Alternative Energy Sources in Sustainable Development of Earth's Climate: Theoretical Issues

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Abstract: The relevance of the study is due to trends in the introduction of alternative energy sources into the structures of world economies, which is a main condition for the sustainable development of the Earth's climate. The article presents the rationale for the conceptual approach to the use of alternative energy sources in the sustainable development of the Earth's climate. The authors disclosed the discursive content of sustainable development of the Earth's climate, due to the transition to alternative energy sources; the structure and content of alternative energy sources are established (renewable energy, de-carbonization). Based on the results of the study, the effectiveness of variable models of sustainable development of the Earth's climate, mediated using

alternative energy sources, is substantiated. The materials of the article have practical application and are focused on assisting specialists developing and implementing alternative energy sources in nature protection practice.

Keywords: climate, global warming, greenhouse gases, gas emissions, sustainable climate development, new energy sources, renewable energy sources (RES), gas emission quotas, de-carbonization.

INTRODUCTION

The relevance of research. It has been established that the Kyoto Protocol (Japan, 2005) is among the first documents to resolve the problem of sustainable development of the Earth's climate at the global level. The main goal of the protocol is aimed at combating environmental pollution by reducing greenhouse gas emissions into the atmosphere and taking into account specific obligations of developed countries and countries with economies in transition to limit or stabilize greenhouse gas emissions from 2008 to 2012 (High Level Group Report Secretary-General for Global Sustainability, 2012). At the same time, the protocol adopted the first international agreement on sustainable climate development by reducing the total greenhouse gas emissions into the atmosphere by 5.2% compared with the 1990 level through the implementation of quotas - trade in national greenhouse gas emissions quotas (Bondarenko et al., 2018; Bukvich & Petrovich, 2017; Makarov & Stepanov, 2017; Stiglitz, 2018; Kiseleva et al., 2018; Valco, 2018). It was established that specific proposals of the Kyoto Protocol were further developed at the Paris Agreement (2015) in the form of specific developments on the transition to sustainable climate development at the global, regional and national levels due to large-scale de-carbonization of the global economy (Stiglitz, 2018). It has been proven that the de-carbonization process means a sharp reduction in the production and burning of fossil fuels, its replacement with renewable energy sources (RES) and atomic energy, as well as the expansion of carbon capture and storage technologies (Bondarenko et al., 2018; Makarov & Stepanov, 2017; Stiglitz, 2018). According to experts, the main methods of de-carbonization of production are: the use of hydrogen as a heat source or reducing agent; direct electrification of industrial processes; the use of biomass as an energy source, a reducing agent (in the production of steel) or as a raw material (plastic production); carbon capture in combination with its use or storage (Bukvich & Petrovich, 2017; Stiglitz, 2018; Heiskanen & Hilden, 2013).

It has been established that in the development of the integration interaction of economic, social and environmental problems aimed at decarbonizing a number of energy-intensive sectors of heavy industry (cement, production of steel, aluminum, plastic), as well as land, sea and air freight transport, the goals of sustainable development of the Earth's climate become dominant (Fedorov & Averchenkov, 2011; Stiglitz, 2018). The conclusions of the prevailing ideas about the proportionality of human activities' impact on the environment are determined not only by the needs of land use, agriculture, urban planning and industry as a whole, but above all by the interest of business in the development and implementation of new technological achievements in the field of alternative energy sources and their energy efficiency in sustainable development Economics (Makarov & Stepanov, 2017). In this regard, this article reveals the discursive content of sustainable development of the Earth's climate due to the transition to

alternative energy sources; the structure and content of alternative energy sources are established (renewable energy, de-carbonization). Based on the results of the study, the variable models of sustainable development of the Earth's climate are substantiated and experimentally proved - the reduction of greenhouse gas emissions, the system of trading in quotas, mediated by the use of alternative energy sources. The materials of the article have both theoretical and practical applications. In theory, it focuses on preparing a person for nature protection activities, due to the need to use alternative energy sources, and in practice, on helping specialists introducing projects on sustainable development of the Earth's climate into nature protection practice.

LITERATURE REVIEW

The study of leading scientific concepts and approaches to the formation of concepts and principles of sustainable development of the Earth's climate demonstrates the quality of the ideas analyzed in the scientific environment, which influenced the appearance in the beginning of the 21st century of a number of works that present it as a leading strategy for environmental protection (Bondarenko et al., 2018; Transformation of our world, 2015; Stiglitz, 2018; Heiskanen & Hilde, 2013; Makarova et al., 2019; Ishmuradova et al., 2018). Theoretical and methodical approaches of these authors are accepted in this study as a methodological basis for solving the tasks. It has been proven that sustainability in the cognition and activities of mankind, which entered the 21st century, is becoming one of the leading paradigmatic attitudes in the relationship between the environment and man (UN Summit on the Adoption of a New Agenda "Transforming our World", 2015). Among them is the development of a strategy for sustainable climate development as a universal approach, based on the present needs for alternative energy sources (High Level Group Report Secretary-General for Global Sustainability, 2012).

