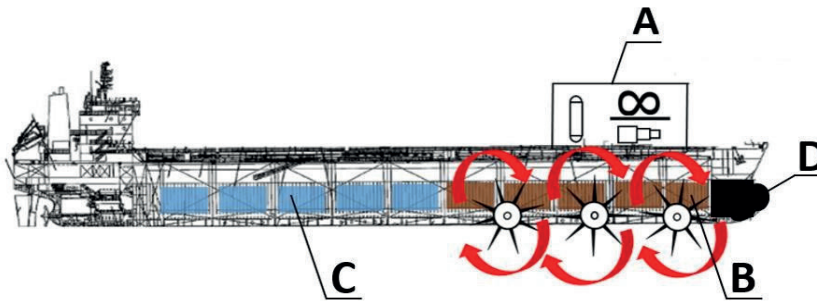

Figure 3. Floating self-propelled station for cleaning and recycling of hydrocarbons (model VL-152)

To create the floating station, it is proposed to use a tanker with a truncated cone-shaped bow equipped with a ramp on which a vertically rotating brush plate assembly is mounted. The horizontally rotating brush plates are mounted on the ramp's horizontal plane and are equipped with combs for removing oil from the brushes. The collected oil, mixed with seawater, is loaded into the tanker's tanks for subsequent recycling and cleaning onboard

the tanker (section B). Seawater purified from hydrocarbons (no more than 15 ppm hydrocarbons) is collected in tanks (section C).

Hydrocarbons separated from the oil-containing seawater are collected in section D.

The uniqueness of the development lies in the implementation of steps 3 and 4 of the above process, which compare favorably with existing technologies and are protected by patents. The implementation of a self-propelled recycling unit solves two important problems:

1. Reduces damage to the marine environment from hydrocarbons.

2. Increases economic efficiency.

Thus, the following conclusions can be drawn from the research conducted:

1. An analysis and summary of scientific and technical materials on oil-containing water treatment revealed the shortcomings of existing methods, both in terms of treatment speed and purification efficiency, the lack of mobility for collecting hydrocarbons from the sea surface and for pumping them from scheduled vessels, and the low economic performance of the process.

2. A modern technology for the treatment and disposal of oil-containing water was proposed for implementation as part of a self-propelled unit based on tankers and chemical and gas carriers previously in operation in the marine and river fleet.

3. The creation of a self-propelled offshore unit will reduce the risk of damage to the marine environment, improve energy efficiency by recycling "waste" hydrocarbons, and reduce the cost of oil-containing water treatment.

Conclusions

Climate change occurring on the planet is deteriorating the quality of life and posing a threat to humanity. Two factors – natural and man-made – have a significant impact on climate change. Moreover, man-made factors play a more significant role than natural factors.

This has necessitated improving the quality of man-made systems, specifically the creation of low-waste, resource-saving, and waste-free processes and production facilities based on them. The next stage involves converting man-made systems to non-hydrocarbon energy, specifically hydrogen, and the development of alternative energy sources. The next

stage is the long-term consideration of using a triad of raw materials, including carbon dioxide, water vapor, and nitrogen. This triad has a high reserve factor, low cost, and is characterized by a high environmental safety index.

Based on the analysis and generalization of the scientific and practical data presented in this section, the following key conclusions can be drawn:

1. Currently, there are no theoretical prerequisites and, accordingly, no mechanism for initiating/slowing down the "climate" crisis on Planet and no way to manage it.

2. In modern society, there is no consensus regarding the causes of the "climate" crisis on the Planet; there are no methods and means for managing the "climate" crisis and overcoming the consequences of the "climate" crisis.

3. Our studies have established that the man-made increase in the concentration of carbon dioxide in the atmospheric air correlates with the increase in the average annual temperature of the atmospheric air, which suggests that carbon dioxide is the main component responsible for the "greenhouse" effect on the Planet.

4. To confirm this assumption or refute it, given in paragraph 3, it is п necessary to conduct additional studies with other components of "greenhouse" gases – hydrocarbons, water vapor, nitrous oxide, fine mineral and organic dust, ozone.

5. To reduce the "greenhouse" effect, it is necessary to develop resource-saving, waste-free technological processes using hydrocarbon raw materials with a gradual replacement of hydrocarbon raw materials with non-hydrocarbon ones.

6. Analysis of the Final Conclusions of the climate summits held in Osaka, Paris, Baku showed that they are practically no different from each other, the main criteria are the average annual increase in atmospheric air temperature, a decrease in the concentration of man-made carbon dioxide in the atmospheric air, the creation of carbon markets, and an increase in the share of the use of eternal solar energy.

7. It is shown that the measures laid down in the Final Conclusion cannot be implemented on a planetary scale and, accordingly, cannot be used as a climate regulator on the Planet.

References:

1. Leonov V.Ye., Gurov A.A. Greenhouse effect. Fiction or result of the action of the technogenic systems? *The scientific heritage*. 2021.Vol.1, № 60(60), p. 2939. DOI: https://doi.org/10.24412/9215-0365-2021-60-1-29-39

2. Leonov V.Ye. The Planetary «Climate» Crisis is a Problem for the International Community. VII International Conferense «Innovative Technologies in Science and Education. European Experience». Materials. Electronic publication. Dnipro: Jurfond. 2024. P. 157-161. ISBN 978-966-934-625-4

3. Zhmur V.N., Leonov V.Ye. Ways to increase economic energy efficiency and environmental safety of sea freight. *American Scientific Journal*. 2018. Vol. 19, pp. 25-31.

