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Editorial

Green Economy and Sustainable Development: The Outlook

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Modern theories that make up the paradigm of sustainable development, and the best practices derived from them, are based on the consistency of individual and public needs, factors of economic growth and ecosystem conservation. The trend of green economy expansion is moving from a challenge facing modern society to the dominant area of scientific thinking, which is increasingly focused on solving the problems of reducing the anthropogenic impact on the environment, primarily on the climate. At the same time, the level of scientific and technological progress, and the quality of life that modern civilization has reached, require the preservation and increase in the specific consumption of various resources in the long term. Therefore, green economy technologies that ensure the transition to sustainable development are initially focused on the optimal and integrated use of non-renewable resources and the maximum involvement of renewable resources in the production of goods specific for a post-industrial era [1]. Based on this, the evolution of sustainable development methodology should be carried out in the system of innovative development of industrial technologies and their adaptation to the latest trends in energy and urbanism, ecology, finance and investment.

At the same time, sustainable development is associated with increasing the responsibility of business, governments and the entire society, around the world, for achieving a balance between current and future needs for subsoils, energy, traditional and new materials, and transport. Such responsibility equalizes environmental and social problems (poverty and malnutrition, inequalities in access to wealth and income distribution), which often have common roots. This, in turn, highlights the importance of interdisciplinary and multilateral research on sustainable development issues, the results of which can answer questions about green economy perspectives.

The green economy—the newest way to obtain and use resources—is a product of the Fourth Industrial Revolution and concentrates many of the achievements of Industry 4.0. The related structural shifts in the economy are caused by the emergence of new industries of waste recycling, zero-emission energy production, absorption of greenhouse gases emissions, green urbanism, and post-mining. These shifts should be matched by a parallel increase in productivity and labor safety, improved access to drinking water, food, energy, as well as in joining the efforts of national states and businesses in the fight against climate change, in replacing minerals with renewable resources.

However, a true transition to a green economy is possible only with the sustainable development of all industries and the saturation of both production and consumption with green technologies. Green production should be developed in basic industries (mining, energy, engineering, chemistry, transport), as well as in high-tech industries that set new horizons for environmentally oriented modernization. These processes, integral to sustainable development, are united in the "green growth" concept, the main trend of green

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economy development, which consists in increasing the production of so-called "sustainable goods and services", the main feature of which is recycling and zero emissions of toxic substances. At the same time, there is no consensus among academicians on the extent to which the growth trend of the green economy will coincide with traditionally driven growth (increase in the production of "high-carbon" energy, industries with large volumes of waste). Therefore, the creation of platforms for discussing the problems of sustainable development and the green economy is important for the publication of research papers on a wide range of related topics.

Thus, the discussions in the field of sustainable development, unfolding in the pages of scientific journals around the world, should provide the answers to a number of challenges facing the world economy.

The first challenge is to achieve the sustainable development goals set by the UN [2] (including ensuring universal access to affordable and clean energy sources, promoting decent work and economic growth, ensuring sustainable cities and communities, responsible consumption and production, et al.), without a simultaneous deterioration in the functioning of existing industries that concentrate investments, jobs, and tax payments. In other words, the balance between current and future production and consumption has not yet been found. The road is left wide open for unbalanced government policies towards a green economy, which could potentially cause a decline in investment activity and significantly slow down economic growth, especially in developing countries. Therefore, modern science faces the issue of ensuring the evolutionary development of green economy and regulating its expansion in such a way that the investments, jobs and consumer demand do not provoke national and global economic crises. It is important that the new "green" jobs are usually created in traditional industries and infrastructure, associated with the reduction in energy consumption, waste generation and emissions of toxic substances.

The second challenge is to ensure the investment attractiveness of the processes that form the green economy and the development of B2B, B2C, B2G, C2B, C2G, G2B, G2G relations in it, in which the development and implementation of standards for companies' environmental responsibility will not destroy the existing incentives for innovation. Setting eco-efficiency requirements for business can be an effective first step towards a green economy, sustainable energy production from alternative sources and sustainable urban development, without increasing pressure on the environment. The fact that these problems are reflected in a wide range of scientific publications inspires optimism for an increase in eco-efficient investments, the share of which reaches its maximum in the green economy.