It has been established that in today's conditions, studies of a group of scientists and specialists who give particular importance to non-carbon energy sources – de-carbonization, renewable energy, atomic and electric energy in the sustainable development of the Earth's climate are of particular interest (Bruntland, 1989; Kondrla & Kralik, 2016; Bukvich & Petrovich, 2017; Makarov & Stepanov, 2017; Stiglitz, 2018; Heiskanen & Hilden, 2013). The conceptual conclusions of these scientists served as a starting point in revising the views of the scientific community on the role of alternative energy sources in the sustainable development of the Earth's climate. New approaches were justified by the results of using modern precise equipment and remote sensing of the atmosphere for greenhouse gas emissions (Fedorov & Averchenkov, 2011; Greenhouse Gas Emissions Trading, 2014; Orekhovskaya et al., 2019).

The established trends have expanded the level of observations of the Earth's atmosphere and climate, and the results of observations have allowed determining approaches to reducing greenhouse gas emissions as a priority condition for the development of climate stability. In connection with the results obtained, the bulk of modern approaches to studying the sustainable development of the Earth's climate is devoted to alternative energy sources, as priority conditions for preserving the environment (Bukvich & Petrovich, 2017; Bondarenko et al., 2018; Stiglitz, 2018; Bunakov et al., 2019). In the course of the study, it was established that despite a significant amount of research and the active interest of modern specialists in the problem of sustainable development of the Earth's climate, many topical issues that require

scientifically sound solutions involving modern technical means remain open. Among research projects, theoretical and methodical justification for the use of alternative energy sources in the sustainable development of the Earth's climate holds a special status. The study of these aspects is the goal of this study.

RESULTS AND DISCUSSION

Discursive Content of the Concept of the Earth's Climate Sustainable Development

It has been established that the concept of sustainable development became widespread in the theory and practice of social ecology after the publication of the report of G.H. Bruntland (1989) in the widely known interpretation: "sustainable development is such a development in which environmental impacts remain within the biosphere economic capacity, so that the natural basis for the reproduction of human life in the present and future is not destroyed." This definition was included in the scientific turnover of specialists and environmental science with certain adjustments due to real situations and transformations of environmental, including climate, processes (High Level Group Report Secretary-General for Global Sustainability, 2012). It has been established that in the transition to sustainable development of the climate, as it follows from its discourse, it is necessary to focus on the long-term satisfaction of human needs, which guarantee a normalized quality of life while maintaining an environment that does not form negative evolutionary factors (Bukvich & Petrovich, 2017). This definition by the scientific audience, interested representatives of business, public organizations and all kinds of foundations was subjected to unprecedented criticism. Based on this difficult situation, as well as on the current state of knowledge of the problem's certain aspects and alternative positions in relation to the results, this article presents the results of modern approaches' study to the definition of this concept's new meanings. It has been established that the methodological basis of the conceptual category of sustainable climate development is based on the laws of B. Commoner (1974), formulated by him in the early 70s of the last century, and which have not lost their significance today:

- Everything relates to everything. All ecological systems are mutually tuned and mutually balanced; there is a universal connection of processes and natural phenomena;
- everything should go somewhere. There is a shortage of some elements that can be obtained using biogenic elements by the type of cycles. The appearance of elements, including business waste, not involved in metabolism, leads to grave consequences;
- nature knows better. While there is no reliable information about the mechanisms and functions of nature, humanity is easily harming natural systems, trying to exploit and modernize them. Any major anthropogenic change in the natural system is harmful to it, because the system has undergone an incomparably longer evolution than the period of development of our civilization;
- Nothing is given for nothing. In nature, every object is worth something, because any ecosystem is a single whole, within which nothing should be lost: everything that was extracted from it by human labor must be returned (Commoner, 1974).

The use of the laws of B. Commoner (1974) during the study determined the compatibility of the general scientific principles of sustainable development of ecological systems with the principles of sustainable development of the Earth's climate:

- Precaution, considering the vulnerability of the natural environment, not allowing its ultimate strengths to be exceeded;

-The considering of the essential mutual relations of climate, nature and man;

- Compliance with the natural laws of climate development, so as not to cause irreversible processes in the environment;

- Compliance with the capacity of natural opportunities as the limit of solving climatic problems by man and society;

- considering the peculiarities of time, situations in the development of climate and the well-being of society.