4. Leonov V.Ye. Ways to Improve Energy Efficiency and Environmental Safety of Sea Freight / V.Ye. Leonov, M.V. Chepok, R.A. Drobitko // Strategy of Quality in Industry and Education. Varna : Technical University. 2015. Vol. 2, pp. 87-93.

5. Leonov V.Ye. Substantiation of Regulation of the Emission Limits of Sulfur and Nitrogen Oxides in Exhaust Gases on Ship Power Engines Scientific Monograph. Findings of Modern Engineering Research and Developments. / V.Ye. Leonov, A.A. Gurov. Riga : Baltija Publishing. 2022. P. 295-326. DOI: https://doi.org/10.30525/978-9934-26-207-4-11

6. Leonov V. Solution of the Two-vector Problem of Resource Saving on Board of the Ship. *American Journal of Traffic and Transportation Engineering.* 2021. Vol. 6, № 6, pp. 147-155. DOI: https://doi.org/10.11648/j.ajtte.20210606.11

7. Leonov V.Ye. Integrated Resource – Saving Technology of Hydrocarbon Raw Material Processing. International Scientific Conference : Development of Scientific Thought :Innovations, Achievments and Prospects: Conference Proccedings, October 3-4, 2025, Riga, Latvia : Baltijs Publishing, 2025. P. 18-21. DOI: https://doi.org/30525/978-9934-26-601-0-4

8. Leonov V.Ye., Gurov A.A. Research and Development of Practical Recommendations for Reducing the Consumption of Marine Fuel (Especially on the Tanker Fleet). Proceedings of the International University Scientific Forum – Practice Oriented Science. UAE, Dubai : 2022, pp. 113-122. DOI: https://doi.org/10.34660/INF.2022.59.71.006

9. Leonov V.Ye. Energy problems of the world community – present, future. Modern science : Theory, practice , innovative technologies : Scientific Monograph. Riga, Latvia : Baltija Publishing 2025. Part 1, pp. 203-230. DOI: https://doi.org/30525/978-9934-26-602-7-9

10. MARPOL Consolidated edition 2011: Articles, Protocols, Annexes and Unified Interpretations of the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the 1978 and 1997 Protocols. London: CPI Group, 2011. 447 p. ISBN 978-92-801-1532-1.

11. DNV GL – One Step at a Time. Abailable at: https://www.dnv.com/expert-story/maritime-impact/One-step-at-a-time.html

12. Ship Energy Efficiency Management Plan (SEEMP). SEEMP Template for Owners and Operators. London: IMO-2018. 12 p.

13. 65/INF IMO Model Course on Energy Efficient Operation of Ships. London : World Maritime Iniversity. 2013. 71 p.

14. Lieonov V.Ye. Tekhnolohiia ochyshchennia stichnykh vod. Navchalnyi posibnyk. / Wastewater Treatment Technology. Tutorial /. Kherson: Vydavnychyi tsentr Khersonskoi derzhavnoi morskoi akademii. 2008, 294 s.

15. Patent 32822 Ukraine. Sposib utilizatsiyi teploty vidpatsovanykh haziv energrhetychnykh ustanovok. / Method for utilizing heat from exhaust gases of power plants /../ V.Ye. Lyenov, V.H. Sherstyuk, A.P. Ben. Publ. 26.05.2018 Bull.Nu. 15.

16. Leonov V., Gurov A. Development of ballast-free logistics maritime transportation in order to reduce the consumption of ship fuel and reduce carbon dioxide. Resource and Energy Saving Technologies in the Chemical Industry. Scientific Monograph. Riga, Latvia : Baltija Publishing. 2022. P. 49-71. DOI: https://doi.org/10.30525/978-9934-26-219-7-2

17. Leonov V. Research on Optimization of Maritime Cargo Transportation in Southeast Asia. Science, Technology and Innovation in the Context of Global Transformation : Scientifics Monograph. Riga, Latvia : Baltija Publishing, 2024. P. 182-204. DOI: https://doi.org/10.30525/978-9934-26-499-3-10

18. Leonov V.Ye. Pollution of the World Ocean with Plastic Waste – No More Plastic. International Scientific Conference-Theoretical and Practical Aspects of the Formation of Scientific Area : Conference Proceedings, March 21-22, 2025. Riga, Latvia : Baltijs Publishing , 2025. p. 140-144.

19. Winnes H. Reducing GHG Emissions from Ships in port areas. *Reaearch in Transportation Business and Management*. 2015. N 4, pp. 73-82. DOI: https://dxdoi.otg10.1016/jrtbm. 2015.10.008

20. Anders B. Laursen. Availability of Elements for Heterogenious Catalysis : Predicting the Industrial viability of Novel Catalysts. *Chinese Journal of Catalysis.* 2018. Vol. 3, Nu 5, pp. 16-26. DOI: https://doi.org/1016/S1872-2067(17)62979-6

21. Guidelines for voluntary Use of the Ship Energy Efficiency Operational Indicator (EEOI)). London; IMO. 2009. 45 p.

22. Rechmatulla N. The Implementation of Technical Energy and CO2 Emission Reduction Measures in Shipping / N. Rehmatulla, J. Galleya, T. Smith // Ocean Engineering. 2017. Vol. 139. P. 184-197. DOI: https://doi.org/10.1016/j.oceaneng.2017.04.029

23. Tran T.A. Research of the Srubber Systems to Clean Marine Diesel Engine Exhaust Gases on Ship. *Journal of Marine Science: Research and Development*. 2017, Nu 3, pp. 243-252. DOI: https://doi.org/10.4172/2155-9910.1000243