The third challenge is the sustainable development of the energy sector and the expansion of its "green" segment producing zero emissions. The key trend in the development of modern industry is its ESG transformation, which combines the reduction of greenhouse gases emissions in energy production and transport (in the economy as a whole—a decrease in specific energy consumption), advances social responsibility and the efficiency of stakeholders' interactions, in solving sustainable development problems. As part of the ESG transformation, the development of green energy is aimed at the decarbonization of industry and cities, as a response to the growth of greenhouse gases emissions and the unfavorable climate changes caused by them. It implies increasing the share of carbon-free transport and cities during transition to the use of renewable energy sources (solar, wind, biomass, biogas, geothermal), as well as hydrogen fuel. It is important that the global research community does not demonstrate a technocratic approach to solving the problems of the green economy and energy, but fundamentally explores the possibilities of developing responsible ESG investment that takes into account environmental and social factors, when making decisions on the creation of new energy and industrial systems, as well as expanding urban agglomerations.

The fourth challenge to sustainable development is associated with the innovations in traditional industries that occupy an important place in the modern economy, in particular, mining. In the transition to a green economy, the most important step should be to ensure the main value of modern society—the labor safety and the protection of human lives. The

technological level of the extractive industries sets the pace for reducing the negative anthropogenic impact on the ecosystem and, at the same time, improving the quality of life of the population in industrial clusters, which is in line with the UN sustainable development goals. Therefore, research into the issues of modernization of mining equipment, in order to improve labor safety and prevent man-made disasters, should take an important place in the mainstream of sustainable development.

Considering the importance of these challenges for sustainable development, the purpose of this Special Issue is to disseminate the results of cutting-edge research and broadcast the opinions of scientists from around the world, providing technological breakthroughs in green energy and urbanism, recycling and modernization of basic industries, conducting fundamental research on the economic problems of the transition to sustainable development.

Acting as the Guest Editors of this Special Issue, we got a chance to see the comprehensive understanding of sustainable development and the green economy emerging in the international scientific community. The positive response of researchers from different countries, supported by the number and high quality of articles published in this Special Issue, contributed to the expansion of horizons in sustainable development research, by combining economic and technological approaches. These approaches are based on the accumulated results of theoretical analysis and practical experience in the balanced use of non-renewable and renewable resources, the transition towards a circular economy and zero emissions. A consistent and multi-stage progress of green economy allows for the protection the world community from crises of overproduction and underconsumption, increasing the equity of access to the modern blessings of civilization, and goes beyond the rigid framework of academic discussions. The stable expansion of the green economy should be accompanied by an increase in the social well-being of not only current, but also future generations, which increases the responsibility of researchers, investors and governments. This is the main idea that this Special Issue promotes.

Articles collected in the Special Issue and selected for publication cover a wide range of sustainability and green economy issues, including green urban development and recycling, strategic production planning and market integration, zero-emission alternative energy sources, and Industry 4.0 technologies to reduce energy consumption, innovative modernization of extractive industries to improve labor safety. A special place is occupied by studies of the post-industrial transformation of industrial clusters.

Articles published in this Special Issue, as a part of Energies, are grouped in accordance with their thematic area, which corresponds to the aforementioned challenges for green economy expansion and sustainable development.

With regard to the first challenge (fundamental research in achieving sustainable development goals and stabilizing the green transformation of the economy), four articles address the sustainability of cities, planned product aging, energy markets integration, regional operational programs financing. Their provisions are related to solving the fundamental problems of sustainable development.

The article by Margeta et al. [3] provides an overview of the problems of energy and water supply in modern cities. The authors note that the high concentration of the world population in urbanistic areas causes an overconcentration of energy and water consumption in them, which makes it relevant to find ways to reduce the dependence of modern cities on their external sources, taking into account climatic features and vulnerability to natural disasters. The relevance of the presented study lies in the fact that the Seawater Steam Engine (SSE) technology proposed by the authors, which is fully consistent with the philosophy of sustainable development and based on the original "loop" concept, makes it possible to ensure the energy security of the city and its provision with critical resources, using methods and means of accumulation of electric and thermal energy, based on geothermal sources.