Based on the laws of B. Commonerb (1974), the general scientific principles of sustainable development of the Earth's climate, 17 goals of sustainable development of the climate proposed by the UN Summit (2015) on the adoption of a new agenda in the field of sustainable development of the climate for the period up to 2030, priority strategies for sustainable development of the Earth's climate have been formed, defining a new semantic content of the concept. It has been proved that the sustainable development of the Earth's climate, starting in 2015, is being transformed into a multi-level management system that "corrects and limits various types of techno-genic activities in connection with the need to preserve the environment for present and future generations of civilization, which must be reproduced in their former quality and evolve under the influence of natural environmental factors" (The UN Summit, 2015).

Structure and Content of Alternative Energy Sources in Sustainable Development of Earth's Climate

Since 1990, the Intergovernmental Panel on Climate Change (IPCC) has been publishing assessment reports summarizing national observations on climate change (High Level Group Report Secretary-General for Global Sustainability, 2012; Heiskanen & Hilden, 2013). Based on the results of the content analysis of the IPCC reports and the observations of this commission on the process of sustainable development of the Earth's climate, the structure and content of technological solutions for the use of alternative energy sources aimed at reducing CO 2 emissions into the Earth's atmosphere are established:

- improving energy efficiency with the help of modern construction projects, providing for the reduction of the need for heating, cooling and energy-intensive ventilation;

- Large-scale implementation of carbon-free technologies to produce electricity based on renewable energy sources (wind, sun, hydropower, geothermal energy);

- Consistent de-carbonization of the electric power industry, introduction of carbon capture and storage technologies (CCS processes, construction of new generation nuclear power plants);

- Transfer to non-carbon energy (hydrogen fuel, biofuel) of automobile, sea and air transport, other sectors of the economy (Safonov, 2015). The alternative energy sources necessary for the effective solution of the technological tasks of sustainable climate development are identified:

1) carbon-free, renewable energy sources (RES), including bio-hydro, wind and solar energy with a sharp reduction in the share of coal, oil, natural gas. Real facts have been established: the transformation of the energy system in 2016–2035 will require an average of $ 2.4 trillion annually in 2010 prices (2.5% of world GDP). For the transition to zero emissions in 2050, a radical revision of the principles of land use, agriculture, urban planning and industry as a whole will be required, as well as the development of new

technological advances in the field of renewable energy and energy efficiency (Bondarenko et al., 2018);

2) De-carbonization. As a source of new energy, it exists due to hydrogen, which is used as a heat source or reducing agent. Other sources of de-carbonization energy are direct electrification of industrial processes; the use of biomass as an energy source, a reducing agent (in the production of steel) or as a raw material (plastic production); carbon sequestration in combination with its use or storage. The choice depends on the selling price of carbonless energy in the regional market. The costs of de-carbonization can be significantly reduced by reducing the costs of renewable energy; increased use of recycling and reuse of materials in combination with optimization of supply chains; the effect of training and economies of scale for future technologies (Fedorov & Averchenkov, 2011; Stiglitz, 2018; Greenhouse Gas Trading, 2014).

Variation Models of Sustainable Development of the Earth's Climate

It has been established that in recent decades, weather anomalies and natural disasters are perceived as the main risks of the dangers that humanity can face. Climate instability has become an existential threat to the entire global community, especially to the economy. According to OECD estimates, by 2060, economic losses from climate instability can exceed 3% of world GDP, and by the end of the century, a 10% rate will be reached (Stiglitz, 2018). In connection with the situation in February 2005, the Kyoto Protocol defined a set of measures to resolve the problem of environmental pollution by reducing greenhouse gas emissions into the atmosphere. The Kyoto Protocol is the first international agreement on climate protection, based on market mechanisms that encourage enterprises and states to take radical measures to reduce greenhouse gases. Based on established trends, approaches to the development of variable models of sustainable climate development are identified:

(1) A model for reducing GHG emissions (greenhouse gases). It has been proven that GHG emissions, which include carbon dioxide (CO 2), nitric oxide (N 2 O), water vapor, fluorine-containing gases (F-gases), account for 73% of global emissions. Until recently, the main market mechanism for limiting GHG emissions has been the carbon tax, the main drawback of which is the uncertainty of the future level of emissions and the uncertainty of the costs of their reduction. To overcome tax-mediated risks, manufacturers often use hybrid models that combine taxes and an emissions trading system (Greenhouse Gas Emissions Trading, 2014). At the level of each individual country, the emission tax has been used since the beginning of the 1990s. The basic principle of emissions trading is limit and trade. It means setting an upper limit on the amount of allowable emissions for a group of entities trading in quotas for a certain period, considering the level of greenhouse gas emissions of a country, industry or industry sector. An emission permit is distributed among entities free of charge or purchased by them at auctions. At the same time, the price of emission permits formed at the auction is the most effective and environmentally efficient method for distributing permissions. This is a commonsense trend, since it reflects the actual costs of reducing greenhouse gas emissions and the true price of carbon, which simplifies investment decisions (Heiskanen & Hilde, 2013). If the subject exceeds its quota, it must buy permission from other participants in the system on the secondary market or auction. In turn, an entity that has not used all the quotas it has received may sell their surplus. It is assumed that limiting the right to greenhouse gas emissions is a financial incentive for investment in emission

reduction measures. For example, renewable energy and green technology. It has been established that the carbon tax model is an effective mechanism for replenishing the budget and regulating many homogeneous sources of emissions. It does not have an effective impact on climate resilience (Fedorov & Averchenkov, 2011).

A model for trading GHG emissions quotas. It has been established that the first international system for trading in quotas (PTS) and managing through it the entire climate policy of the world is the PTS of the European Union. The organization was established in 2005. 31 countries participate in the EU PTS. It covers strategically important sectors of the economy: electric power, oil refining, metallurgical, glass, paper, cement industries, air transportation, etc. (more than 11 thousand enterprises with the most significant annual emissions). In general, these sectors account for about 45% of all emissions in the EU (Greenhouse gas emissions trading, 2014). The practice of functioning of the PTS proves its own inability to address issues of sustainable climate development. On the one hand, it is vulnerable to external shocks, similar to the 2008 economic crisis, and does not fit well with the energy policies of different countries; on the other, it is characterized by a structural imbalance between supply and demand of quotas, expressed in excess of unused quotas. Since 2008, the EU has accumulated 1.7 billion quotas, which prevents the determination of the true carbon price and does not stimulate the transition to a low-carbon economy (Bukvich & Petrovich, 2017).

It has been established that currently there are more than 20 models of PTS in the world. They differ among themselves in terms of sectors, participants, methods of allocation of quotas, volume of regulated emissions, prices per ton of CO 2. The existing PTS cover 28 jurisdictions: one PTS is international, five are national, and 17 operate in the provinces and states of the USA, China and Canada, 5 - in large cities in the Asia-Pacific region (Fedorov & Averchenkov, 2011). Experts note that the trend towards the creation of PTS models in emerging economies, including in Asia and Latin America, is gaining momentum in the emissions trading market. A new generation of PTS models is being developed in these regions, adapted to reduce atmospheric emissions, limit local environmental pollution and modernize energy systems in a growing economy (Makarov & Stepanov, 2017. It has been proven that the Chinese national quota market will be the largest in the world and ahead of the EU PTS in the future. Even at present, eight pilot PTS models in several provinces and cities of China cover 1.3 billion tons of CO 2, which is 10% of the annual GHG emissions in the country (Bukvich & Petrovich, 2017). It was established that despite the active promotion of market-based instruments to combat global warming, the international community was not able to achieve significant success in this area. More effective is the combination of various models of sustainable climate development, including investments in state infrastructures and transport, urban planning, support for the production of electricity based on alternative energy sources, variable models of sustainable climate development.

CONCLUSIONS

The results of the study confirm the theoretical and practical significance of the problem of the Earth's climate sustainable development, due to the trends of research interests in alternative energy sources, aimed at saving the environment. An intensive search for new ideas for the sustainable development of the Earth's climate as an ideal model of the human environment has concentrated research interest on the structure and content of alternative energy sources, which have significantly expanded the

interpretation of sustainable climate development in market reality. The theoretical and methodical approach to the use of alternative energy sources is justified as a methodological basis for the sustainable development of the Earth's climate. In the course of the study, it was established, despite the active interest of modern specialists in the problem of sustainable development of the Earth's climate, many questions that require correct, scientifically sound solutions remain open in its study. In this regard, the study revealed the discursive content of sustainable development of the Earth's climate due to the transition to alternative energy sources; the structure and content of alternative energy sources are established (renewable energy, de-carbonization). Based on the results of the study, the varieties of models of the Earth's climate sustainable development (the GHG emission reduction model; the GHG emissions trading model) are justified and experimentally proved, mediated by the use of alternative energy sources. The materials of the article have both theoretical and practical applications. In theoretical terms, they are focused on preparing a person for environmental protection, due to the need to use alternative energy sources, in practical - on assisting specialists introducing projects on sustainable development of the Earth's climate in nature protection practice.

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