Niklewicz-Pijaczyńska et al. [4] presented a method for identifying the purchasing attitudes of durable goods' buyers, considering deliberate product aging. The authors

analyze the negative externalities associated with the efforts of producers to program the replacement of goods by consumers, which generate significant private and social costs, and hinders sustainable development. The article presents a critique of the deliberate aging of products as inconsistent with the goals of sustainable development and contradictive to its model, and shows the results of an analysis of the factors of purchase of restitution goods, mainly, the income of buyers and the specifics of the goods. The main conclusion of the authors can be considered as the recognition of planned product aging as inappropriate for the tasks of preserving the environment by the majority of consumers, who positively assessed the transition to closed cycles of durable goods production.

In the article by Rybak et al. [5], the problem of achieving the Seventh Sustainable Development Goal (SDG7: affordable, reliable, sustainable and clean energy for all by 2030) is explored from the point of view of the integration of energy markets of European countries. The spatial information system proposed by the authors, based on the indicators used by Eurostat, was subjected to cluster and TSA analysis. As a result, it was found that in the course of the transformation of the energy systems of European countries, new unique clusters arise, and there is a need for additional indicators for assessing the production of affordable and clean energy. The author's findings, presented in the article, contribute to SDG7 achievement, in terms of realizing the potential of green energy to balance economic growth and increase health and well-being rates, as well as avoiding crises in energy production and consumption.

Mach et al. [6] reviewed the effectiveness of Regional Operational Programs, in the context of sustainable development of Polish provinces, by analyzing the correlation between public regulation and regional economic indicators that characterize sustainability (with an emphasis on employment and income indicators, housing construction). In the presented study, the authors used a method for determining the closeness of the relationship between public spending in the field of sustainable development and macroeconomic determinants, based on the temporal variability of the correlation and regression dependencies of the used determinants. Its use made it possible to determine the positive impact of Regional Operational Programs on regional entrepreneurial and socio-institutional capital. Its increase advances the regions on the path to sustainable development, which has a practical aspect for the effectiveness of EU funds disbursement.

With regard to the second challenge—the development of economic relations and processes that form a modern green economy—three articles have been published. They explore the problems of economic evaluation in waste disposal and recycling, increasing the efficiency in the use of material resources and optimizing their production, consumption and environmental regulation of the processes of the post-industrial economy. The scientific provisions outlined in these articles are of a practical nature and designed to help solve the short- and medium-term problems of the transition to the green economy.

The article by Stehlíková et al. [7] provides an approach to economic incentives for improving waste management (using the example of the Slovak Republic), taking into account the economic situation of households—the second waste producer after industry. In the course of the study, the authors used statistical methods, such as correlation analysis of economic indicators of household well-being and the quality of waste management, the results of which were verified using polynomial dependencies. The extension of this methodology to the regions of Slovakia, using cluster analysis, made it possible to determine the economic incentives for processing communal waste, to reduce their storage volumes and energy production.

Tausova et al. [8] analyzed the compliance of established practices and emerging trends in the use of material resources with the Environmental Policy Goals adopted in the European Union. The authors rightly note that the transition to a circular economy includes, in addition to new technologies for the design and consumption of materials, a reduction in the material and energy intensity of existing industrial production. The article provides a comparative analysis for the consumption of material resources in EU countries, using the cluster approach and statistical data processing by JMP software. The

authors have established that the relationship between tax regulation on the use of natural resources and energy production, and changes in the material consumption of industry, is close to linear. The results of the study made it possible to identify the heterogeneity of EU countries in the effectiveness of the economic policy of reducing the use of natural material resources and switching to their recycling, which helps to improve the process of setting energy and environmental goals.

Raszka et al. [9], in their article, give a comprehensive assessment of the potential for the post-industrial development of cities and municipalities, taking into account social, economic and environmental criteria. In their study, the authors set the task of identifying strategic goals, the achievement of which means sustainable development acceleration, using a multidimensional analysis method for this, considering the distances between individual diagnostic variables. The application of the research method to the Wałbrzych Region (Poland) made it possible to rank the municipalities in terms of the social, economic and environmental potential of post-industrial development, which outlines the ways to improve regional environmental and economic policy. The authors paid special attention to the changes in the living conditions of the population and the structure of jobs, development of cultural service and tourism.

Eight articles are devoted to the third challenge to sustainable development—overcoming the green energy limitations and decreasing greenhouse gases emissions. The authors consider the issues of optimizing the use of green energy, taking into account the achieved standards of living, the dependence of carbon dioxide emissions on changes in energy consumption, the development of alternative solar energy, greening of traditional thermal engineering, the impact of diffusion of Industry 4.0 technologies on energy consumption, achievement of near-zero carbon dioxide emission in urban areas. The main conclusions and proposals presented in these articles are mostly practical and can be used both in strategic and operational management of the green economy processes.

Malinowski [10] analyzes the relationship between the quality of life in the EU and the development of alternative energy, focusing on the key role of green modernization of energy production, in ensuring a high standard of living for future generations. The article presents the results of empirical studies on the relationship between the development of green energy and living standards, based on the TOPSIS method and multi-criteria selection of variables, which include publicly available data from the EUROSTAT database. The results of the statistical analysis performed showed a relatively high value of the Spearman rank correlation coefficient, between quality of life indicators and the development of green energy, which confirms the idea of the inevitability of the transition to alternative energy sources in the mainstream of sustainable development as a condition for increasing the well-being of future generations.

Fong et al. [11] studied the dependence of the dynamics of energy consumption and emissions of carbon dioxide (the main greenhouse gas) as the main obstacle to sustainable development. The originality of the author's approach is the use of economic indicators (labor, capital and energy resources) to analyze carbon dioxide emissions in relation to GDP production. The statistical data obtained in the Guangdong-Hong Kong-Macau Greater Bay Area were used as the factual basis of the study, and analyzed in three stages (SBM-DEA model, SFA analysis). The results of the study made it possible to propose a number of recommendations for the development of state incentives for energy efficient and low-carbon production, and the provision of modern environmental protection standards.

In the article by Rybár et al. [12], the concept of a non-metallic flat plate solar collector is reproduced and a technique for evaluating its efficiency is shown. In accordance with the principles of the transition to a green economy, the development of green energy should be accompanied by a reduction in the material intensity of energy production from alternative sources, in particular, a reduction in the content of metals in solar equipment. In accordance with this, the authors proposed, and experimentally confirmed, the prospect of replacing the metal parts of the solar collector with a block of foam glass. The article presents a two-stage evaluation of the flat plate solar collector, a quantitative evaluation

with a theoretical curve of the efficiency, followed by verification during experimental tests. As a result of experimental verification, the functionality of the concept of the flat plate solar collector was confirmed and problem areas were identified that require special attention when developing a prototype.

Bajno et al. [13], in their article, considered the possibilities of improving the traditional chimney system in reducing energy consumption, based on data obtained from the use of artificial neural networks in predicting temperature distributions in the building of chimney systems. The transition to the operation of energy-efficient buildings requires solving the problems of thermal energy losses, as soon as possible, in relation to a large number of existing buildings, as well as for facilities under construction. The authors conclude that improving the insulation of chimney systems is required to reduce energy consumption in older buildings, as well as avoiding the overheating of parts of rooms by regulating the amount of heat supplied to various parts of the building.

Beer et al. [14], in their article, presented the results of the development of the concept of a concentrated solar heater for segmented heat accumulators and an assessment of the prospects for its use in cooking, without burning fossil fuels. The traditional design of the earth oven, considered by the authors, is successfully supplemented with batteries that receive thermal energy from solar radiation in sufficient quantities. The original design proposed by the authors is quite simple and includes solar vacuum heat pipes, a solar radiation concentrator and heat accumulators. The design parameters were determined based on computational fluid dynamics and the transient simulation of selected operating situations and applied for three spatial points. As a result of the simulation, the possibility of safe and healthy cooking using heat accumulators was confirmed.

In the article by Khouri et al. [15], the prospects for innovative development of electricity production from solar energy, associated with the expansion of the range of materials used in the solar industry, are considered. The authors analyze the prospects for the use of the high purity polyvinyl butyral as a sealing material, based on the results of the molding process, homogenization, and analysis of physical and chemical characteristics during laboratory tests. The article pointed out that the applicability of polyvinyl butyral varies, depending on the location of the solar power plant, affecting UV radiation, atmospheric permeability, temperature ranges.

In an article by Wachnik et al. [16], the problem of the information gap in reducing the energy consumption in the industry, due to Industry 4.0 technologies diffusion, is considered. The authors advocate an absolute sense of the success of energy reduction industry-specific projects, associated with the development of IT, allowing for the optimization of decisions in the design of energy systems. Using the example of projects to minimize energy consumption at enterprises located in Poland, the authors presented the characteristics of information gaps in ICT projects in the industry, which are part of the methodology for reducing information risks in the energy sector and, ultimately, energy consumption.

Xu et al. [17] proposed the use of a three-stage planning method to achieve zero carbon dioxide emissions in the process of developing an integrated energy-planning scheme. The authors used a goal of the setting of regional integrated energy planning, which includes the definition of objects and the development of a strategy, as well as the formation of a methodology. The article proposes indicators for achieving planning goals, which are indices of the share of renewable energy in primary energy, the share of renewable energy in total consumption, and the reduction of carbon dioxide emissions, which are determined for each analyzed area for subsequent comparison. It is important that the results of the author's research can be translated, to improve integrated energy planning in various regions.

The fourth challenge facing sustainable development—the innovative modernization of traditional extractive industries to improve labor safety—is the subject of an article by Szurgacz et al. [18] The authors explore the safety issues of machines and workers in coal mines, associated with mechanical support in a longwall complex. In conditions of

increasing output capacity of longwall, it is important to ensure the introduction of new technologies to protect the working space from the impact of rock mass. In accordance with that, the authors develop the mean of automation in the hydraulic control of the roof support, suggesting the introduction of a two-valve unit into the hydraulic system that provides automatic expansion of the support sections. The article presents the results of tests of a real installation of automated control of mechanical support in a longwall, showing a reduction in working time of the support operator, which is important for improving labor safety and productivity.

The articles published in the Special Issue, "Green Economy and Sustainable Development", highlight topics of the future prospects for reducing the anthropogenic impact on the environment, while maintaining the trend towards improving the well-being of mankind. In the near future, the economies of countries—the main producers of raw materials and energy—should take a massive step forward, in terms of reducing greenhouse gases emissions (to zero in the future), expanding materials recycling and responsible waste management. The contribution of science to accelerating the transition to sustainable development and green economy is to form a systemic response to such challenges as reducing the anthropogenic impact on the environment, ensuring access to alternative energy with zero emissions for everyone, creating jobs and attracting investments in the green economy, increasing environmental and labor safety in traditional industries, including the mining of minerals.

To help in solving the problems of sustainable development, the current Special Issue brings together the work of researchers from the world's leading centers of Earth science, on the economic assessment of the prospects for the development of green energy and green urbanism, strategic planning in sustainable development, innovative modernization of mining and thermal power, material engineering.

Along with this, in the modern world, there are many gaps that hinder the transition to sustainable development and determine the further advancement of scientific ideas. These include post-mining and restoration of biodiversity in industrial clusters, the promotion of new materials and technologies for recycling and renewable energy, the development of unmanned equipment on the Industry 4.0 technology platform, etc. We are confident that this Special Issue of "Energies", dedicated to sustainable development, will contribute to the consolidation and popularization of the ideas of research teams from many countries around the world, including China, Australia, Slovakia, Poland, Russia and Germany.

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